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Fire protection in data centers

Detection, alarming, evacuation, extinguishing

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1. Introduction

Safe data centers are the indispensable backbone of today's highly engineered society. They are processing an ever-increasing quantity of videos, voice and data throughout a global network of several billion devices. Applications such as social media, cloud computing, online banking and e-healthcare solutions impact our life every day. In today's world, no one can afford not to be connected.

Failure of the internal data center or of the vital data center which serves the general public, poses a significant problem within a short time. Employees who are not able to carry out their work and unhappy customers, who cannot get in touch with their service provider or contractor, represent merely the tip of the iceberg of our technical vulnerability.

Therefore, the most important objective in a data center is maximum availability (99.995% per year)¹. It is thus understood that data centers have to be designed, implemented and operated in such a way that a high level of availability can be guaranteed, even in case of a fire. High availability can only be achieved if all relevant influencing factors are planned, implemented and put into effect in the company in a coordinated and consistent way.

For maximum protection, a comprehensive fire safety system is needed to ensure business continuity, personal safety and damage mitigation in case of fire. The cornerstones of such a system are a fire detection system that guarantees earliest and most reliable fire detection in a highly ventilated area and that activates the alarming devices, the relevant fire safety controls and appropriate response measures.

1.1. Fire hazards in data centers

Data centers face many challenges – from managing complexity to improving energy efficiency and meeting fire safety, security and business regulatory requirements. Human failure (e.g. non-observance of fire protection regulation) or technical reasons can lead to a fire incident. A latent risk of fire exists due to the presence of both, constant ignition source electricity and plentiful supply of combustible materials such as plastics in printed circuit boards. Short circuits, due to the extensive cabling, can have serious consequences.

Major fires may be rare, but even minor ones can cause significant disruption. It is all about how an individual owner or company views their risk strategy. However, the potential impact on the business could be huge. The potential risks, however, can be drastically reduced by taking appropriate fire protection measures.

1.1.1. Fire load

Fire risks are largely determined by the fire load of a room, an area, or a building. This term describes the latent energy which can be released by the combustion of materials in fixtures, fittings, furniture, cabling or electronic equipment during an outbreak of fire.

The typical fire load in data centers can be classified as "low" to "medium". Due to the construction and technical level of the electronic equipment and installations, older data centers usually have a larger fire load than newer ones.

¹ TIER IV, TIA 942 Standard

It must also be considered that modernization, reconstruction or remodeling of the data center can alter the fire load.

If not already required by local codes and regulations, the chief engineer of the data center or a similarly qualified person should be permanently on the look-out for changes in the fire load, and should initiate appropriate measures to reduce fire risks as much as possible.

1.1.2. Fire risks

Fire risks result basically from the probability of occurrence and the effect caused by fire. There are four major reasons why there is a potential risk of fire in a data center:

- **Heavy power load:** heavy power loads or a defective piece of equipment can very quickly lead to a short circuit or overheating
- **Electrical fire risk:** constant ignition source (electricity) and combustible materials such as plastics in printed circuit boards
- **Infrastructure:** extensive cabling, particularly below raised floors
- **Ventilation:** comprehensive air-cooling, resulting in a higher air exchange, increases risk of spreading the fire

Risk = probability of occurrence x effect

During the past years, integrated risk management has become increasingly more relevant for companies as well as for data centers. Risk management must take into account external circumstances or requirements, such as trends and new developments, legal stipulations or "best practice".

Not only the objective risk plays an important role in risk identification, but also the subjective risk perception and the change of risks. It does not suffice to consider experiences made in the past. In the future, risks may occur that have been hitherto unrecognized or underestimated, as single risk or in combination.

It is therefore of utmost importance for the fire safety and security managers to continually expand their expertise in the fields of security and fire safety, to exchange knowledge and experience, and thus be able to learn from each other.

1.2. Fire protection for data centers

The goals of fire protection are to efficiently protect people, assets, data and the environment from the dangers and effects of fire, and to minimize material damages, loss of data, operational interruptions and the consequent loss of business.

To guarantee adequate fire safety standards, national and regional directives have been established in the vast majority of countries. Personal safety is generally regulated by laws and official requirements, while the protection of material assets is mainly determined by the guidelines and directives drawn up by insurance companies.

Effective fire protection is based on the coordination of the appropriate structural, technical and organizational fire protection measures.

1.2.1. Fire protection objectives

The primary goal is to minimize any operational interruptions – even in case of a fire – and to protect people and property effectively. Fire safety is therefore a long-term investment that must be carefully planned to ensure the business continuity of a data center.

If a damaging fire can no longer be prevented, the effects of the fire must be limited as efficiently as possible.

Typical protection objectives are:

- No business interruptions.
- Keep data safe at all times.
- Personal injury must be prevented.
- Asset damage must be kept to an absolute minimum.
- Environmental damage, for example due to extinguishing water must be avoided.

1.2.2. Fire protection concept

A fire protection concept consists of a series of coordinated measures. Only the combination of these measures results in the desired protective effects. Structural/mechanical, organizational/personnel and technical measures are important elements for a fire protection concept for data centers. The required protection effect is based on a systematic risk analysis, on the individual risk policy (i.e. protection objectives, legal constraints) and on the appropriate resources (e.g. financial, personnel).

The fire protection relevant specifications must be defined by the customer at a possibly early stage. If they are defined at a later stage, this often leads to compromises and excessive costs. This applies to both new buildings and reconstruction works.

1.2.3. Fire protection measures

Fire protection measures can be divided into passive measures and active measures.

Generally speaking, passive (structural) measures define a building's resistance and endurance after a fire has developed, while active measures are aimed at preventing the outbreak and spread of fire and smoke.

1.2.3.1. Passive measures

Although passive protection measures are not the subject of this document, they are extremely important. The majority of passive protection measures are related to the building structure, construction methods, and materials used to make a building as fire resistant as local circumstances demand.

The main elements of passive (structural) fire protection measures include:

- Fire compartmentalization of a building.
- Use of materials to prevent building collapse.
- Fire-resistant construction elements to limit spread.
- Provision of fire-resistant escape routes/exits/staircases/elevators.
- Selection of materials to reduce fire load.
- Selection of materials to prevent toxic vapors.

For buildings under construction, most of these measures are defined by national or local codes. However, one must bear in mind that in the case of many older buildings, it is difficult to improve effective passive protection, without first undertaking drastic reconstruction.

1.2.3.2. Active measures

Having included passive protection methods in a building's construction does not mean that the active measures can be neglected, reduced, or omitted. Active protection can be divided into the following measures:

Organizational measures and staff-related measures

The advantage of many data centers is that they are able to summon professional help relatively quickly in emergency situations. Despite this fact, all data centers should aim at achieving a high level of competence in dealing with emergencies and in recognizing potential sources of danger, independent of outside assistance.

Organizational and staff-related measures include:

- Staff training (prevention and intervention).
- Provision of alarm and emergency plans.
- Periodic maintenance and checking of extinguishing equipment.
- Keeping escape routes accessible and unobstructed.

Structural and mechanical measures

- Escape routes and intervention entrances
- Fire brigade key cabinet (intervention entrance)
- Fire compartments
- Fire-retarding sealing
- Fire-proof safes (documents, discs, etc.)
- Security and fire resistance of doors and windows
- Others

Technical measures

- Danger management system / building automation system
- Fire detection system
- Gas detection system
- Water detection system (e.g. technical rooms)
- Door controls (e.g. sluice)
- Elevator controls (people and goods)
- Smoke and heat venting systems
- Energy supply (emergency power, UPS)
- Evacuation system
- Escape route and emergency lighting

- Exterior lighting (area, entrance, emergency exits)
- Monitoring of the emergency exits
- Automated gas extinguishing systems
- Sprinkler systems
- Mitigation of acoustic trauma for human being and reduction of sound pressure levels on hard disk drives (HDDs)
- Manual fire extinguisher, wall hydrants
- Exterior hydrants (pillar hydrants, ground hydrants)
- Others

Detection measures

The main tasks of an automated fire protection system are to detect (an incipient stage) fire, sound an acoustic alarm, notify the fire service and activate the pre-programmed control functions. Such a system consists of a control unit with peripheral input devices (such as manual call points and automatic fire detectors), output devices (such as sounders and beacons) and output contacts to control other systems (such as smoke control systems, HVAC systems, elevators, automated extinguishing systems, etc.).

To minimize the danger to life and minimize business interruptions and loss of data as well as any damage to property, it is important to detect a fire as early as possible. Optimal product selection combined with the appropriate knowledge make it possible to design a fire detection system capable of detecting a fire extremely early and virtually eliminate any danger of false alarms.

Chapter 2 describes the measures needed to ensure that a fire is detected reliably and at the earliest possible stage.

Alarm and evacuation measures

When a fire breaks out prompt warning is essential and buildings must be evacuated within minutes to protect people's lives.

The purpose of a (acoustic) fire alarm is to warn people of the potential hazard.

In a basic installation the fire detection system must activate the installed alarm devices and transmit the alarm signal to the fire department.

More sophisticated installations may include a dedicated voice alarm system, which can be instrumental in preventing panic by providing clear information about the danger and any required evacuation procedures through calm and concise announcements.

In addition to the type of alarm and evacuation system provided, evacuation plans, escape route identifications, emergency lighting systems and smoke venting systems are essential to ensure a fast and safe evacuation of all persons.

To enable a safe evacuation, the emergency lighting must be turned on in all relevant areas.

Air handling systems remove smoke from a building allowing the escape routes to be kept clear of smoke which is essential to enable people to leave the building in a quick and safe manner.

Chapter 3 describes the measures needed to alert staff and the intervention forces, and how to ensure a fast and safe evacuation

Intervention measures

To limit the danger to human life and the extent of the damage, it is extremely important to start intervention and extinguishing measures as soon as possible after the outbreak of fire. All extinguishing equipment must always be kept in perfect working order: this is a prerequisite for any successful intervention.

Intervention measures activated by the fire control panel include:

- Automatic closing of fire doors, dampers etc.
- Activation of smoke handling systems
- Automatic alarm transmission to the fire department

Important extinguishing systems include:

- Portable fire extinguishing equipment
- Hose reel equipment
- Self-actuated sprinkler systems
- Dedicated automated extinguishing systems

Chapter 4 describes the available extinguishing equipment in more detail.

1.3. Fire protection for critical areas in data centers

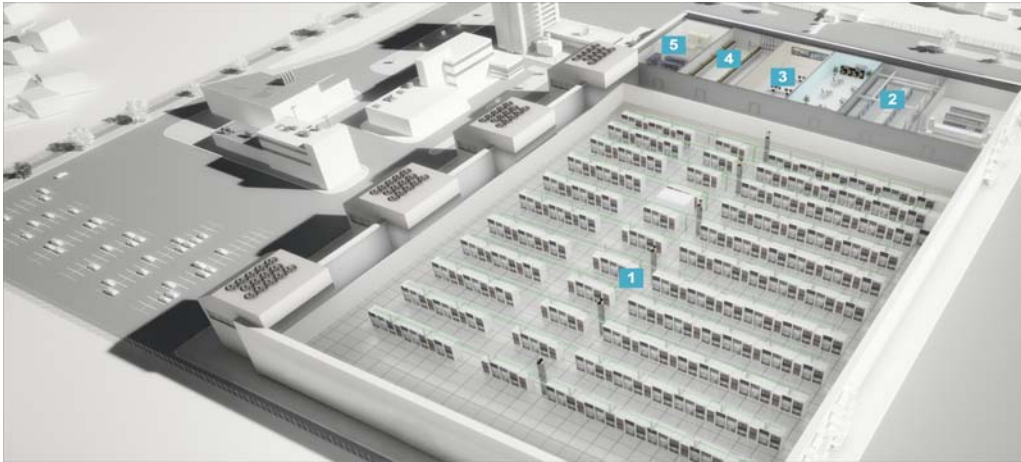
Server rooms and data centers can be divided into different categories according to size and safety requirements.

Safety requirements have become increasingly important in an international environment and they can be used for smaller server rooms as well as for larger data centers.

Different data center types are normally classified as follows:

- Server rooms (< 50 m²)
The largest group within the category of data centers. Depending on the company size, this category includes rooms with one server rack to rooms with up to two dozen server racks.
- Medium size data centers (approx. 50 – 300 m²)
Contains rooms with a larger number of server racks, which are operated and supported by a professional operator.
- Large data centers (>300 m²)
Usually operated by institutional operators such as universities and research facilities as well as larger professional suppliers.
- Backup data centers (recovery center)
Serve as a guarantee for availability and data security in the event of a main data center breakdown due to natural disasters, technical faults or attacks.
- Communication rooms
Digital communication runs on specific servers installed in appropriately secured rooms. Communication rooms guarantee transfer of electronic data.

The below image shows typical rooms for fire protection in a large data center:



- 1 Large server room
- 2 Electrical switching room
- 3 Control room
- 4 Room with security and safety equipment (e.g. extinguishing cylinders, etc.)
- 5 Emergency power supply (e.g. generator and battery/UPS rooms)

The following section briefly describes different typical rooms with regards to fire protection. More detailed information can be found for some of those rooms in separate documents (see below).

1.3.1. Server rooms

Depending on the size of the server, computer or IT room different protection concepts might be applicable.



Rooms with servers, computers and IT equipment contain the constant ignition source electricity and plentiful supply of combustible materials such as plastics in printed circuit boards. Short circuits, due to the extensive cabling, can have serious consequences.



Highly sensitive fire detectors are able to detect even the lowest smoke concentrations which may be caused by a malfunction of an electric or electronic element, for example. In the event of a fire, the fire protection system then needs to react reliably and appropriately, triggering a coordinated alarm which leads people out of the danger area and activates extinguishing systems. An automated dry extinguishing system can provide optimal protection for sensitive electronic equipment. The most important factor when designing an extinguishing system for a server room environment is to make sure that it extinguishes fires without harming sensitive electronic equipment, e.g. by selecting the appropriate extinguishing agent and nozzles designed to prevent excessive noise. Furthermore, the chosen agent needs to be environmentally sustainable and safe for people and electric and electronic equipment in the protected area.

More detailed information regarding fire protection in these rooms is given in the document **“fire protection in server rooms”**.

1.3.2. Emergency power supply



For data centers emergency power supply (e.g. generators or battery/UPS rooms) is mission critical as it ensures business continuity in case of blackouts. Therefore, specific attention has to be taken to protect these areas.

With the help of fast detection, operators are quickly informed about an event and all required technical and organizational measures can be started immediately. The ideal fire protection includes fast and reliable fire detection without false alarms and provides exact location assuring the appropriate response, like reliable extinguishing of the fire.

More detailed information regarding fire protection in these rooms is given in the document **“fire protection in emergency power supply rooms”**.

1.3.3. Electrical switching rooms



An electrical switching room is the area dedicated to electrical equipment sized proportionally to building type. Large buildings may have a main electrical room and subsidiary electrical rooms. Electrical equipment may be for power distribution equipment, or for communications equipment.

Due to the high density of cables, switches and other electrical equipment, the fire load is considerable and the critical nature of the room with its power distribution function also makes it important to the availability of the data center.

Typical fire source is energized or energy active electrical equipment:

- Electrical sources
- Fuse boxes
- Wiring

Electrical fire may be fought in the same way as an ordinary combustible fire, but water, foam, and other conductive agents are not to be used. While the fire is electrically energized, it can be fought with any extinguishing agent rated for electrical fire. Early and reliable fire detection in association with an automated dry extinguishing solution offer optimal protection.

1.3.4. Control rooms



The control room needs to be a safe environment for operating and supervising the data center. All disciplines critical to the data center can be monitored by a management station. The management of all kinds of events must be ensured at all times. Personnel and equipment must be protected and allowed to perform even under difficult circumstances.

An early and reliable fire detection system and a clever alarming concept is the right choice. Especially in the control room integration into the management system is a wise choice. Depending on the criticalness of the equipment, an automated extinguishing solution similar to the server room – to protect people and IT equipment in the room – is recommendable.

1.3.5. Summary table

	Small server rooms	Mid-size to large server rooms	Energy power supply	Electrical switching rooms	Control rooms
Characteristic	Small room cram-full with heavy loaded cables and IT equipment, strong air-flow	Room cram-full with energized wires, heat sources and strong air-flow	Rooms with equipment using liquid combustible or batteries	Room cram-full with heavy loaded cables	Small room with loaded cables
Fire detection	ASD	<ul style="list-style-type: none"> ASD Point-type detectors 	Point-type detectors	ASD or point-type detectors	Point-type detectors
Alarm and evacuation	<ul style="list-style-type: none"> General alarm Simultaneous evacuation 	<ul style="list-style-type: none"> General alarm Simultaneous evacuation 	<ul style="list-style-type: none"> General alarm Simultaneous evacuation 	<ul style="list-style-type: none"> General alarm Simultaneous evacuation 	<ul style="list-style-type: none"> General alarm Simultaneous evacuation
Escape routes	<ul style="list-style-type: none"> Prompt 	<ul style="list-style-type: none"> Prompt 	<ul style="list-style-type: none"> Prompt 	<ul style="list-style-type: none"> Prompt 	<ul style="list-style-type: none"> Prompt
Extinguishing	Modular system ²	Centralized dry extinguishing system with Novec 1230 or nitrogen ²	Gas/water-combined extinguishing system	Modular system or centralized dry extinguishing system with Novec 1230 or nitrogen	Centralized dry extinguishing system with Novec 1230 or nitrogen
Special infrastructure	Display and control panel with access to: <ul style="list-style-type: none"> Fire detection system Air handling system 				

²System/nozzle needs to ensure reduction of sound pressure levels on hard disk drives (HDDs)

1.4. Purpose of this document

This short introduction shows how complex the problems of fire protection in data centers are, especially if one considers the great variety of buildings which exist. It becomes clear that each building has to be considered on an individual basis. As a result, the establishment of universal guidelines is quite complicated.

This document provides an overview of the most important topics in technical fire protection for data center applications. These include:

- Fire detection (chapter 2)
- Alarming and evacuation (chapter 3)
- Extinguishing (chapter 4)

Detailed information regarding the planning and execution of fire protection measures in critical rooms or areas is provided in associated documents.

2. Fire detection

The earlier a fire is detected, the more time there is for evacuation and extinguishing, and the less damage can occur. Earliest possible detection is thus the key to minimizing damage and gaining precious intervention time.

2.1. Fire basics

To ensure reliable, early detection of fire, it is important to be familiar with the different fire phenomena, fire propagation and possible deceptive phenomena.

2.1.1. Fire phenomena

Fire phenomena are physical values that are subject to measurable change in the development of a fire (e.g. smoke, heat, radiation, gas).

Large volumes of volatile fire aerosols are produced with almost all hostile fires. Smoke has thus become the most important fire phenomenon for the early detection of fire.

Liquid fires directly develop flames which immediately create a temperature increase and heat radiation.

2.1.2. Fire propagation

The fire phenomena generated by fire propagate differently, depending on the room size and the room conditions such as a high air circulation. This must be taken into account when planning a fire detection system.

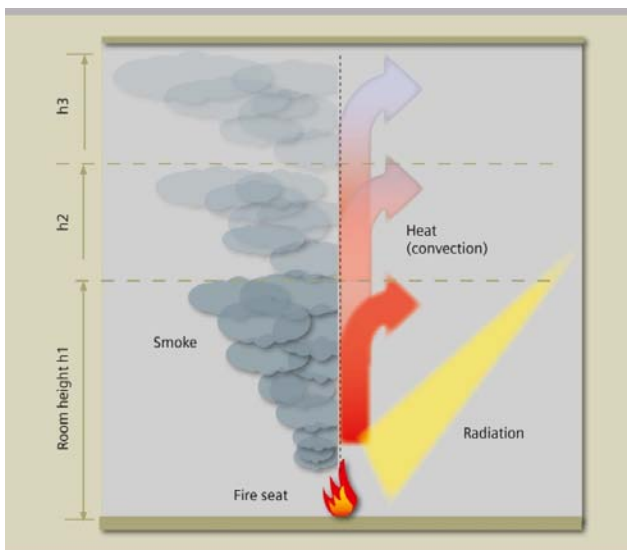


Figure 2.1.2-1 Propagation characteristics of fire phenomena

In general, the higher the room, the greater the distance between the seat of fire and the fire detectors on the ceiling. This is why the intensity of the fire phenomenon to be detected (e.g. smoke density, temperature increase or radiation intensity) decreases with increasing ceiling height. It must be taken into consideration that with an increasing ceiling height (and consequent larger room volume) an incipient stage fire can become larger without necessarily increasing the danger of rapid fire propagation.

High air circulation, for example, significantly dilutes the concentration of smoke. This is why very sensitive smoke detection systems are often used for this type of application.

2.1.3. Deceptive phenomena

The fire detector has the task of detecting fire from fire aerosols, heat and radiation at an early stage and to trigger an alarm. Aerosols, heat and radiation, however, are also generated by production processes, by electrical equipment such as motors, or by environmental factors such as sunlight. If these deceptive phenomena are sufficiently intense and exist over a certain period of time, they may influence fire detectors enough to trigger an unwanted alarm.

State-of-the-art fire detectors are largely capable of distinguishing between deceptive phenomena and genuine fires. However, massive deceptive phenomena are to be expected, predominantly due to strong air-flow up to 15 m/s. A combination of ASD and point-type detectors is highly advisable in order to guarantee early and reliable detection of fire at pyrolysis stage.

In case of a data center the following needs to be considered in order to avoid false alarms:

- Maintenance work: Due to the generally high air change rate, deceptive phenomena caused by small works e.g. soldering. During maintenance work the air conditioning may be switched off or reduced and/or the section should be switched to manual release mode. This allows the system to be discharged manually should a fire develop during maintenance works.

2.2. Fire detection system

2.2.1. Tasks

The task of an automated fire detection system is to detect fire as early as possible, to sound the alarm and to activate the preprogrammed control functions.

State-of-the-art fire detection systems are capable of detecting fire very early and as a consequence minimizing any damage that may be caused. By optimal product selection and appropriate knowledge it is possible to build systems that virtually rule out unwanted alarms.

The principal requirement on a fire detection system is early and reliable alarming in the event of fire. As a consequence of this:

- All persons in the danger zone should be able to save themselves.
- Fire control systems can be activated to prevent the fire from spreading to more than one fire sector.
- Response measures can be initiated as early as possible, so that damage to property and operational interruptions can be reduced to a minimum.

2.2.2. Elements

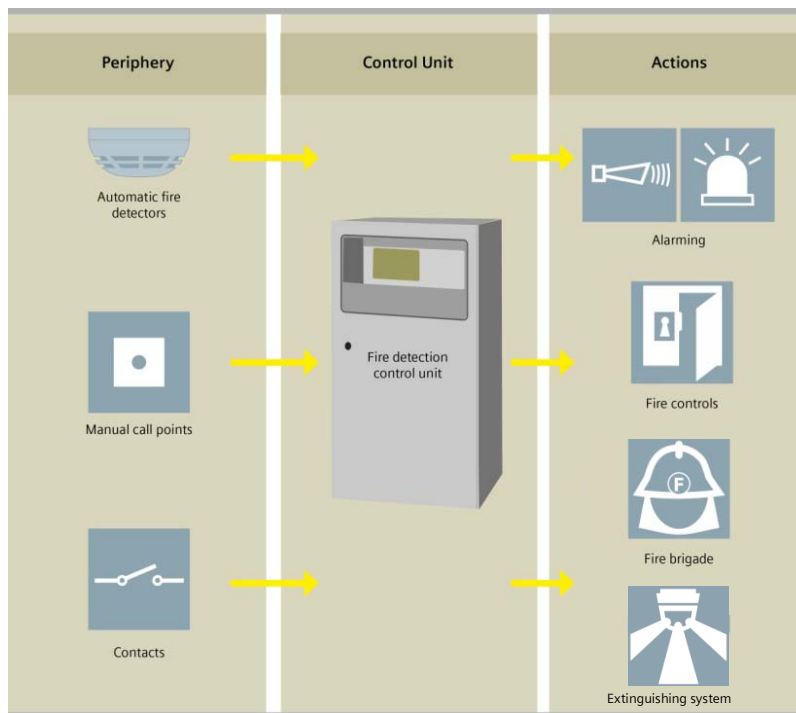


Figure 2.2.2-1 Setup of a fire detection system

Periphery

Fire-related information is collected from all parts of the building by the input periphery (automatic detectors, manual call points and input contacts) and transmitted to the control unit.

The intelligent, automatic fire detectors (point-type detector or aspirating smoke detection) detect and analyze the different fire phenomena and automatically report the current hazard levels to the control unit. When selecting the correct fire detector for each location (together with its settings and placement), it is also crucial to consider the type of fire to be expected, the room height, ambient conditions such as air changes and possible deceptive phenomena.

Manual call points enable direct alarm activation by people who recognize an incipient stage fire or smoke in their vicinity.

Contacts (e.g. from the activation of a sprinkler extinguishing system) report a fire alarm indirectly.

Control unit/panel

The system is monitored, controlled and operated by the fire detection control unit, which evaluates the hazard messages from the peripheral devices activates audible alarm warnings, fire control installations and sends a signal to extinguishing control panel.

Actions

The actions initiated by the control unit/panel include alarming, activating the fire controls and alerting the fire brigade. Optical and acoustic alarm devices warn the people in the building. The activation of the preprogrammed fire controls causes fire doors to be closed, and smoke and heat extraction systems to be activated, in certain cases extinguishing systems may also be activated.

Integration

Centralized danger management and supervision of the complete fire protection installation ensures highest safety of people, assets and business processes.

3. Alarming and evacuation

3.1. Introduction

Once a fire has been detected by an automatic detector or by a person activating a manual call point, the fire detection system will generate the preprogrammed control and alarm signals.

A major factor that can affect the success of building evacuation is that many people do not take the sounding of fire alarm sufficiently seriously or do not understand the meaning of the acoustic signal. Such doubts lead to unnecessary delays in people's reaction to the warning. The more clearly the information can be conveyed to the people in the building, the better the situation will be understood and the more quickly the necessary actions will be taken.

A fast and efficient evacuation procedure is essential. This not only saves lives, but once the evacuation of the building has been completed, the fire services can concentrate on minimizing the damage to property.

Personnel in data centers should be trained on the procedures and protocols on how to perform intervention during a fire alarm. They need to demonstrate and understand these procedures and protocols. In each alarm situation trained personnel are expected to maintain a professional behavior and guide people to the nearest exit.

3.2. Alarming

3.2.1. Objectives

The purpose of a fire alarm is to warn people about the presence of a fire within the premises. In a data center context these people may be divided into 3 target groups:

- Selected members of staff
- Staff working in the building (in general) or visitors
- The municipal fire service

For each of these target groups various technical solutions are available, which can alert the people concerned in the most appropriate and efficient manner.

3.2.2. Alerting selected members of staff

Alarms to the in-house staff are always generated without delay to allow the cause of the alarm to be investigated. Time is of the essence: investigation must begin immediately. It is still possible that the fire is small enough to be dealt with by local means. The aim is to prevent any unnecessary disruption until absolutely necessary. Without activating the main alarm, members of staff may be alerted in one (or more) of the following ways:

Pager	Alarm activation via an in-house pager system, causing the pagers carried by all members of staff to vibrate.
Mobile/Cell phone (SMS)	Transmission of a preprogrammed text message.
Local acoustic	Activation of buzzers or speakers in staff areas only: e.g. control room, manager's office, site or facility management.

3.2.3. Alerting people in the building

In case of an alarm in data center, a step-by-step procedure should be accomplished to investigate first. After verification of the situation if the situation cannot be contained or creates risks beyond the capabilities of the personnel in attendance then a general alarm (evacuation) can then be activated

Acoustic alarms	Acoustic alarm equipment is used to alert people in the danger zone as well as internal intervention forces. Alarm devices are connected to the control unit either directly with separated stub line or via a monitored output.
Visual alarms	Visual alarms are used in very noisy environments such as generator rooms. For these requirements visual alarm devices are required, checks should be made so that they do not conflict with colors of other visual alarm devices creating confusion as to their meaning.
Voice alarms	Conventional alarm elements, such as flashing lights or horns, have limited information content and are increasingly ignored also by trained staff. Using a voice alarm system will provide clear voice information with the procedure to be taken to reduce the danger in data centers. In addition the voice evacuation system assures a programmed intervention information and evacuation sequence in accordance with the evacuation plan. These systems enable step-by-step alarm and evacuation depending on the situation. In addition in data centers where extinguishing is used, a clear message is broadcasted before starting the release of the extinguishing agent.

3.2.4. Alerting the public fire department

Alarm transmission to the intervention forces for the internal – and external alarm or organization like the local or remote fire brigade is accomplished by means of monitored dedicated lines, telephone lines, dialup connection, radio connection, network connection or a combination of these transmission methods.

3.2.5. Alarm strategies

General alarms	A general alarm is a defined audible signal which is sounded throughout the building. The alarm is automatically activated by the fire detection system, or manually from the control room. In the majority of buildings this should trigger the immediate and total evacuation of the building.
Staged alarms	Staged alarms are based on systems capable of generating an “alert signal” and a different “evacuate signal”. Such systems may be applicable in large or complex buildings. Generally those people potentially most at risk are those closest to the point where the fire was detected or where the manual call point was activated. These people should leave the building immediately and therefore an “evacuate signal” will be sounded in this area. In other areas of the building an “alert signal” will be sounded, indicating that people in those areas will only have to leave the building if it becomes necessary, see evacuation.

3.2.6. Alarm Verification Concept AVC

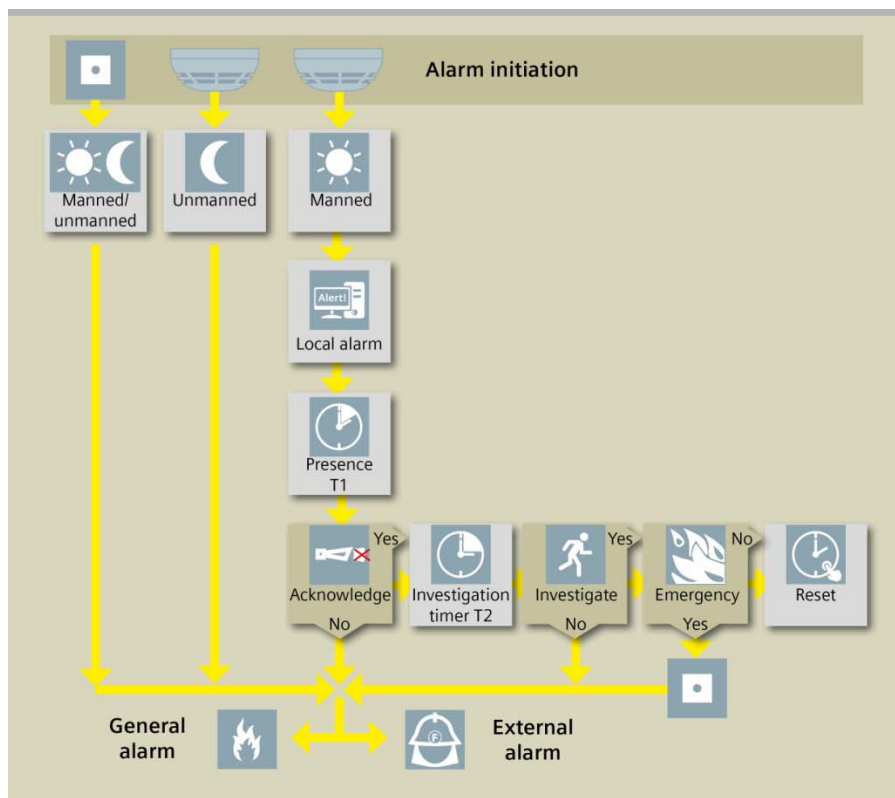


Figure 3.2.6-1 Alarm Verification Concept

The Alarm Verification Concept (AVC) allows in-house personnel to carry out a local investigation before the municipal fire service is alerted or the building evacuated. This reduces the number of unnecessary calls and is based on a dual timing principle. It is only applicable to the “day/manned” mode of the fire detection system. In the “night/unmanned” mode (when a local investigation cannot be ensured) the fire service will be alerted without delay. Manual call points also alert the fire service without delay (at all times).

In the “day/manned” mode any alarm initiated from an automatic smoke detector will start timer T1. If T1 times out without any response from an operator, the fire service is called immediately. If the alarm is acknowledged on the fire alarm panel while T1 is running, the system recognizes this as a sign that an operator is present. In this case, timer T2 is started for a predetermined investigation period. The duration of this investigation period should be determined in consultation with the fire service.

If the local investigation verifies the existence of a major fire, the fire service can be summoned immediately by simply activating any manual call point. The fire service will also be called if T2 times out. On the other hand, if local investigation establishes that only a minor, easily dealt with fire exists, the fire alarm can be reset while T2 is still running.

3.3. Smoke control

3.3.1. Objectives

Smoke presents the greatest danger to life in the case of a fire. This is not only due to smoke inhalation injuries and asphyxiation, but also due to smoke-filled corridors and staircases, which make evacuation considerably more difficult and raise panic levels. For this reason it is imperative that smoke is restricted to the immediate locality of the fire for as long as possible and is actively extracted from the building by appropriate means. Many buildings are subdivided into fire compartments by fire doors and fire-resisting walls and floors. Customized smoke control systems are designed to restrict the spread of fire and smoke, conducting the heat and smoke through the installed ducting into the external atmosphere (generally through the roof of the building).

3.3.2. Elements

Fire doors

Fire doors are used to compartmentalize a building, effectively restricting smoke to the immediate locality of the fire. Many fire doors are held open magnetically and these will normally swing closed as the retaining power is removed when the fire control panel detects a fire.

Smoke dampers and extraction fans

Effective smoke control prevents it from spreading in an uncontrolled manner throughout the building, for example, via the heating, ventilation and air conditioning system. This is achieved by smoke dampers which are installed in the air ducts and are controlled automatically by the fire protection system. The smoke is conducted through the air ducts to the outside world and the efficiency of this process can be increased by the use of extraction fans.

3.4. Evacuation

3.4.1. Objectives

The basic objective is to move those people in an endangered area to a place of safety. The evacuation of a building, however, is a drastic measure and should only be initiated when absolutely necessary.

The measures required to ensure safe evacuation will vary from building to building and priority must be given to the requirements specified by the local authorities. Unfortunately these regulations differ widely from country to country and the local fire services often specify very distinct and individual evacuation concepts for buildings within their jurisdiction.

Key objectives:

- People working in the building should remain undisturbed for as long as possible.
- An evacuation should be initiated as soon as it becomes unavoidable.
- The evacuation should be carried out as quickly and efficiently as possible.

3.4.2. Evacuation concepts

For each data center an appropriate evacuation strategy must be defined in accordance with the physical organization of the building, local regulations and in discussions with the local fire authorities.

Visual, sirens and alarm horns	<p>As soon as a visual, siren or horn is activated personnel inside the building must evacuate, including personnel in the data room (center).</p> <p>Prior to release of an extinguishing agent, visual warning strobes are used together with audible sounders to alert and evacuate personnel from the room prior to discharge of the extinguishing agent.</p>
Voice evacuation	<p>People tend to fear life-threatening situations. And if many people are threatened by a danger, fear quickly escalates to panic. The voice evacuation system assures a programmed evacuation sequence in accordance with the evacuation plan. Evacuation can be initiated as an automatic or manual function.</p>
Escape routes	<p>Escape routes are indicated by specific signal using pictographic showing a fleeing person. These signs have the task to indicate and facilitate the escape routes. Escape route guidance are illuminated symbols arranged in short intervals that even in case of smoke it is possible to have visibility to the next sign.</p> <p>Some buildings have these signs at low level or in the floor to assist escape should smoke obscure signs at higher levels.</p> <p><i>Note: These signs and application may also be under country legislation.</i></p>

3.4.3. Organization

A successful evacuation can only be achieved when the appropriate infrastructure and management organization are in place and are regularly reviewed.

Up-to-date evacuation plans	<p>In many countries approved plans for fire alarm and evacuation measures are required by law. These plans must detail all necessary actions to be taken during emergencies and designate the persons responsible for the implementation of such actions. In countries where no such legislation exists, the individual data center manager must create his own plans. Department heads and senior staff should consult with local authorities and the fire service to formulate the most effective plans for the premises.</p>
Regular fire drills	<p>Regular meetings and fire drills are essential in keeping evacuation plans up to date and the staff fully prepared for any emergency.</p> <p>Regular checks should be made to ensure:</p> <ul style="list-style-type: none">• Escape routes are always free from blockages of any sort and that any emergency fire exits remain unlocked (although they will generally be supervised by an in-house alarm system for security purposes).• Emergency lighting is well-maintained and always in perfect working order.

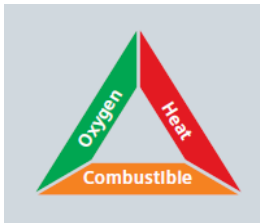
4. Extinguishing

4.1. Introduction

When it comes to data centers, NFPA (National Fire Protection Association) provides most details on how to protect it against fire. NFPA 75 for example says that if a building has a water sprinkler standard, then usually so should the data center, too. But it needs to be kept in mind that water-based fire protection systems, such as sprinklers, provide primarily structural protection and not asset protection. Therefore, sometimes complying with regulations doesn't necessarily mean that valuable assets are made safe. Also, NFPA focuses on the protection of the building – and not individual rooms - and recommends sprinklers. However, sprinklers damage the electronic equipment – for example in a server room – of a data center. For the protection of the delicate electronic equipment Siemens therefore recommends the use of dry extinguishing systems (i.e. with inert gases or chemical agents/clean agents). Depending on the application, resp. the rooms to be protected (i.e. server rooms, emergency power supply, control room, etc.) – as well as the national and regional directives of a country – different solutions are appropriate.

4.2. Principles

For a fire to exist, three elements need to be present:



- Heat to raise the material to its ignition temperature
- Oxygen to sustain combustion
- Fuel to support the combustion

Extinguishing a fire implies interfering with the combustion process in such a way that the preconditions to maintain combustion are no longer present. This can be achieved by removing any one of these three elements or by interfering directly with the combustion process. This results in the four basic extinguishing mechanisms:

- Reducing the temperature of the inflammable materials or the flames (cooling)
- Cutting off the supply of oxygen (smothering, inerting)
- Physically separating the inflammable materials from the flames (starvation)
- Use of chemicals to inhibit the combustion process

4.3. Extinguishing agents

A variety of extinguishing agents are used, each of which utilizes one (or more) of the above mentioned mechanisms.

4.3.1. Gas

Gases are fast, highly efficient, electrically non-conductive and clean. Their properties make them particularly suitable for rooms with high value content. Some types of extinguishing gas rely on the removal of oxygen, while others rely on chemical inhibition of the combustion process:

Natural gases (oxygen depletion)

The following natural gases are suitable for extinguishing purposes:

- Carbon dioxide (CO₂)
- Nitrogen (N₂)
- Argon (Ar)

Mixtures of these gases are also commercially available.

Automated extinguishing systems using such gases (or gas mixtures) rely on the partial displacement of air (and consequently oxygen) from the protected area. The concentration of oxygen in air is 20.8 vol.-% and reducing this concentration to below 13% will stop the combustion process for most combustible materials.

When CO₂ is not used then the remaining oxygen concentration (generally between 10 and 13 vol.-%) is not life threatening. However, this is not the case if CO₂ is used; as a concentration of as little as 5 vol.-% of CO₂ gas can be life threatening. This has nothing to do with the reduced oxygen content of the air, but is purely due to the toxicity of the CO₂ itself. As concentrations of up to 50% may be reached in some extinguishing systems, it would be fatal for anyone remaining in the gas-flooded area.

Chemical extinguishing gases (inhibition of combustion process)

Due to their chemical properties, extinguishing agents such as Novec 1230 fluid and HFC227ea inhibit the combustion process by extracting energy from the fire. On being released into the atmosphere, these gases form an extinguishing mixture. A correctly controlled concentration of this mixture extracts heat from the fire and cools the burning material down to the point where the fire is extinguished.

For HFC227ea and Novec 1230 fluid, the concentration level used in practice is below the NOAEL value (Non Observed Adverse Effect Level). It does not therefore pose a health threat to people present in the protected area. However, the area should always be evacuated before the agent is released.

4.3.2. Foam

Blanketing the burning surface of a combustible material (either solid or liquid) with foam effectively separates it from the surrounding air, depriving the fire of the necessary oxygen. The cooling effect of the foam also contributes to the extinguishing process. Foam is particularly suitable for use in fire extinguishers.

4.3.3. Chemical powder

Extinguishing powder relies on interrupting the combustion process by interfering with the chemical reaction and the associated extraction of energy. Powder is mainly used in fire extinguishers. One disadvantage of this type of extinguisher is that it leaves a very fine residue which is difficult to remove and is highly corrosive. The powder is also incompatible with electrical and electronic equipment.

4.3.4. Water

The most commonly used extinguishing agent is water. Water is not only an effective extinguishing agent; in most cases it is readily available, ecologically acceptable and inexpensive.

The extinguishing effect of water relies not only on the cooling of the burning material but also on the suppression of oxygen by the steam that is generated. Water has a very high latent heat of vaporization, which is four times that of all other non-combustible liquids. Water is absolutely non-toxic and can be stored at room temperature and pressure.

The boiling point of water (100 °C) is considerably lower than the temperature range where the pyrolysis (thermo chemical decomposition) of solid combustible material can be expected to occur (250 - 400°C). It therefore permits the surface temperature of the fuel to be cooled to well below these temperatures.

However, water also has a number of disadvantages and can itself cause considerable damage to property. As it boils at 100 °C and freezes at 0 °C, it can also lead to damage of any water-carrying pipes. Water is a conductor of electricity, making it unsuitable for electrical fires. It is ineffective in extinguishing certain combustible liquids, particularly those that are not water soluble or float on water (such as oil, petrol or diesel). Water is also unsuitable for some hot metals (e.g. magnesium) or for chemicals. For such materials other extinguishing agents must be used, for example foam, gas or powder.

4.4. Extinguishing systems

4.4.1. Gas extinguishing systems

The main application area for gas extinguishing systems is the protection of closed rooms. They are particularly suitable for rooms that contain sensitive objects or equipment where water cannot be used. These typically include all types of electrical equipment and computer rooms.

The gases are stored in pressurized cylinders:

- The non-liquefiable inert gases Ar, N₂ and gas mixtures are stored in gas cylinders at a pressure of 300 bar.
- In high-pressure systems CO₂ (which does liquefy under pressure) is stored in gas cylinders at 56 bar; in low-pressure systems it is stored in large cooled containers.
- Clean agents such as HFC227ea and Novec 1230 fluid are stored in gas cylinders, pressurized with nitrogen, which acts as a propellant. The industry's most common storage pressures are 25 bar (particularly in the USA) and 42 bar, which allows for higher flow rates, smaller pipe diameters and longer pipe runs.

Extinguishing is controlled either manually or preferably automatically by means of a fire detection system. Only a quick, faultless actuation prevents consequential damage, as a fire should be extinguished during its formation phase. However, to prevent human casualties, an alarm must first be sounded to warn people of the imminent flooding of the area. The gas will only be released after a predefined delay has given people sufficient time to evacuate the area.

When the system is actuated, the cylinder valves of high-pressure systems (or the container valves of low-pressure systems) will be opened. Doors and other openings are closed automatically and any other air-handling equipment (e.g. ventilation systems and smoke dampers) are controlled to ensure that the area is sealed off. However, the inrush of the extinguishing gas into a closed room will automatically increase the pressure within the room. To prevent damage occurring, overpressure relief dampers temporarily open, before re-closing again automatically.

The extinguishing gas is guided through a piping network to nozzles that are evenly distributed on the ceiling. The gas quickly fills the room and a homogenous concentration is built up throughout the room. To completely extinguish the fire, this concentration must be maintained over a sufficiently long period of time.

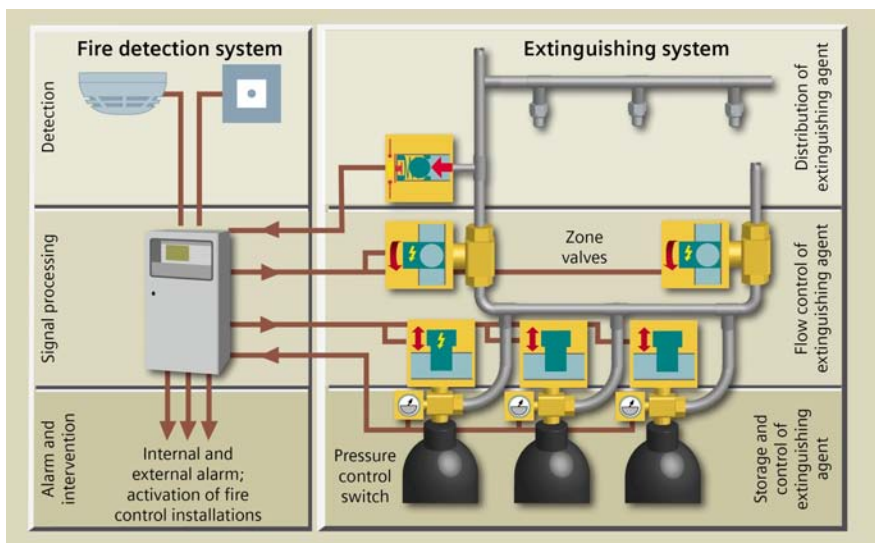


Figure 4.3.2-1 Principle of a gas extinguishing system

4.4.2. Fire extinguishers

Fire extinguishers are mobile or portable manual devices designed for preventing incipient stage fires from getting out of control. The extinguishing agent is expelled under pressure. In some types of extinguisher the agent is kept under constant pressure, while in others the pressure is generated by releasing a propellant gas at the time that the extinguisher is activated.

Extinguishing agents include water, foam, carbon dioxide and powder. These substances function in different ways and are suitable for different types of fires. Fires are categorized into five main fire classes A, B, C, D and F.

EN fire class	Description
A Solid materials	Solid materials subject to thermal decomposition which normally form members. Examples: wood, paper, leather, textiles and coal
B Liquids	Liquids or materials which melt under heat and only create flames. Examples: alcohol, oil, wax, resin, paraffin, petrol, paints, tar and acetone
C Gases	Gaseous materials which are often stored under pressure. Examples: hydrogen, natural gas, acetylene, methane, ethane, propane and butane
D Metals	Strongly ember-forming, combustible metals. Examples: aluminum, magnesium, potassium, sodium, beryllium, lithium and barium
F Cooking oils	Combustible cooking oils and fats commonly found in commercial kitchens.

Figure 4.3.3-1 Material fire classes

Notes:

1. In the European norms electrical fires are not considered to constitute a fire class on their own, as electricity is a source of ignition that will feed the fire until removed.
2. The above table reflects the European classification system. Definitions used by regulatory bodies in other parts of the world may show some minor differences. For example in the USA:
Cooking materials: Class K / Liquids + Gases: Class B / Electrical equipment: Class C

Extinguisher types	Class of Fire				
	A	B	C	D	F
	Solids	Liquids	Gases	Metal	Cooking oils
Water	Yes	No	No	No	No
Foam	Yes	Yes	No	No	No
ABC Powder	Yes	Yes	Yes	No	No
Dry powder (Metal Fires)	No	No	No	Yes	No
CO ₂	No	Yes	No	No	No
Wet chemical	No	No	No	No	Yes

Figure 4.3.3-2 Fire extinguisher applications

4.4.3. Wall hydrants

Wall hydrants are used to complement fire extinguishers in dealing with incipient stage fires. They are intended both for trained staff and fire service use. Wall hydrants are evenly distributed throughout the building, providing water outlets from the building's extinguishing water pipe network. Care must be taken to prevent contamination of the drinking water supply by the water used for extinguishing. For this reason the extinguishing water is generally taken from a separate water supply tank and fed under pressure into the pipe network via fire pumps.

4.4.4. Sprinkler systems

The primary purpose of a fire sprinkler (or pre-action) system is to douse or confine the fire through the application of water to its area or room of origin in order to protect the structure. Actually taking NFPA 75 into account, sprinklers are intended to protect the building, hence it recommends sprinklers. However, in case of a fire sprinklers are damaging the electronic equipment in data center and eventually causing short circuits that would further ignite fires across the area.

Water sprinklers are usually present in the server room because server rooms are usually developed using existing office space already fitted with water sprinklers. It essentially consists of a grid of water pipes equipped with fusible heads that melt over a certain temperature to allow pressurized water to spray over a specific area.

In using sprinkler systems important limitations have to be borne in mind:

- Limited to Class A fire suppression
- Likelihood of accidental discharge if a head or pipe is broken
- Requires significant cleanup time regardless of the event that triggered the discharge
- Will cause significant collateral water damage to IT equipment and surroundings

Pre-action water systems, similar as a water sprinkler system except they require at least two alarm conditions to be activated, can also be used as an alternative.

In this case an accidental activation will not cause the system to discharge because an event triggering an alarm must be followed by a second event confirming a fire condition (e.g. a broken sprinkler head alone would not cause system discharge unless smoke or heat is also detected) before system discharge takes place. This confirmation mechanism explains the term "pre-action." Generally conventional water sprinkler systems can be converted to pre-action systems with small money. Analogously to water sprinkler systems, pre-action implies major drawbacks in computer room applications:

- Limited to Class A fire suppression
- More costly than a conventional water sprinkler system
- Requires significant cleanup time regardless of the event that triggered the discharge
- Can be zoned, but discharge sometimes takes place throughout the entire zone
- Will cause significant water damage to IT equipment and surrounding finishes or materials

In either case false floor and strong air-ventilation determine additional drawbacks for using sprinklers in computer rooms due to lack of protection in the first case and spread of fire in the second respectively.

In general, sprinkler systems protect the building while dry extinguishing systems protect data and the equipment. In some cases dry extinguishing systems cannot take the place of a sprinkler system, it can only be installed in addition to it. At the end of the day, the local fire inspection is the authority and has jurisdiction over what is permissible.

For the protection of the assets Siemens therefore recommends to use dry extinguishing systems to keep the electronic equipment safe. If a fire does occur, the first step is rapid detection. There are a number of advanced detectors that sense fire in its early stages and then trigger an automated dry extinguishing system before a sprinkler system is being activated.

4.5. Extinguishing in data centers

A data center is a complex building with diverse demands on the extinguishing infrastructure to be provided.

What is installed will be largely determined by:

- Local building codes
- Insurance guidelines
- Official fire protection reports
- Size of the property

To confidently recommend to your customers the extinguishing system best suited for their application, you need to consider a few key factors first. Here are the most important ones:

Category

Ask your customer if an entire building, a single room or just one object needs to be protected.

Fire classes

Fires are divided into classes, such as solid materials, flammable liquids or gases, electrical equipment, combustible metals or cooking oil or fat. This helps define the correct extinguishing method and agent for the materials concerned.

Fire load

The fire load indicates how fast a fire will spread.

Applications/risks of fire

Different applications, e.g. data centers, archives, etc., have different risks of fire. They include open fires, smoldering fires, deep-seated fires, etc. and influence the choice of extinguishing system and agent.

Health, safety and environment

The presence of people in the room, the possibility of a fire creating environmental damage as well as legal requirements also determine which extinguishing system is the ideal choice.

Space requirements

In some cases, space plays a major role when choosing the appropriate system and agent (e.g. due to space restrictions). Chemical agents usually require less space than natural agents; high-pressure systems may also impact the space requirements.

Approvals and regulations

Some national regulations and approval requirements can influence the choice of system and agent, e.g. the required amount of agent can vary from regulation to regulation. Furthermore, systems with specially approved components usually offer higher reliability.

Code of practice

Differences in calculations can occur due to different code of practices in different countries.

4.5.1. General recommendations

Gas extinguishing systems Siemens recommends the following extinguishing systems appropriate for data centers:

- Chemical agent systems
- Inert gas systems

For mission-critical applications like data center rooms, a waterless fire extinguishing system is a must. Not even the newest water-combined technologies using limited water amounts are recommended due to the sensitivity of the infrastructure in data centers. Here the potential damage of the extinguishant is a factor that strongly defines towards dry agent and residue-free technologies. The only exception is the protection of the diesel generators, where water-combined solutions are appropriate.

Also the use of sprinklers in the buildings or rooms hosting data centers, with the aim to bring a second level of protection, is strongly discouraged. The risk of having a false discharge in the sprinkler system is too high a price to pay, only for the potential scenario that the automated dry extinguishing would not work. Such cases can be considered if the sprinkler in use is type pre-action or even better pre-action dry pipe systems.

Sound impact on hard drives and storage systems

Siemens has investigated the influence of noise on hard disk drives and storage systems intensively. The findings conclude that all today available magnetic hard disk drives are noise sensitive. Therefore, the performance of hard disk drives can be disturbed by the high noise levels during the discharge of dry extinguishing systems.

However, by selecting the appropriate extinguishing system and nozzle as well as implementing the silent extinguishing measures, noise-induced disruptions to hard disk drives and entire storage systems can be prevented ([→ additional information and white paper](#)).

4.5.2. Planning and installing an automatic gas extinguishing system

When planning and installing a gas extinguishing system the following should be given special attention:

- Modular and centralized extinguishing systems
- Pressure relief
- Extinguishing concentration
- Flooding areas incl. void ceilings and raised floors
- Room integrity

Modular and centralized extinguishing systems

A gas extinguishing system provides efficient fire protection for electrical and electronic installations. This would be an appropriate solution for the protection of computer and IT rooms, particularly as no residues are left behind as a consequence of an extinguishing incident and fire damage can be restricted to an individual piece of equipment. Such systems are very effective in putting out fires and preventing any reignition, allowing normal operation to be resumed as quickly and smoothly as possible.

Standard applications include centralized systems and modular systems. In a centralized system, all gas cylinders are installed in a central location outside the protected zone and preferably in a dedicated storage room. Centralized systems always require a site-specific design, as all pipe diameters and nozzles must be calculated individually according to the particular application. Modular systems, on the other hand, consist of space-saving compact units that are installed within the protection zone itself. These units combine fast and reliable detection with quiet and safe extinguishing in one compact package. They are particularly suitable for the protection of small enclosures with volumes up to 132 m³ that contain electronic and electrical equipment. The main cost-saving advantage of such systems is that they can be installed quickly and easily, and service and maintenance costs are very low.

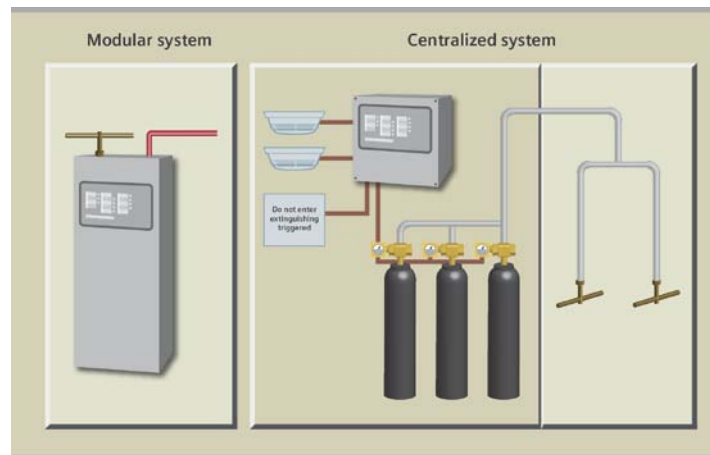


Figure 4.4.2-1 Modular and centralized extinguishing systems

Pressure relief in installation of gas extinguishing systems

Overpressure flaps are a must when a gas extinguishing system is installed!

Protection of the building

Overpressure flaps prevent the damage from the dangerous overpressure caused when discharging a gas extinguishing system. An overpressure not vented early enough can create serious damages to the structure like doors, windows, walls, equipment and also people who have not evacuated the area.

Ventilation of smoke gases

Overpressure flaps assist venting the toxic smoke gases to free air or to a ducted canalization system, during the extinguishing flooding process. Thereby avoiding to the best possible extent, that combustion gases do not flow through leakages in doors, windows and walls to adjacent areas where injury to personnel is possible.

Maximum pressure increase

The maximum pressure increase value for a room, without suffering any damage, must be defined according to the construction of the room (including windows, doors, firewalls, ventilation openings, etc.) or according to the sensitivity of equipment to be placed in the room (i.e. computer hard disks). Here the weakest element defines the maximum acceptable pressure increase.

Higher pressure resistance than 1 mbar, should only be accepted in the project, with proper consultation with the customer and the customer accepts the associated risks.

Important: When defining the maximum acceptable overpressure in a room, the relevant specialists should be involved: architects, construction engineers, facility managers. In practice usually due to architectural, technical or economic reasons, the venting openings are considered small in size.

This is where the conflict is created that the design goes towards the limit of maximum admitted overpressure for the room, bringing potential overpressure problems to infrastructure like computer hard disks or high pressure loads to doors and walls.

Overpressure flaps must close after the relief of the overpressure!

Overpressure flaps should be positioned in the rooms so that they are not directly in the direction of the extinguishing agent discharge. Also they should not be positioned in places where mobile objects can block them or reduce their efficiency. It is usually recommended that they are placed in the upper third of the room.

Protection of room

In a data center configuration with cold / hot aisles (see fig. 4.4.2-2 and 4.4.2-3), the extinguishing flooding process presents some differences compared to traditional room flooding.

- The flooding of the racks with circulation system active (considered to be the expected situation) will mostly occur through the nozzles located in the false floor.
- For the calculation of extinguishing volumes, it is recommended to consider the false floor (zone 1) and the ambient (zone 2) as showed in the fig. 4.4.2-2 and 4.4.2-3, respectively for cold / hot aisle systems with and without housing.
- Since the cooling system will not be stopped, it is important to take into account in the total volume calculated for the extinguishing agent, the additional volume of the circulation system (if system located inside the room this should be disregarded).
- Before the flooding process is initiated, the fresh air inlet should in all cases be shut off (closed system).

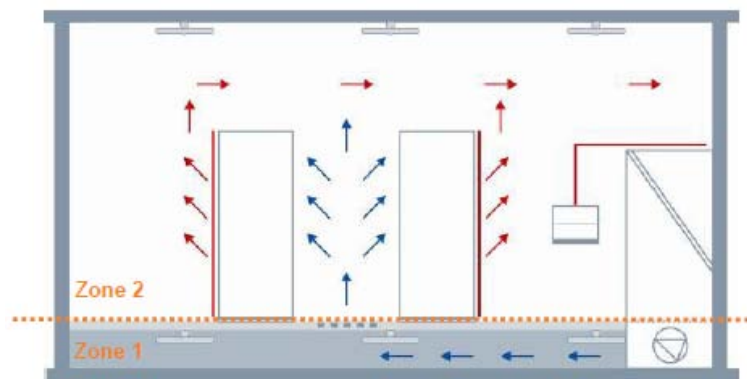


Figure 4.4.2-2 Fire extinguishing in cold / hot aisle without containment

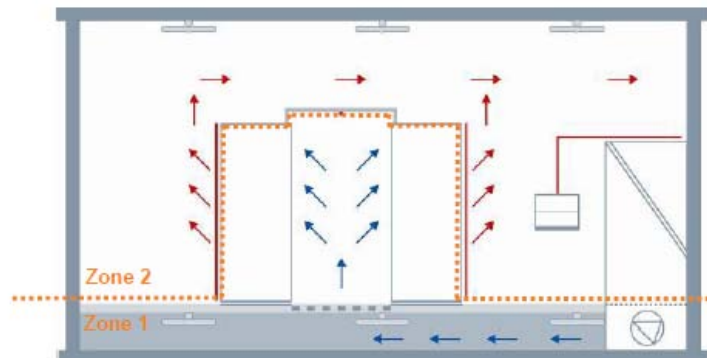


Figure 4.4.2-3 Fire extinguishing in cold / hot aisle with containment

Protection of ceiling void and raised floors

Modern trend is that cables are routed along the ceiling over the racks, with power cable rails and data cable trays on the ceiling, without dividing the room to form the so called ceiling void. Different for raised floors, there the trend is to keep the room divided, mainly for circulating the cooled air back into the room through cold aisles or racks. Nevertheless, it is still usual to find data centers that both have raised floors and ceiling voids. A proper engineering concept should always consider the entire volume, including raised floors and ceiling voids, to assure the extinguishing agent concentration and consequently efficiency of the extinguishing system.

The extinguishing agent concentration in the area to be protected is one of the key parameters (design concentration). The entire gas extinguishing system design must aim at establishing the desired concentration within the so-called flooding time, in the room to be protected. Of course, it is vital that the room to be protected is capable of allowing the establishment of the extinguishing agent concentration and maintaining it during the retention time. Decisive here is that the number of unavoidable existing leakage must not exceed a certain threshold, that would avoid reaching the retention time (10 min. according to VdS, or what local authorities mandate) or turns the system uneconomic due to the need of extended discharge to supplement the leakage.

Two methods have proven themselves as control instruments:

- 1 Actual discharge test with concentration measurement devices
- 2 Door fan test (see below paragraph "Room integrity, retention time and door fan test")

As a rule, the door fan test is preferred over the real discharge test for technical and/or economic reasons. This test provides an estimate of the leakage area on the outside limiting shell of the protected area. Limiting shells are construction elements that protect the room against the outside and ensure gas tightness. Non-gas tight structures, partitions, raised floors and ceiling voids are not considered limiting shells. The above mentioned structures are viewed as non-existent if conducting the door fan method. The risk of insufficient extinguishing gas concentration may arise if these elements are not considered when calculating the amount of extinguishing gas required.

Siemens recommends these areas to be considered when calculating the design volume and to even install extinguishing nozzles in these areas. Siemens also recommends that ceiling panels are properly closed and secured. Under no circumstances should the discharging extinguishing agent displace individual ceiling panels, which would allow the gas into the ceiling volume. In this event, the risk arises that the system can no longer establish the required concentration of extinguishing agent and therefore reducing the very success of the extinguishing system.

Room integrity, hold time and door fan test

It is essential to determine the likely period during which the extinguishing concentration will be maintained within the protected enclosure. This is known as the holding time. The predicted holding time shall be determined by the door fan test.

Holding time

Room integrity of the protected area is a key issue. A leaky room or enclosure will not retain the extinguishing agent for long enough, so the fire could reignite. Failure to achieve the retention time is not a failing of the extinguishing system; it's a failure of the customer's room or enclosure. Very few rooms are entirely airtight. Especially in data centers where cabling, ventilation, lighting and other systems are connected to the protected volume, small gaps are likely to occur:

- around doors and windows
- where stud walls join the floor and ceiling
- at cable entries
- through the floor and ceiling tiles
- into light fittings
- into power points
- through plasterboard

Obvious visible leaks (e.g. at cable entries) can be sealed, others may be impossible to locate or seal.

Room preparation

When a room is being prepared to host an extinguishing system, some key integrity aspects have to be taken into account:

- All windows have to be fixed closed or automated to be operated by the extinguishing control system, before the extinguishing agent is released.
- Doors have to be automated (magnet device or similar) to automatically closed by the extinguishing control system, before the extinguishing agent is released.

These aspects are mandatory according to VdS in Germany, and strongly recommended for all systems in other countries.

Door fan test

The data center is an environment where many different technologies are installed and constantly maintained. Therefore, several different suppliers enter the premises to update, service or replace infrastructure. This also means the room is often physically changed, because of new cabling being installed, modifications in ducts and trays and unavoidable new openings being drilled. The tightness of the room is the key factor to assure the extinguishing agent concentration build-up, Siemens strongly recommends that door fan tests are performed before installing the extinguishing system and then regularly once or twice a year.

The door fan test offers a simple, cost-effective and environmentally friendly method for measuring room tightness. To test a room, a fan is placed in the entrance door. It blows air into the extinguishing area to create a positive pressure or removes air from the room to create a negative pressure, creating an overpressure or partial vacuum of approx. 50 Pa, and allowing any leaks to easily be located.

The door fan tests yield two important results:

- Predicted hold time: An indication of how long the protected area will retain the extinguishant for
- Equivalent Leakage Area (ELA): The total area of leakage

Room cleanness after installation of an extinguishing system

Since the beginning of the extinguishing practice in data centers, high importance has been given to the fact of using "clean" agents. That is the reason why inert gas and chemical agent systems have such a great acceptance for this application: no residue and no need for cleaning up after a discharge. This topic is of key relevance when infrastructure highly sensible to dirt and dust particles is present, like servers and disk-drives in data centers. After discharge of an extinguishing system, and during the entire flooding process, there will be air flows and turbulences within the protected room. This is normal in every extinguishing process, and in all type of technologies. Therefore, special attention should be paid to the cleanness of the room, when extinguishing systems are installed. The risk of blowing years of cumulated dust and dirt on cabinets and other objects, into the sensitive equipments, is unacceptable. The sensitivity of IT infrastructure to dust and dirt is so high, that in many cases the data center rooms work with a positive room pressure, means they have constantly a higher pressure than the rest of the building, so no particles can get into the data center when doors open (due to the overpressure).

Installation

Location of the extinguishing cylinders

The cylinders shall be placed if possible outside the protected area in a separate room or corridor close as possible to the risk area to reduce pipe lengths. If the cylinders are stored in a corridor, safety precaution shall be taken to avoid unauthorized actuation of the extinguishing system.

Installation of piping network

Pipes and pipe connections shall be made of metal and be able to withstand the maximal possible pressure. Sections of pipe which could be subjected to static pressure (closed piping) shall be protected by a pressure relief valve.

- The inside and the outside of the pipes shall be effectively protected against corrosion, if necessitated by environmental conditions.
- To protect sensitive machinery, e.g. computers, from corrosive particles in the pipe system galvanized steel must be used as a minimum.
- Make sure that the pipe networks have been blown-out by compressed air in order to avoid that any dust particle might be brought in the mission critical room during the discharge of the extinguishing agent.
- Bonding of pipe network to earth: Upon the triggering of a system, the friction of any extinguishing agent in the pipe loads the agent with friction electricity and is likely to generate electric arcs. The pipe must be earthed to prevent any risk of becoming live from other electrical circuits being faulty. This is also a requirement under some country regulations (bonding of extraneous metal work).

Installation of nozzles

- Make sure that nozzles are positioned that no damage to protected object can occur during discharge of the extinguishing agent.
- Make sure that no nozzle is positioned so that out coming agent flow will be blocked by any obstacles, air ducts or partitions which would lead to incomplete extinguishing agent evaporation. Consequentially the correct distribution would not be guaranteed (this is especially important when using Novec 1230 and in false floors and suspended ceilings).

4.5.3. Summary

Although complying with the local standards, codes of practice and insurance guidelines is a legal obligation for data center owners, they are also well aware that it is in their own interest to ensure that both the data centers and the people are well-protected. Extinguishing systems not only protect people and property extremely effectively, they also contribute to the smooth running of the data center operations. A well-planned extinguishing concept that is appropriate to the size, situation and substance of the data center is essential.

4.6. Advantage Engineering – share the experience

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