SECURITON

Logistics & Distribution Warehouses

SecuriSmoke ASD

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1 Introduction

Warehouses and storage facilities are a key economic sector, attracting significant investment driven by urban population growth, change in consumers' behaviour and innovative goods and service fulfilment. As well as growing, the sector is rapidly modernising to include automated racking and retrieval systems that maximise the use of space. These new layouts provide further challenges to an already difficult fire detection environment and are addressed thoroughly in this guide.

Illustrating the size and rapid growth of automated warehousing operations, the warehouse robotics market alone is projected to grow at a CAGR of 17.7% to reach US$ 21.1 bn by 2030 from a base year valued at US$ 9.3 bn in 2025 [1].

Racking systems are designed for maximum storage capacity per square meter/foot. As such, a higher roof and narrower aisle width are desirable from a business profitability perspective. As the level of warehousing automation increases, very high rack configuration and ultra narrow aisles become possible to further maximise total storage volume on the same footprint. While older warehouses for general use have a roof height of 7-8 m (23-26 ft) only, the roof height of a typical new built warehouse is 11.5-12 m (30-40 ft) to cater for various racking systems and movement of forklifts. This increases the fire load, provides conditions for rapid fire spread, and hinders the movement of smoke towards under-ceiling detection points.

At the same time, newly constructed warehouse footprint sizes have been growing because logistics and distribution operations have moved towards fewer but larger regional distribution centres, a single national distribution centre or through specialist logistic warehousing service providers for businesses to reach a scale of global distribution with flexible ongoing OPEX[1], rather than upfront CAPEX investment. This results in typically 25,000-40,000 m^2 (269,100-430,600 ft^2) size buildings or even larger buildings of up to 80,000 m^2 (861,100 ft^2). Goods can be routinely placed on racks 30 to 40 m (100-130 ft) high, while some go up to 60 m (200 ft) above the floor where ASRS[2] equipment is installed [2], [3], [4]. At the same time, aisle width is reducing from typically 3.2 m (10.5 ft) or more, down to as slim as 1.5 to 2.0 m (5 to 7 ft) as warehousing automation advancement and wider adoption of ASRS equipment.

Persistently, fire risks and a high percentage of total loss due to fires in industrial and warehouse/storage type occupancies remain high. For example, in China there were 4,161 large warehouse fires reported in 2020. On average, more than four warehouse fires occur each day in the United States, with US fire departments responding to an annual average of 1,508 fires in warehouses between 2018 and 2022. These fires caused an estimated annual average of three civilian deaths, 19 civilian injuries, and US$ 323 million in direct property damage. In Germany, the German Insurers' Association's (GDV[3]) fire statistics from 2001 to 2016 show a total of over 76,000 risks and approximately 7,000 claims from warehouses during this period, with almost 60% of average claims for damages exceeding € 500,000 [5], [6], [7]. Examples of large damage claims include one of € 150 million from a car manufacturer in Germany, and a US$ 100 million claim for a distribution centre of a retail chain in the USA. These statistics harden the desire for businesses to adopt rigid risk management regimes and for the insurers to manage risks through the recommendation of best practices in fire safety and protection.

Over 25% of fires in storage warehousing facilities originated from electrical distribution, lighting equipment or heating equipment. While sprinklers are deemed as standard fire protection for storages, only about 30% in reported fires from warehouses were equipped with sprinklers in the USA. Of these, 12% were deemed as failure to operate or to operate ineffectively [8], [9]. Even in warehouses with installed fire detection systems, some of these did not activate alarms as expected in the event of a fire.

Adequate fire detection systems to automatically alarm local fire services can make a huge difference in minimising the fire damage. However, the ability to detect and alert early allows warehouse operators on-site to control the initial outbreak or to remove potential hazards that could lead to a real fire. Early and reliable fire detection is critical to many large storage warehousing and distribution facilities to avoid business interruption. When an advanced Early Warning Fire Detection (EWFD) system can be designed and installed at a low TCO[4], it can satisfy building and life safety objectives as well as protection of business assets, regardless of the size and use of the warehouse.

[1] OPEX: operating expenditure, CAPEX: capital expenditure
[2] ASRS: Automatic Storage and Retrieval Systems
[3] GDV: Gesamtverband der Deutschen Versicherungswirtschaft e.V.
[4] TCO: Total Cost of Ownership (of an Early Warning Fire Detection system)

The primary challenges to EWFD include the potential rapid spread of fire and smoke from the time of ignition; smoke dilution and heat dispersion in large open spaces with high ceilings; varied and changing building uses including major seasonal displays; and very high sensitivity yet reliable detection without false or nuisance alarms is required if incipient and smouldering fires are to be detected and managed in a timely manner. Additionally, services and maintenance access is undesirable during opening times or even restricted due to health and occupational safety reasons and business disruption.

SecuriSmoke ASD systems address all the key challenges to deliver early and reliable fire detection in logistics and distribution warehouses. The purpose of this Design Guide is to provide fire safety and protection consultants, qualified fire system specifiers, design engineers and technicians with recommendations for the application and use of SecuriSmoke ASD within typical warehouse facilities. The design recommendations focus on aspects of prescriptive (Deem-to-Satisfy) code requirements, risk-based detection point placements and industry practices to address the key issues of best prevention practices. Given the large size of many modern warehouses, particular emphasis is given to the SecuriSmoke ASD 2000 models: these are some of the most powerful aspirating smoke detectors ever built and can offer both value and flexibility of pipe layout in extra-large spaces.

This Design Guide is also suitable for facility management and end-customers alike to gain a high-level insight to cost-effective, fit-for-purpose and fire-engineered fire detection and protection solutions. It facilitates the best risk management practices and reliable emergency response procedures, manual and automatic suppression actuation as well as control of other BMS[5] components (e.g. procedures of power-down forced ventilation fans or power-on smoke extraction systems), through early intervention and elimination of potential fire incidents.

The Design Guide also provides key requirements on Inspection, Testing and Maintenance (ITM) of SecuriSmoke ASD; and world-class technical and application support offered by Securiton through its headquarters teams in Europe and its vast global network of regional offices and distribution partners.

[5] BMS: Building Management System

2 Aspects of Fire Safety and Prevention

Warehouses store and handle a wide range of materials and products, mostly in configurations known as high-density bulk storage; block stack-up storage or high-bay racking; and multi-tier rack storage. The advent of automated ASRS equipment means racking systems can be designed for processes optimisation, and invariably goods are densely packed amid flammable plastics and cardboard packaging, in a rather complicated transport, storage and retrieval ecosystem. This set-up presents challenges to fire prevention and fire safety.

The rise of e-commerce has driven warehouses to be taller, more densely racked and more automated: multilevel mezzanine structures, or multi-row racking systems are now commonplace. Meanwhile the typical aisle width has decreased from a 3 m (10 ft) to ultra-narrow aisles of less than 1.2 m (4 ft). This presents a challenge for detecting a fire at its incipient or early development stage. Stratification in many warehouses utilising natural ventilation can further impede smoke detection, when conventional point type smoke or heat detectors are installed close to the roofline. Detectors relying on line-of-sight are now obstructed by racks and face interferences from warehouse machinery such as forklifts, and even smoke and heat detection requires careful planning.

A relatively high percentage of warehouses have sprinklers installed. Although ceiling-level sprinklers are installed under ceilings as high as 13.8 m (45 ft) [10], [11], many high-bay warehouses also have an in-rack sprinkler system since some modern automated warehouses can have a roof height of 30 m (98 ft) or more. This is due to the ineffectiveness of ceiling level sprinklers to control a fire with a significant fuel load, rapid vertical fire propagation and fire spread from one aisle to another. As such, multilayer fire detection or ceiling level fire detection combined with risk-based local detection is desirable for early detection of a fire incident regardless of where it is originated. Control of mechanical ventilation (such as the use of big fans in non-ambient-controlled warehouses) may be important for the ceiling level sprinklers to be effective.

The logistics industry is geared to deliver uninterrupted service, which is key to order fulfilments and delivery, and for high-value manufacturing processes to ensure Just-in-Time (JIT) production. Any operation interruption due to a fire event could lead to an unacceptable extended service downtime to customers, leading to loss of business, contractual penalties and reputational damage for the warehouse operator. For example, a fire in 2019 destroyed one of the robot-controlled distribution warehouses of a UK retailer, resulting in more than £6 million of direct stock loss. With the fire burning for days affecting neighbouring businesses due to the risk of a toxic release or a large cylinder explosion [12], the knock-on effects were worse: shares in the retailer dropped by 10% in a day.

A central element of best fire safety practices is the use of Early warning Fire Detection (EWFD). This chapter highlights the following key aspects of fire safety and fire prevention in logistics and distribution warehouses:
- Warehousing and operation characteristics
- Fire risk, consequence and safety
- Challenges to Early Warning Fire Detection
- Code compliance and Performance-based Design

2.1 Warehousing and operation characteristics

While warehouse design and construction are done to meet requirements of the facility owners or operators, common design considerations include facility parameters/dimensions, available local utility for firefighting (e.g. water supply), storage commodity (for building occupancy), stock handling and construction methods (wall, floor and roof). To cater for warehousing operation, considerations are given to types of storage spaces; space configurations, durable and functional requirements, energy-efficiency, safety and security of people and goods, health and comfort level, as well as emerging issues throughout the life of the building such as change of occupancy or expanded use of ASRS equipment as a retrofit [13].

Fire system design includes the assessment of potential fire ignition sources, the suppression agents and methods, detection and/or suppression release, the presence of ASRS equipment and local fire extinguishing, the probability for failure of detection and suppression system, local fire service response and its firefighting priority.

Features already common in modern warehouse designs are higher bays, sophisticated material handling equipment, broadband connectivity access for full automation and remote access, and connectivity throughout existing and expanded distribution networks. A wide range of storage alternatives, picking alternatives, material handling equipment and software exist, to meet the physical and operational requirements of the warehouses. warehouse spaces shall also be flexible to accommodate future operations and storage needs as well as operation mission changes.

This Design Guide focuses on logistics and distribution warehouses, housing standard, non-hazardous materials. They typically include advanced racking systems, including high-bay with ASRS automation. Designs such as multi-tier racking and multilevel mezzanine warehouses are also included. These are typical warehouses used by large multiple retailers, e-commerce, and manufacturers both for supply and storage of finished goods.

More specialist warehousing, such as those designed to store hazardous materials; deep freeze warehouses; and those with particular challenges to detection equipment such as tobacco warehouses, fall beyond the scope of this guide but may be covered by other Securiton design documentation. The table below shows relevant Securiton guides both to specialist warehousing and areas around the warehouse such as loading docks. All are available from www.securiton.com/en/industries-applications under their relevant industry heading.

Warehouse characteristic	Securiton guide
Warehouse general function	
Hazardous materials	DG Hazardous Areas 202302
Dusty or dirty materials	CS Harsh Environments 052024
Refrigerated storages	DG Refrigerated Storages 092021 CS Ultra-low temperature storage 122025
Tobacco storage	CS Tobacco warehouses 202403
Tyre storage	CS Tyre Production and Storage warehouse 202311
Partially open storage areas	CS Partially Enclosed Buildings 052025
Warehouse adjacent function	
Loading Docks	CS Loading Docks 202302
Packaging machines	CS Packaging Machines 032026
Cable trays and pathways	CDG Cable Pathway Spaces 092022
Machinery	CS Large Industrial Machinery and Equipment

Table 1 Securiton Guides to particular warehouse functions

2.1.1 Heated, unheated and ambient-controlled warehouses

Unheated warehouses commonly rely on natural ventilation while heated warehouses (through warm or radiant air) require good airtightness during the heating seasons. Warm air rises to the ceiling and causes hot air stratification. To avoid this issue, big fans (mounted below the ceiling level) force the air to circulate. The impact of the resulting higher airflow must be taken into account when designing the fire detection system.

Figure 1 (a) illustrates a typical large warehousing facility with a floor-standing heating system, while in some heated warehouses, large fans may be installed to force air circulation when warmer air tends to congregate around the ceiling Figure 1 (b).

(a) Warehouse with a floor-standing heater

(b) Use of fans to the de-stratification of hot air

Figure 1 Heated warehouses and hot air distribution

Goods sensitive to ambient conditions need to be stored and handled in an ambient-controlled environment. For example, European Good Distribution Practice Guidelines [14] and the World Health organisation generally require pharmaceutical products to be kept in dry, well-ventilated conditions and at a temperature range of 15°C to 25°C (59°F to 77°F). Vaccines must typically be stored and handled in a range of 2°C to 8°C (35.6°F to 46.4°F) and therefore their storage falls under the refrigerated category.

2.1.2 Warehouse racking systems

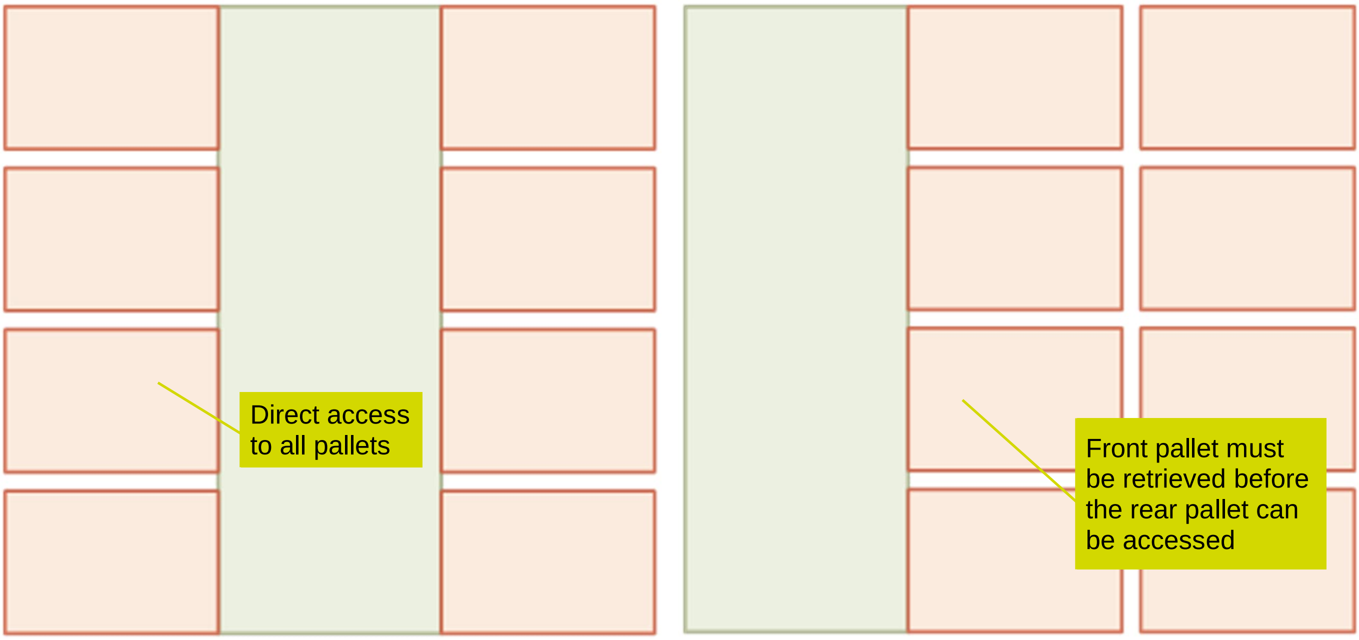
Warehouse racking, also known as storage or pallet racking, is a material handling system designed for mass storage of goods combined on skids and pallets, or motorised containers in the case of automatic storage and retrieval systems (ASRS). Different types of goods and warehousing processes require specific racking systems to achieve the objectives of efficient space utilisation, easy inventory organisation, increased productivity, automation, safety, and flawless workflows to the type of inventory management and cost.

One key design consideration of racking systems is to maximise the use of available floor areas as well as vertical space. In general, racking with high selectivity and low density are selective, double deep, and very narrow aisle racking systems. High-density applications are push-back, drive-in, and pallet flow. Based on the inventory and processing needs, methods, and goals, suitable material handling equipment, conveyors and ASRS equipment are designed to facilitate warehousing processes within the floor and vertical spaces, mainly through the aisles between the racking systems, for storage or order fulfilment.

Typically, a standard aisle measures 3.2 m (10.5 ft) or more, narrow aisles range from 2.6 to 3.2 m (8.5 to 10.5 ft), while VNA[6] can be as slim as 1.5 to 2.0 m (5 to 7 ft.) [15]. As warehousing automation advancement and wider adoption of ASRS equipment, UNA[7] become popular where the aisle width is reduced further to 1.0 to 1.2 m (3.5 to 4 ft) or less. With these racking systems, aisles are usually not treated as aisles in a conventional sense but as multi-row racking systems from a fire safety and protection perspective.

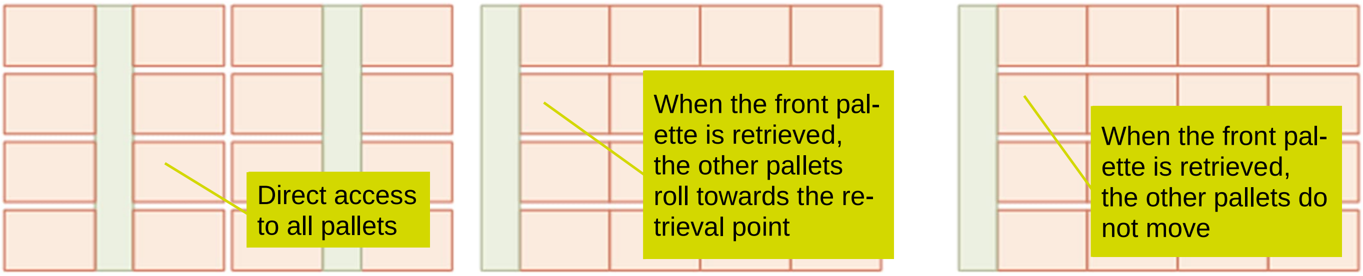
The advantage of storage solutions with narrow aisle racking dimensions is to store 30-50% more products in the same space, potentially eliminating the need for offsite storage or building expansion. However, it also represents significantly changes in fire risk and fire protection due to much higher density of goods, increased fuel load and potential fire spread from aisle to aisle.

Figure 2 illustrates typical warehouse racking systems for the purpose of this Design Guide.
(a) Single (left) and Double (right) Racking System (with standard, narrow or very narrow aisle))
(b) Multi-row Racking System: Open, Push Back and Solid (with ultra narrow or no aisle)



(a) Single (left) and double (right) racking system (with wider aisle)

[6] VNA: Very Narrow Aisles
[7] UNA: Ultra Narrow Aisles



(b) Multi-row racking system: open (left), push back (middle) and solid (right) (with VNA or UNA)

Figure 2 warehouse Racking Systems

2.1.3 High-bay and multi-row rack warehouses with ASRS automation

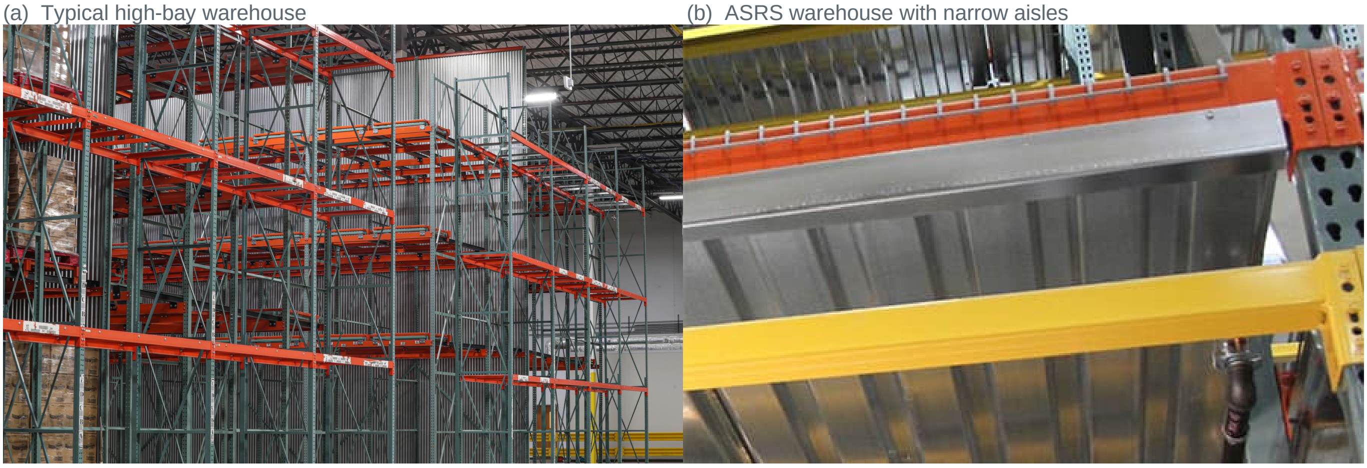
ASRS equipment often refers to a combination of high-density storage racks, robotic retrieval machines like cranes or shuttles, driven by sophisticated WMS[8] control software. With a global market expected to exceed US $18 billion by 2032 [16], ASRS adoption is surging forward for retail, warehousing, and distribution companies looking to increase their storage density, throughput, and efficiency. High-bay and multi-row rack warehouses are popular due to their vertical high-density storage capacity on a given floor footprint. With the use of robots or varieties of ASRS automation, the rack height is pushed further while the width of the aisle becomes narrower, typically 1.2 m (4 ft) or less. With the use of in-rack sprinklers and the possible use of ASRS with built-in integrated detection and suppression modules, the design of EWFD system needs to take these factors into account.

Figure 3 (a) and (b) illustrates a typical high-bay storage and a ASRS automatic operated warehouse and distribution centre. Figure 3 (c) shows vertical or horizontal fire baffles (steel inserts in pallet racks) that are designed to achieve following objectives:

- Ensure proper flue space and contain flames around an opening in order to limit fire spread;
- Reflect or conduct hot smoke or heat from a fire towards fire detection zones and suppression system activation.

(a) Typical high-bay warehouse

(b) ASRS warehouse with narrow aisles



(c) Illustration of fire baffles installed in high-bay and multi-row racks (left: vertical type; right: horizontal type)

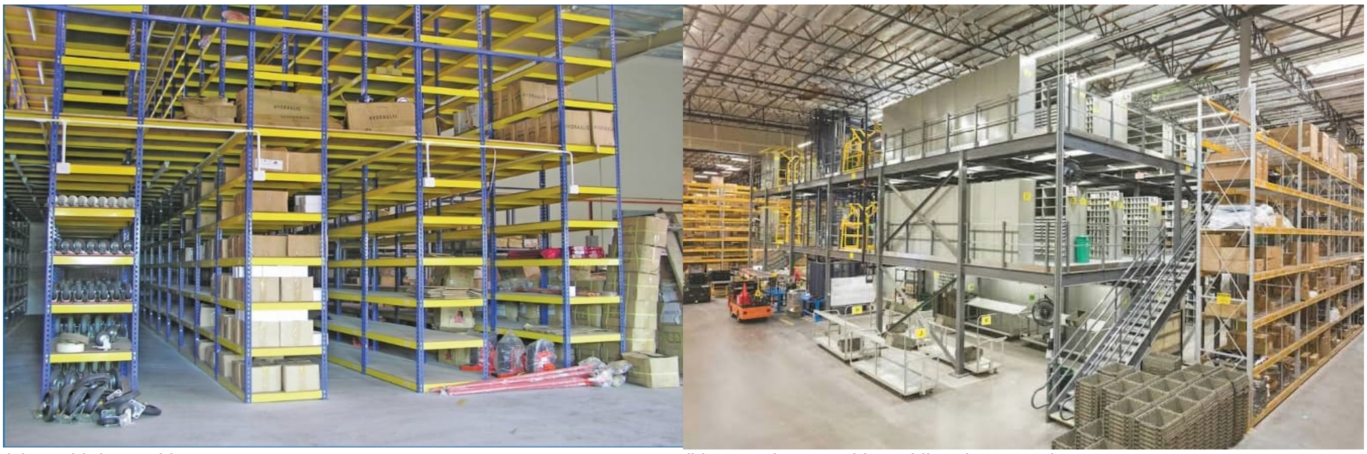
Figure 3 High-bay and multi-row rack warehouses with ASRS automation

[8] WMS: warehouse management system

ASRS equipment plays an important role in modern day warehouse automation. With unit-load and mini-load type, they can run operations such as order picking and packing, staging orders for shipping automatically. With fewer people present and higher racking density and height, this means a fire incident is less likely to be detected by a human at an early stage, and the ability to deal with the situation quickly is significantly reduced. However, this challenge presents an opportunity to apply EWFD at the locations where the risks are highest, in addition to the ceiling level detection.

2.1.4 Multi-tier racking and multilevel mezzanines

Figure 4 illustrates typical multi-tier racking system and racks on multilevel mezzanines. One key design consideration for an EWFD system is the need for detection in compartments and allowing detectors to cover the possible future installation of multi-tier racking or mezzanines in a warehouse.



(a) Multi-tier racking systems (b) Warehouse with multilevel mezzanines

Figure 4 Multi-tier racking and multilevel mezzanines

2.2 Fire risk, consequence and safety

Despite ongoing focus on fire safety in logistics and distribution warehouses, fire continues to cause massive damage. Data shows while the overall number of fires is trending downwards, the loss costs are rising significantly [17][18] due to the fact when the fires do occur, they tend to grow very quickly due to the modern density of goods. Narrow, high racking also makes it extremely difficult for firefighters to access and tackle the blaze.

The following statistics and examples give an idea as to the scale of the problem:

- In China, there were 4,161 large warehouse fires in 2020 [19].
- In South Africa, a total of 436 warehouse fires were registered between 2011 and 2015 (81 fires per year), with a steady increase from 61 fires in 2011 to 127 fires in 2015.
- In the UK, trends in non-residential buildings (including industrial and storage properties) showed a 20% increase in fires and a 16% increase in deaths, from 2008 to 2017 [20].
- In Germany, the German Insurers' Association's (GDV) fire statistics from 2001 to 2016 show a total of over 76,000 risks and approximately 7,000 claims from warehouses during this period, with almost 60% of average claims for damages exceeding € 500,000.
- On average, more than four warehouse fires occur each day in the United States, with U.S. fire departments responding to an annual average of 1,508 fires in warehouses between 2018 and 2022. These fires caused an estimated annual average of three civilian deaths, 19 civilian injuries, and US$ 323 million in direct property damage.

Closer analysis of the US data above shows that shop tools and industrial equipment were involved in 19% of the warehouse fires and were responsible for 17% of civilian injuries and 21% of the direct property damage. Electrical distribution or lighting equipment was involved in 19% of the warehouse fires and was responsible for 22% of the direct property damage. Operating equipment such as heating, blower, dryer, was the leading heat source in warehouse fires, responsible for 44% of the fires, 36% of the civilian injuries, and 35% of the direct property damage. Flammable and combustible liquids and gases were the materials first ignited in 8% of the fires, but these fires caused 34% of the civilian injuries [21]. Bulk material processing and handling equipment used for storage loading and unloading, conveyors, battery-powered pallet trucks, movers and lifters, present potential fire risks due to overheating from battery, or due to electrical and mechanical failures [22].

Emerging warehousing trends that bring in new challenges include:

- Much taller: racking height in some automated warehouses can be more than 30 m (100 ft) tall.
- Much more fuel load and higher fuel density: The multi-row racks with UNA or no aisles (see chapter 2.1.3) commonly found in today's warehouses come in many shapes and sizes, most of which are deeper than 6 m (20 ft) that do not qualify as conventional open racking concept. This immediately challenges the effectiveness of existing fire detection and protection methods from codes and standards compliance perspectives. For example, if multi-row racks deem as solid shelf racking, it would result an impractical to follow the requirements of NFPA 13 that mandate the installation of in-rack sprinklers at every tier level for these types of storage racks [23].
- Recent surges in popularity of e-commerce and omni-channel business models, companies may rush into ASRS implementation without fully aware of the property and operational risks associated with ASRS.
- Transformations in warehouse facilities in recent years, includes the ASRS introduction, storage of new hazards (e.g. lithium-ion batteries), use of multi-row racking, elevated walkways within storage racks, among other new factors, present significant challenges to fire service response.

While good housekeeping may reduce the likelihood of a fire from happening, the vast size of the facility and significant amounts of stored goods in high density, present challenges to risk mitigation and risk management under some unique hazardous conditions. Most, if not all Logistics & Distribution warehouses are designed for processing and distribution of goods either for their own businesses or as a service hub connecting businesses to their customers. Business continuity and avoiding any loss due to fire are paramount. Regardless of storage occupancy or type of commodities handled, EWFD is a key to risk management of these storage facilities to ensure a high level of service availability and reliability. Naturally, any fire or non-fire incident, such as a false fire alarm can result in significant downtime of the facility's operation and services.

Figure 5 illustrates key aspects and advantages of using a reliable EWFD system:

- How the intensity and destructive power of a blaze grow exponentially, from an incipient stage, through a growth period and into a fully-fledged fire which will rapidly cause a total loss as well as being extremely dangerous to persons.
- How business operation interruptions and potential losses due to fire damage may be minimised by EWFD, compared to standard detection and the even greater damages when only sprinklers are used, with no prior detection.
- Suitable points for a staged response where EWFD is coupled with multiple stages of alert and alarm.

In automated warehouse facilities, where fewer people are normally present in the storage areas, early detection is less focused on evacuation alone and more critical for protecting high-value assets, limiting fire development, and maintaining business continuity. Late detection in challenging environments such as large open spaces can leave very little time to intervene before severe damage to the building, stored goods, automated systems, and operations becomes likely.

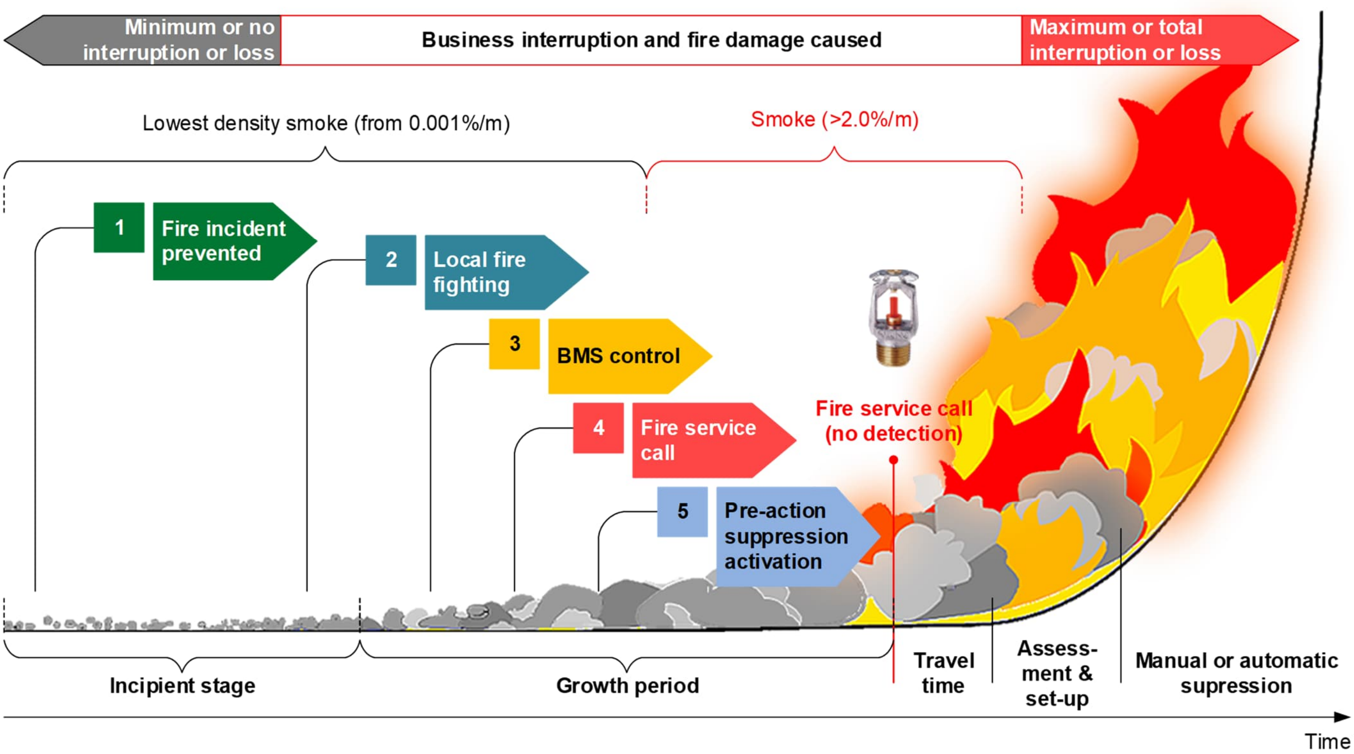


Figure 5 Impact of a detection system on life safety and loss due to fire damages

2.3 Challenges to Early Warning Fire Detection

Fire detection and protection solutions need to be effective and fit-for-purpose to manage existing and emerging challenges, like taller buildings, racking systems with extreme high density, much narrower or minimal aisle widths in the cases of multi-row racks due to the use of ASRS automation, and the demand of highly optimised use of warehouse space with operational flexibility.

Early Warning Fire Detection design must consider what type of detection technology is chosen; the level of detection performance and reliability; and the manner in which the systems are installed and maintained. The primary challenges of fire safety and use of suitable EWFD system are:

- The potential rapid spread of fire from the time of ignition.
- Requirement for early detection of a fire in its incipient stage to eliminate the fire. However, smoke under the stored goods can be suppressed due to lack of flue or aisle space. In addition, due to very large open space and usually high ceiling, smoke can be diluted quickly or may stratify.
- To avoid costly business interruptions, detectors should produce no false or nuisance alarms despite the challenging ambient conditions.
- The system must have the ability to provide multiple levels of alert and alarm to facilitate a comprehensive emergency response plan.
- EWFD system must be operating reliably in a variety of challenging environments including vapours, fumes and dust, and extreme high or low temperatures.
- Easy and non-intrusive access to the detection system for routine or urgent servicing and maintenance without interrupting the operation is a requirement.

Proper design of EWFD system for specific fire risk mitigation is of fundamental importance to ensure business continuity and prevent property loss, paired with enhanced life safety for people working in the warehouse facilities. SecuriSmoke ASD systems address all the key challenges in order to deliver early and reliable fire detection in logistics and distribution warehouses.

Challenge	SecuriSmoke ASD
Large Open Space	Active aspirating sampling with powerful fans and global approval listings.
Forced, changing or natural ventilation	Flexible placement of sampling points and spacing between them. Suitable for buildings with natural ventilation where indoor ambient conditions may be influenced by outdoor surroundings.
Rapidly diluted smoke and stratification	Very high, consistent detection sensitivity for incipient fires; position of sampling holes at various levels closer to the potential sources of fire risk.
Wide ambient temperature range	Practically no limitation to detector installation location SecuriSmoke ASD operating temperature range is -30°C to 60°C (-22°F to 140°F).
Risk-based detection with complex design considerations	Unique features include option of dual detection chambers; high number of sampling holes for required level of sensitivity. Flexible sampling pipe and sampling hole placement for detection at multilevel mezzanines, compartments, in-rack/above-rack, vertical riser type, or enclosures and vaults alike concealed spaces. SecuriSmoke ASD 2000 offers more pipe channels, dual alarm zones, wide sensitivity range, longer pipe run with powerful aspirator and sufficient sampling holes, for large coverage from one single detector delivering VEWFD and EWFD protection.
Obstructed or difficult access	Active sampling technology with detectors and testing points often located in areas easy to access or outside the protected areas. In warehouses, these can be positioned at locations away from ASRS equipment or machine and processing lines.
False alarms	Built-in features for false alarm rejection. Redundancy design options (e.g. SecuriSmoke ASD 2002/2004 with two detectors, designed to cover one single protected zone).
Harsh environment	SecuriSmoke 2000 has triple in-built filter system to filter out dust particles; high-power IR LED for maintenance-free longevity. Suitable accessories such as dust or metal dust filters can be used to address dust, high humidity or corrosive ambient conditions (see 0).
Flexible design caters for change of storage use	Use of Securiton design tools for large scale project design, give provisions of coverage expansion if needed (see chapter 4.4).

Challenge	SecuriSmoke ASD
Low TCO and easy access for maintenance	SecuriSmoke ASD main detector units are installed remotely in an easy access area with only sampling pipes run into the protected areas. Routine ITM services are done from the main detector unit with no interruption to business operation.

Table 2 Challenges to and solutions for warehouse protection with Early Warning Fire Detection

In summary, warehouses pose substantial challenges for fire protection due to their building layouts, storage configurations, technologies, ceiling heights, and types of commodities stored, with the specific challenges influenced by the characteristics of a given warehouse.

2.4 Code Compliance and Performance-based Design

Fire protection professionals work within the prescriptive constraints of the applicable building codes and standards such as NFPA 101 [24], NFPA 5000 [25] and The International Building Code [26] while applying the best engineering practices to address industry and building occupancy specific needs[9]. Fire hazards inside logistics and distribution warehouses are generally assessed in line with the classification of occupancy as well as commodities (for example NFPA 1 [27] and FM Global DS 8-1 [28]). Where specific to storage fire safety, material, waste and hazard of contents are further divided into varieties of classes (e.g. FM Global DS 8-9 Storage of Class 1, 2, 3, 4 and Plastic Commodities [29]). Flammable and combustible liquids storage is addressed separately because relevant fire hazards in these storages require suitable fire protection measures.

To enhance risk management, fire prevention and fire protection further, FM Global maintains a comprehensive suite of property loss prevention Data Sheets for various warehouses and storage facilities covering Coal and Charcoal Storage, Storage of Hanging Garments, Roll Paper Storage, Baled Storage, Rolled Nonwoven Fabric Storage, Idle Pallet Storage, Storage of Wood Chips, Rubber Tire Storage, Storage of Carpets, Carousel Storage and Retrieval Systems

In addition to these covered by FM Global, NFPA codes are also extended to include some other unique storage facilities, such as Guide for Fire Protection for Archives and Records Centers [30] and Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG) [31].

Other relevant industry guidelines include the NFPA warehouse protection business guide [32] and special provisions for ASRS protection [33], as well as a risk-based approach to the optimisation of fire detection, fire protection and human interaction to supplement prescriptive baseline life and building safety design [34]. Different countries can have its own industry-specific fire protection guidelines and directives to regulate fire protection and safety for large warehouses. For example, in China:

- Per GB 50116 design code for automatic fire alarm system [35], EWFD system is used in many challenging applications relevant to tobacco warehouses, such as when ceiling height exceeds 12 m (ft), areas where access is difficult as well as dusty or potentially corrosive environments.
- General large warehouses fire safety directives and industry guidelines such as GA1134-2014 (General rules for fire safety management of storage places), GB51157-2016 (design code for logistics warehouses), as well as local AHJ directive from Shanghai (Hu Xiao (2006) No 303) where it mandates the use of EWFD system for all large warehouses with exceeds 12,000 m^2 (129,167 ft^2) for single level or 9,600m^2 (103,333 ft^2) for multiple level of warehouses;
- Specific to the fire protection of tobacco warehouses, national directives stipulate the critical importance of fire prevention supported with suitably advanced EWFD and protection systems. Per State Tobacco Monopoly Administration directive (Clause 17, GuoYanYun (2004) No. 317), automatic fire alarm system must be installed for all tobacco warehouses with area of 500 m^2 (5,382 ft^2) or more, or total building area of 1,000 m^2 (10,764 ft^2). For all warehouses used also for fumigation resulting phosphine gas (PH_3), such automatic fire alarm systems must be suitable for long term reliable use and functioning in such corrosive and dusty environments.

Warehouses are likely to have items with varying commodity classifications being stored. The actual fire risk and combustible fuel loads are subject to the respective commodity classifications, handling and storage of the commodity. Sprinkler design, per NFPA 13 [10], can account for this by either designing to the highest-hazard commodity (costly) or by creating separate zones for higher- and lower-hazard commodities (limit of flexibility). Such standards are widely adopted by AHJs and large insurance company risk management guidelines (e.g., FM Global and AXA XL Risk Consulting [36]).

Codes are also being adapted to reflect new warehousing practices. For example, NFPA 13 historically defined high-piled storage racks, where solid shelves larger than 1.9 m^2 (20 ft^2) have been installed, as solid shelf racks.

[9] Each country or state/province might have its own (or adopted) building and fire code or directives. Examples are the Muster-Verwaltungsvorschrift Technische Baubestimmungen (MVV TB) in Germany or The Regulatory Reform (Fire Safety) Order 2005 in the UK.

When pallet loads stored within open racks are not provided with minimum 150 mm (6 in) wide flues on all four sides of the load, the storage arrangement is also defined as solid shelf racking. Because of the shielding effect created by racks that qualify as solid shelf, in-rack sprinkler protection is required at every tier level. For several cycles prior to 2022 Edition, NFPA 13 has permitted multiple-row racks that are provided with minimum 150 mm (6 in) wide transverse flue spaces a maximum of every 1.5 m (5 ft) horizontally, but void of longitudinal flue spaces, to qualify as open racking. In NFPA 13 2022 Edition, the definition of open racking for multi-row racks was changed and required either a minimum 150 mm (6 in) flue spaces around each pallet load within the multi-row rack, or a multi-row rack to be provided with minimum 150 mm (6 in) wide transverse flue spaces no more than 1.5 m (5 ft) apart and the rack depth limited to a maximum of 6.0 m (20 ft) as defined by minimum 1.1 m (3.5 ft) wide aisles.

While the above code changes justify the extensive requirement of in-rack sprinklers, use of fire baffles (vertical or horizontal types) is an alternative to in-rack sprinklers for non-ASRS installations deeper than 6 m (20 ft). The fire baffles behind every 6 m (20 ft) of rack contain the spread of flames, heat, and smoke within the storage area. These barriers or compartments control the movement of fire and smoke, allowing for safer evacuation routes and facilitating effective firefighting operations [37]. These active and passive fire protection measures also highlight the importance of the use of EWFD system so fire can be detected much earlier and fire development may be interrupted before it grows damaging and dangerous.

Although there might be marginal differences from one country to another in prescriptive (DtS) building and fire code requirements on fire detection, a combination of DtS prescriptive and risk-based design approach is the best engineering practice to meet prescriptive requirements as well as to satisfy facility operators' need for business continuity and property protection.

Performance-based Design (PBD) is typically implemented when elements of fire safety and protection system design are not covered in the prescriptive codes among others due to unique building structure, environmental conditions, added detection for early warning or extended egress considerations [38]. A PBD approach is commonly adopted for either of the following:

- As a means to determine equivalency to a prescriptive code or standard
- As an approach to achieve broadly defined fire safety goals and objectives

While PBD may be required for large warehouses, the majority of warehouse facilities can be designed to the prescriptive codes meeting the codes and standards for general building and life safety with added detection and protection based on a risk assessment and in addition applying appropriate system design to these targeted risk areas and locations. Table 3 illustrates how Early Warning Fire Detection system performance, as well as the fire safety goals and objectives are defined.

Sensitivity	BS/EN 54-20 [39][10]	NFPA 76 [40]
Class A or VEWFD[11]	Very high sensitivity: An ASD system is capable of providing very early warning of a potential fire condition, particularly in high-risk areas with the benefits of staged responses.	Systems that detect low-energy fires, before the fire conditions threaten mission critical service, benefits of staged responses with a sampling hole sensitivity alert of 0.66% obs/m (0.2% obs/ft).
Class B or EWFD	Enhanced sensitivity: An ASD system is for applications where an additional degree of confidence is required for the protection of a particular risk such as with unusually high airflow.	Systems that use smoke, heat, or flame detectors to detect fires before high heat conditions threaten human life or cause significant damage to mission critical service.
Class C or SFD	Normal sensitivity: An ASD system designed to give equivalent performance to standard point detection systems meeting the requirements of EN 54-7 [41].	Systems that use fire detection-initiating devices to achieve certain life safety and property protection, in accordance with applicable standards such as NFPA 72 [42].

Table 3 Similarity in Early Warning Fire Detection definitions for smoke detection

Differences exist for example between NFPA 72 [42], BS 5839-1 [43] or VdS 2095 [44] for Aspirating Smoke Detectors (ASD) as the equivalency to point type smoke detectors in normal built environments (e.g. air change rate of up to 60 ACH[12]), coupled with other risk-orientated codes of practices (e.g. FIA Code of Practice [45], BS 6266 [46]) and risk management orientated FM Global Data Sheets related to specific types of storage such as DS 8-3 [47].

[10] ISO 7240-20 and AS 7240-20 are derived from BS/EN 54-20.
[11] VEWFD: Very Early Warning Fire Detection
[12] ACH: Air Change per Hour

3 Early Warning Fire Detection Design

This Design Guide focuses on logistics and distribution warehouses in the following application scenarios:

- General large open space and high ceiling.
- Multi-tier racking and multilevel mezzanines.
- High bay racking and tall multi-row racks.
- Risk-based protection and detection methods in challenging environments.

This chapter outlines design recommendations and methods using SecuriSmoke ASD products to protect the above-mentioned applications, as follows:

1 Securiton detection product portfolio
2 Design criteria and remarks
3 Detection design schemes and considerations.

3.1 Securiton SecuriSmoke Detection Product Portfolio

Model	Key performance parameters[13]						
Sampling holes, pipe length, spacing/sensitivity							
	Max. # of holes (Class)/Sensitivity/Zone						
Class	A	B	C	Alarm Sensitivity % obs/m	Alarm zones	**Max. aggregated pipe length**	**Max. distance to furthest hole**
SecuriSmoke ASD 2001	31	80	120	0.01 - 30	1	400 m (1,312 ft)	150 m (492 ft)
SecuriSmoke ASD 2002	62	160	240	0.01 - 30	2	700 m (2,296 ft)	2x155 m (2x508 ft)
SecuriSmoke ASD 2004	62	160	240	0.01 - 30	2	700 m (2,296 ft)	4x90 m (4x295 ft)
Supplement product selection							
SecuriSmoke ASD 531	6	8	12	0.02 - 10	1	75 m (246 ft)	40 m (131 ft)
SecuriSmoke ASD 532	8	12	16	0.02 - 10	1	120 m (394 ft)	70 m (229 ft)
SecuriSmoke ASD 533 1/2	32	100	100	0.02 - 10	2	400 m (1,312 ft)	2x80 m (2x262 ft)
SecuriSmoke ASD 535-3/4	36	112	240	0.02 - 10	2	600 m (1,968 ft)	2x110 m (2x360 ft)

Rating and operational data		
SecuriSmoke ASD	IP54 (IP66 for SecuriSmoke ASD 535-3/4 HD)	
	Operating temperature	**# of Relays: Built-in + (Expanded – Module)**
SecuriSmoke ASD 531	-10 to +55°C (14 to 131°F)	2 + (5)
SecuriSmoke ASD 532/533	-20 to +60°C (-4 to 140°F)	2 + (10) or 3 + (10)
SecuriSmoke ASD 535/535HD	-30 to +60°C (-22 to +140°F)	3 + (10)
SecuriSmoke ASD 2001[14]	-30 to +60°C (-22 to +140°F)	3 + (10)
SecuriSmoke ASD 2002	-30 to +60°C (-22 to +140°F)	5 + (10)
SecuriSmoke ASD 2004	-30 to +60°C (-22 to +140°F)	5 + (10)
REK	0 to +50°C (32 to 122°F)	1 (NA)

Table 4 SecuriSmoke ASD products

Inside some areas within large warehouses, or as part of detection-suppression integration, heat-based detection and control may be desirable for certain fire hazards, for instance the use of Securiton SecuriHeat Line Type Heat

[13] Highlight performance parameters as per EN54-20 (ASD), and REK point-type detector sensitivity per EN54-7. SecuriSmoke ASD sampling hole class sensitivity and corresponding hole coverage are as shown in Table 6.
[14] Operating parameters for ASD 2000 to be confirmed September 2026

Detection (LTHD) for cable tray or electrical cabinets protection. Large warehouses also require other forms of detection for general offices and support areas. Securiton's other related detection portfolio is listed in Table 5 for reference.

Model	Type	Function[15]
SecuriBeam	Linear Type Smoke Detector (LTSD)	Detect and Control
SecuriHeat d-LIST and ADW	Line Type Heat Detector (LTHD)	Detect and Control
Smoke Switch LRS	Duct Type (Smoke)	Detect and Control
Fire Door Control	Open/Close	Control
Smoke with Temperature and/or CO	Multi-criteria point type	Detect
MCP	Manual Call Point	Control

Table 5 Securiton detection portfolio (point type and others)

3.2 SecuriSmoke ASD Design Criteria

Airflow and detection sensitivity are two main factors that affect SecuriSmoke ASD sampling hole spacing. Table 6 summarises some key design criteria for deploying Early Warning Fire Detection to protect large warehouses.

To provide clarity, below are some key terminologies:

- **Transport Time:** time for (smoke) aerosols to transfer from a sampling hole to the ASD detector
- **Maximum Transport Time:** maximum time for (smoke) aerosols to transfer from the furthest sampling hole to the ASD detector
- **Response Time:** time between the generation of combustion aerosols at their source and the indication of their presence at the ASD detector
- **Reaction Time:** time between (smoke) aerosols reaching a defined level of obscurity (e.g., End-of-test EOT condition) and the notification of their presence at the ASD detector

Pipe network layout and length of single or aggregated pipe length, and the fan type and fan speed setting also determine the transport time from each sampling hole to the detector, hence a maximum transport time from the furthest sampling hole(s). Both sampling hole sensitivity and transport time are calculated with the SecuriSmoke ASD PipeFlow design tool. For ASD 2000 installations, the enhanced PipeFlow 3D is available. PipeFlow offers to calculate a pipe layout in three modes:

1. EN 54-20 (also its derivatives ISO 7240-20 [48] and AS 7240.20 [49]): PipeFlow optimises its calculation for transport time, balances the sensitivity for each hole and takes the characteristic curves of all EN 54-20 test fires [39] into consideration. PipeFlow then indicates the sensitivity to which the detector must be set in order to allow for each sampling hole to reach the required sensitivity according to the selected class.
2. NFPA 72 and NFPA 76[16]: PipeFlow optimises its calculation for the required transport time for VEWFD, EWFD or SFD.
3. GB 50116[16]: PipeFlow additionally takes the reduced maximum pipe length into consideration.

Design recommendations described in this chapter assume the transport time meets the respective sampling hole or detector unit sensitivity level in Table 6 for target Class A (VEWFD), Class B (EWFD) or Class C (SFD) design.

In general, simply follow relevant codes and standards for the design of smoke detection system to meet prescriptive requirements. Two key considerations in design are:

1. Sensitivity requirements versus detection requirements in relation to the height of the ceiling.
2. The smoke detector spacing (or ASD sampling hole spacing as equivalent) in relation to the airflow.

Table 7, Table 8 and Table 9 illustrate the design parameters commonly referred to when designing Early Warning Fire Detection with SecuriSmoke ASD in accordance with the codes such as FIA Code of Practice [45]. Smoke detector spacing based on air change rate (ACH[17]) per NFPA 72 [42] or FM DS 5-48 [50].

Note that individual countries may have different provisions regarding height limits or multilayer detection prescribed as DtS. Examples of maximum height for the use of ASD in Germany is 20 m (65.5 ft) (DIN VDE 0833-2), in the Netherlands it is 45 m (147.6 ft) (NEN 2535 [51]) and in France it is 12 m (39.4 ft) (R7 [52]). When the ceiling heights exceed the respective maximum limit, the use of ASD is considered a PBD engineering design which often requires proof with a successful fire test during the commissioning and acceptance phase.

[15] Products listed as "Detect" or "Control" function are connected to building FACPs such as Securiton SecuriFire Fire Alarm Systems.
[16] NFPA 76 and GB 50116 calculation is only available in PipeFlow 3D
[17] ACH: Air Change per Hour

Recommended ceiling heights for ASD types (Table 8) varies from generally applicable (low limit) to ceiling with design for property protection with rapid fire service attendance time of 5 min. This includes sloped ceilings with slopes not greater than 10% of ceiling height (high limit).

Model	Key design criteria		
NFPA/FM Global	**VEWFD**	**EWFD**	**SFD[18]**
Hole sensitivity	3.28% obs/m (1.0% obs/ft)	4.92% obs/m (1.5% obs/ft)	Point type over number of holes
Hole coverage	18.6 m^2 (200 ft^2)	37.2 m^2 (400 ft^2)	83.6 m^2 (900 ft^2)
Transport time	<60 sec	<90 sec	<120 sec
EN/AS/ISO/BS	**Class A**	**Class B**	**Class C#1**
Hole sensitivity[19]	0.4% obs/m (0.12% obs/ft)	1.16% obs/m (0.35% obs/ft)	6.67% obs/m (2.0% obs/ft)
Hole coverage[20]	15-25 m^2 (166-269 ft^2)	25-35 m^2 (269-388 ft^2)	Up to 7.5 m (25 ft) radius
Transport time[21]	<60 sec	<90 sec	<120 sec
Reaction time[22]	<60 sec	<60 sec	<60 sec

Table 6 Key design criteria (SecuriSmoke ASD)

Parameters	Key design considerations		
EN 54-20 Class	Class A	Class B	Class C
ASD Sampling Type and Smoke Characteristics	Smoke is not visible due to low quantity of smoke and/or high dilution caused by air movement or LOS[23]	Smoke is visible but insufficient to be detected by point or beam technologies (per [39] or [53])	Smoke visible and sufficient to be detected by point or beam technologies (per [39] or [41])
Primary Detection (sampling where smoke is likely to travel)			
	Best	Appropriate (Small areas only)	Not appropriate
Secondary Detection (positioning sampling holes per the codes for point detectors)			
	For Early warning applications	For challenging applications	Appropriate
Localised Sampling (custom protection of specific equipment)			
	Appropriate for high risk	Appropriate for low risk	Not appropriate
In-cabinet Sampling (localised sampling)			
	Appropriate for high risk	Appropriate for low risk	Not appropriate
Duct Sampling			
	Appropriate for high risk	Appropriate for low risk	Not appropriate

Table 7 Sensitivity requirements vs. detection requirements (FIA Code of Practice [45])

ASD Type 1	ASD Type 2	ASD Type 3	ASD Type 4
Any ASD system approved to EN 54-20	ASD system with at least 5 Class C holes or at least 2 Class B holes	ASD system with at least 15 Class C holes or at least 5 Class B holes	ASD system with at least 15 Class B holes
10.5-18 m (34.4-60 ft)	15-26 m (49.2–85 ft)	25-43 m (82-141 ft)	40-43 m (131.3-141 ft)

Table 8 Recommended ceiling heights

[18] SFD/Class C refers to point type detectors, usually tested to an alarm sensitivity of 2.0 dB/m (36.9% obs/m (11.247% obs/ft)).
[19] For Securiton ASD products. Individual hole sensitivity can be determined using SecuriSmoke ASD PipeFlow design tool.
[20] Hole spacing is more a mixture of DtS (per point type detectors in BS 5839-1 or VdS 2095) and PBD (BS 6266, FIA Code of Practice or VdS 2095 Appendices) provisions with adjustments based on airflow and design to required sensitivity Class A, B or C.
[21] Transport Time of AS7240-20 conformed Class A, B and C are 60 sec, 90 sec and 120 sec respectively in AS1670-1.
[22] Reaction Time of 60 sec after EOT refers to EN54-20 test requirements for relevant tests to Class A, B or C sensitivity.
[23] LOS: Large Open Space

Air changes per hour (ACH)	Spacing [m² (ft²)]
60	12 (125)
30	23 (250)
20	35 (375)
15	46 (500)
12	58 (625)
10	69 (750)
8.6	81 (875)
7.5	84 (900)
6.7	84 (900)
6	84 (900)

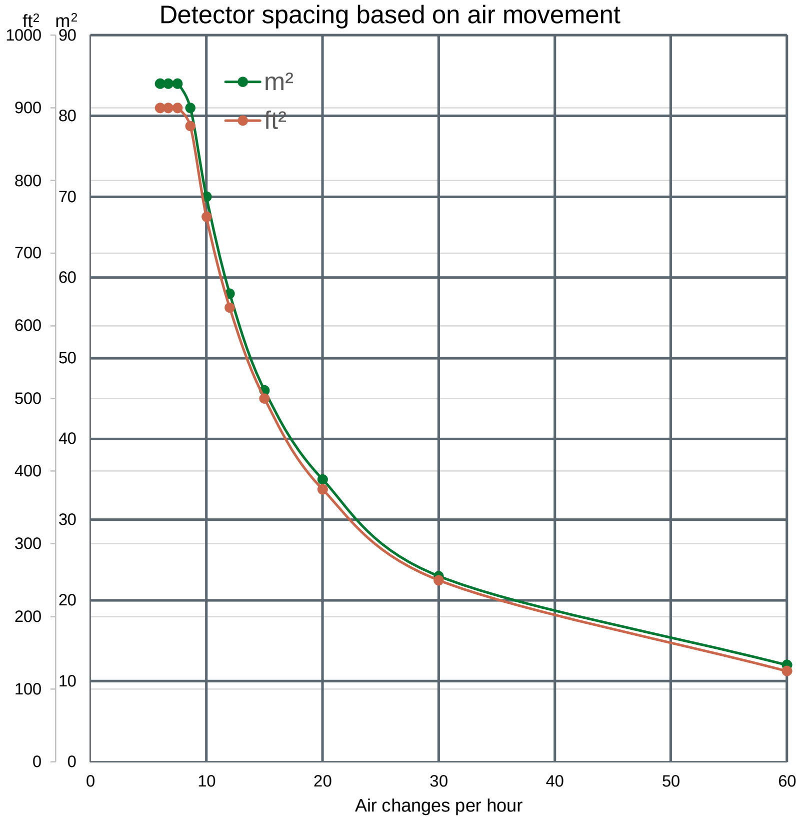


Table 9 Smoke detector spacing based on air change rate (NFPA 72 [42]/FM DS 5-48 [50])

Because each ASD sampling hole in effect represents a single point type smoke detector, the key criteria or variables included in this chapter focus on SecuriSmoke ASD design with regards to:
- Sampling hole spacing
- Sampling hole placement
- Sampling hole orientation (in general perpendicular downwards to the floor unless mentioned otherwise)

3.3 Detection Design: General Open Space

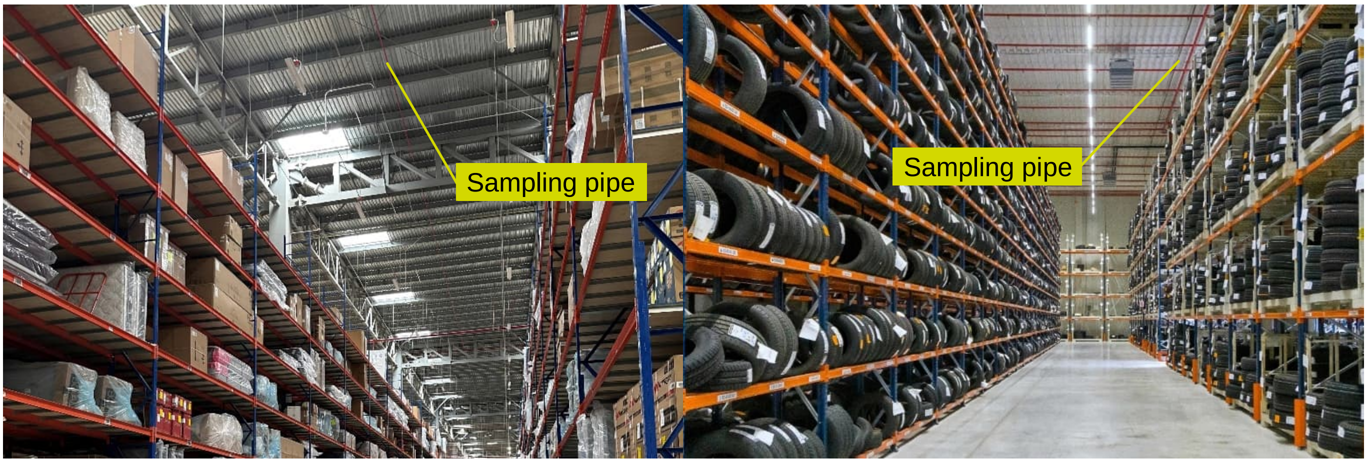
For large warehouses, SecuriSmoke ASD Early Warning Fire Detection system is used for ceiling level detection to meet prescriptive code requirements in building and life safety. SecuriSmoke ASD can cater for enhanced detection performance design to meet risk-based fire safety objectives and to avoid loss due to fire or smoke damages and ensure business continuity.

This chapter describes the following three detection methods:
1 Underside roof[24] (sloped or flat)
2 Underside roof with beam/joist
3 High-bay racking, multi-row racks and in-rack detection

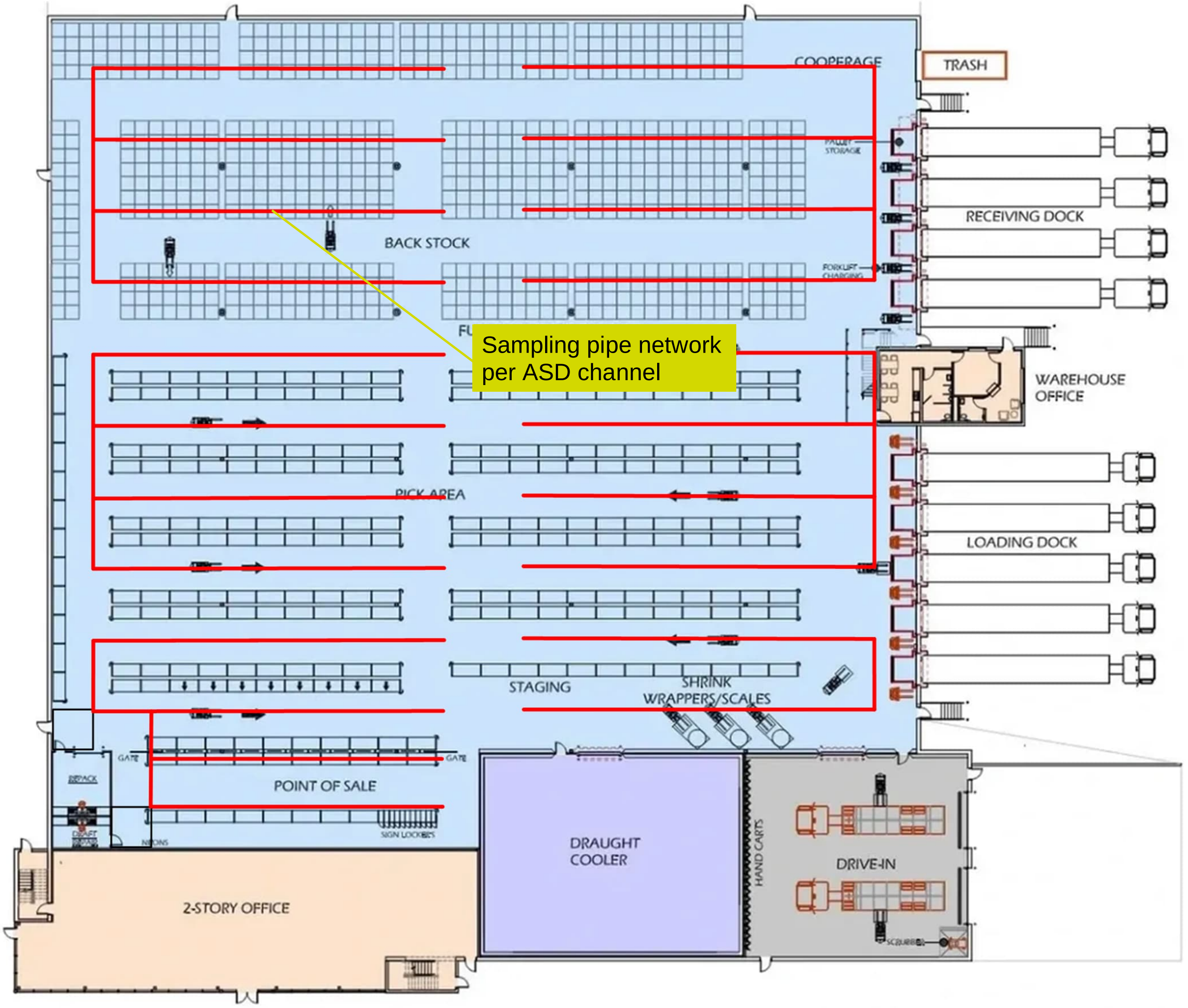
[24] In the context of this document the terms ‘roof’ and ‘ceiling’ are use synonymously. Both refer to the upper limit of the structure

3.3.1 Underside roof (sloped or flat)

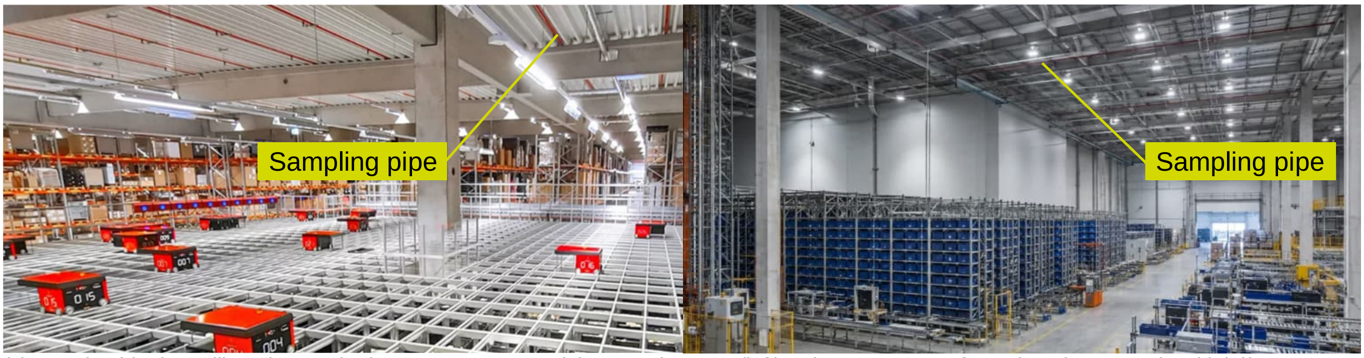
Figure 6 illustrates how SecuriSmoke ASD sampling pipes and sampling holes are located underside a flat ceiling. These layouts are relevant to ceilings which are not interrupted by significant joists, beams or other structural elements. For such structures, refer to Figure 7 in Chapter 3.3.2.



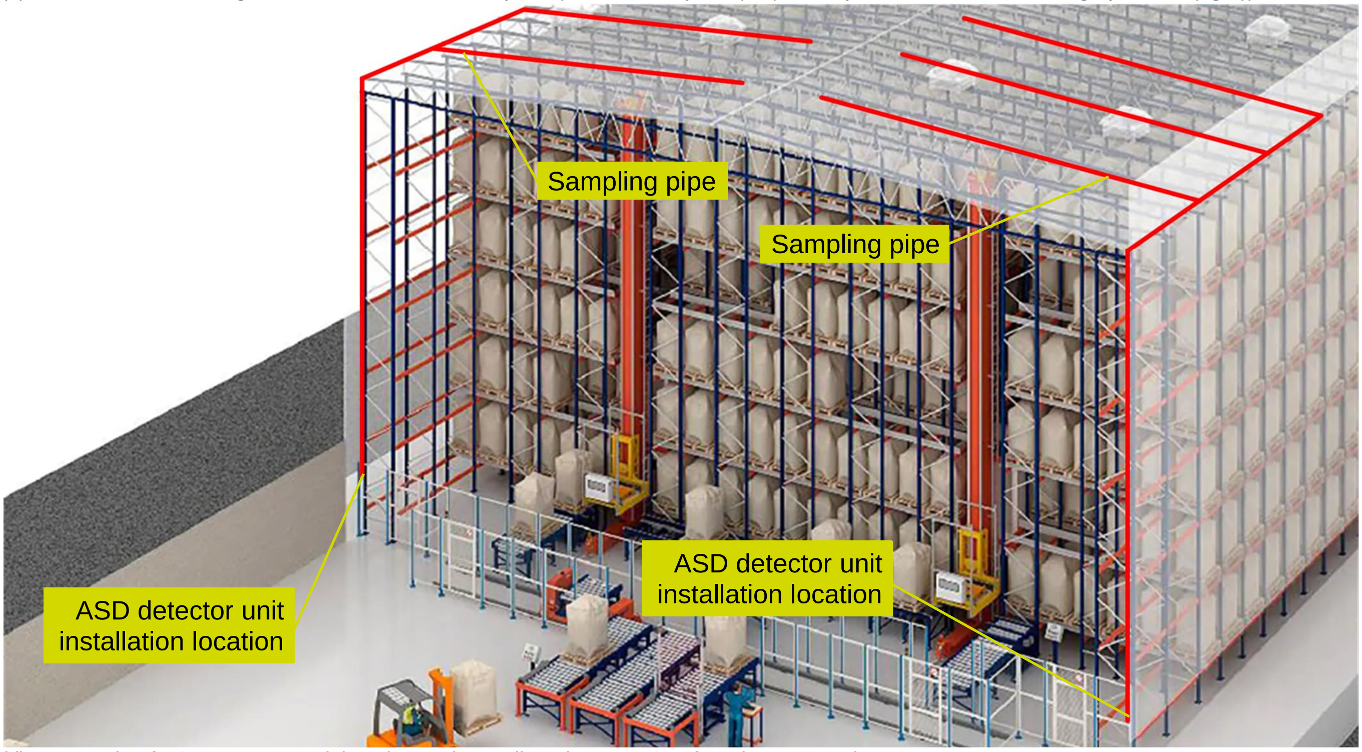
(a) ASD pipe layout at ceiling level with exposed roof structure, for example commodity warehouse (left) and a trye warehouse (right)



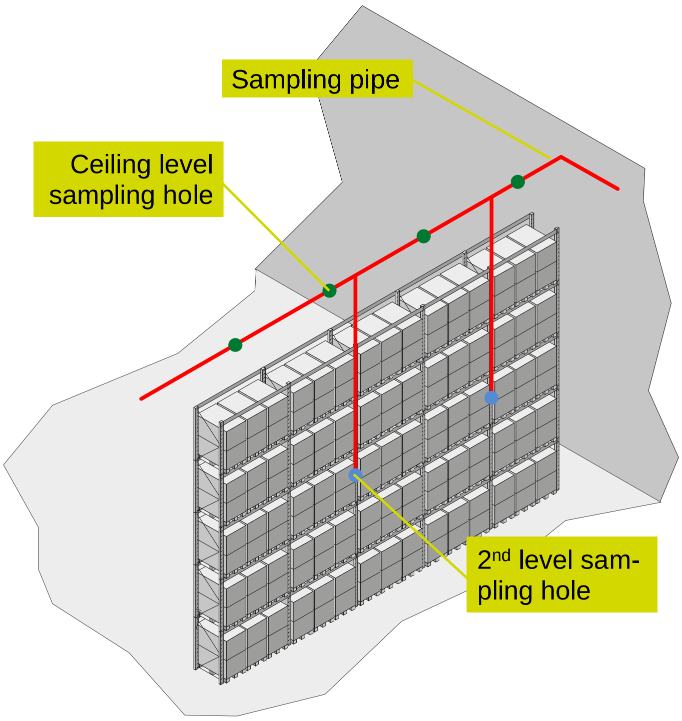
(b) ASD pipe layout options at ceiling level



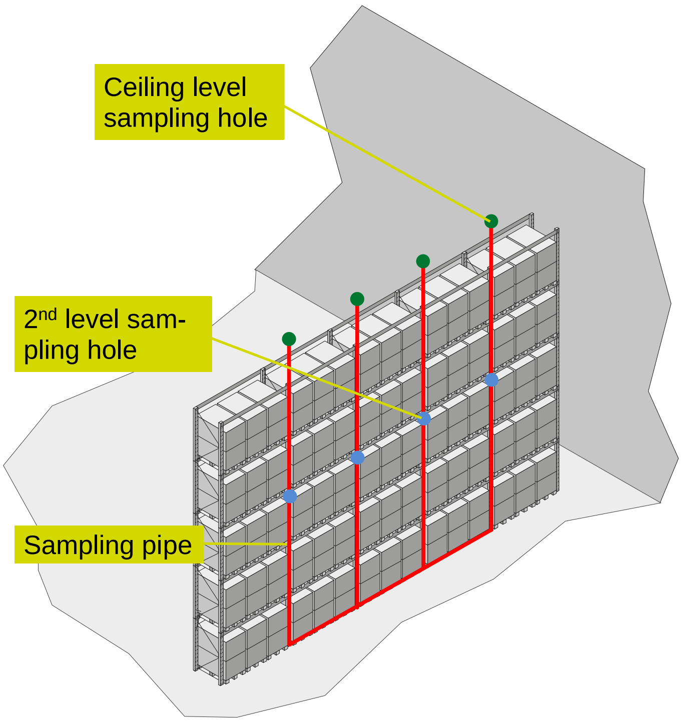
(c) Underside the ceiling above robotic movement space (above rack space (left) or in open areas of warehousing operation (right))



(d) Example of ASD Detector Unit location and sampling pipe run away from busy operation areas



(e) 2-level or alternate sampling downwards from ceiling



(f) Ceiling level detection upwards from 2nd level detection

Figure 6 Fire detection placement ASD (underside ceiling)

Variable	Design recommendation
Spacing	For general design (Figure 6 (a) and (b)) flat or slightly sloped ceilings with regard to sensitivity class and ceiling height, refer to Table 7 and Table 8. For airflow < 60 ACH: From 84 m^2 (900 ft^2) @6 ACH down to 12 m^2 (125 ft^2) @60 ACH, refer to NFPA 72 [42] or FM DS 5-48 [50]. If a higher detection sensitivity is required, refer to Table 6 for recommendations for Class A (VEWFD) and Class B (EWFD). For multi-row racks warehouses with ceiling height exceeding 9.0 m (30 ft), Class A (VEWFD) is recommended.
Placement	Place the pipe under the ceiling centre line of the aisle (Figure 6 (b)) for wider aisles, or on top of the racks. Research supports that smoke spreads inside the rack and exits at the top of the rack. For warehouses with extensive ASRS robotics for automated operation ASD pipes remain underside the roof (Figure 6 (c)). In automated warehouses always consider ASRS equipment movement and position the ASD detector unit and the run of the pipes away from these areas (Figure 6 (d)). If 2nd-level detection is required or desired, ceiling level detection can be achieved by extending the vertical sampling pipes for 2nd-level detection to the ceiling level (Figure 6 (f)). Always consider a blind end-cap to be located at a lower level, either inside or outside the warehouse main operation areas with easy access. It serves as a commissioning and ongoing ITM[25] test point for easy access.[26]
Orientation	Perpendicular downwards (ceiling level), outwards (vertical)
2-level detection or alternate level sampling holes	When 2-level detection is required by code or to address the concern of stratification, or to provide additional detection for racking spaces underneath the robotic movement surface, apply alternate sampling at two different levels by extending every sampling holes down from the ceiling along vertical rack structure wherever possible (Figure 6 (e)). Always consider the minimum clearance between top of the storage to ceiling sprinkler deflectors plus the top tier maximum storage height recommended come to approximately 1.5 m (5 ft) when designing alternate level sampling holes positions, always keep the sampling pipes within warehouse operation safety clearance area.
Sloped roofs	Generally, sloped roofs with a slope no greater than 10% of the roof height are treated as flat ceilings.
Risk, Performance-based Design	For warehouses with ceiling height exceeding 30 m (100 ft) or multi-row with extensive use of solid shelving, Performance-based Design (PBD) may be incorporated where ASD pipe network and sampling point locations may be designed in such way that the detection performance meets the performance requirements. Often the physical structures of the buildings are used for pipe installation. Enhanced detection coverage can be achieved as result of PBD scheme assessment where additional sampling holes are positioned near locations of potential fire hazards. These areas may include concealed spaces where electrical cablings, light fixtures or motorised fans are.

[25] ITM: Inspection, Testing and Maintenance

[26] For the initial commissioning and ongoing ITM (Inspection, Testing and Maintenance), the blind end-cap is replaced temporary with an end-cap with a predefined sampling hole. Measurements of transport time from the dedicated maintenance test point during maintenance should be confirmed to be within + 15% or + 3 seconds, whichever is the greater, of the same measurement taken at commissioning [45].

3.3.2 Underside roof with beam/joist

Figure 7 illustrates how SecuriSmoke ASD sampling pipes and sampling holes are located underside the beams/joist or inside deep beam pockets[27].

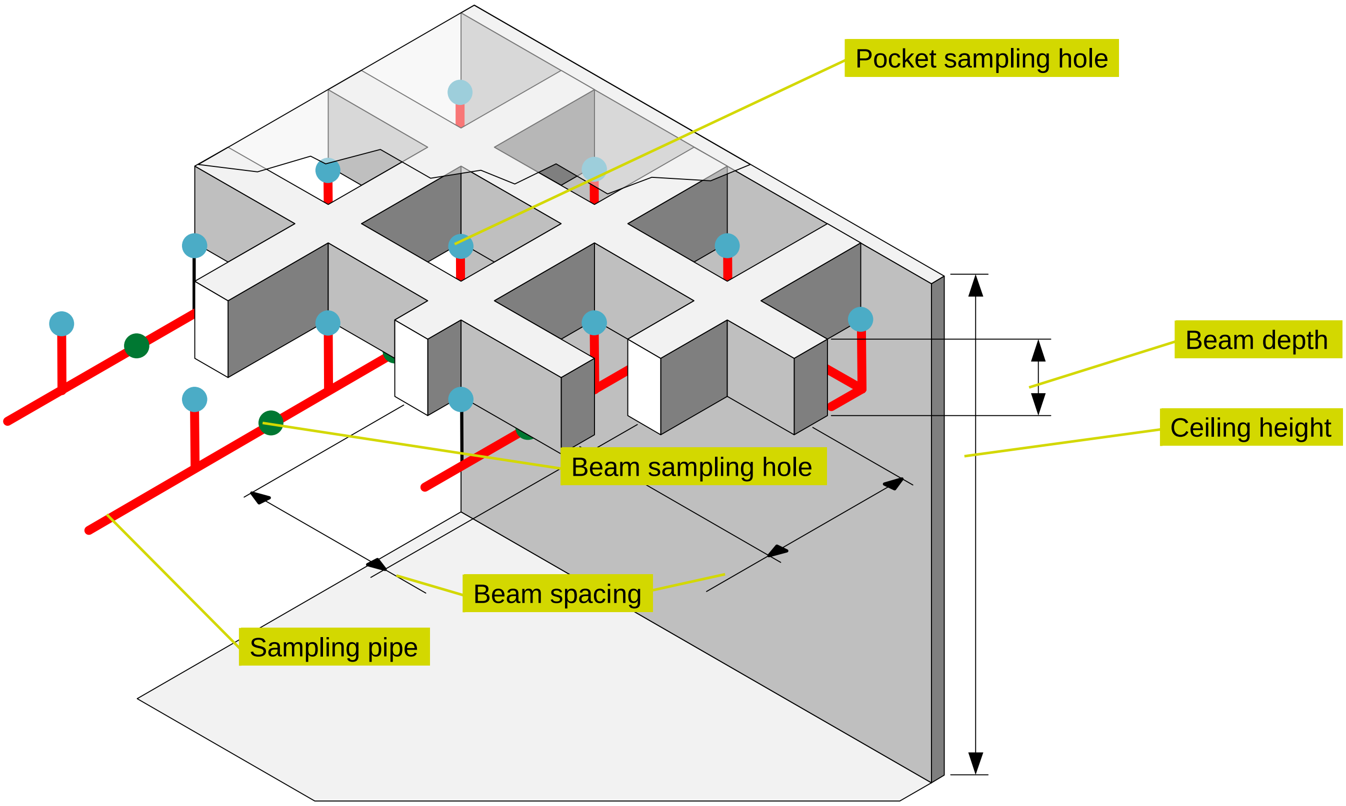


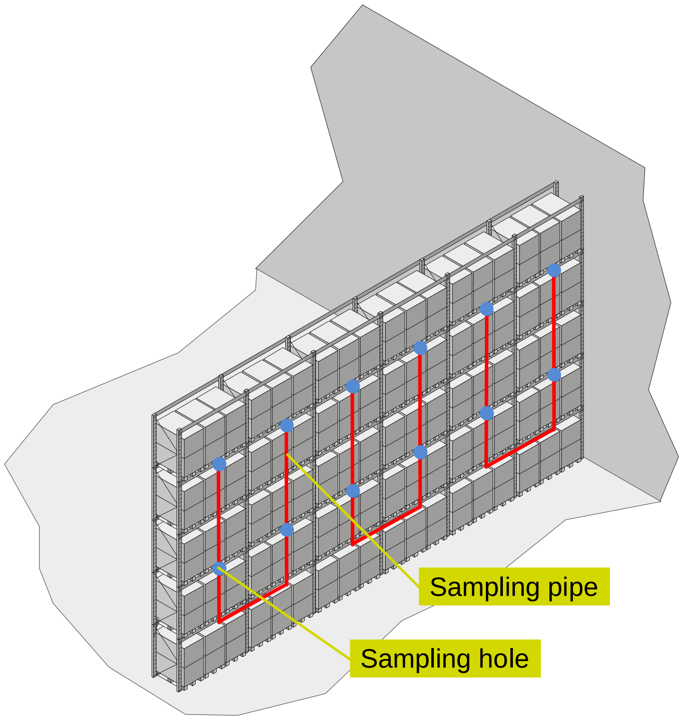
Figure 7: ASD pipe layout under ceiling with beams/joists

Variable	Design Recommendation
Spacing	In relation to airflow, refer to chapter 3.2 above. For detection design on ceilings with beams or joists (Figure 7). Beam depth < 10% of ceiling height: smooth ceiling spacing is applied, on the bottom of the beams (see sampling holes in green) Beam depth ≥ 10% of ceiling height: i. Beam spacing < 40% of ceiling height: use smooth ceiling spacing ***parallel*** to the beams and half the spacing ***perpendicular*** to the beams, on the bottom of the beams (see sampling holes in green) ii. Beam spacing ≥ 40% of ceiling height: a sampling hole shall be placed on the ceiling within each beam pocket (see alternative sampling hole in blue). Note that more than one sampling hole may be required to cover a given beam pocket. For airflow < 60 ACH: From 84 m² (900 ft²) @6 ACH down to 12 m² (125 ft²) @60 ACH, refer to NFPA 72 [42] or FM DS 5-48 [50]. If a higher detection sensitivity is required, refer to Table 6 for recommendations for Class A (VEWFD) and Class B (EWFD).
Placement	Refer to PBD design approach [54] or prescriptive codes (e.g., NFPA 72 [42], summarised above)
Orientation	Perpendicular downwards (ceiling level)

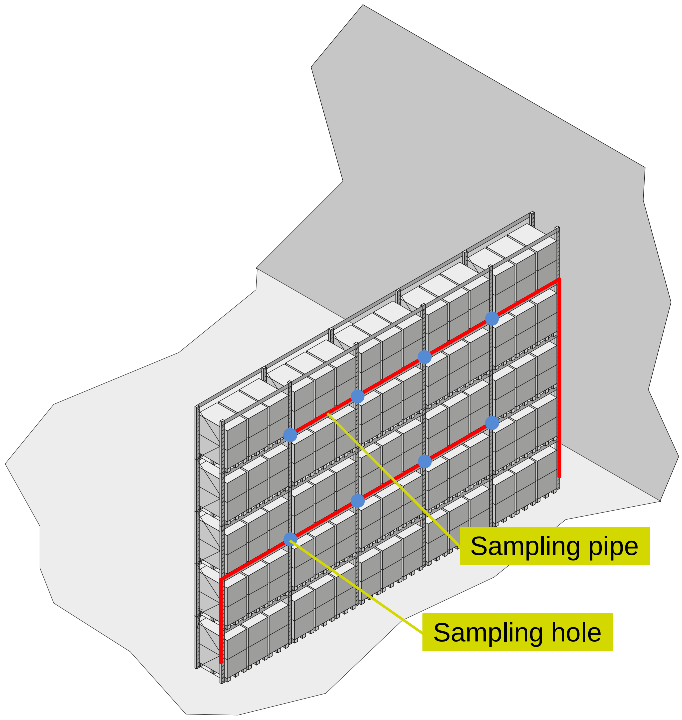
[27] The airflow velocity shall be taken into consideration when designing the spacing and the placement of the sampling holes. It is recommended to choose the spacing and placement recommendations fitting the provisions of chapter 3.2.

3.3.3 High-bay racking, multi-row racks and in-rack detection

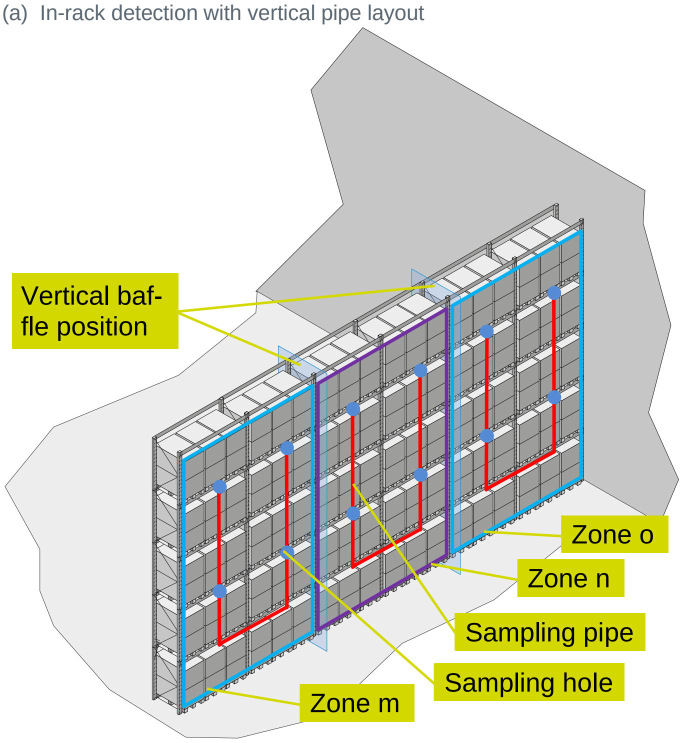
Figure 8 illustrates how SecuriSmoke ASD sampling pipes and sampling holes are positioned for in-rack detection in high-bay racking warehouses or multi-row racks.



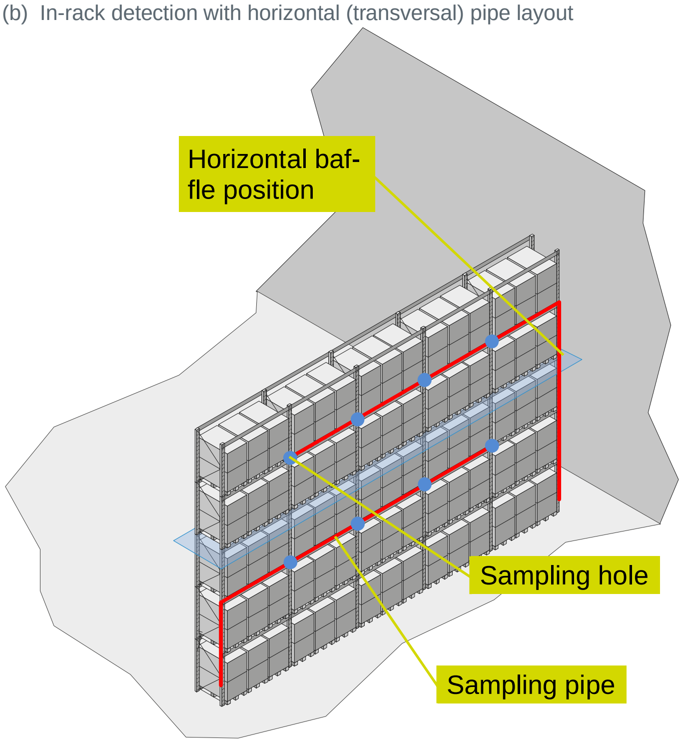
(a) In-rack detection with vertical pipe layout



(b) In-rack detection with horizontal (transversal) pipe layout



(c) In-rack detection with zoning where vertical baffles are installed



(d) In-rack detection where horizontal baffles are installed

Figure 8 In-rack fire detection placement in high-bay or multi-row racks

Variable	Design recommendation
Spacing	In-rack detection may be applied (example as shown as blue lines in Figure 8 (a) and (b)) with the following considerations: Vertical sampling hole spacing (Figure 8 (a)): i. Take into account in-rack sprinkler vertical spacing, space the sampling pipes from 4.5 m (15 ft) to 12.0 m (40 ft). Exception for reduced spacing may be given in case of solid shelf storing high value or storing sensitive commodities. ii. The very top of ASD sampling pipe may be aligned with top of the in-rack sprinkler pipe, or at a height that meets local code requirement for 2-level smoke detector installation when ceiling height exceeds prescriptive code provisions Horizontal (transverse) sampling hole spacing (Figure 8 (b)): i. It is recommended to design SecuriSmoke ASD for VEWFD (Class A) or EWFD (Class B). ii. Sampling hole spacing should not be greater than 4.5 m (15 ft); spacing may be reduced if sampling pipe vertical spacing is wider; for example, if vertical spacing is the maximum of 12 m (40 ft), the sampling hole spacing could be reduced to 3.0 m (10 ft) for better coverage.
Placement	For racks with fire baffles installed, each SecuriSmoke ASD alarm zone should be in line with the partitioned compartment for vertically installed fire baffles (Figure 8 (c)). For zone identification use a separate pipe run for each zone or install REK on each pipe run. For racks with horizontal baffles (Figure 8 (d)) use a separate pipe run for each level or install REK on each pipe run. For multi-row racks it is recommended to run a sampling pipe in every second or third row of racks observing the spacing recommendations above. Always consider a blind end-cap to be located at a lower level, either inside or outside the tyre production and storage warehouses main operation areas with easy access. It serves as a commissioning and ongoing ITM test point for easy access.
Orientation	Facing to the aisle.
Risk, Performance-based Design	For warehouses with ceiling height exceeding 30 m (100 ft) or multi-row with extensive use of solid shelving, Performance-based Design (PBD) may be incorporated where ASD pipe network and sampling point locations may be designed in such way that the detection performance meets the performance requirements. Often the physical structures of the buildings are used for pipe installation. Enhanced detection coverage can be achieved as result of PBD scheme assessment where additional sampling holes are positioned near locations of potential fire hazards. These areas may include concealed spaces where electrical cablings, light fixtures or motorised fans are. Typically, a standard aisle measures more than 3.2 m (10.5 ft), VNA width can be as narrow as 1.5 to 2 m (5 to 7 ft.). UNA width is less than 1.0 to 1.2 m (3.5 to 4 ft) are usually not treated as aisles in a conventional sense but as multi-row racking systems. In these multi-row layouts, Class A (VEWFD) is recommended with also reduced pipe spacings such that the pipe runs at ceiling are aligned with the flue spaces (horizontal) or centreline of every or every second UNAs.

3.4 Detection Design: Multi-tier racks and mezzanine

Multi-tier pallet or shelving racks take advantage of unused space in warehouses that have high ceilings. Multi-tier racks resemble mezzanines in that they take advantage of unused space and have different levels above the floor. The use of multi-tier racks makes it possible to increase storage space while providing direct access to products. The typical use of multi-tier racking is operations that store small items, such as auto parts and pharmaceuticals storage. Many warehouses, such as record storages and big box home centres, use multi-tier racking systems or construct multilevel mezzanines floors as additional work and storage space within the warehouse building structure. This allows for maximum storage volume and for easy access to stored goods without the need of high-bay racking that requires ASRS equipment or forklifts to transport the goods.

Figure 9 illustrates how SecuriSmoke ASD sampling pipes are positioned at the ground level, the upper level and the ceiling level of a multi-tier racking or multilevel mezzanines structure within a warehouse.

Figure 9 Fire detection placement (multi-tier racks and multilevel mezzanine coverage)

Variable	Design recommendation
Spacing	It is recommended to design SecuriSmoke ASD for VEWFD (Class A) or EWFD (Class B) When designed as underside ceiling detection, whether being the ceiling of the ground-level areas or roof level of the warehouses themselves (Figure 9), refer to chapter 3.3.1 and 3.3.3. When there are compartmentations to be considered, provide at least two sampling holes inside each compartment or to use REK detectors for location fire alarm addressability.
Placement	Cover each aisle when designed as ground level or mezzanine level(s) underside ceiling detection. To allow for zoning or localisation, run a pipe network per level or use REK to identify the level (indicated in blue in Figure 9).
Orientation	Perpendicular downwards.

3.5 Detection Design: Risk-Based

ASRS (Automated Storage and Retrieval System) refers to computer-controlled robotic technologies that automatically place and retrieve loads from specific storage locations within a warehouse or distribution centre. These systems replace manual forklift operations with robotic shuttles, cranes, or vertical carousels which all serve to maximize efficiency and space.

Depending on the size, weight, and volume of the goods which must be handled, ASRS solutions generally fall into the following categories:

- Unit-Load ASRS: Designed to handle large, heavy loads—typically entire pallets of goods. These use tall, automated stacker cranes to manoeuvre in narrow aisles.
- Mini-Load ASRS: Built for smaller items, cases, or trays. They are highly efficient for case-picking in e-commerce and pharmaceutical facilities.
- Shuttle Systems: Autonomous robotic carts that travel along tracks within storage racks to retrieve specific totes or bins, commonly utilized in dense "cube" storage systems.
- Vertical Lift Modules (VLMs): Enclosed, high-rise vertical systems that use a central robotic inserter/extractor to retrieve trays and bring them directly to an operator (goods-to-person).

From a fire detection point of view, the first three categories are covered in the above chapters. Key distinction of VLMs is that they are (partially) enclosed. Partially or fully enclosed systems will naturally trap any smoke from a developing fire inside, lengthening the time it takes to be detected by a system covering the general area – often significantly. For such systems, a small, independent ASD is recommended. This will serve both to ensure the early warning standards of fire detection for the warehouse are not compromised, and as object protection for a key and expensive piece of machinery.

Figure 10 below illustrates typical placement of sampling pipes in an enclosed VLM. It is recommended to run a vertical segment of sampling pipe in each compartment – with sampling holes at the bottom, in the middle and at the top – of the VLM. It is preferable to position the control unit at an accessible point low down on the outside of the enclosed machinery. Often the SecuriSmoke ASD 531 is enough for such localised, supplementary protection.

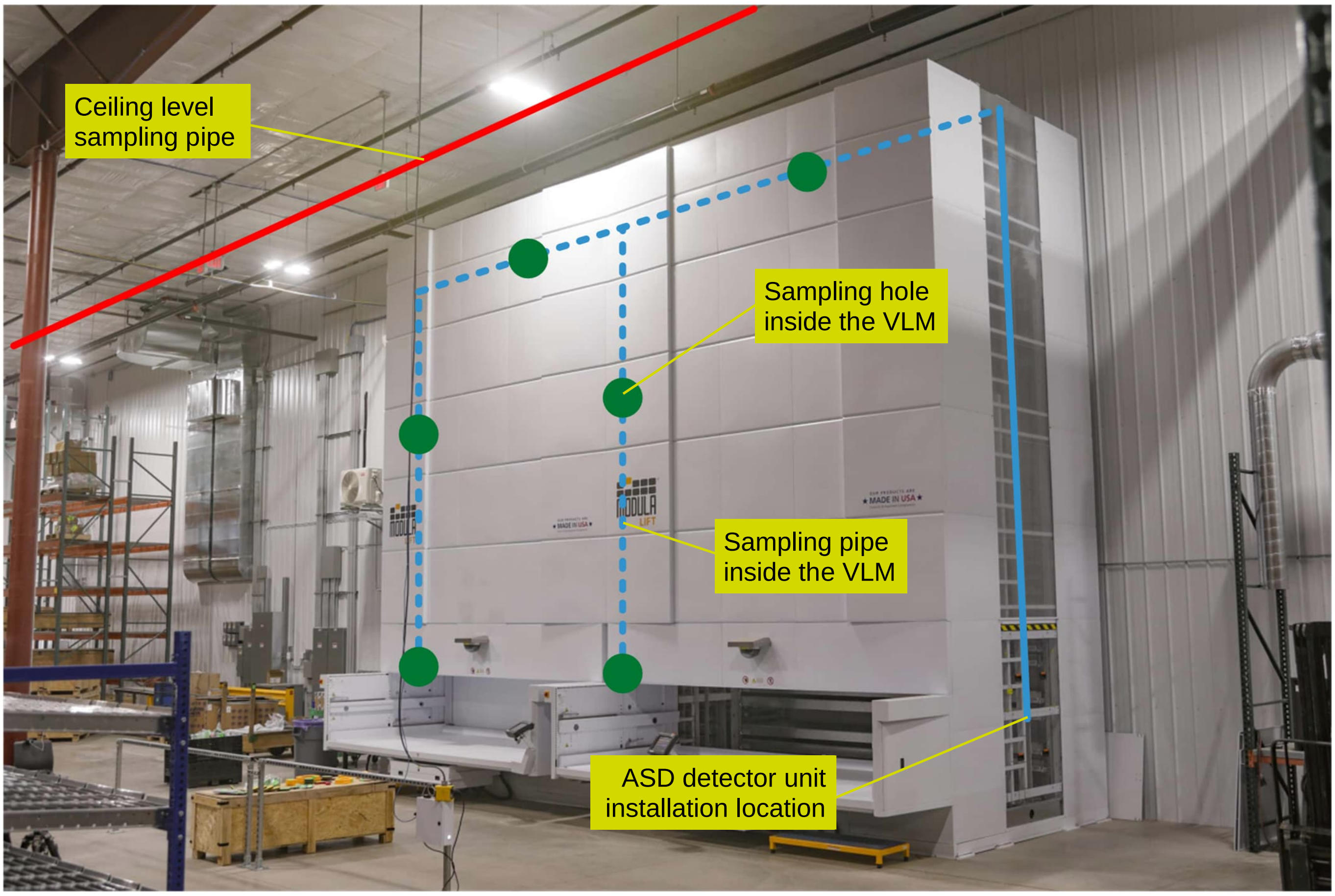


Figure 10 Fire detection placement (localised and supplementary protection)

For other warehouse functions where a risk-based detection can be applied refer to Table 1 Securiton Guides to particular warehouse functions in chapter 2.1.

4 Securiton 360° Fire Protection Solution

Securiton 360° Fire Protection Solution (illustrated in Figure 11 below) is built on its advanced Securiton Fire Alarm Systems (FAS). SecuriFire is not just reliable in operation with its modular, decentralised system architecture, it is also versatile and expandable to cater for current and future needs to connect all approved fire safety devices such as signalling, alarming, display and control units.

SecuriSmoke ASD detectors can also be networked through RS485 or TCP/IP. The networked detectors from one or multiple sites can be centrally monitored and managed from a remote location, such as an on-site control room or any authorised off-site location or certified remote monitoring centre.

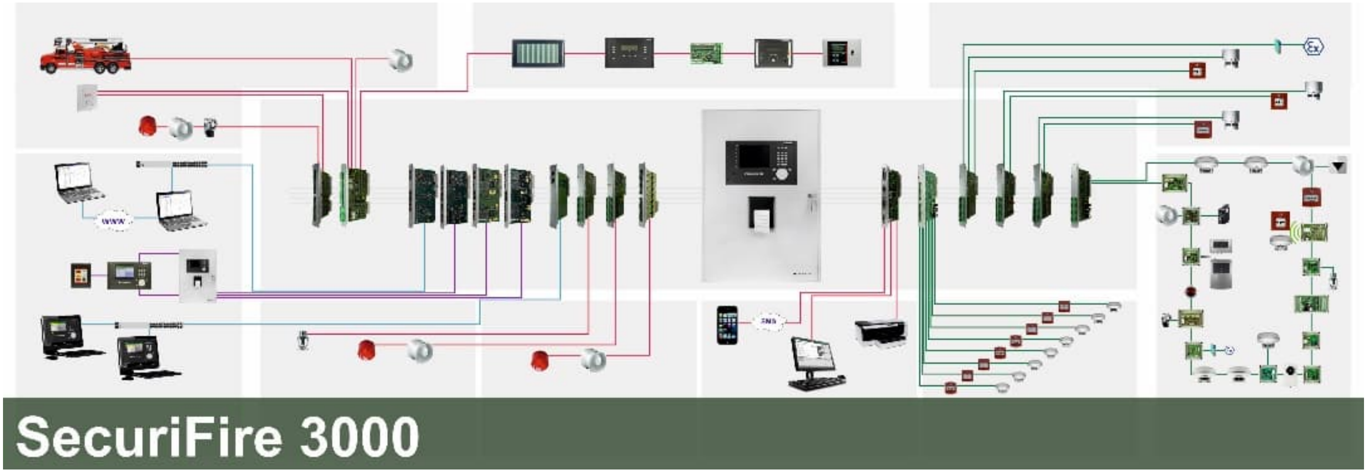


Figure 11 Securiton 360° Fire Protection Solution (FACP and Connections)

4.1 Features and Benefits

Developed in Switzerland and manufactured in Germany, Securiton AG as a whole is certified in accordance with ISO standards 9001, 14001 and 45001 and thus meets globally applicable standards with regard to quality management, environmental management, and occupational health and safety management systems.

The following table is a summary of the benefits of Securiton SecuriSmoke ASD detection products.

Features	Benefits
Early and reliable smoke detection	Ensure safe egress for life safety.
ASD unit away from sampling pipes	Easy access for services while ensuring operation continuity; Simplify intrinsically safe design.
Automatic on-demand fault alarms	Minimal service required, hence low Total Cost of Ownership (TCO).
5-level of alerts and alarms	Enable fully integrated and orderly verify, control and response.
Optimal alarm settings supported with design tool for code compliance	Eliminate false alarms in challenging environments.
Dynamic use of aspirating technology to address unique operating conditions	Consistent detection performance in areas with pressure difference, high or low temperature or humidity.
Seamlessly integrated with fire alarm system (FAS) and building management system (BMS) components	SecuriSmoke ASD is designed as a key component of a total fire prevention and protection solution.
Use for applications with challenging environments	Aspects of SecuriSmoke ASD product design for use in applications with challenging ambient environments include high IP enclosure and wide temperature range suitable for natural ventilated build environment installation; complete sealed sampling air path, separated sampled air from detector electronics; conformal coatings of PCBs and special coating treatments to connectors and contacts. Use of suitable accessories to manage dusty or high humidity where condensation could occur.

Features	Benefits
ASD 2000 – with click-mount field replaceable parts	Keep product life cycle costs low with simple and field serviceable parts such as smoke sensors, airflow sensors, fan unit, main board and coarse filters.
ASD 2000 – coarse filter accessible without having to open the device	Filters can be cleaned and changed very regularly at little to no cost.

4.2 Integrated Verify, Control and Respond

One of the advantages of using SecuriSmoke ASD detectors is the five levels of alerts ('Pre-signal1', 'Pre-signal2', 'Pre-signal3') and alarm signals ('Alarm', 'Alarm2'). These alarm signals can be used for power-down and building system control, detection to suppression actuation.

Table 10 below shows the typical use of SecuriSmoke ASD multilevel alarms. Table 11 illustrates various suppression actuation schemes with SecuriSmoke ASD or the combination of SecuriSmoke ASD with other Securiton detection systems such as Optical Smoke Switches ORS and SecuriHeat Line Type Heat Detection.

Level	Signal	Typical use
1	Pre-signal1	Verify and control (manual extinguishing as needed)
2	Pre-signal2	Manual control or shutdown of HVAC and operation to affected areas if required; call emergency team
3	Pre-signal3	Auto control or shutdown of HVAC and related BMS; Initiate smoke and fire management and other related processes; evacuate the site
4	Alarm	Actuate clean agent suppression where applicable; initiate fire alarm; call fire brigade
5	Alarm2	Actuate pre-action sprinkler

Table 10 Alert and alarm levels and their typical use for SecuriSmoke ASD

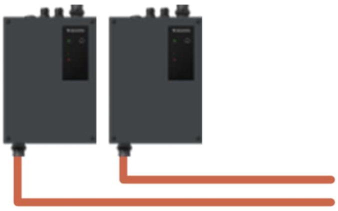
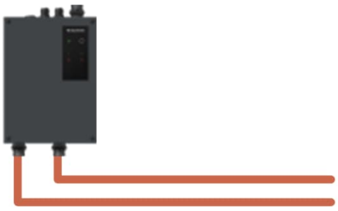
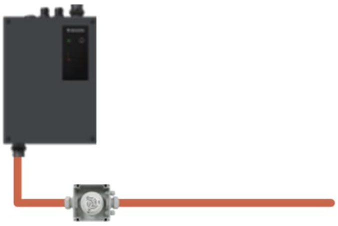
Scheme	Illustration	Remarks
A		2 x SecuriSmoke ASD 531, 532, 533-1, 535-3 or ASD 2001 for full redundancy or cross zone coincidence design
B		Single SecuriSmoke ASD 533-2, ASD 535-4 or ASD 2002 with one set of pipe network, each smoke sensor set to different sensitivity
C		Single SecuriSmoke ASD 533-2, ASD 535-4 or ASD 2002 with two independent pipe networks, each smoke sensor set to different sensitivity
D		Use REK in place of 2nd ASD in Scheme A, or localised suppression
F		Combination of Optical Smoke Switches ORS, localised suppression
G	Scheme A to F + SecuriHeat d-LIST	Combine with SecuriHeat Line Type Heat Detection

Table 11 SecuriSmoke ASD, REK and SecuriHeat for control and suppression actuation

4.3 Non-intrusive System Access for ITM

Another advantage of using SecuriSmoke ASD detectors is the non-intrusive access to the system while the protected areas, in this case Large Logistics & Distribution warehouses with high density of stored goods, machine movement and long operating hours, remain in full operation. Examples of relevant codes and standards for fire detection and alarm systems Inspection, Testing and Maintenance (ITM) include ISO 7240-14 [55], NFPA 72 [42], BS 5839 [43] and AS1851 [56]. In general, codes and standards also make references to the manufacturer's design, installation, and operation manual listed with relevant product-type approvals such as UL, EN or FM Approval. Testing methods refer to NFPA 76 [40], FIA CoP [45], or local applicable requirements.

Table 12 below is a simplified ITM schedule for SecuriSmoke ASD product services. Note that SecuriSmoke ASD 2000 models do not require the replacement of the interior dust filter, as they use an advanced centrifugal filter system. The coarse filter on the ASD 2000 is situated at an externally accessible point, while the ultrasonic airflow filter is largely maintenance free. Refer to Securiton product manuals for more details.

Service Item	Fault/Alarm	Trimestral	Yearly
Cleaning the detector housing exterior (air outlet)	(✓)[28]	?	✓
Cleaning of sampling pipe tube network, accessory parts, airflow sensors	(✓)	?	✓
Clean/replace coarse filters	(✓)	✓[29]	✓
Cleaning of air flow sensor (not applicable to SecuriSmoke ASD 2000)	(✓)	✓	✓
Check correct seating (no leakage)	(✓)	?	✓
Check of fault and alarm release	✓	?	✓
Update maintenance protocol	✓	?	✓
Analyse event memory	✓	?	✓
Analyse airflow issues (caused by operational changes)	✓	?	✓

Table 12 Typical Inspection, Testing and Maintenance (ITM) Schedule for SecuriSmoke ASD

4.4 Support with Peace of Mind

SecuriSmoke ASD products are supported with a range of software tools to facilitate design, installation, commissioning, trouble shooting and maintenance.

Tool	Usage
Design	ASD PipeFlow (for the ASD 53x family) allows the design and planning of aspirating smoke detection systems at a very early stage. ASD PipeFlow 3D is a much enhanced version for the ASD 2000 family for designing and planning aspirating smoke detection systems at a very early stage.
Install and Service	EasyConfig for simple systems directly on the device. The ASD Config software tool is used for more complex systems and application-specific adaptations when using devices from the ASD 53x family. The SecuriSmoke MobileConfig App for the ASD 2000 family is used to commission, maintain and trouble shoot an ASD 2000 installation.
Monitor and manage	All tools offer extensive analysis functions and setting options to ensure safe, cost-effective operation of the aspirating smoke detection system.

Applications and design support includes mainly:
- Partner accreditation program
- Application design and field engineering support
- Worldwide reach through a network of partners as well as subsidiaries and investment companies, with branch offices or local employees around the world.

[28] ✓ indicates 'shall do'; (✓) indicates 'as needed'; ? indicates 'only if required by local codes and standards'
[29] As per manufacturer recommendation for protected areas with high level of dust present or natural ventilated areas subject to dusty air particulates.

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Appendix A: SecuriSmoke ASD accessories

This Appendix provides a summary of SecuriSmoke ASD accessories (see Table 13) for challenging environments:

1 Dusty
2 High humidity or high air temperature

Challenging Environment	Illustration	Description
Dusty		DFU 911 (large volume) or FBS 25 PC (small volume) dust filter unit increases the service life of the smoke sensors used in the ASD and greatly reduces the likelihood of false alarms
		DTB 25 PC Dirt trap box used in very dusty rooms. Inserted into the sampling pipe before dust filter
		ADB 500 automatic blow-out device 1 sampling pipe is automatically blown out and cleaned, to prevent fault messages caused by clogged aspiration points and also to avoid false alarms.
		MV 25 ABS Manual ball valve for revision and cleaning works with compressed air
High Humidity or High Air Temperature		WRB 25 ABS Water retaining box Used in rooms with high humidity
		WRT 25 ABSRED Water retaining tube Used in rooms with high humidity, must be drained manually
		LK 35 – ABS used as an air cooler when the sampling pipe is in a room >60°C. Can also be used as a water separator in rooms with high amount of air humidity and / or condensing water because of temperature differences

Table 13 Summary of SecuriSmoke ASD accessories for challenging environments

SECURITON

Securiton AG

Alarm- and Security Systems
Alpenstrasse 20, 3052 Zollikofen, Switzerland
www.securiton.com, info@securiton.com

A company of the Swiss Securitas Group

07.2026