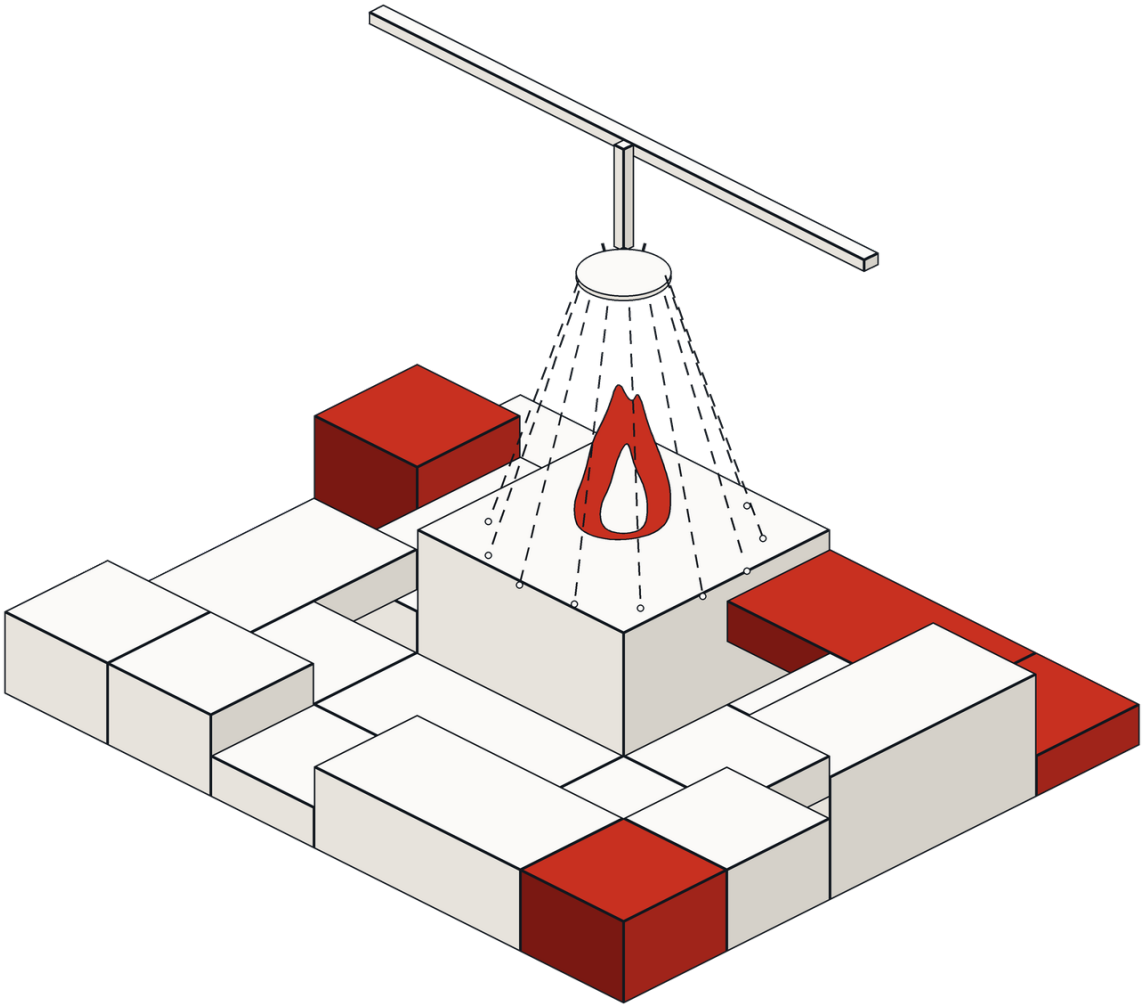
ATTABOTICS

An Introduction to ASRS Fire Suppression - White Paper



Executive Summary

Automated Storage and Retrieval Systems (ASRS) are transforming warehouse and fulfillment operations by increasing storage density, improving throughput, and reducing labor requirements. However, these systems introduce unique fire protection challenges not typically encountered in conventional rack storage. High storage densities, narrow flue spaces, plastic totes, battery-powered robotics, and limited firefighter access can significantly influence fire growth and suppression effectiveness. The National Fire Protection Association (NFPA) and Factory Mutual (FM) Global have both identified ASRS as a specialized storage hazard requiring careful evaluation of storage configuration, commodity classification, containment methods, and suppression system design.

This paper examines key fire risks associated with ASRS technologies and outlines best practices for fire suppression system design, code compliance, and operational risk mitigation. Please note this paper is not meant to be a substitute for engaging proper subject matter experts or authorities having jurisdiction (AHJ). We see this paper an introduction to topics, classifications, containment methods and system design.

1. Introduction

Warehouse automation has evolved rapidly over the past decade, driven by e-commerce growth, labor shortages, and demand for higher throughput. ASRS systems can increase storage density by 30-50% or more compared to conventional warehouses while significantly reducing labor travel. This increased density, however, changes fire behavior and may challenge traditional sprinkler system assumptions.

Unlike conventional pallet rack storage, ASRS installations frequently include:

- Plastic totes and bins
- Robotic shuttles or stacker cranes
- Limited longitudinal and transverse flue spaces
- Storage heights exceeding 40 ft (12 m)
- Enclosed rack structures
- Electrical and battery-powered equipment

These features can create fire scenarios requiring specialized suppression strategies.



2. Governing Bodies and Regulatory Framework

Successful fire protection planning for an Automated Storage and Retrieval System (ASRS) requires early alignment among code authorities, fire protection engineers, owners, insurers, and the automation provider. These parties have different responsibilities: some establish model requirements, some adopt and enforce law, while others set underwriting or project-specific protection expectations. No single national organization approves every U.S. warehouse installation.

National Fire Protection Association (NFPA)

NFPA develops consensus fire and life-safety codes and standards, including NFPA 13 for automatic sprinkler systems, NFPA 72 for alarm/signaling, and NFPA 25 for ongoing inspection and maintenance. NFPA is a standards-development organization, not the local permitting or enforcement authority. A standard becomes legally applicable when adopted or referenced by governing codes or regulations; a project may also adopt more stringent contractual or insurer requirements.

International Code Council (ICC) and National Model Codes

The International Code Council publishes the International Fire Code (IFC) and International Building Code (IBC), widely used U.S. model codes. IFC Chapter 32 addresses high-piled combustible storage, including commodity classification, permits, access, and

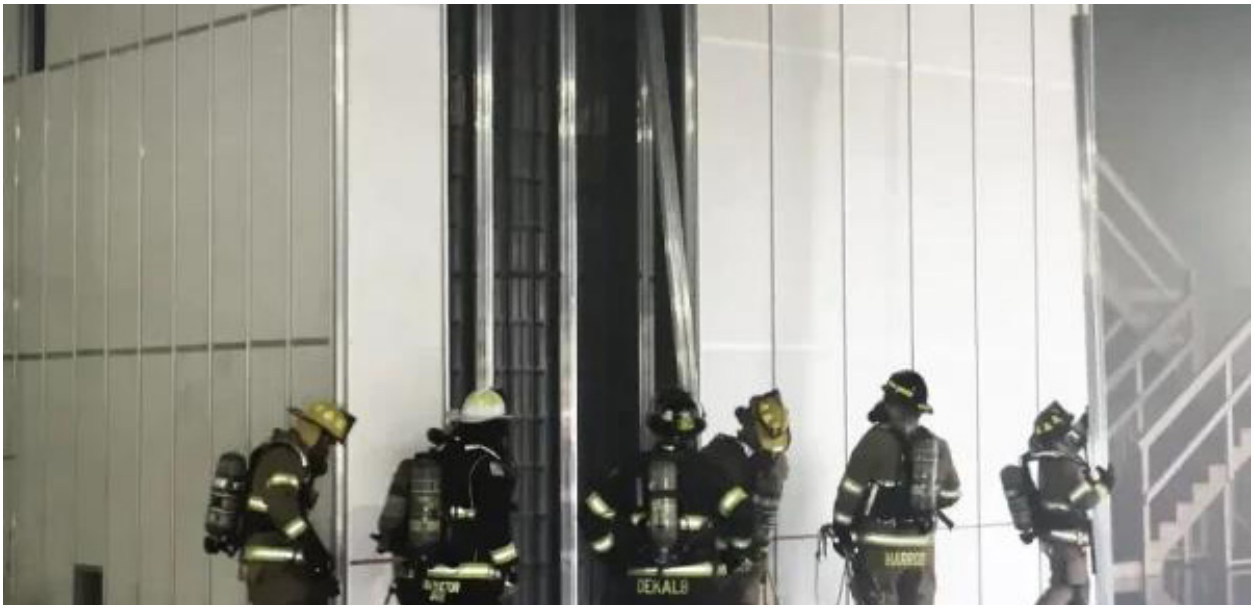
protection features; the 2024 IFC includes Section 3209 on automated storage. Model codes are not universally applicable federal law. States and municipalities adopt specific editions, amendments, and administrative procedures. The National Fire Code of Canada is a separate model code used in Canadian jurisdictions; it is not the U.S. IFC.

State, Provincial, and Local Authorities Having Jurisdiction (AHJ)

State/provincial agencies, municipal building departments, and fire prevention offices establish or enforce the legally adopted codes within their jurisdiction. The designated AHJ may include a fire marshal, building official, or other authorized reviewer. Their responsibilities can include high-piled storage permits, construction approvals, plans review, acceptance tests, occupancy authorization, and interpretations of alternative methods. Identifying the exact AHJ, adopted code edition, local amendments, and approval pathway at project initiation is essential.

Local Fire Department and Fire Marshal

Fire departments and fire marshals contribute operational and preventive-fire-protection perspectives, but the local fire department is not always the formal code-enforcing AHJ. Early discussions should address apparatus access, hydrants and water supply, fire department connections, smoke management where required, standpipes where applicable, response tactics, isolation/shutdown procedures, and access into automated storage arrays. A coordinated emergency-response plan should be developed before commissioning.



FM (formerly FM Global), Property Insurers, and FM Approvals

FM provides property-loss-prevention engineering guidance, including Data Sheet 8-34 for automatic storage and retrieval systems, 8-9 for stored commodities, and 8-1 for commodity classification. FM loss-prevention data sheets are generally insurer engineering guidance rather than municipal law, but may become project requirements through insurance or owner specifications. FM Approvals independently tests and certifies eligible products; FM Approved equipment does not by itself establish approval of an entire ASRS fire protection concept. Other insurers may use their own standards or engineering review.

Fire Protection Engineers, System Designers, and Independent Testing

Qualified fire protection engineers and licensed design professionals evaluate commodities, tote composition, storage geometry, sprinkler options, water supply, detection, and possible alternative protection strategies. Depending on project scope, engineers may submit hydraulic calculations, fire test evidence, engineering analyses, and performance-based justifications to the AHJ and insurer. Accredited test laboratories or certification organizations may supply relevant product listings and test documentation. An engineered alternative requires acceptance by applicable authorities; test data alone does not waive code requirements.

Recommended Engagement Sequence

1. Confirm jurisdiction, adopted fire/building codes and editions, and the designated AHJ.
2. Share the ASRS concept, storage dimensions, commodities, container materials, and access arrangement with the AHJ, owner, insurer, and fire protection engineer.
3. Agree on the protection basis (prescriptive design or proposed alternative) and on which FM recommendations or additional insurer conditions apply.
4. Determine whether full-scale or commodity-specific fire-test evidence and third-party review are required.
5. Submit coordinated drawings, calculations, equipment interfaces, emergency procedures, and permit documents.
6. Confirm witnessed acceptance testing, ongoing inspection plans, and the change-management process for stored products or equipment.

The objective of these early discussions is to define an approvable and insurable fire-protection strategy—not to assume that a particular ASRS architecture, tote design, or ceiling-only sprinkler concept is automatically compliant. See Appendix A for relevant technical references.

3. Evolution of Traditional ASRS Technology

ASRS systems generally provide the most value by maximizing the cubic storage volume by reducing aisle widths and minimizing empty space. While operationally beneficial, dense storage can accelerate heat buildup and restrict sprinkler water penetration.

Historically, ASRS applications rely on plastic totes, bins, and trays. Plastics have significantly higher heat release rates than traditional corrugated materials and can rapidly intensify a fire event. Different types of expanded and unexpanded plastics are used in ASRS solutions depending on the payload stored and stability the bin is to provide. Commodity type and container material are therefore critical variables in suppression design.

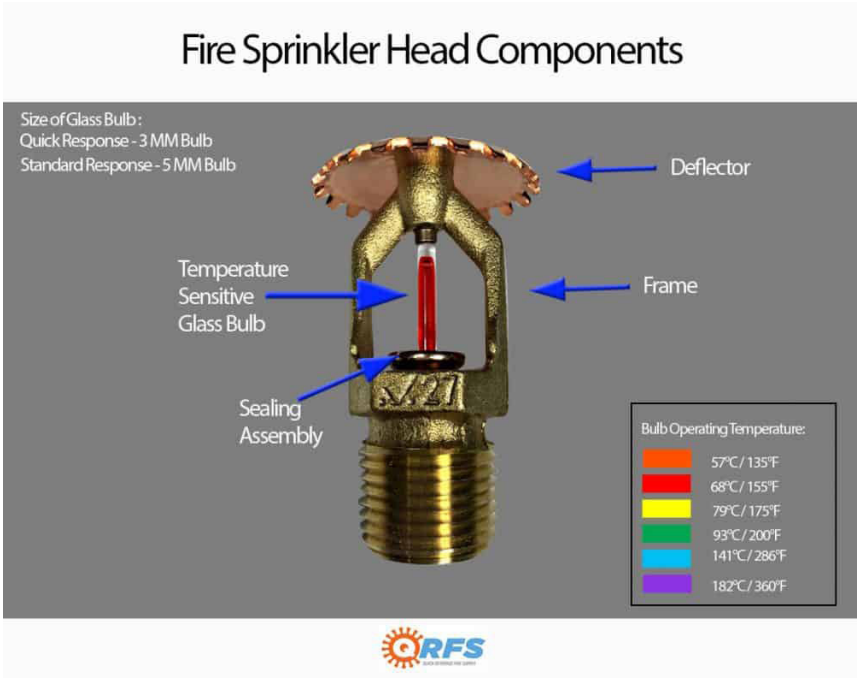
Further, the types of products being stored directly impact the fire suppression profile. The International Fire Code Chapter 32 provides guidance for storage of products in a facility and is generally recognized as the benchmark for fire suppression design. The IFC calculation utilizes factors such as square footage, storage heights and commodity classifications to determine the high pile calculation.

4. How Fire Suppression Systems Work

To understand how traditional Automated Storage and Retrieval Systems (ASRS) affect fire protection performance, it is first necessary to understand how sprinkler systems are intended to operate. Modern fire suppression systems depend on a sequence of events: a fire generates heat, that heat activates sprinklers, and water reaches the burning commodity in sufficient quantity to control or suppress the fire. While this process has proven highly effective in conventional warehouses, many traditional ASRS design characteristics can interfere with one or more of these critical steps.

Fundamentals of Automatic Sprinkler Protection

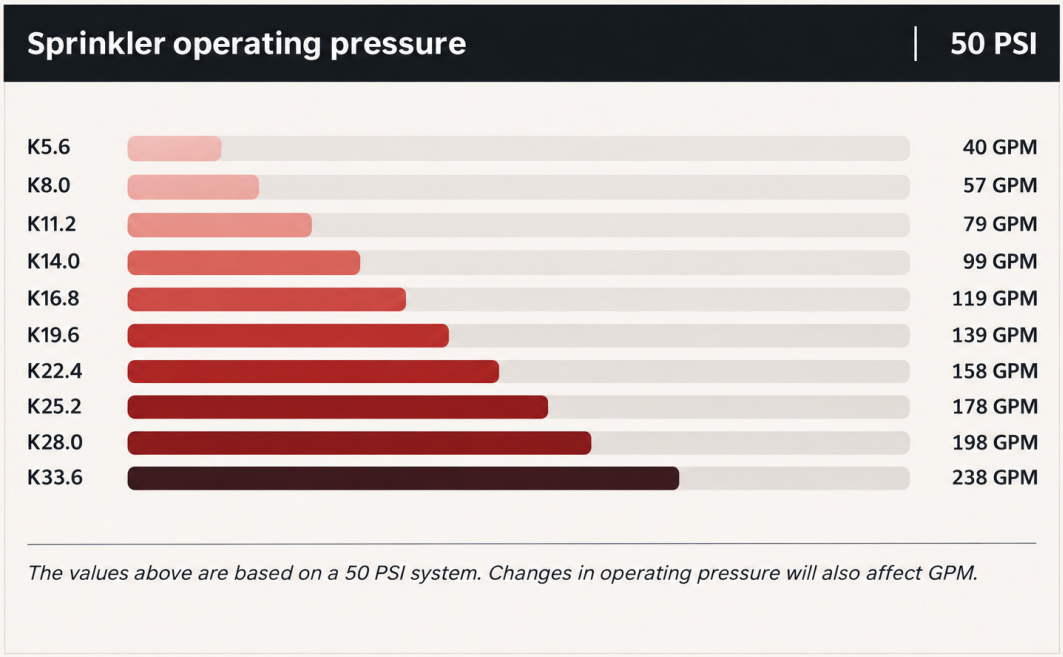
Automatic sprinklers are heat-activated devices designed to react individually when temperatures near the sprinkler exceed a predetermined threshold. The purpose of the sprinkler system is to control or suppress a fire before it can spread beyond the area of origin. Water discharged from the sprinkler absorbs heat, cools burning materials, limits fire spread, and helps protect structural elements and adjacent storage.

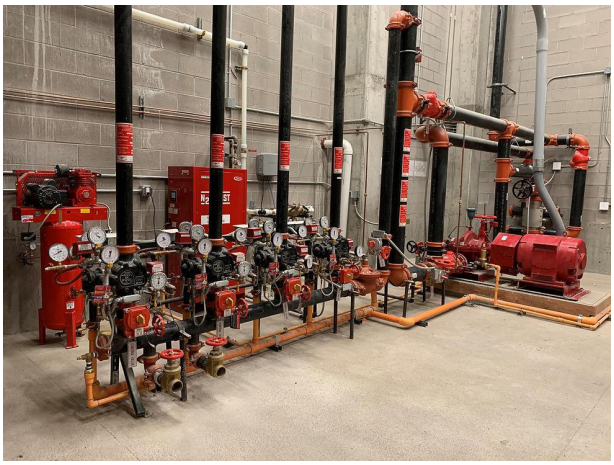


Warehouse sprinkler systems are typically designed based on several factors:

- Commodity classification
- Packaging materials
- Storage height
- Rack configuration
- Building height
- Available water supply

> The higher the fire hazard presented by the stored material, the greater the water demand required to achieve effective suppression.







Fire Growth Within a Storage Environment

When a fire begins within a storage system, it initially affects only a small area. As heat is released, a thermal plume develops and rises toward the ceiling. Ceiling-mounted sprinklers are designed to detect this rising heat and activate before the fire can grow beyond the capabilities of the suppression system.



The effectiveness of this process depends on two primary factors:

- Heat must be able to reach the sprinkler quickly.
- Water must be able to reach the fire after sprinkler activation.

Traditional warehouse storage configurations generally support both requirements through open rack designs and adequate flue spaces. Traditional ASRS systems, however, often alter these conditions significantly.

Traditional ASRS Characteristics That Affect Fire Suppression

Although ASRS technologies vary widely, many traditional systems share design characteristics that can directly influence fire suppression performance.

High Storage Density

One of the primary objectives of traditional ASRS technology is maximizing storage density. By reducing aisle widths and minimizing unused space, operators can store more inventory within the same building footprint.

While beneficial for warehouse productivity, increased storage density concentrates combustible materials into a smaller volume, creating larger fuel packages and potentially higher fire intensity. Dense storage can also make it more difficult for sprinkler water to penetrate through the storage array to reach the seat of the fire.

Increased Storage Heights

Traditional unit-load and crane-based ASRS systems commonly utilize storage heights exceeding those found in conventional warehouses. Some systems may extend 100 feet or more in height.

As storage height increases:

- Fires have more opportunity to grow before sprinkler activation.
- Greater heat release rates can develop.
- More water may be required to achieve suppression.
- Vertical fire spread becomes a more significant concern.

The increased distance between the fire and the ceiling can create conditions where a larger fire is established before ceiling sprinklers begin operating.

Reduced Flue Spaces

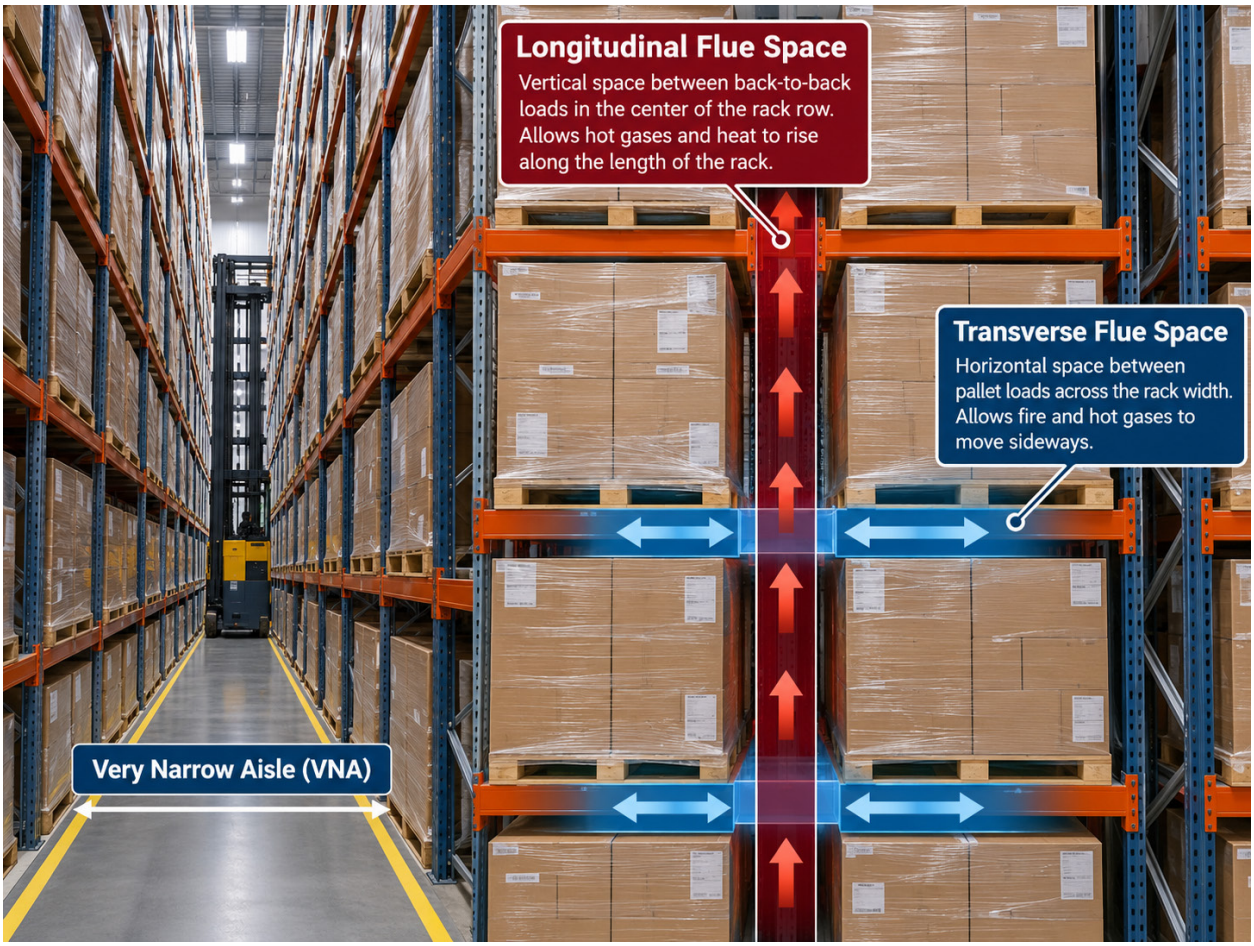
Conventional rack storage relies on longitudinal and transverse flue spaces to facilitate both heat movement and water penetration.

Traditional ASRS systems are frequently designed to maximize storage density by reducing these spaces. Deep-lane storage, tightly packed pallets, tote-based storage, and shuttle systems may limit the pathways that sprinklers depend upon for effective operation.

Reduced flue spaces can result in:

- Delayed heat movement to the ceiling
- Slower sprinkler activation
- Poor water penetration
- Increased potential for concealed fire growth

> In many cases, loss of flue space is one of the most significant fire protection challenges associated with ASRS installations.



Plastic Totes, Bins, and Storage Containers

Tote Design and Sprinkler Water Distribution

An important consideration in ASRS fire protection is whether storage totes have solid or perforated bottoms and whether their design permits sprinkler water to drain through the storage array.

Solid-bottom plastic totes may act as collection basins when exposed to overhead sprinkler discharge. Water can accumulate inside the totes rather than reaching lower storage levels where a fire may be developing. The contents of a tote, particularly packaged merchandise, can further obstruct water penetration even when openings are present.

In contrast, totes incorporating engineered drainage holes or perforations may allow sprinkler water to pass through the container rather than accumulate. Depending on the storage configuration, such openings can:

- Reduce water accumulation within individual totes.
- Facilitate downward drainage of sprinkler discharge to lower storage levels.

- Improve the potential for water to reach burning materials beneath the initially wetted containers.
- Reduce retained water weight and the associated structural loading on the storage system.
- Support more effective distribution of suppression water throughout portions of the storage array.



However, perforations must be evaluated carefully. Hole size, location, spacing, obstruction by stored products, container nesting, and the alignment of totes between storage levels can all influence actual water penetration. Water draining through a tote may bypass burning material, and openings may also influence airflow or fire propagation.

Fire Protection Design Considerations

The widespread use of plastic storage media may drive more demanding sprinkler protection requirements and can influence whether ceiling-only sprinklers are sufficient or supplemental suppression is needed within the storage array.

The selection of solid-bottom versus perforated totes should therefore be evaluated as part of the overall ASRS fire protection strategy, including commodity classification,

storage geometry, sprinkler discharge characteristics, and the potential for vertical fire propagation.

Where drainage openings are incorporated into tote designs, their effectiveness should be demonstrated through applicable fire testing, engineering analysis, or other evidence acceptable to the authority having jurisdiction (AHJ) and the property's insurer. Perforated totes should not automatically be assumed to justify reduced sprinkler design criteria or eliminate the need for supplemental protection.

Rack Shelving and Horizontal Obstructions

Traditional ASRS systems often incorporate shelves, trays, shuttle rails, storage trays, and structural components throughout the storage array.

These features can create physical barriers that interfere with sprinkler discharge. Water that would normally penetrate through an open rack structure may instead be blocked, redirected, or prevented from reaching lower storage levels.

The result can be uneven water distribution and reduced suppression effectiveness within the areas where protection is needed most.

Automated Equipment Within the Storage Array

Unlike conventional storage systems, ASRS installations contain substantial mechanical and electrical infrastructure, including stacker cranes, shuttle vehicles, conveyors, power rails, sensors and controls equipment.

These components may create additional sprinkler obstructions while simultaneously introducing potential ignition sources. Electrical failures, overheating equipment, and power distribution systems can all contribute to the overall fire risk profile.

Limited Emergency Response Access

Traditional ASRS systems are designed for machines rather than people. Narrow aisles, enclosed rack structures, and high-density storage can make it difficult for emergency responders to access the fire area.

Limited access can affect:

- Manual hose stream operations
- Fire investigation activities
- Final extinguishment efforts
- Post-fire recovery operations

As a result, suppression systems within ASRS facilities must often achieve a higher degree of fire control before firefighters can effectively intervene.

The Importance of Water Penetration

Regardless of the technology employed, fire suppression ultimately depends on getting water to the burning fuel.

In conventional storage environments, water discharged from ceiling sprinklers can often travel through open rack structures and flue spaces before reaching the fire. Traditional ASRS installations may present multiple obstacles to this process, including dense storage arrangements, plastic containers, shelving systems, automated equipment and reduced flue spaces.

> When water penetration is compromised, sprinkler systems may activate as intended but fail to deliver sufficient water to the fire itself. This distinction is critical because sprinkler activation alone does not guarantee fire suppression.

Ceiling Sprinklers Versus In-Rack Protection

Most warehouses rely primarily on ceiling-mounted sprinkler systems. These systems assume that water discharged from above can be of sufficient quantity and spread to penetrate the storage arrangement and reach the burning commodities below.

As traditional tote based ASRS stacking systems become taller, denser, and more complex, these assumptions may no longer hold true. In these situations, fire protection engineers may incorporate in-rack sprinklers to introduce water directly into the storage array.

In-rack systems can reduce vertical fire spread, improve water delivery, compensate for reduced flue spaces and improve protection of high-density storage. However, they also increase installation costs, maintenance requirements, and system complexity by reducing or even eliminating potential shuttle or robot travel paths.



1. ESFR Pendent

EARLY SUPPRESSION FAST RESPONSE

Designed to suppress high-challenge storage fires early using high-volume, high-momentum water discharge.



2. Standard Pendent (CMDA)

CONTROL MODE DENSITY/AREA

Ceiling-mounted, downward-facing sprinkler commonly used in conventional warehouse protection.



3. Upright Sprinkler

STANDARD SPRAY

Installed above exposed piping with the deflector facing upward to redirect water downward.



4. CMSA Sprinkler

CONTROL MODE SPECIFIC APPLICATION

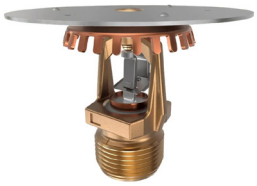
Uses larger water droplets and application-specific hydraulic criteria to control storage fires.



5. In-Rack Sprinkler with Guard

INTERMEDIATE-LEVEL PROTECTION

Mounted within storage racks; guards and water shields can protect against physical damage and discharge from above.



6. Intermediate-Level Sprinkler

SHIELDED IN-RACK CONFIGURATION

Designed for protection at intermediate elevations with a shield to reduce cooling from upper-level sprinkler discharge.

Comparison for ASRS fire protection

Type	Typical location	Primary objective
ESFR	Ceiling	Early fire suppression
CMDA	Ceiling	Control fire growth
CMSA	Ceiling	Control high-challenge storage fires
Upright	Exposed overhead piping	Depends on sprinkler listing
In-rack	Inside storage array	Apply water near the fire
Intermediate-level	Multiple storage elevations	Protect lower storage l



Why Storage Configuration Matters

The effectiveness of a fire suppression system is influenced not only by what is stored, but by how it is stored. Two facilities storing identical products may require very different fire protection solutions if one uses conventional selective pallet racking and the other uses a high-density ASRS.

Traditional ASRS technologies achieve their operational advantages through increased storage density, higher storage heights, reduced flue spaces, extensive use of plastic containers, automated handling equipment, and limited access areas. These same characteristics can challenge the assumptions upon which conventional fire suppression systems are designed. As a result, fire protection must be evaluated as an integral component of ASRS design rather than as a separate building system. Early consideration of suppression requirements, commodity classification, storage configuration, and emergency response strategies is essential to developing a safe, compliant, and insurable automated warehouse.

5. Design Recommendations: Integrating Fire Protection into ASRS Design

Fire protection should be incorporated into the engineering phase of the project before the ASRS layout has been finalized. Fire suppression requirements should be considered alongside throughput, storage density, and operational objectives during the earliest phases of system design. Decisions regarding products stored, system geometry, existing building details and tote design can have a significant impact on the complexity and cost of the fire protection system.

Preserve Water Penetration Paths Wherever Possible

Many traditional ASRS systems achieve density by minimizing flue spaces and tightly packing storage locations. While operationally attractive, these configurations can significantly limit the ability of sprinkler water to reach a fire.

ASRS designers should evaluate longitudinal flue spaces, transverse flue spaces, rack depth, shelf construction and water penetration pathways

For example, a deep-lane shuttle system that utilizes solid shelving over multiple levels may require substantial in-rack sprinkler protection because water cannot effectively penetrate to lower tiers. By comparison, a storage architecture that maintains vertical pathways for sprinkler discharge may allow greater reliance on ceiling-level protection. The ability of heat to travel upward and water to travel downward should be considered a core design criterion rather than a byproduct of the storage system.

Limit Combustible Components

One of the largest contributors to ASRS fire severity is often not the product itself but the storage container holding it. Traditional ASRS systems commonly utilize plastic totes, trays, bins or shelving components. When selecting storage media, designers should evaluate:

- Container material composition
- Total plastic content
- Open versus enclosed geometry
- Fire performance characteristics

Reducing combustible materials within the storage structure can significantly improve suppression effectiveness and may reduce overall sprinkler system demands.

Incorporate Fire-Resistant Storage Containers

A more advanced approach is to actively incorporate fire protection features into the storage media itself rather than relying entirely on building infrastructure.

Example: Attabotics Guardian Bin

The Attabotics Guardian Bin represents a shift from traditional fire protection philosophy by embedding fire mitigation directly into the storage container.

Unlike conventional plastic totes, which may contribute additional fuel to a fire, the Guardian Bin is designed to isolate and contain fire hazards at the source. By limiting oxygen availability and reducing fire spread potential from one storage location to adjacent locations, the bin acts as a passive fire protection element within the ASRS architecture.

The concept offers several potential advantages:

- Reduced fire propagation between adjacent bins
- Lower likelihood of fire spreading vertically through the storage structure
- Reduced dependence on water penetration into individual storage locations
- Enhanced protection of high-risk commodities
- Potential reduction in overall system fire loading

If a fire originates within a tote, flames can spread rapidly to adjacent containers before sprinkler water reaches the seat of the fire. By contrast, a fire-resistant storage container such as the Guardian Bin helps contain the event within a single storage location, allowing suppression systems additional time to activate and reducing the overall size of the fire before intervention occurs. This layered approach follows a fundamental principle of modern fire protection engineering: preventing fire growth is often more effective than simply increasing sprinkler water demand.

Design for Ceiling-Only Protection Whenever Practical

In-rack sprinklers can provide excellent protection, but they also introduce significant operational challenges. These challenges include:

- Increased installation costs
- Additional piping throughout the storage structure
- More complex inspections and testing
- Potential conflicts with automation equipment
- Increased maintenance requirements

ASRS designers should evaluate whether storage arrangements can be configured to support ceiling-only protection before resorting to extensive in-rack sprinkler systems.

Potential design strategies include:

- Reducing storage height where practical
- Maintaining flue spaces
- Limiting rack depth
- Using fire-resistant storage containers
- Reducing plastic fuel load within the storage array

> A slightly less dense storage solution may produce substantial savings in sprinkler infrastructure, maintenance costs, and insurance premiums over the life of the facility.

Integrate Fire Protection and Controls Systems

Modern ASRS systems are highly automated and can provide valuable support during a fire event. Upon activation of the fire alarm system, the warehouse control system should be capable of:

- Stopping robotic movement
- Isolating affected storage zones
- Removing power from equipment
- Positioning shuttles and cranes in safe locations
- Providing fire department access to incident areas
- Supporting rapid identification of affected inventory

For example, if thermal detection identifies a fire within a specific bin location, the ASRS control system could automatically prevent movement in the affected aisle while simultaneously identifying the exact location of the incident for responding personnel. This integration transforms the automation platform into an active participant in fire risk mitigation rather than simply another potential hazard.

Adopt a Layered Fire Protection Strategy

The most effective ASRS facilities do not rely on a single protection mechanism. Instead, they combine multiple layers of defense. An optimized fire protection strategy should include:

- Commodity evaluation
- Fire-conscious storage architecture
- Fire-resistant storage containers such as Guardian Bin technology

- Automatic sprinkler protection
- Early detection systems
- Integrated control system response
- Emergency response planning
- Ongoing inspection and testing

Each layer compensates for potential weaknesses in another layer, creating a more resilient system overall.

6. Conclusion

The most successful ASRS fire protection strategies begin during system design rather than after the automation solution has been selected. While traditional ASRS technologies deliver significant operational benefits through increased storage density, taller storage structures, reduced aisle space, and automated handling, these same characteristics can create challenges for fire detection, sprinkler activation, water penetration, and emergency response. As a result, fire protection must be considered a core design criterion alongside throughput, capacity, and operational efficiency.

Designers should focus on preserving the fundamental elements required for effective fire suppression. Maintaining water penetration pathways, preserving heat movement toward ceiling-level sprinklers, minimizing unnecessary combustible materials, and carefully evaluating storage height and rack geometry can significantly improve overall fire protection performance. Early collaboration between automation suppliers, fire protection engineers, insurers, and owners can help avoid costly redesigns while improving code compliance and long-term insurability.

A key recommendation is to adopt a layered fire protection strategy that combines multiple forms of risk mitigation rather than relying exclusively on sprinkler systems. Effective solutions should incorporate commodity evaluation, fire-conscious storage architecture, fire-resistant storage containers, automatic suppression systems, rapid detection technologies, integrated control system response, emergency response planning, and ongoing inspection and testing programs. Each layer reduces the likelihood that a single failure or design limitation will result in uncontrolled fire growth.

Particular attention should be given to the selection of storage media and container design. Traditional plastic totes and trays can contribute significantly to a facility's fuel load and may increase fire severity. By contrast, storage containers that incorporate

passive fire mitigation features can help contain a fire within a single storage location, reduce fire propagation to adjacent inventory, and provide valuable time for suppression systems to activate. This approach shifts the fire protection philosophy from simply suppressing fires after they grow to actively limiting their ability to spread.

Similarly, ASRS architectures that support water penetration and reduce dependence on extensive in-rack sprinkler systems can provide meaningful advantages throughout the life of the facility. Reducing suppression system complexity can lower installation costs, simplify maintenance, improve system reliability, and reduce operational disruptions while still maintaining a high level of protection.

Ultimately, the future of warehouse fire protection lies in solutions that integrate fire safety directly into the storage architecture itself. The most effective ASRS designs are not those that simply maximize storage density, but those that balance operational performance with fire protection principles. Systems that combine high-density storage with fire-resistant containers, unobstructed suppression pathways, intelligent controls, and integrated life-safety features offer a superior approach to managing fire risk. By addressing fire hazards at the source and reducing the potential for fire propagation throughout the storage array, operators can achieve safer, more insurable, and more resilient warehouse operations while maintaining the benefits of advanced automation.

Appendix A. Applicable Codes, Standards, and Technical Guidance

This appendix is a reference checklist, not a determination that every item applies to every project. Confirm the adopted edition, amendments, insurer specifications, hazardous commodity inventory, and storage arrangement before design. Published editions are not necessarily the locally enforced editions.

A.1 NFPA Codes and Standards

NFPA 1 — Fire Code: General fire prevention provisions; relevant where adopted.

NFPA 13 — Standard for the Installation of Sprinkler Systems: Primary sprinkler design, storage protection, installation and acceptance criteria.

NFPA 14 — Standard for the Installation of Standpipe and Hose Systems: Standpipes and fire department hose access, where required.

NFPA 20 — Standard for the Installation of Stationary Pumps for Fire Protection: Fire pumps where public water supply is insufficient.

NFPA 22 — Standard for Water Tanks for Private Fire Protection: On-site fire water storage tanks, where used.

NFPA 24 — Standard for the Installation of Private Fire Service Mains and Their Appurtenances: Private fire mains, yard piping and related appurtenances.

NFPA 25 — Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems: Ongoing ITM for installed sprinkler and water-based systems.

NFPA 30 — Flammable and Combustible Liquids Code: Special commodity or process hazards involving ignitable liquids.

NFPA 30B — Code for the Manufacture and Storage of Aerosol Products: Aerosol products in inventory; may require specific storage protection.

NFPA 70 — National Electrical Code: Electrical installation, robotics power, charging and equipment interfaces.

NFPA 72 — National Fire Alarm and Signaling Code: Detection, notification, supervisory signals and system interfaces.

NFPA 75 — Standard for the Fire Protection of Information Technology Equipment: Potentially relevant to dedicated IT or control rooms.

NFPA 101 — Life Safety Code: Occupant safety and egress where adopted.

NFPA 855 — Standard for the Installation of Stationary Energy Storage Systems: Evaluate applicability to stationary battery systems; not every mobile robot battery is an ESS.

A.2 FM Property Loss Prevention Data Sheets

FM DS 8-34 — Protection for Automatic Storage and Retrieval Systems: ASRS-specific protection guidance; a key early review document.

FM DS 8-9 — Storage of Class 1, 2, 3, 4 and Plastic Commodities: Sprinkler protection recommendations for common storage commodities.

FM DS 8-1 — Commodity Classification: Commodity hazard classification and packaging considerations.

FM DS 2-0 — Installation Guidelines for Automatic Sprinklers: Installation guidance; coordinate with the applicable occupancy-specific data sheet.

FM DS 3-26 — Fire Protection Water Demand for Nonstorage Sprinklered Properties: Potentially relevant to nonstorage areas; not a substitute for storage design criteria.

FM DS 8-33 — Carousel Storage: Consider only for applicable carousel arrangements.

FM DS 7-29 — Ignitable Liquid Storage in Portable Containers: Potentially relevant when stored inventory includes ignitable liquids.

FM DS 7-31 — Storage of Aerosol Products: Potentially relevant to aerosol inventory.

A.3 Building Codes, Guidance, and Other References

International Fire Code (IFC), Chapter 32 — High-Piled Combustible Storage: Core high-piled storage provisions; 2024 IFC Section 3209 addresses automated storage.

International Fire Code (IFC), Chapter 9 — Fire Protection and Life Safety Systems: Sprinkler, alarm, and other protection triggers.

International Building Code (IBC): Building occupancy, construction, fire resistance, access and occupancy considerations.

ICC High-Piled Combustible Storage Application Guide (2024 edition): Explanatory application guide for IFC Chapter 32, not independently an adopted code.

NFPA 13 Automatic Sprinkler Systems Handbook: Commentary and examples supplementing—not replacing—the adopted NFPA 13 standard.

National Fire Code of Canada and applicable provincial codes: Check for Canadian projects such as installations in Alberta; consult the provincial/municipal AHJ.

UL / other nationally recognized testing laboratory product listings: Verify the exact sprinkler, alarm, battery, and related equipment listings required by the design.

OSHA requirements and applicable industrial machinery / electrical safety standards: Worker safety and safe maintenance/lockout; separate from sprinkler approval.

A.4 Reference Publishers and Source Links

NFPA codes and standards: https://www.nfpa.org/codes-and-standards

NFPA 13 overview: https://www.nfpa.org/product/nfpa-13-standard-for-the-installation-of-sprinkler-systems/p0013code

FM property loss prevention data sheets: https://www.fm.com/resources/fm-data-sheets

ICC digital codes (IFC and IBC): https://codes.iccsafe.org/

ICC High-Piled Combustible Storage Application Guide: https://shop.iccsafe.org/high-piled-combustible-storage-application-guide-2024-edition-based-on-the-2024-international-fire-code.html

> *Editorial note: This white paper is background information and does not substitute for project-specific code analysis, fire protection engineering, AHJ approval, or insurer acceptance.*

A.5 ASRS Research & Additional Reference

NFPA Research Foundation – ASRS Fire Protection Guidance: https://content.nfpa.org/-/media/Project/Storefront/Catalog/Files/Research/Research-Foundation/Current-projects/ProjectSummaryASRS.pdf?utm_source=attabotics&utm_medium=white-paper&utm_campaign=fire-suppression-white-paper

Tactical Measures for Manual Firefighting for AutoStore System: https://content.nfpa.org/-/media/Project/Storefront/Catalog/Files/Research/Research-Foundation/Symposia/2022-SUPDET/Papers/SUPDET22-Tactical-Measures-for-Manual-Firefighting-for-the-AutoStore-system.pdf?utm_source=attabotics&utm_medium=white-paper&utm_campaign=fire-suppression-white-paper

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