Fire Protection Leaflet

This leaflet has been developed by VdS, ZVEI (German electrical and electronics industry association), and bvfa (German Federal Association for Fire Protection Technology).

Interaction of Fire Detection and Fire Alarm Systems (FDAS) and Fire Extinguishing Systems (FES)

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This leaflet addresses architects, expert planners, and experts for planning and/or inspection of structural fire protection, shortly: anyone developing fire protection concepts, specialist planning for fire protection engineering, and specialist planning for installation and design of fire detection and fire alarm systems and fire extinguishing systems. The aim is to ensure an optimum interaction of FDAS and FES as early as in the planning stage. The leaflet does neither cover legal requirements, applicable technical standards, nor does it replace system-related documentation by the corresponding system manufacturer required to establish a planning that satisfies the requirements laid down in the law on contracts for work and services and in the liability law.

Selection of suitable fire protection measures can be based on information given in VdS 3429 (Guidance Document for Selection of Fire Protection Systems).

1 Objective of fire protection engineering

§ 3 Paragraph 1 of the Federal Building Regulations (MBO) says:

> Systems shall be arranged, installed, converted, and maintained so as not to put public safety and order, health, and natural bases of human life at risk.

Therefore, § 14 of MBO and the corresponding sections of the German regional building codes (LBO) require regarding fire protection:

> Structural installations shall be arranged, built, converted, and maintained so that formation of fire and spread of fire as well as smoke (fire spread) are prevented and so that rescue of humans and animals in case of fire as well as effective fire fighting are possible.

For practically effective life safety at any time and in view of limited capacities of fire brigades to rescue persons, all fire protection measures shall be designed so that all users of a building get the possibility of safe self-rescue in good time. Both fire detection and fire alarm systems as well as fire extinguishing systems contribute to achieving

this goal, although in a different way. This leaflet is supposed to show the effectiveness and contribution of fire detection and fire alarm systems and fire extinguishing systems to achieving the protection objectives defined in §§ 3 and 14 of MBO in consideration of the priority of life safety given under constitutional law.

The task of fire detection and fire alarm systems is detection of an initial fire as early as possible and alerting of anyone concerned in good time so that safe leaving of the dangerous area becomes possible. Therefore, smoke detectors are used to detect a fire; these shall detect the fire at a time when thermal fire detection devices cannot yet respond. In these cases, fire detection and fire alarm systems are of utmost benefit to life safety. Suitable fire detectors are able to detect even rapidly developing initial fires.

Sprinkler systems detect a fire automatically, fight it and inform providers of assistance. Consequently, they also serve the purposes of life safety as well as protection of the building and of property. All fire extinguishing systems working with water to fight the fire (e.g. sprinkler systems) delimit fire spread by cooling and surface wetting or extinguish the fire directly.

Should evacuation be difficult, e.g. in case of large gatherings or if mobility of the persons to be evacuated is restricted, early automatic fire fighting is of further benefit to achieving the required objective of life safety.

Fire extinguishing systems working with gaseous extinguishing media are used where the extinguishing medium shall not cause residues or where the use of water is inappropriate for other reasons (e.g. reaction of chemicals with water or rooms with electrical control and distribution equipment).

Fire extinguishing systems always support intervention measures taken by the fire service.

On the one hand, fire detection and fire alarm systems and fire extinguishing systems are used each as an independent system, and on the other hand there is a multitude of applications where both systems interact effectively. Fire detection and fire alarm systems give persons more time for self-rescue as they detect a fire in the early stage already, whereas fire extinguishing systems reduce both fire spread and duration of the fire and, thus, reduce smoke gas formation and maintain the load-bearing capacity of a building. The mechanisms of both system types and their interaction in view of the different protection objectives are considered in Clauses 3 and 4.

To ensure that fire protection systems are effective, it is required to take these objectives and the modes of action into account when planning fire protection (fire protection concept, fire protection certificate) and to have the technical planning and installation done by approved installers.

2 Modes of action, fields and limits of application of fire detection and fire alarm systems and fire extinguishing systems

2.1 Modes of action of fire detection and fire alarm systems

Fire detection and fire alarm systems use fire detectors to detect a fire as early as possible. To detect a fire early and reliably, a distinct differentiation of fire characteristics and deceptive parameters is required.

The fire characteristics presently usable for fire detection are visible and invisible fire smoke aerosols, thermal convection and heat radiation, UV and IR flame radiation, as well as combinations of these fire characteristics. Gas sensors are more and more used to detect smoke. Here, fire gases, such as CO, CO_2, $(NO)_x$, and NH_3 are to be detected. Normally, these fire gases are analysed in combination with other fire characteristics to generate an alarm.

In objects, where an initial fire first emits nothing else than smoke, only a fire detection and fire alarm system is capable of alerting endangered persons early enough to allow their timely leaving of the hazardous area without being injured.

At the same time when the location of the detection is indicated, the intervention service is called. Persons lingering in the hazardous area can be alerted via an internal alarm systems and be demanded to leave the building via a voice alarm system.

The control and indicating equipment of a fire detection and fire alarm system processes a multitude of information on the fire location and its environment. This information can be used for various fire controls to achieve the protection objectives.

2.2 Fields and limits of application of fire detection and fire alarm systems

Fire detection and fire alarm systems are used where fast detection, early internal and external alarms, and the triggering of fire controls are important. A fire call is transmitted to a provider of assistance and at the same time activates the alarm device to alert persons at risk. For fires starting with a smouldering fire and little development of smoke (approx. 90 % of all fires), proper selection of a detection system shall ensure that the high requirements of life safety are met. In addition to automatic fire detection, manual call points are installed; they can be used by anyone in the area to trigger an alarm immediately.

Most of the fire detection and fire alarm systems used today provide for localisation the actual location of the detection by indicating the zone and detector number. By means of e.g. the plan of detector zones or electronic displays/printouts, the intervention service is directly guided to the place where the fire broke out.

Fire detection and fire alarm systems do not only respond to heat also used to trigger sprinkler systems, but also to other characteristics, such as smoke, increase in heat, flame radiation, and gases. Heat can be detected by a sensor with a very short thermal time constant and much earlier than by sprinkler systems.

The requirements for planning, project engineering, installation, and maintenance of fire detection and fire alarm systems are defined in VdS 2095 and DIN VDE 0833-2 and DIN 14675. Experience has shown that there is a direct connection between ambient conditions, the quality of project engineering and execution, as well as proper maintenance and the number of potential false alarms.

In combination with water spray and gas extinguishing systems, fire detection and fire alarm systems are used to trigger the electrical control devices to actuate the fire extinguishing systems.

Furthermore, FDAS can also be used to receive and process technical alarm signals.

A fire detection and fire alarm system is not able to fight a fire. Consequently, transmission of the alarm to a permanently manned location of a provider of assistance, intervening by the intervention service, and fire controls may be required to prevent greater loss.

2.3 Modes of action of water extinguishing systems

The extinguishing effect of a water extinguishing system is the consequence of cooling down the seat of fire with water. Heat is withdrawn thanks to the heat capacity of water. A larger surface by many small drops ensures faster cooling down of the seat of fire and evaporation of water. Therefore, small drops have more effect than a water jet. However, do take into account that large drops penetrate rising fire gases more easily and, therefore, reach the seat of fire better. On the other hand, evaporation of water can contribute to inerting of the fire zone. The size of drops shall be selected to suit the type of fire to be expected. Wetting of adjacent areas by spraying water drops beyond the seat of fire helps to limit fire spread.

The sprinkler system is a fire extinguishing system of selective effect, which is actuated by the heat contingent of the smoke and fire gases in interaction with the corresponding nozzle sealing element(s) (glass bulb or fusible link).

Other than the selectively acting sprinkler system, the water spray system works with simultaneous supply of water to a group/section of nozzles to become effective in view of extinguishing. Actuation of the systems is realised with a hydraulic or pneumatic triggering system independent of electrical energy for a fire detection and fire alarm system.

2.4 Fields and limits of application of water extinguishing systems

Stationary water extinguishing systems are able to extinguish and/or control fires as required by the protection objective. Since sprinkler systems provide a temperature-sensitive actuation element, a sufficiently high temperature combined with a corresponding air flow has to reach the sprinkler for a certain period of time.

Problems occur with fires developing much smoke and little heat. An extinguishing success is also based on the condition that the water reaches the fire ground. The use of sprinkler systems in very high rooms provided with ceiling protection only is restricted due to its functioning. In high rack storage in-rack sprinklers ensure protection.

Thanks to a multitude of sprinkler variants to be distinguished by their response temperature, the response speed, the spray pattern, and the water

flow rate, the sprinkler system is adjusted to the risks to be protected.

Special sprinklers, such as ESFR of quick response behaviour, with large water drops, and of a high flow rate for high areas or safety double sprinklers for the use in sensitive areas, complete the system.

A water spray system is suitable for rooms of more than 15 m in height, too. In addition to the use in high rooms, a water spray system also smakes sense in areas with rapid fire spread and in bulk storage. Since the system is triggered by fire detectors, fire fighting starts earlier. Reliable fire fighting even of smouldering fires without any considerable development of heat, can be ensured using such a combination with a fire detection and fire alarm system.

Water mist systems generate smaller water drops than the conventional sprinkler or water spray system, which improves heat dissipation. Pay attention to the fact that the system could become ineffective with an increased air flow rate as the drops are very small.

Water extinguishing systems are generally inappropriate to fight

- gas fires (fire class C);
- metal fires (fire class D);
- fires where substances are involved that heavily react with water; and
- fires where substances are involved that release hazardous substances upon contact with water.

In case of combustible liquids (fire class B), addition of foam concentrate shall generally be provided. Water mist technology might be used; however, this requires corresponding proof.

2.5 Modes of action of fire extinguishing systems using gaseous extinguishing media

Fire extinguishing systems using gaseous extinguishing media mainly consist of a system for fire detection and the actual extinguishing system. Upon detection of a fire, the fire detection and fire alarm system activates the control device which triggers the extinguishing system i.e. the opening of the corresponding valves after a delay time and alarm just as required. Shutdown or closing of facilities which could put successful fire fighting at risk is also triggered, such as ventilation systems, belt conveyors, automatic door systems, fire dampers etc.

A variety of extinguishing gases is used in fire extinguishing systems using gaseous extinguishing media. The main extinguishing effect of inert gases is due to the reduction of the oxygen content in the ambient air down to a value too low for the combustion process to be continued so that the fire is smothered. The cooling effect is minor compared to the smothering effect. Inert gases are e.g. CO_2, argon, nitrogen, and mixtures of these gases, such as Inergen (52 % nitrogen, 40 % argon, 8 % CO_2) and Argonite (50 % argon, 50 % nitrogen).

Halogenated hydrocarbons are used, too. Withdrawal of heat in the reaction zone is of great importance to these so-called chemical extinguishing gases. In addition, radicals are generated, which intervene in the combustion process in the reaction zone. These extinguishing gases are e.g. HFC 227 ea (trade name e.g. FM 200) and Keton FK-5-1-12 (trade name e.g. Novec 1230).

2.6 Fields and limits of application of fire extinguishing systems using gaseous extinguishing media

The concentration required for extinguishment shall be reached within the shortest possible time and maintained over a particular time. Both times as well as the concentration of extinguishing gas depend on the substances and the local conditions.

This is the reason why requirements for the tightness of the room shall be met for fire extinguishing systems designed to protect rooms or enclosed facilities. Increases in pressure by discharge of the extinguishing gas shall be taken into account; corresponding pressure reliefs shall be provided.

Room flooding systems are mainly used in:

- rooms with electric and electronic equipment, such as EDP rooms, control centres, rooms for high- and low-voltage distribution, transformers;
- rooms where combustible liquids are handled or stored.

Due to its special physical properties, CO_2 can be used for the protection of open or only partly enclosed equipment, too. The main applications for local application protection are:

- machines for paint manufacture and processing;
- printing machines;
- rolling mills;
- quenching bathes;
- oil bathes.

Moreover, CO_2 provides the option of "snowing down", i.e. CO_2 escapes from the nozzles without any intense jet pulse. This is of advantage particularly to the protection of liquid bathes.

Since the concentration of extinguishing gas required to get sufficient extinguishing effect could put life safety at risk, the safety of persons in the protection zone is an important aspect always to be sufficiently considered in the planning process. The relevant provisions for life safety shall be observed as given for the corresponding extinguishing gas and concentration (also see VdS 3518).

3 Assessment of systems as to the protection objectives

The tables below show the positive contribution of a fire extinguishing system and/or a fire detection and fire alarm system to achieve a particular protection objective. This analysis has been based on a reasonable use of the systems, i.e. taking the fields and limits of application mentioned in Clause 2 into consideration.

Life safety

	Fire extinguishing systems	Fire detection and fire alarm systems
Damage due to smoke, heat, and flame	Reduction in heat and smoke gases released by fire by immediate extinguishment/limiting of fire.	Early alarm to alert users of a building and control of required fire protection equipment (e.g. smoke and heat exhaust ventilation systems).
Securing of escape and rescue routes	Extinguishment/limiting of fire.	Control of required fire protection equipment (e.g. smoke- and fire-resisting closures).
Fire fighting	Automatic fire fighting by immediate actuation of the system and indication of the location of fire detection, extinguishment/limiting of fire and support of intervention measures taken by the fire brigade.	Automatic transmission of the fire call to the fire service, localisation and indication of the location of alarm release.

Protection of property

	Fire extinguishing systems	Fire detection and fire alarm systems
Damage by fire heat	Limitation of fire spread and reduction of released heat by automatic actuation and immediate extinguishment/limiting of fire.	Automatic transmission of the fire signal to the fire service and control of required fire protection equipment (e.g. smoke and heat exhaust ventilation systems). Shutdown of sensitive equipment, such as EDP systems.
Damage by smoke	Reduction of smoke formation by automatic actuation and immediate extinguishment/limiting of fire.	Automatic transmission of the fire signal to the fire service and control of required fire protection equipment (e.g. smoke and heat exhaust ventilation systems).

Environmental protection

	Fire extinguishing systems	Fire detection and fire alarm systems
Generation of combustion residues/release of hazardous substances into the environment	Reduction in the formation and release of hazardous substances by automatic actuation and immediate extinguishment/limiting of fire.	Reduction in the formation of hazardous substances by automatic transmission of the fire signal to the fire service to start fire fighting; reduction in the release of hazardous substances by control of required fire protection equipment (e.g. fire-resisting closures).

4 Interaction of fire detection and fire alarm systems and fire extinguishing systems

To provide for an optimum use of the advantages of both technologies, it is often recommended to use both in parallel. There are two ways of doing this:

On the one hand, fire detection and fire alarm systems and sprinkler systems can be used as technically separate systems drawing utmost benefit out of each system. They complement each other in their mode of action to achieve the defined protection objective.

On the other hand, fire detection and fire alarm systems can trigger fire extinguishing systems directly or via electrical control devices. Connecting them technically allows using all detectable fire characteristics to trigger the fire extinguishing system. Normally, smoke detectors are used for detection. In special applications heat or flame detectors are used. This way an earlier actuation of the fire extinguishing system is often possible.

Technological and legal separation of the responsibility lying with the specialist firms in charge of the trades 'fire detection and fire alarm system' and 'fire extinguishing system' is realised by a standardised interface for extinguishing systems defined in the Guidelines VdS 2496 (Triggering of Fire Extinguishing Systems) and VdS 2095 (Automatic Fire Detection and Fire Alarm Systems, Planning and Installation). They define the technical and organisational requirements of this interface.

4.1 Particularities for a connection of water extinguishing systems with fire detection and fire alarm systems

To protect highly sensitive equipment where an increased equipment safety shall be reached, the water extinguishing system is subject to a supplementary pilot control by the fire detection and fire alarm system: only when the corresponding fire detector(s) transmit(s) an alarm and additionally at least one sprinkler is actuated, water will be released.

Upon actuation of a water extinguishing system the automatic activation of a pressure switch generates an alarm to be processed by the control and indicating equipment, which can be transmitted to the intervention service.

Due to the actuation of the water extinguishing system, e.g. water mist could affect the fire detection and fire alarm system (unintentional release). However, this can be prevented to a large extent by correspondingly synchronised planning.

4.2 Particularities for a connection of fire detection and fire alarm systems with fire extinguishing systems using gaseous extinguishing media

For fire extinguishing systems using gaseous extinguishing media, deceptive alarms are largely excluded by coincidence detection (type B). The reduction in monitoring surface for one detector required here additionally ensures early alarm and actuation of the gas extinguishing system.

To prevent entrainment of extinguishing agent into other areas, it could be reasonable to take the following measures for fire extinguishing systems using gaseous extinguishing media:

- sufficiently tight structural separation between the flooding zones;
- proper selection and electrical connection of the fire detectors/fire detection elements;
- electrical lock of activation of the extinguishing system for other areas.

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