



Sprinkler Systems: An Overrated Panacea Against Warehouse Fires?

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In September 2019, the author published a guide to mitigating the risks associated with warehouses.¹ In particular, the article highlighted fire hazards from a property insurance perspective, possible fire protection measures and advice on underwriting warehouse risks. In recent times, several large and spectacular warehouse fires have occurred, causing losses in the triple-digit millions. For the most part, sprinkler systems were installed in the warehouses affected, but for various reasons they were unable to prevent the major losses.

If one takes a closer look at these damages, the question arises whether sprinkler systems for large warehouses are sufficient as a fire protection measure, or whether other supplementary measures are required.

An additional challenge for fire protection is the increasing change in warehouse design to automated and robot-assisted storage systems (also known as Automatic Storage and Retrieval Systems, ASRS for short), which multiply the storage capacity available in a rack warehouse, resulting in an enormous and compact storage density. At the same time, however, this also increases the value load per square metre of storage space and, in the event of damage, the amount of damage.

Another sign that future insured losses could increase is the trend towards ever-larger storage buildings and areas in order to reduce the storage costs per square metre.

In new buildings in particular, it can be observed that constructive preventive fire protection measures are being dispensed with and sprinkler systems are being installed as a compensatory measure in order to use the warehouses as homogeneously and flexibly as possible. For reasons of efficiency and cost, an Early Suppression Fast Response (ESFR) sprinkler system is preferred, instead of a classic

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

sprinkler system with ceiling and shelf sprinklers, which is often installed only on the ceiling and not on the shelves.

This article will explore the question of whether a sprinkler system is sufficient as the sole fire protection measure, and discuss possible measures to reduce the impact of large warehouse fires in the future and the millions of dollars in damage that can be expected as a result.

Loss examples

Fires in warehouses can cause very big monetary losses. For example, in 1977 a car manufacturer in Cologne suffered a total loss of about EUR 150 million.² In the U.S., a distribution warehouse of a supermarket chain was damaged to the tune of more than USD 100 million in 1982.³

There have been reports of some extremely large losses in warehouses worldwide in recent times, some of which caused insured losses of well over EUR 100 million. Examples are as follows:

- 5 February 2019, UK:⁴ warehouse area 22,300 m²
- 10 March 2022, Taiwan:⁵ warehouse area approx. 66,000 m²
- 17 March 2022, U.S.:⁶ storage area 112,000 m²
- 17 June 2021, Korea:⁷ warehouse space 127,000 m²
- 20 December 2021, U.S.:⁸ storage area 140,000 m²

The information published on the fire protection measures in place in these warehouses is sparse. Sprinkler systems were installed in the majority although they were unable to prevent serious damage. According to the press reports, neither the existing sprinkler systems nor the fire brigade were able to control and extinguish the fires before a major fire and ultimately total loss occurred, despite a massive deployment of fire-fighters and fire-fighting equipment.

It was striking that in all cases the storage area was very large. There was also a high fire load due to the stored goods: in some cases flammable liquids and gases. Subdivision of the warehouses into fire-proof or complex sections by structural measures was apparently not done, or the existing fire protection partitions seemed to have considerable deficiencies, e.g. defective fire protection closures, missing bulkheads and intervening building constructions, which allowed the fire to spread into neighbouring areas via the existing fire protection partitions.

In this respect, the question arises as to which fire protection measure is necessary to prevent such mega-damages in large and extensive warehouses. A central question is also whether, if constructive fire protection measures are dispensed with, the installation of a fire-fighting system as the sole preventive measure is sufficient.

Sprinkler systems

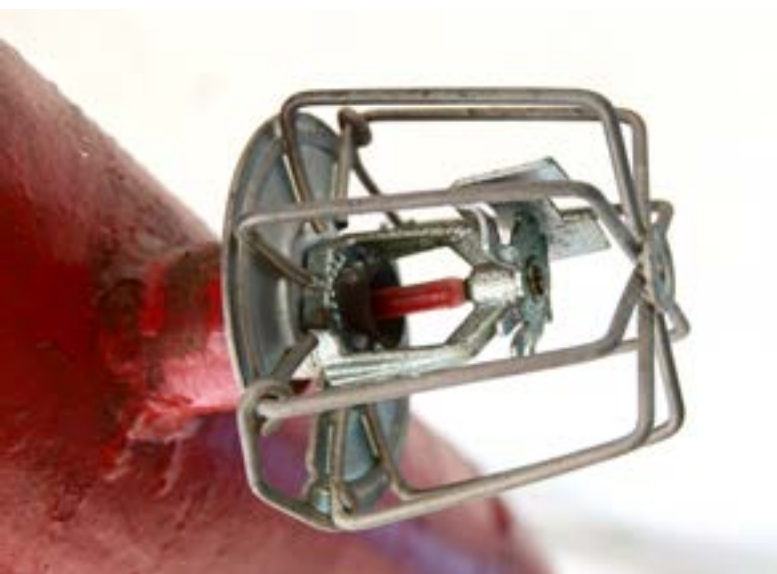
A sprinkler system consists of a pipe network connected to a water supply and pump system. The pipe network is usually installed below the building ceiling but also in shelves or fixtures. Sprinkler heads are installed at regular intervals on the pipe network, from which water escapes in the event of a fire. The sprinkler head contains a plug, e.g. a glass tube or fusible link, which initially prevents water from escaping.

If the temperature at the sprinkler head rises, e.g. in the event of a fire, the fusible link melts or the glass tube filled with a liquid bursts when a defined temperature is reached, and the water under pressure in the pipe network can escape. It then bounces against the sprinkler spray disc and is sprayed in an umbrella shape over the fire. Each sprinkler triggers independently of the other sprinklers.

There are different types of sprinkler systems, e.g. wet, dry or pre-controlled sprinkler systems, which are installed depending on the relevant conditions.⁹

Sprinkler systems are known worldwide as a very effective fire protection measure to fight and possibly extinguish an incipient fire in a building. However, in order to achieve this high level of effectiveness, such a system must be precisely adapted to each building, otherwise there is a risk that the installed sprinkler system will recognise an incipient fire only after a delay and thus reach its operational limits.

Furthermore, the effectiveness of sprinkler systems is undermined where the scope of protection, extinguishing agent, mode of action, response behaviour and/or water supply are not adapted to, or suitable for, the operational



risk potential. In these cases, additional structural, technical and operational protective measures are often required, in addition to other necessary fire-fighting systems, such as a water spray or gas extinguishing system.

Failure of sprinkler systems

When considering the reasons installed sprinkler systems fail or do not show the effectiveness for which they were installed, a number of possibilities arise:

- The planning and design parameters of the sprinkler system are not adapted to the existing building/storage design and the associated hazardous situation. Reasons for this are, for example:
 - > selection of an unsuitable firefighting system for the warehouse design
 - > incorrect size and arrangement of the pipe network as well as incorrect selection of sprinkler heads and their arrangement, e.g. non-consideration of the room height, which may lead to delayed activation of the sprinkler system in case of fire
 - > incorrect dimensioning of the water supply and pump capacity
 - > no emergency power supply for the sprinkler pump system in the event of a power failure
 - > incorrect selection of sprinkler heads and their arrangement, e.g. not using shelf sprinklers, especially if shelves are impermeable to water or the distribution of water is impeded or prevented by the storage aids used or the products stored (so-called spray obstruction)
 - > insufficient consideration of the existing fire load (e.g. stored goods, storage quantity, storage height, packaging material)
 - > insufficient acceptance and inspection of the effectiveness of the sprinkler system components during commissioning or rectification of detected defects, e.g. blocked water flow in the pipe network due to stones or other foreign bodies
 - > failure to take into account the weather conditions and ambient temperatures to be expected in the sprinklered area
 - > concept of triggering only manually, not automatically, e.g. design as a semi-stationary sprinkler system
- Failure to adapt the installed sprinkler system to changes in the storage concept, for example:
 - > changes in the goods to be stored, e.g. storage of fire-hazardous products such as flammable liquids instead of the originally stored goods
 - > changes in the type of storage, e.g. new shelving or storage systems or storage area design, the height of storage or the packaging material used, e.g. a change from cardboard to plastic packaging
 - > subsequent/additional installations, e.g. office walls or ventilation ducts that hinder the effectiveness of the installed sprinkler system
- Deactivation of the sprinkler system, e.g. in the case of new buildings and renovation/conversion work by disconnecting it from the water supply or deactivating the sprinkler pumps and failing or forgetting to reactivate the sprinkler system after completion of the work
- The sprinkler system being deactivated during a fire by company employees or fire brigade personnel, e.g. with the intention of limiting the water damage
- Insufficient coverage of the sprinkler's effective range by large covers, or enclosed equipment and machinery
- Failure to comply with the maximum storage height or the maximum permissible storage areas in accordance with the sprinkler system design
- Spray failure from falling short of the minimum distance between the stored products and the sprinkler head
- Insufficient fire protection separation between sprinklered and non-sprinklered areas, e.g. by fire or complex partitions, so that a fire from a non-sprinklered area can spread to the sprinklered area and thus overwhelm the sprinkler system
- Intentional arson with prior manipulation of the sprinkler system or arson at several locations so that the sprinkler system is deliberately overwhelmed
- Destruction of parts of the sprinkler system by an explosion or deflagration

Sprinkler systems are technical structures, so their effectiveness can be impaired by technical defects. It is necessary to regularly check, maintain and service the components of the sprinkler system (water supply, pump system, and pipe network, as well as sprinklers). Depending on the component, inspection intervals range from weekly to annually.

Common technical deficiencies result from:

- Obstruction of water discharge from the sprinkler nozzles
- Insufficient performance of the system, e.g. due to change of use
- Human error, e.g. closed gate valves
- Defects in the power supply or the installed pump systems
- Pipelines clogged with foreign bodies or reduction of water flow rates due to long-term deposits of water constituents on the inner walls of the pipes
- Glued/over-painted, covered, dusted glass tubes or fusible plugs that delay or prevent the sprinkler from triggering when the triggering temperature is reached

Fire protection concept

It is often the case in large warehouse fires that warehouses commonly comprise just one coherent fire section or complex. If it is not possible to get a fire under control in its initial phase, either with fire-fighting equipment such as fire extinguishers and wall hydrants or through an installed fire-fighting system, the blaze can spread unhindered and cover the entire warehouse.

If there is an existing high fire load, caused by the stored products, packaging and storage aids used, as well as the enormous expansion of the warehouse and storage heights, even a fire brigade may be unable to prevent a major loss. Instead, they often have to limit themselves to protecting neighbouring properties and buildings to prevent the fire spreading.

If one wants to avoid major or total damage to a warehouse in the event of a fire, it is therefore indispensable, in addition to the usual operational and technical fire protection measures such as a sprinkler system, either to divide the warehouse into corresponding sections by means of fire/complex partition walls with a defined fire resistance duration of e.g. 180/240 minutes, or to divide the required storage area into several buildings, separated by sufficient spatial distance.

As a rule, this prevents a fire spreading over the entire storage area. The division into smaller fire compartments helps the fire brigade to make a better and more successful attempt to extinguish the fire, as they do not have to fight a fire that is too extensive.

A multi-storey storage building should be divided into several fire compartments by means of fire walls running through all storeys and fire-resistant ceilings, in addition to an existing sprinkler system.

In addition to the sprinkler system, it is advisable to install an automatic fire detection system with alarm forwarding to a permanently manned location as, if designed correctly, it detects a possible incipient fire much earlier than a sprinkler system. The fire detection system must also be adapted to the corresponding warehouse design. In order to guarantee the functionality of the system at all times, it should be maintained regularly, like any technical system, and any defects detected should be rectified immediately.

If changes are planned and made in the storage type, density, or height, or in the stored goods, packaging materials or storage aids, it should always be checked at the same time whether these changes could have a negative influence on the effectiveness of the installed sprinkler system. Depending on the new risk situation, it may become evident that the previously installed sprinkler system is so limited in its effectiveness that a completely new design for comparable protection becomes necessary. It may be necessary to adapt the installed extinguishing system to the new warehouse situation in order to guarantee the success and effectiveness of the fire-fighting system in the future as well.

In addition, there are other technical, operational, structural, and defensive fire protection measures to optimise the fire protection standard in a warehouse.

Underwriting

To assess the risk of fire in a warehouse to be insured, sufficient risk information should be available, as it enables the estimation of the possible loss exposure, such as the origin, spread of a possible fire and the associated consequential damage.

Survey reports are an important source of information, but they should not be older than two to three years, as goods, packaging and storage facilities are often subject to constant change. In this respect, it is important to know the changes that have occurred over time for the underwriting decision, especially whether the fire protection measures in the warehouse have been adapted to the changed risk situation. Previously adequate fire protection measures that are no longer effective because of changes can lead to significantly greater damage in the event of a fire.

Special attention should be paid to the division of a warehouse into fire compartments/complexes as well as the installation and adequate design of a sprinkler system for the existing warehouse situation. In the case of older reports, it should be explicitly asked when the extinguishing system was last inspected by a recognised expert, whether all outstanding recommendations have been followed and deficiencies rectified, and to what extent changes have been made to the warehouse concept (height, stored goods, storage area, type of storage, etc.) since the last inspection.

It is important that at least one fire compartment is fully protected by the fire extinguishing system and that the existing fire/complex wall between the sprinklered and non-sprinklered areas has no weak points.

It is advisable to pay attention to accessibility for the fire brigade to the warehouse: this includes fire brigade bypass, staging areas, access to the warehouse, and also the knowledge of the local fire brigade. The fire brigade should be informed about the main hazards in a warehouse, e.g. where fire-hazard products are stored.

If clients cannot provide up-to-date and sufficient underwriting information, it is advisable to be cautious with price and capacity considerations. In addition, maximum loss estimates should be made rather conservatively. If spatial or structural complex separations are missing or insufficient, the potential maximum loss in a warehouse should be assumed in case of doubt to be 100%.

Finally, the author's comments on the underwriting of warehouse risks from an earlier publication should be taken into account, as their relevance continues to apply without restriction. There, in addition to important fire protection measures, particular attention is paid to necessary information for the assessment of property and business interruption damage with special consideration of the underlying insurance contract.

Summary

Storage risks of any kind have the potential, in the event of fire, to cause major damage up to and including total loss, with substantial consequences for the company. Key factors for this are:

- High fire load (due to the stored material or/and packaging)
- Type of storage, storage area, storage height, arrangement of stored goods

Essential fire protection measures for warehouses

Structural measures

- Fire compartment/complex separations
- Fire-resistant partitioning and closure of necessary openings in fire-retardant walls
- Roofing of fire compartment/complex partitions
- Accommodation of technical equipment in separate fire-resistant partitioned rooms

Technical measures

- Selection and installation of an automatic fire alarm and fire-fighting system suitable for the planned warehouse concept, with alarm to a permanently manned helpdesk
- Design and installation of an automatic fire detection and fire-fighting system in accordance with the latest state-of-the-art designs, e.g. guidelines of the VdS Schadenverhütung (institution for loss prevention/corporate security and safety) or of the Federal Mutual Insurance
- Supplementing/upgrading existing automatic fire-fighting systems in the event of planned changes to the warehouse design (e.g. storage type, height, goods, packaging material, storage aids, etc.)

Operational measures

- Regular review of the effectiveness of the installed fire protection measures and the existing fire protection concept and, if necessary, adaptation to the changed operating conditions
- Inspection, testing and regular revision of the installed fire-fighting and fire-alarm systems by an independent expert, e.g. VdS Schadenverhütung technical testing centre
- Immediate rectification of any defects found in existing fire protection measures, electrical and other technical installations
- Preparation of a Business Continuity Plan

Defensive fire protection

- Familiarisation of the local fire brigade with the characteristics of the warehouse and regular fire drills
- Ensuring a sufficient and reliable water supply
- Equipping staff with sufficient initial fire-fighting equipment and training employees in the safe use of this equipment
- Order and cleanliness

- Lack of subdivision into complexes and fire compartments
- Missing or inadequate fire extinguishing systems, e.g. sprinkler system or inadequate maintenance/adaptation of the system to changes in the storage concept
- Use of combustible building materials (e.g. composite panels) in building construction
- Risk of business interruption after fire damage

Effective fire protection requires supplementary measures as well as that provided by sprinklers or other fire-fighting systems. In this respect, it is advisable to discuss a planned fire protection concept for a warehouse with the insurers and to take their advice into account.

In the event of changes in the process/operating sequence of a warehouse, the effectiveness of the existing design should be checked regularly and, where necessary, adapted to the changed circumstances in order to guarantee the effectiveness of the sprinkler system even after the changes have been implemented.

Fire events show time and again that a sprinkler system as the sole fire protection measure is not sufficient to prevent major damage/total loss, but also that a sprinkler system is an important tool in a holistic fire protection concept.

Endnotes

- 1 <https://www.genre.com/knowledge/publications/2019/september/pmint19-4-en>
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