Fire Protection in Bus Depots

CFPA-E Guideline No 48:2026 F

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Fire Safety | Security | Natural Hazards

The CFPA Europe develops and publishes common guidelines about fire safety, security, and natural hazards with the aim to achieve similar interpretation and to give examples of acceptable solutions, concepts, and models. The aim is to facilitate and support fire protection, security, and protection against natural hazards across Europe, and the whole world.

Today fire safety, security and protection against natural hazards form an integral part of a modern strategy for survival, sustainability, and competitiveness. Therefore, the market imposes new demands for quality.

These Guidelines are intended for all interested parties and the public. Interested parties includes plant owners, insurers, rescue services, consultants, safety companies and the like so that, in the course of their work, they may be able to help manage risk in society.

The Guidelines reflect best practice developed by the national members of CFPA Europe. Where these Guidelines and national requirements conflict, national requirements shall apply.

This Guideline has been compiled by the Fire Safety Commission and is adopted by the members of CFPA Europe.

More information: www.cfpa-e.eu

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Key words:

1 Introduction

Fires in bus depots prompted insurers and transport companies to jointly create this publication on fire protection in depots. The information is intended to provide practical assistance for fire protection. The damage experience has shown the limits of conventional fire protection concepts in such depots, not all the usual fire protection measures can be used effectively and sensibly here.

The individual measures are differentiated – also depending on the protection goal - always to be defined in an individual fire protection concept.

It is recommended to involve the insurer as early as the conception phase. For the planning and implementation of fire protection measures as well as for the planning of new buildings and conversions, the findings from damage must be taken into account.

The alternative drive types represent new risks for a protection concept for bus depots. This publication describes which components have to be taken into account for this purpose and what fire risk they pose. It is also considered how the intervention of rescue workers and/or extinguishing techniques can reduce the risk or damage in an area that is already on fire.

This publication provides information on loss prevention, particularly from the point of view of property insurance. It is aimed in particular at operators of depots, planners, fire protection agencies and fire protection engineers as well as insurers.

This guideline is based on the German VdS 0825 guideline.

2 Scope

This guideline is concerning bus depots, not bus terminals.

The information generally applies to new depots to be built as well as to conversions and modernization measures in existing depots, taking into account the specific fire protection requirements. Existing companies should adapt their fire protection measures to these instructions as far as possible. Fire protection must be checked and adapted, particularly when switching to alternative types of drive. The damage prevention measures described can also be implemented to improve fire protection in companies with intercity buses and coaches.

In addition to the diesel-powered buses, the charging and refuelling infrastructure must also be taken into account for alternatively powered buses. As a rule, the operation of bus depots must be completely rethought when converting from diesel-powered buses to electric buses and/or fuel cell buses and/or CNG/LPG/NG/LNG buses, and, as experience has shown, must be adapted and possibly also converted.

Statutory regulations and official requirements, e.g. from building authorities, trade supervisory authorities and national statutory accident insurance institutions, as well as individual contractual regulations with the insurer should be followed and remain unaffected by this information. The use of this publication does not overrule relevant standards or other technical rules. Where references are given, these are for explanation purposes but do not claim to be complete. This also applies to the measures for explosion protection as well as occupational health and safety.

In the case of fuel cell buses, powered by hydrogen as its power source for electrically driven wheels, the dangers of hydrogen must also be considered.

The fire protection of gas-powered buses (CNG/LPG/NG/LNG) is not included in this guideline, they need a specific fire risk assessment, as the fire and explosion hazards are at least comparable to those of diesel buses and compressed gas tanks.

3 Definitions

ATEX directive: ATEX designates the directive for explosion protection. ATEX is the abbreviation of the French term for explosive atmospheres, "atmosphères explosives".

(Bus) Depot: The term "depot" is used in this document as a generic term for all buildings of a public transport company that are located at one location. These include e.g. the Parking facilities/areas (storage halls, carports, outdoor parking areas), workshops, buildings for operational readiness (tank and washing facilities), workshop and driver administration, social rooms, canteen, parking spaces/ multi-storey car parks, loading infrastructure, storage, supply and disposal areas and traffic routes; a bus depot is where buses are left overnight and can be recharged.

Battery: The term battery is also used here for rechargeable batteries (accumulators). For the sake of simplicity, no distinction is made between batteries and accumulators.

Contingency Area: A contingency area is designed to park a bus with a potentially damaged lithium-ion battery

CNG: CNG stands for Compressed Natural Gas mainly composed of methane. CNG is highly compressed (up to 200 bar), but still gaseous natural gas.

Fuel Cell Buses: A bus that uses a hydrogen fuel cell as its power source for electrically driven wheels, sometimes augmented in a hybrid fashion with batteries or a supercapacitor. The only emission from the bus is water.

LNG: Liquified natural gas (predominantly methane with some mixture of ethane) that has been cooled to liquid form for ease and safety of non-pressurized storage or transport.

LPG: Liquid petroleum gas (LPG or LP gas) is a fuel gas which contains a flammable mixture of hydrocarbon gases, specifically propane, n-butane and isobutane; it can also contain some propylene, butylene, and isobutylene/isobutene.

NG: Natural gas (also fossil gas, methane gas, and gas) is a naturally occurring compound of gaseous hydrocarbons, primarily methane (95%), small amounts of higher alkanes, and traces of carbon dioxide and nitrogen, hydrogen sulphides and helium.

4 Risks

Typical risks in bus fires are:

- Extremely high fire loads
- Fire spreads very quickly

- Large amounts of smoke in a short time
- Release of large amounts of heat
- Rapid rise in temperature
- Temperatures of over 1,000 °C
- Fire spreads, even over large distances.

Between 2007 and 2022 there were extensive fires in bus depots all over the world, e.g. in Germany in the cities of Bielefeld, Bottrop, Burghausen, Darmstadt, Düsseldorf, Hamburg, Hanover, Heidelberg, Mannheim, Munich, Pforzheim, Salzgitter, Springe and Stuttgart.

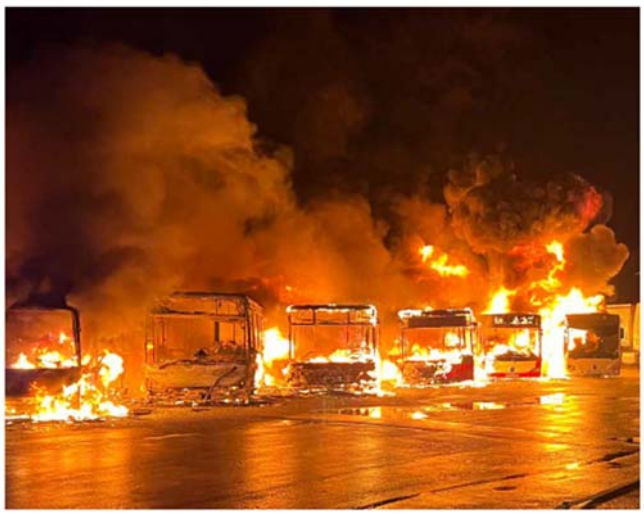

Figure 1: Fire in an open parking space (Photo: Velbert fire brigade)

4.1 Findings on the spread of fire in bus depots

The spaces between the parked buses in the parking facilities are very narrow - usually less than 1 meter.

The spread of fire in a bus to full fire can spread within a very short time (approx.2-3 minutes).

The fire spread to the neighbouring buses without much delay due to the strong heat radiation, so that buses that are parked close together can also be fully engulfed in a very short time. Halls and carports promote fire spread.

The removal of heat and flue gases cannot be realized to the required extent.

Conclusion: Due to the typically tightly parked buses in a depot, a total loss of all vehicles including the hall can be expected in the event of a fire. Calculations from the simulation showed that increasing the smoke extraction area had no effect on smoke and heat removal.

Note on free parking: As fire incidents have shown, fire flashovers are possible even at distances of significantly more than 5 meters.

4.2 Differences between diesel-powered and electric-powered buses

The most common causes of fire in diesel buses can be found in the engine compartment and the units located there. In electric buses, the batteries themselves can have a special fire risk

behaviour, but there are no fire risks through the diesel drive, the exhaust aftertreatment system and various ancillary units, which a diesel bus has.

In the case of electric buses, the batteries and the charging infrastructure must be critically examined as possible causes of fire. Electric buses pose specific risks from the electrical installation in the depot (charging infrastructure) and from the battery systems in the vehicle.
Claims experience so far has not shown any higher probability of fire in electric buses than in diesel or other powered buses. In addition, it has been shown so far that the fires in diesel buses primarily occurred while the bus was being driven. In the case of electric buses, it can be assumed that the risk of fire is greatest during charging.

4.3 Fire load

The fire load of buses is extremely high due to the materials used in the interior and, as a rule, cannot be reached from the outside through the bodywork of extinguishing agents (e.g. from a sprinkler system).

The fire loads of diesel buses and e-buses are roughly comparable.

A reduction in the fire load is also unlikely in the future. The use of plastics and thus also the fire load are white higher (lightweight construction, plastic side walls, etc.).

A reduction in the high fire load from bus interior materials would be possible by adapting the international regulations for the fire behaviour of bus interior materials. The requirements for bus interior materials are at a lower level than the requirements for interior materials in other transport sectors such as rail vehicles, ships and aircraft.

The fire behaviour of buses is significantly influenced by the interior materials used. The electric drive does not change the interior materials or the fire loads unless the traction battery is actively involved in the fire.

4.4 Business interruption due to failure of public transport

In addition to protecting the depot and the buses in it, disruptions or failures in transport operations are an additional risk consider. Public transport is classified as "critical infrastructure". The failure of a large number of buses when a bus depot is destroyed can have a significant impact on local public transport, especially school and commuter transport. The so-called alternative options in the event of damage are very limited due to the increasing specialization and the high technical diversity of the individual public transport providers.

A key protection goal is therefore minimizing operational failures caused by fires in a bus depot.

For fire protection in depots, on the one hand, the protection goals from building law must be ensured:

- The outbreak of a fire and the spread of fire and smoke (fire spread) should be prevented.
- In the event of a fire, the rescue of people and animals and effective extinguishing work should be made possible.

On the other hand, the interests of the operators and users to consider:

- The avoidance of property damage and
- minimizing downtime

The damage experience shows that the fire protection measures from the public law regulations are not sufficient to avoid such effects in a depot. In order to prevent or at least minimize damage to property and the resulting operational failures, fire protection measures may be necessary that go beyond the measures to meet the protection goals under building law.

4.5 Business Continuity Management/Emergency Program/Emergency Schedules

The goal of Business Continuity Management (BCM) is to proactively investigate failures of critical processes and resources and to develop realistic strategies and concrete plans for reducing the negative effects. BCM is therefore not about preventing physical failures, but about creating measures in the event that the impairment of business activities can no longer be avoided.

For the critical resources in a company, emergency plans or business continuity plans, the so-called business continuity plans (BCP), are developed, tested and regularly reviewed in the BCM. In the event of a failure of critical resources, this ensures orderly emergency operation and then a structured restoration of normal operation.

A functioning BCM thus leads to a reduction in the extent of damage and shortens the duration of the impairment of the company. In addition, valuable time can be gained for strategic crisis management, since the crisis team does not have to worry about time-critical processes, but instead activates the business continuity plans.

In public transport operations, special attention must also be paid to the interoperability between different operators when analysing the alternative or compensation options. The interaction of different systems and technologies should be fundamentally examined, tested and evaluated in practice and checked regularly.

4.6 Basic information on adapting the depots to the new challenges

In addition to the protection of the depots and the buses located there, disruptions or failures of the transport operation must be taken into account. The protection concept must therefore take into account the minimization of operational failures caused by fires in a bus depot

In addition to the diesel-powered buses, the charging and refuelling infrastructure must also be considered for alternatively powered buses. As a rule, the operation of bus depots has to be completely rethought and usually rebuilt when switching from diesel-powered buses to electric buses and/or fuel cell buses. This means, among other things, a new and, above all, more powerful power supply, new workshop areas (with e.g. roof workplaces, high- voltage workplaces), new professional qualifications and much more. With all these changes, the operator must carry out a new risk analysis and assessment for each workplace in order to be able to identify the dangers and take protective measures

4.7 Typical causes of fires in buses

Causes of diesel bus fires (Engine compartments are becoming increasingly closed and the installed equipment such as mufflers and particulate filters is cooled less effectively, which increases the risk of fire):

- Leaking fuel supply injection lines
- Overheated ball bearings (belt drive)
- Defects in exhaust aftertreatment systems (stand regeneration)
- Short circuit by mechanical damage (e.g. accident)
- Defects in the 24 V vehicle electrical system
- Defects in the fossil auxiliary heating
- Compressed air lines clogged with soot (coked).

Causes of electric bus fires:

- Manufacturing defects/insulation damage (separator) in the battery
- Short-circuit in the battery due to aging or dendrites
- Improper charging
- Faulty HV screw connections
- Defects in the 24 V vehicle electrical system
- Defects in the fossil auxiliary heating (if still available)
- Heat from outside
- Short circuit by mechanical damage (e.g. accident)

5 Battery and hydrogen

5.1 Experiences from fire damage and battery construction in buses

Batteries are constantly being further developed. As before, major and fundamental changes are to be expected (e.g. cell chemistry). It is therefore not possible and also not useful to describe every type of battery and to address the specific dangers. However, some basic statements can be made that describe the risks. These must be considered when preparing a risk analysis from the point of view of property protection and also from the point of view of occupational safety for the risk assessment.

It is assumed that:

1. The energy density of batteries will continue to increase.

2. Fire/smoke detection outside the battery/vehicle will most likely not have any significant impact on the possibilities for employees/emergency personnel to intervene in the affected fire compartment.

3. Further development of the battery management system (BMS) will be necessary in order to identify critical safety states of the battery at an early stage

4. the evaluation of several signals with regard to the battery status must be analysed and critical statuses should be reported to a control centre (e.g. via battery management system/charging management system). Monitoring outside of the charging phase is fundamentally useful and should be checked.

5. The quality of the battery is crucial both for a fire event inside the cells and for the spread of fire outside the battery. In current e-buses, the batteries are generally located in a sheet metal housing (protection against flames according to ECE-R 100.3). Access from the outside is not possible here due to the enclosure and the location of the construction (on the roof or in the ground) and is also not expedient.

6. An incipient thermal runaway in a cell cannot be stopped and a loss of the entire battery pack and thus also the e-bus must be expected. Due to the structure of the battery modules or battery packs, however, cooling is hardly possible because the cooling/ extinguishing water can hardly be brought to the heat source due to the nested structure.

7. In the event of a fire in a depot full of buses, the emergency services usually have little opportunity to get to the source of the fire.

8. The gas/smoke development can be up to 100,000 litres per module, depending on the battery type. Therefore, self-contained breathing apparatus is required for the emergency services.

9. The effects of a fire from the buses in a depot are characterized by a large amount of smoke and temperatures > 1,000 °C due to the high proportion of plastic. This alone means that the environmental impact of heavy smoke must be taken into account.

For the fire protection of buses, a distinction must be made between diesel-powered and electrically powered drives.

The use of engine compartment extinguishing systems in new vehicles is required by law for diesel-powered buses – as well as for the rooms for the additional fossil-fuel heaters, which can also be used in electrically-powered buses (ECE R 107). According to the experience of property insurers, retrofitting existing buses can make sense in order to be able to control fires in the engine compartment and in the space for the additional heater. When the extinguishing systems are triggered, a message is usually sent to the person driving the vehicle. It makes sense for such a message to also be made for vehicles parked in the depot and e.g. is forwarded to a depot management system.

So far, there has been no adequate, effective extinguishing system or extinguishing agent for the batteries of electrically powered buses. Accordingly, the battery management system must be so sensitive that it recognizes anomalies in good time to issue a message and interrupt the charging process in the event of critical conditions. This requires an interface to the charging management of the depot.

In the case of a burning bus with a thermally reacting battery, extinguishing the battery is not possible. Water is a suitable extinguishing agent for a burning bus. However, a battery cannot be extinguished, only an attempt can be made to cool it as effectively as possible. This means that the fire brigade has to use large amounts of extinguishing water to cool the battery. According to current knowledge, normally no attempt should be made to open the batteries in order to get water onto the cells. This could favour further electrochemical reactions that can lead to even more severe thermal reactions in the battery. Manipulation of the high-voltage batteries cannot be brought into line with the accident prevention regulations (UVV), are counterproductive and must therefore be avoided at all costs.

5.2 Hydrogen

Appropriate measures must be defined and implemented based on the result of the risk analysis. This can e.g. be hydrogen sensors, automatic smoke and heat extraction, explosion protection measures (ATEX), explosion-proof electrical systems, natural ventilation openings, structural measures, operational safety concept.

Hydrogen refill infrastructures should only be positioned in open-air areas, sufficiently far from any possible ignition source.

For every type of vehicle with hydrogen, a risk regularly reassessment is necessary.

6 Charging infrastructure in a depot

For electrical infrastructures of the energy supply, separate operating rooms may be required in terms of fire protection in accordance with the ordinance on the construction of operating rooms for electrical systems according to national regulations. This applies to all voltage ranges and storage systems that are used.
Lithium-ion storage systems (e.g. grid storage, second use) should only be operated in rooms that are separate from fire protection system.

Switchgear combinations (switchgear) must be operated in operating rooms with separate fire protection ("closed electrical operating sites" in accordance with national standards).

Risk assessments must be conducted, taking into account both supervised and unsupervised loading processes.

Due to the high power, charging devices must be permanently connected to the low-voltage supply. Mobile chargers that are supplied via CEE plug connections are only permitted in exceptional cases and for a short period of operation and must be specified as part of the risk assessment. For longer periods of operation of mobile charging devices, further fire protection measures that go beyond the legal requirements are recommended. This can e.g.be thermal sensors on power lines and/or integrated local aerosol extinguishing systems.

Before all systems are commissioned, an inspection must be carried out by suitably qualified persons.

Fault and operational reports should be forwarded to a permanently manned office, where an alarm plan/procedure plan must be in place.

In order to also consider, the special requirements for property protection, it is recommended that an acceptance test be carried out by an approved and qualified expert for testing electrical systems.

Control rooms are to be monitored by fire alarm systems or by suitable radio-networked alarm systems. This applies in particular to transformer stations on the route for recharging. A connection to a permanently occupied position such as e.g. the control centre of the transport company is recommended.

Medium-voltage systems, transformers, direct current systems, low-voltage main distribution (NSHV) must be separated from one another in a fire-resistant manner and monitored with fire alarm systems or another suitable, reliable alarm system.

Fire protection must be considered when routing the cables, e.g. bulkheads, when running cables through firewalls. In the case of subsequent assignments, bulkheads must be professionally closed again. Cable penetrations should be checked regularly.

It is advisable to install suitable extinguishing systems for transformers and switchgear combinations.

For all operational changes such for example the use of new drive technologies, the conversion or adjustment of the energy supply, the fire protection concept must be checked and adjusted if necessary.

6.1 Charging management systems

Anomalies in cells or modules detected by the battery management system should be reported to a permanently manned location via a charge management system. If critical anomalies are identified, the charging process must be switched off automatically.

Charging management systems should be tamper- proof and have fallback levels so that the charging process does not/do not have to be switched off in the event of a failure.

Cyber security for charging infrastructure systems and the charging management system must be considered

6.2 Provisional solutions

Ideally, the planning, assembly and commissioning take place in stages after written approval by the responsible person (e.g. a responsible electrician).

Supply lines, distributions, charging devices must be protected against mechanical hazards during operation. Temporarily laid lines are to be selected and dimensioned in accordance with standards, considering the possible external influences, the length, the type of laying and the current load. Suitable cables (e.g. H07RN-F) are available for use on construction sites.

All points to be observed should be planned with a suitable specialist electrician.

6.3 Monitoring of facilities of the loading infrastructure

Significantly more frequent visual inspections and metrological tests are required for temporary installations than for permanently installed systems. The inspection intervals must be determined considering national occupational safety regulations. The following periods may be suitable: Monthly visual inspection, metrological examination every six months or as required, to be observed are requirements changes to CE declarations of conformity and the manufacturer's specifications for test intervals.

Continuous temperature monitoring of the charging infrastructure should be taken into account as early as the planning phase. This makes it possible to detect overheating at an early stage, before a fault or fire can occur. This also makes remote monitoring possible. Transmission to the control centre makes sense so that a message can be sent if critical values are exceeded and appropriate measures can be initiated at an early stage.

By permanently monitoring the heat development at the contact points in the switchgear assembly (switchgear) instead of random, discontinuous measurement with a thermal imaging camera, errors can be detected immediately, and maintenance measures can be initiated.

The technology can also be retrofitted in existing buildings.

6.4 Workshop areas

In workshops, chargers are used both for vehicles and for battery-operated tools. Chargers for vehicles may only be used by trained personnel who receive regular instruction. The charging process should be interrupted at the end of work.

Depending on the size of the workshop and the existing fire protection systems, the charging of tool batteries should take place in a separate area that is partitioned off in accordance with fire safety requirements.

In both cases, the aim is to avoid fires in workshops due to overheating or dead batteries. The specifications of the manufacturer must be observed.

Risk assessments in accordance with the Industrial Safety Ordinance must be prepared in advance and the employees must be instructed accordingly. As part of the risk assessment, the dangers of mobile devices, industrial trucks, mobile IT, etc. must be assessed.

Workshop areas should be separated from storage areas in terms of fire protection. It is also advisable to divide the workshop areas into fire compartments

7 Fire protection measures

7.1 Structural fire protection

The protection goal is: The use of suitable building materials should reduce the risk of fire starting and spreading in and through the building from the outset.

The following points must therefore be observed for structural fire protection:

- Non-combustible building materials have proven themselves and should be used.
- The use of combustible insulating materials, especially in roof areas, should be avoided. A fire can often spread through combustible insulation materials in the roof spread quickly and over a large area.
- The structure and roof structure of closed storage facilities should have a fire resistance rating of at least 90 minutes.
- An increased fire resistance duration of 120 minutes may be required, e.g. B. in extended or multi-storey parking facilities or to protect special areas (electric charging infrastructure or similar).
- In open, covered parking facilities (car ports), the fire resistance period may can also be reduced from 90 to 60 or 30 minutes, e.g. B. when conditions are favourable for firefighting.
- Both with open covered storage locations (bus ports, car ports) as well as for outdoor parking facilities, the erection of fire- resistant walls or firewalls is recommended to prevent fire spreading to the neighbouring buses, as it has been shown that smoke and heat extraction systems are not sufficient to reduce large heat loads in a timely manner.
- In the case of multi-storey storage facilities, additional measures to reduce the effects of a fire must be taken into account. These include e.g. increased fire resistance, additionally by silicate or fibre cement panels, which also allow easier renovation after a fire.
- Windows and door systems in the exterior walls of the storage facility, when vehicles or other combustible objects are parked near these openings, should have a fire resistance rating of at least 90 minutes.
- Formation of fire compartments that are as small as possible.

Figure 2: Fire in a depot hall divided by fire walls: Fire section on the left affected by the fire, adjacent fire section on the right without the effects of the fire. Buses from this area remained unharmed. (Image source: ÜSTRA, Hanover)

By arranging fire compartments, which are ideally kept small, the extent of damage in the event of a fire can be effectively limited.

Suitable fire protection curtains with fire resistance can also be installed to subdivide existing storage halls. The additional use of fire-fighting systems can be useful here.

7.1.1 Size of fire compartments

In the case of all fires in depots, it was evident that all vehicles parked in a fire compartment were destroyed by fire. It therefore makes sense to make the fire compartments as small as possible.

In this regard, based on claims experience, there is a recommendation that only a limited number of buses should be parked in a fire compartment. It can be assumed, that for an average-sized public transport operation, a loss of 15-20% of the bus fleet would result in a significant reduction in public transport. The maximum loss of vehicles that can be tolerated must always be determined individually. In practice, around 20 vehicles per fire compartment have proved effective in order to maintain the most trouble-free operation possible after a fire. Influencing variables include the size of the depot and the overall concept of the public transport provider (number of depots, vehicle reserves, circulation lengths, etc.).

7.1.2 Outdoor parking

Even with outdoor parking, the parking area should be subdivided into smaller sections in terms of fire protection. This can be done with sufficiently large distances between the partial parking areas (so- called “spatial separation”). Experiences from fire incidents have shown that the distance of 5 m established by the building regulations for spatial fire compartment formation in the case of burning buses is often not sufficient. Wider free strips are therefore recommended to prevent the spread of fire.

A subdivision into partial parking areas can also be implemented using suitable walls made of non-combustible building materials (so-called "structural separation"). It is next to a sufficiently high fire resistance (recommended 60 minutes) also to pay attention to the statics. The walls should protrude at least 0.5 meters above and to the sides of the parked buses in order to prevent the fire from spreading to the buses in the neighbouring area as far as possible. Experience has shown that the spread of fire cannot be prevented with walls that are only as high as a bus is. A subdivision by walls in the free parking area can e.g. also be done with concrete block stones.

The partial parking areas should not exceed the following (parking) depths, both in the case of spatial and structural separation:

- 40 m if two opposite sides are freely accessible for firefighting,
- 20 m if only one side is accessible for firefighting.

7.1.3 Movement areas for the fire brigade

In consultation with the fire brigade, the installation and movement areas required for the most effective fire brigade deployment should be determined.

7.1.4 PV systems on roofs of bus depots

In the event of defects, photovoltaic systems (PV systems) can represent an ignition source for combustible building materials in the roof. This must be taken into account during planning. Possible risk minimization measures are described in CFPA-E guideline No. 37 "Photovoltaic systems: Recommendations on loss prevention".

The effectiveness of existing fire protection technical facilities (e.g. firewalls, automatic firefighting systems, smoke and heat extraction systems, lightning protection systems) must not be restricted by PV systems.

When planning a PV system, it must be ensured that a fire compartment separation is not eliminated and that the fire cannot spread to neighbouring fire compartments.

The operating equipment (inverters, cables and lines) must not be installed in the parking area of the vehicles.

7.2 Technical fire protection

7.2.1 Automatic fire alarm systems

Early fire detection and alerting of the fire brigade can basically be guaranteed by installing a suitable automatic fire alarm system.

According to damage experience, however, the speed at which fires spread in bus parking areas is so high that it is no longer possible for the fire brigade to successfully fight the fire within a fire section affected by the fire, even if they arrive early. In this respect, the installation of a fire alarm system will not have any significant impact on the course of the fire and the extent of damage within a fire compartment.

It should be kept in mind, the evaluation of fire alarm system reports can provide information about the origin and progression of a fire. This is very important for both the operator and the property insurer for the traceability of fire incidents in storage facilities. The fire-resistant separation of the fire alarm control panel and the secure storage location of the reports for later evaluation are specified in the relevant regulations.

Adjusted automatic fire alarm system concept
An adjusted fire alarm system concept must be created for the use of an automatic fire alarm system in the parking facility for buses. In this context, the handling of unwanted alarms is particularly important to clarify, for example, through exhaust gases or to select a detection technology that takes the type of vehicle drive into account.

A monitoring of "other" areas of use such as e.g. workshop and offices by a fire alarm system is recommended in order to limit the fire to an area that is as small as possible by means of an early deployment of the fire brigade. The fire alarm of the fire alarm system should be switched to a permanently manned location (e.g. company control centre), preferably directly to the fire department.

If the parked vehicles have on-board fire detection systems, they should be integrated into the charging management and depot management system.

7.2.2 Stationary fire-fighting systems

Stationary fire-fighting systems (sprinkler systems, spray water systems, water mist systems, etc.) are generally very effective fire-fighting equipment.

Due to the body structure of vehicles (cars and buses), with water-based fire-fighting systems, the extinguishing water from the ceiling cannot reach the interior of the vehicle and the extinguishing effect cannot be fully developed. An independent final extinguishing of vehicle and battery fires is therefore not possible.

Based on the current state of knowledge, it is not possible to assess whether a fire-fighting system can reliably prevent the spread of fire between buses that are parked in the dense manner that is usual in depots. The necessary evidence based on fire tests was not provided at the time these guidelines were drawn up, either for sprinkler systems or for spray water or water mist systems.

A protection target for a fire compartment in halls areas with buses (parking facilities, workshops, etc.) is the protection of the building structures from thermal effects. Efficient cooling can prevent failure due to loss of load-bearing capacity due to high temperatures in the components.

Without cooling by an automatic fire-fighting system, there is a high probability of a total loss of the fire compartment.

In single-storey storage facilities, a full-coverage, stationary fire-fighting system can be a useful additional fire protection measure to protect the supporting structure. However, it cannot create fire compartments substitute.

In multi-storey storage facilities without a comprehensive stationary fire-fighting system, a total loss of the building can be assumed in the event of a fire. If the building statics are damaged in the fire area, this usually has effects on the entire building structure, leading to the necessary demolition of the entire building (subsequent total loss and longer-term failure of the location).

Fire-fighting systems should always be set up according to a recognized set of rules and regularly checked according to the national regulations and standards.

The design should always be agreed on with the insurer and a recognized expert body and should be based on the evidence of suitable fire tests.

7.3 Protective fire protection

7.3.1 General

For the fire brigade to be effective in the objects described here, the building code principles must be fulfilled. That means, the rescue of persons should be completed before the fire brigade arrives.

Due to the materials used in vehicle construction (including plastics) and the parking situation, the fire spreads rapidly after the fire has started. By the time the fire brigade arrives, the fire will have progressed so far that it can no longer be controlled by a fire brigade that is capable of doing what is appropriate for the local situation. Measures for early fire detection and automatic alarming of the fire brigade (automatic fire alarm system) are also not sufficient for this.

Without an automatic fire-fighting system, based on past experience with damage, a total loss of the fire section can be assumed (see also the explanations in the section "Technical fire protection").

7.3.2 Requirements for a defensive firefighting operation (minimum requirements)

For the above reasons, without special preventive fire protection equipment supporting the fire brigade, only a purely defensive deployment of the fire brigade is possible (keeping the fire to the structural fire cutting limits).

In principle, the following measures are considered necessary:

1. Fire brigade plan according to national standards for orientation at bus depots with more than 2.000 m² of floor space in coordination with the local fire protection department. The fire resistance of the load-bearing and stiffening components must be shown in the fire brigade plans.
2. Free-standing and adjacent parking areas in depots with a total floor area of more than 5.000 m² must have a driveway that is passable for fire-fighting vehicles. Driveways around the building must meet the national requirements.
3. An extinguishing water supply with the following capacity is appropriate (similar to industrial buildings):
   - up to 2.500 m² floor area: 96 m³/h
   - over 4.000 m² floor area: 192 m³/h
   Intermediate values can be interpolated.
4. Electrical installations that go beyond normal domestic installations (e.g. charging infrastructure for electric buses, overhead lines), should be able to be de-energized from outside the building by the fire brigade.
5. It must be checked whether special measures are required for retaining extinguishing water.
6. Parking facilities for gas-powered buses must be clearly marked from the outside (e.g. according to ISO 17840-2:2019-04 "Road vehicles - Information for first aiders and rescue workers - Part 2: Rescue data sheets for buses, coaches and commercial vehicles").

7.3.3 Additional requirements for an offensive firefighting operation

If the fire brigade is to be able to fight the fire aggressively, further supportive preventative fire protection equipment is required based on an automatic fire fighting system (see above). Extinguishing work within a fire compartment affected by the fire is only possible, if the following parameters are observed:

1. A building collapse is not to be expected (fire- resistant supporting structure made of non-combustible building materials and equipment for heat extraction).

2. From a floor area of 1.000 m², systems for smoke extraction are necessary for effective extinguishing work. Even if there is an extinguishing system, the effectiveness of the smoke extraction system can be assumed due to the significant release of heat
3. Fire-fighting water connection facilities for quick intervention are available (wall hydrant, fire- fighting water volume 200 l/min, withdrawal from three points at the same time).
4. There are access corridors with a width of at least 0.90 m between the rows of buses (e.g. analogous to a main corridor system or for subdividing elongated buildings with lateral access). The penetration depth of the fire brigade in a fire compartment should not exceed 35 m.

Other facilities that go beyond this may be required depending on the specific property and must be agreed with the local fire protection department.

7.4 Operationally more organizational fire protection

Organizational fire protection measures are only effective if they are practiced in day-to-day operations and observed by everyone in the company, including management and employees of external companies.

The organizational fire protection measures contribute to minimizing the probability of occurrence and the extent of operational disruptions or the damage events resulting from them.

The following points are important components of organizational fire protection and should always be observed:

- Order and cleanliness
- Periodical maintenance of the vehicles, according to the manufacturer's instructions
- Testing of the electrical light and power facilities according to national regulations and insures standards
- Electric floor conveyor charging stations according to national regulations and insures standards
- Permit procedure for hot work, see CFPA-E guideline No. 12 "Fire safety basics for hot work operatives"
- Compliance with the smoking ban
- No accumulation of combustible materials on buildings or enclosures

Depending on the size of the company, organizational fire protection should be implemented in a fire protection management system and coordinated by a fire protection officer.

The conversion to alternative drive technologies brings with it new specific hazards. In the search for suitable protection concepts, the individual case-related risk analysis is therefore unavoidable for the time being. The comments on the fire protection analysis listed here provide assistance:

- For the risk assessment, a risk analysis should be requested from the vehicle manufacturers/ charging infrastructure manufacturers as part of the procurement process.
- An exact fire risk analysis must always be carried out on a project basis.
- It is also always necessary to check whether the conversion to alternative drives, a change in use or a structural change there is a change to a structure that requires a (new) permit.
- It should always be checked whether adjustments to the fire protection concept are necessary in this context.

7.4.1 Fire protection in general

The aim of this document is to take a holistic view of the structural, technical and organisational/operational fire protection in the company buildings, workshops, depots and in the vehicles, so that the emergence of a fire and the spread of fire and smoke (fire propagation) is prevented and, in the event of a fire, self-rescue and third-party rescue as well as effective extinguishing work are possible. Furthermore, both the essential requirements and the necessary processes for the creation of a fire protection concept are described.

All employees are to be instructed regularly in accordance with risk assessment.

The necessary instructions on fire protection for employees must be carried out regularly (recommended frequency: annually).

7.4.2 Fire protection manager

Appointment of a fire protection manager is required due to the extensive fire protection tasks and the interfaces to be coordinated. Depending on the size of the company, organizational fire protection should be implemented in a fire protection management system analogous to occupational safety and coordinated by a fire protection manager.

The fire protection manager should carry out regular inspections in which the organizational fire protection measures are checked and documented. Keeping fire protection checklists has proven to be helpful for these inspections. An adapted checklist should be created for the company, in which daily, weekly and monthly checks are also shown and documented.

7.4.3 Damage/accident areas

An emergency area is designed to park a bus with a potentially damaged lithium-ion battery in such a way that, in the event of a vehicle fire that breaks out with a delay, it prevents it from spreading to neighbouring objects (e.g. vehicles, buildings, vegetation, etc.).

At the same time, potential risks to the environment from operating materials that may escape from the battery are reduced. The accident area is not intended to prevent a fire, but to prevent it from spreading.

When setting up a breakdown area for buses that have been involved in an accident, it is necessary to consider the entire process chain from the accident through to putting the bus back into operation. Merely creating an accident area does not do justice to the overall risk potential that can emanate from a bus that has been involved in an accident. This is due to the dangers that can arise from a damaged HV system and/or the batteries. Accordingly, a risk analysis must be drawn up for the entire process chain.

7.4.4 Protection measures vehicles - electric bus and diesel bus

Basically, it can be said, adherence to the normative specifications is ensured by homologous specifications (e.g. European Certificate of Conformity (COC)):

- Fire detection and alarm technology with connection to the control centre, danger alarm system at the traffic control centre.
- E-Bus: Monitoring of the charging process (e.g. temperature and cell voltage) with activation.
- Diesel-bus: fire suppression systems/ extinguishing systems – engine extinguishing system mandatory EU standard ECE-R 107 since 2021.

- Maintenance/repair according to the manufacturer's instructions.

7.4.5 Operation and organization

To ensure a secure operation and organization, following measures should be taken:

- Rescue guidelines and rescue data sheets for buses (COM)
- Creation of an emergency manual for the control centre, drivers and operating personnel
- Creation of service and work instructions
- Training and further education concept (employees, rescue and auxiliary workers)
- Explosion protection concept
- For charging lithium-ion batteries from portable devices, appropriate protective measures should be taken to prevent fire and smoke from spreading to hazardous areas (e.g. charging in a separate room with smoke evacuation to safe areas or in "fireproof cabinets" suitable for lithium batteries).
- Permit for hot work

7.4.6 Interfaces to the fire department for the emergency case

For the most effective fire brigade deployment, the following should be available:

- Competent company employees (e.g. fire protection managers) to support the fire brigade in the event of an emergency
- Emergency kit with important components, e.g. functional vests for better assignment and as a contact for the operations manager of the fire brigade, flashlight, means of communication.

7.4.7 Emergency concept for vehicle fires

In addition to the specifications of the vehicle manufacturer, the generally recognized rules of technology must also be observed when creating an emergency plan. The following documents from the vehicle manufacturer form the basis for this:

- Buses with alternative drive systems are to be marked in accordance with ISO 17840 and rescue cards/rescue manuals are to be made available on the vehicle. A digital assignment of the emergency services via stored data of the vehicle including the battery would be innovative.
- Dealing with the energy stores (damaged batteries)
- Air conditioning refrigerant
- Lifting and recovery concept
- Safety concept in the event of serious accidents with deformations in the electrical area (vehicle may be live)
- Safety data sheets: electrical and chemical parts and components, e.g. batteries, super caps
- Requirements for emergency areas

Before new vehicle types are put into operation, the responsible assistance and rescue services (e.g. fire brigade, police) should be informed. Exercises with the fire brigade are recommended.

The technical defect during line use must be given special consideration in the risk analysis, and the risks from the hight voltage technology must be considered in particular.

7.4.8 Evacuation concept in case of danger

An evacuation plan should be drawn up for emergencies (e.g. fire incidents, flooding, bomb disposal). The following points must be taken into account:

- Definition of evacuation routes, use of emergency exits

- Area concept for storing salvaged busses.

7.4.9 Organizational measures in case of fire

For the event of a fire, an emergency plan should be drawn up. The following points must be considered:

- Provision of a suitable parking area for buses that are still in regular service.
- Ensuring an external energy supply (electrical energy or hydrogen).
- Draw up an installation plan (operational plan for buses).

7.4.10 Training of rescue and auxiliary workers

Rescue personnel such as fire brigade, police and towing companies should be continuously informed about the dangers and special technical features. Type and frequency should be coordinated depending on the regional characteristics. In principle, an annual training interval makes sense. In the case of major technical innovations and new vehicle types, the interval may need to be shortened.

During the instructions, care must be taken to ensure that not only the primary dangers such as gas, hydrogen and electricity are pointed out, but also the secondary dangers caused by reaction products or components of the storage media, e.g. the batteries or other systems, e.g. refrigerants of the climate control system are caused. The specifications of the vehicle manufacturer's rescue cards must be observed. It is important that the respective rescue card is available quickly.

It can be called up, for example, via a QR code attached to the vehicle, or it can be stored in laminated form at a fixed location in the vehicle.

The training of rescue personnel should include the following content:

- Position of the energy storage (battery, fuel cell or pressure vessel).
- Position of the high voltage components/cables in the vehicles.
- Position of possible explosive materials (e.g. pedestrian protection active system; airbag(s); seat belt pre-tensioner(s); etc.).
- Operate vehicles and related facilities.
- Carrying out general activities that do not require the high voltage system to be disconnected from the power supply.
- Carrying out all necessary mechanical activities on the vehicle.
- Switching off the high voltage system by pressing the emergency stop button (usually in the area of the driver's workplace).
- De-energizing the vehicle as additional safety measure by a qualified electrician or an authorized person.
- Determination of the person to be contacted in the event of ambiguities
- Impermissible work on the vehicle.
- Which work requires which qualifications?
- In contrast to a car, the high voltage system is not automatically switched off after an accident.
- Information on damaged areas.

In addition to the content of the training, it makes sense to conduct inspections of the bus depots with rescue services. This is intended to increase local and plant knowledge. In the case of electromobility, the focus should be on setting up and switching off the electrical infrastructure. Special features of gas and hydrogen systems should also be emphasized.

The staff who become active in the event of technical defects in buses in scheduled service must be specially trained in protecting the work area in public traffic and in protecting the environment.

When informing towing contractors, the special technical features of these vehicles must be pointed out. In particular, reference should be made to the lifting concept and the dimensions (weight, height). Furthermore, the vehicle manufacturer's specifications must be observed when towing and in the event of a recovery

European guidelines

Fire (https://cfpa-e.eu/category-guidelines/fire-prevention-and-protection/)
Guideline No 1 F - Internal fire protection control
Guideline No 2 F - Panic & emergency exit devices
Guideline No 3 F - Certification of thermographers
Guideline No 4 F - Introduction to qualitative fire risk assessment
Guideline No 5 F - Guidance signs, emergency lighting and general lighting
Guideline No 6 F - Fire safety in care homes
Guideline No 7 F - Safety distance between waste containers and buildings
Guideline No 8 F - withdrawn
Guideline No 9 F - Fire safety in restaurants
Guideline No 10 F - Smoke alarms in the home
Guideline No 11 F - Recommended numbers of fire protection trained staff
Guideline No 12 F - Fire safety basics for hot work operatives
Guideline No 13 F - Fire protection documentation
Guideline No 14 F - Fire protection in information technology facilities
Guideline No 15 F - Fire safety in guest harbours and marinas
Guideline No 16 F - Fire protection in offices
Guideline No 17 F - Fire safety in farm buildings
Guideline No 18 F - Fire protection on chemical manufacturing sites
Guideline No 19 F - Fire safety engineering concerning evacuation from buildings
Guideline No 20 F - Fire safety in camping sites
Guideline No 21 F - Fire prevention on construction sites
Guideline No 22 F - Wind turbines – Fire protection guideline
Guideline No 23 F - Securing the operational readiness of fire control system
Guideline No 24 F - Fire safe homes
Guideline No 25 F - Emergency plan
Guideline No 26 F - withdrawn
Guideline No 27 F - Fire safety in apartment buildings
Guideline No 28 F - Fire safety in laboratories
Guideline No 29 F - Protection of paintings: transports, exhibition and storage
Guideline No 30 F - Managing fire safety in historic buildings
Guideline No 31 F - Protection against self-ignition end explosions in handling and storage of silage and fodder in farms
Guideline No 32 F - Treatment and storage of waste and combustible secondary raw materials
Guideline No 33 F - Evacuation of people with disabilities
Guideline No 34 F - Fire safety measures with emergency power supply
Guideline No 35 F - Fire safety in warehouses
Guideline No 36 F - Fire prevention in large tents
Guideline No 37 F - Photovoltaic systems: recommendations on loss prevention
Guideline No 38 F - Fire safety recommendations for short-term rental accommodations
Guideline No 37 F - Fire protection in schools
Guideline No 38 F - Fire safety recommendations for short-term rental accommodations
Guideline No 39 F - Fire protection in schools
Guideline No 40 F - Procedure to certify CFPA-E Fire Safety Specialists in Building Design
Guideline No 41 F - Safety instructions for the use and charging of small and medium size lithium ion powered devices
Guideline No 42 F - Guidance document for Selection of Fire Protection Systems
Guideline No 43 F - Foam Concentrates - The selection criteria

Guideline No 44 F – Fire safety recommendations for electric vehicles
Guideline No 45 F – Fire Safety Recommendations for Medium-size Electric Vehicles
Guideline No 46 F – Fire Safety Recommendations for Battery Energy Storage Systems (BESS)
Guideline No 47 F – Transport and storage of batteries
Guideline No 48 F – Fire Protection in Bus Depots

Natural hazards *https://cfpa-e.eu/category-guidelines/natural-hazards/)*
Guideline No 1 N - Protection against flood
Guideline No 2 N - Business resilience – An introduction to protecting your business
Guideline No 3 N - Protection of buildings against wind damage
Guideline No 4 N - Lighting protection
Guideline No 5 N - Managing heavy snow loads on roofs
Guideline No 6 N - Forest fires
Guideline No 7 N - Demountable / Mobile flood protection systems
Guideline No 8 N - Ensuring supplies of firefighting water in extreme weather conditions
Guideline No 9 N - Protection against hail damage
Guideline No 10 N - Heavy rain and flash flood; Recommendations on flood prevention and protection

Security *(https://cfpa-e.eu/category-guidelines/security/)*
Guideline No 1 S - Arson document
Guideline No 2 S - Protection of empty buildings
Guideline No 3 S - Security systems for empty buildings
Guideline No 4 S - Guidance on keyholder selections and duties
Guideline No 5 S - Security guidelines for museums and showrooms
Guideline No 6 S - Security guidelines emergency exit doors in non-residential premises
Guideline No 7 S - Developing evacuation and salvage plans for works of art and heritage buildings
Guideline No 8 S - Security in schools
Guideline No 9 S - Recommendation for the control of metal theft
Guideline No 10 S - Protection of business intelligence
Guideline No 11 S - Cyber security for small and medium-sized enterprises
Guideline No 12 S - Security Guidelines for Businesses
Guideline No 13 S - Cybersecurity Basic level – Basic IT security
Guideline No 14 S - Security Report Rental, Storage and Exhibition of Art Objects

Comments and corrective actions:

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