Protecting your warehouse: considerations and challenges when choosing sprinkler protection

At a glance

• The effectiveness of sprinkler systems depends on numerous factors and the requirements of every building should be considered individually. Taller and larger-sized warehouses pose particular challenges for the effectiveness of sprinkler systems.

• Racked storage arrangements, their height and the packaging materials used all have an impact on how fast a fire can spread and the effectiveness of the sprinkler system.

• Obstructions, caused by: ventilation ducts, walkways, conveyors, cable trays, oversized objects in storage, solid shelves and open top containers need to be carefully considered and evaluated.

• Existing sprinkler systems can be severely challenged by changes in the type of products stored and the storage arrangements.

• Sprinkler systems should always meet internationally recognized fire tests and standards.

Rising to the challenge of modern warehousing

Warehouses today are bigger with higher racked storage areas usually served by forklifts and automated equipment. There is significantly more plastic, including polystyrene material used in packaging, which increases the fire risk.

Despite changes, in the types of warehousing and packaging, until the 1980s sprinkler technology had changed little and struggled to keep pace with fire risks posed by modern storage methods. Increased testing in recent years, using different types and sizes of sprinkler, has led to a number of new innovations, particularly larger holes (orifices) in the sprinkler and deflector design to distribute water more effectively for specific protection schemes.

Choosing an appropriate sprinkler system for large warehouses and logistics centers

There are number of specific aspects, relating to the design and installation of sprinkler systems, which need to be considered when selecting systems for storage premises.

These include the following:

• Types of products to be stored. The combustibility needs to be assessed and categorized/classified as indicated in the chosen sprinkler installation standard. Packaging must form part of that assessment, as plastics increase the fire load. Will there also be idle pallets in storage?

• Method of storage. This may be free standing on the floor, in open frame racks, on solid or slatted shelves, or in bespoke automatic storage systems.

• Some products need extra consideration as they are considered a special challenge such as: aerosols, flammable liquids, hanging garments, plastic tote boxes, non-woven synthetic fabrics, rubber tyres, paper reels and spirit based liquors in wooden barrels. The appropriate sections of the sprinkler standards for these products must be followed.

• Additional aspects which will affect available design options for sprinkler systems in storage locations and must be considered at planning stage include: building height, storage heights, roof/ceiling slope and clearance from top of goods stored to the roof/ceiling sprinkler protection.

• Will the building or compartment be heated to protect the system from frost damage? Dry systems should generally be avoided, for storage protection, due to delays in the delivery of water and the fact that some design options exclude dry system design. Where permitted, additional requirements, and limitations, are given in the sprinkler standards.

• Where multiple design options are available, after evaluation of the restrictions for a warehouse or logistics location, it may be that ceiling only sprinklers may be an option or roof level sprinklers, supplemented by in-rack sprinklers. Each of these options come with some positives and negatives for the end user to be aware of. Please refer to tables on following pages.
Challenges which may affect sprinkler system design and capability if not addressed in storage facilities

Challenges arise, during the planning, installation and on-going operation of warehouse and logistics locations, which may severely compromise the performance of a sprinkler system. These aspects need to be monitored and addressed to ensure compliance with standards and ensure the system has not been applied outside of proven performance test data where applicable.

Examples of challenges:

- Introduction of other services or building features that may obstruct the spray pattern of the sprinkler discharge, such as ductwork, cable trays, large roof drain pipes, ventilation fans and roof vents. All of these should be verified against published restrictions in the sprinkler standard.

- Obstructions to sprinklers can be isolated, such as a single lighting fixture, heater unit or a beam. Other types of obstruction may be continuous, such as ducts, conveyors, conduits or pipes.

- Introduction of solid shelves in racks or storage of unusually large items, compared to a traditional pallet load, will shield a fire from the sprinklers delaying operation, and impacting spray patterns and water delivery to the seat of a fire.

- Storage in open top containers should be avoided and is not permitted with ESFR and CMSA sprinkler designs, as water will be collected rather than reach the fire and may make the storage rack unstable.

- Installation of elevated walkways or picking levels in aisles severely compromises the system design concept, regardless of whether the walkway is solid or open steel mesh. Such configurations should be constructed so that a floor or mezzanine is made continuous across the aisles and storage rack with no openings which may allow fire to spread from one level to another.

- Storage should not be permitted in aisles between racks. This encourages fire spread from one rack to another.

- Changes in packaging or products needs to be regularly evaluated to ensure sprinkler system capability is not compromised. The introduction of plastic totes is an example of a change which can have a severe impact on the sprinkler protection.

- The installing contractors may not be fully aware of every product you may store or how it may be packaged. We would encourage clear communications between all parties and also ensure specifications and drawings are reviewed prior to installation. Where systems do not meet the necessary design codes and standards, it could mean a building is not adequately protected against the risk of fire.

Orifice size and pressure

ESFR and CMSA sprinkler designs are based on full scale fire tests. They indicate the required number of sprinklers needed to control or suppress a fire in a specific storage arrangement of specific groups of products.

Their design criteria are indicated by an Assumed Maximum Number of Sprinkler in Operation (AMNOSO) at a specific pressure for a specific K Factor sprinkler. It is crucial that the correct sprinkler type and K factor are selected, as per the design standard, and any additional requirements, of the manufacturer, are followed, as stated on the sprinkler head manufacturer's data sheet.

The K factor refers to the orifice size of the sprinkler. Larger K factors have proven to be more effective in storage applications, even in Control Mode Density Area applications (see graph). Trying to achieve a higher density from a smaller orifice sprinkler results in the generation of finer water spray, which might not be able to penetrate the fire, whereas larger water droplets are more likely to penetrate a heat plume and reach the fire.

For information the metric K factor relates to the amount of water (in liters) released per minute at a pressure of one bar, so a K240 would release 240 l/min at 1 bar pressure.

The correct selection of K factor and operating pressure is as critical to effective sprinkler protection as goods classification, storage arrangement and storage height. This is especially true in high buildings.
Large orifice sprinklers
Tests show that sprinklers with larger orifices are more effective at putting out fires by delivering larger quantities of water. This means you need fewer sprinklers to put out a fire.

Comparing the three main types of sprinkler

Control Mode Density Area (CMDA)

What it does: Controls a fire within a certain area by discharging a given density of water
Where it is used: Usually small orifice sprinklers, at roof level, that are often supplemented by further sprinklers installed in storage racking
Positives:
- In-rack sprinklers are closer to the seat of the fire
- There is less water, smoke and fire damage
- It is a more flexible arrangement
Negatives:
- If you have a roof-only system it is less effective
- If you include in-rack sprinklers it can be costly to keep adapting them as your storage configuration changes
- More sprinklers means more pipes and valves are required
- You usually need a water supply for at least 90 minutes
Zurich’s view: CMDA sprinklers are best where highly valuable or sensitive goods are stored

Control Mode Specific Application (CMSA)

What it does: Controls a fire using sprinklers at certain pressures that are determined by fire tests for a specific application
Where it is used: Usually provides roof-only protection for storage where proven full-scale fire tests have been undertaken to indicate parameters for K factor, water pressure, ceiling height and storage arrangements
Positives:
- Doesn’t need in-rack sprinklers so storage arrangements can be more flexible
- Large sprinkler orifices deliver larger water droplets
Negatives:
- Storage heights are more limited when compared with Early Suppression Fast Response systems
- Adequate flue spaces between racks are critical
- More sprinklers are needed
- It is not appropriate for certain types of goods or storage arrangements
- You usually need a water supply for at least 90-120 minutes
Zurich’s view: CMSA sprinklers often eliminate the need for in-rack sprinklers but must meet strict design requirements

At 470°C steel starts to expand and weaken. Using K115 sprinklers, the fire was above this danger line for more than 10 minutes, which would put a building at risk of collapse. The larger orifice K240 sprinklers suppressed the fire far more quickly with temperatures only reaching 260°C.
### Early Suppression Fast Response (ESFR)

**What it does:** A fast-response sprinkler that provides fire suppression for specific high-challenge fire risks

**Where it is used:** A roof-only system that relies on very quick sprinkler response activation and uses large quantities of water

**Positives:**
- Suppresses rather than just controlling a fire
- Doesn’t need in-rack sprinklers so storage arrangements can be more flexible
- Larger water droplets are delivered from fewer sprinklers
- Storage heights up to 13.1 meters are permitted
- Usually only requires a 60-minute water supply

**Negatives:**
- It is not appropriate for certain types of good or storage arrangements
- Must follow strict design patterns
- Small obstructions (17mm or more) could compromise protection so the installation needs to be checked regularly, which means it is not a ‘fit and forget’ system
- Roof vents are generally not allowed unless certain restrictions are met

**Zurich’s view:** EFSR sprinklers often eliminate the need for in-rack sprinklers but must meet strict design requirements and can easily be compromised by obstructions

### Basis for selection

One system does not suit all types of warehouse. It is essential to choose the right protection. If a roof-only system is being considered, and ESFR is appropriate to the type of building and goods being stored, it would be Zurich’s preferred choice, as this design solution offers fire suppression, rather than fire control.

### Q&As

**Q:** We have to regularly reconfigure our warehousing as the type of stock we hold changes all the time. What type of sprinkler would work best?

**A:** You should avoid a CMDA system – this requires on-rack sprinklers to be effective, so it would be costly adapting it every time you re-arrange your warehouse layouts. A CMSA system might be better.

**Q:** How can I cut back on the number of sprinklers I install without compromising safety or increasing the fire risk?

**A:** If you use sprinklers with larger orifices (the K factor) these release more water with larger droplets that can penetrate the heat plume and are more effective at putting out the fire. If your warehouse can meet strict design requirements, then an EFSR system might be best.