

A large, solid black silhouette of a person wearing a hard hat, positioned on the left side of the cover. The background is a deep red with faint, white, wavy lines that create a sense of depth and movement.

FIREPROOFING THE NEXT-GEN WAREHOUSE

Designing Safer, Smarter
Automated Storage Systems

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EXECUTIVE SUMMARY

The rapid adoption of Automated Storage and Retrieval Systems (ASRS) is revolutionizing warehouse efficiency and density. However, these advanced systems introduce unique and complex fire safety challenges that standard guidelines (such as NFPA 13) do not fully address. Dense storage, limited human presence, access difficulties for firefighters, and the presence of automation complexities demand a specialized, integrated approach to fire protection design from the project's inception. Failure to address these risks proactively can lead to catastrophic losses, operational disruption, and significant financial consequences. Examples of the catastrophic consequences along with recommendations on how to address are the purpose of this white paper.

This paper explores the critical importance of integrating comprehensive fire protection strategies into the design and implementation of ASRS facilities. It highlights the limitations of the current standards, the crucial roles of insurance providers and fire marshals, and the economic imperative of getting fire safety right the first time. We will outline a best-practice process for designing safe, resilient, and insurable automated warehouses. Philip Blackwelder and his team brings extensive international expertise not just in fire protection principles, but specifically in the design and implementation of ASRS and the integration of robust fire safety measures to ensure these systems are inherently protected and meet customer needs within reasonable cost parameters. Our experience ensures facilities meet operational requirements while safeguarding people, property, and business continuity.

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01 INTRODUCTION

THE RISE OF AUTOMATION AND THE ESCALATING NEED FOR ADVANCED FIRE SAFETY

Modern supply chains demand speed, accuracy, and efficiency. Advanced manufacturing facilities and distribution centers increasingly rely on ASRS to achieve these goals through:

- **Unprecedented Storage Density:** Maximizing vertical and horizontal space.
- **Increased Throughput:** Faster processing of goods.
- **Reduced Labor Dependency:** Streamlining operations.
- **Increased visibility and management of inventory**
- **Safer storage and handling of goods**

While these benefits are compelling, the very nature of ASRS creates a unique fire risk profile:

Dense Storage Configurations:

Fire can spread rapidly through tightly packed goods, often stored at significant heights.

Obstructed Visibility:

The lack of open aisles and presence of dense racking can prevent early visual detection of smoke or flames by personnel or standard detection systems.

Access Challenges:

Automation zones are often difficult for personnel and emergency responders to access safely and quickly. Large footprints and tall structures complicate firefighting efforts.

Automation Hazards:

Systems involve electrical components (like charging stations), moving equipment (potential ignition sources from friction, collision, electrical faults), and sometimes specific hazards like lithium-ion batteries. High voltage systems present risks to responders.

Addressing these challenges requires moving beyond basic code compliance towards a holistic, risk-informed design philosophy considering types of materials stored and structural design of the system.

02 WHY STANDARD APPROACHES FALL SHORT

UNDERSTANDING ASRS FIRE DYNAMICS

The National Fire Protection Association (NFPA) standard NFPA 13

Standard for the Installation of Sprinkler Systems, provides foundational guidance. However, for complex ASRS environments, it often serves as a starting point rather than a complete solution. As noted, NFPA 13 needs further development for these specialized applications.

Key limitations and considerations include:

Commodity Classification is Crucial

but Complex: The type of goods stored (plastics, paper, chemicals, etc.) and their packaging (pallets, plastic totes – solid vs. perforated bottoms) dramatically impacts fire spread and the required sprinkler design (density, water application rate, droplet size). NFPA provides classifications but applying them within the unique geometry of an ASRS requires expert analysis.



Detection Needs Beyond Visual: Reliance on early warning detection systems, such as Air-Sampling Smoke Detection (e.g., VESDA) or advanced heat detection, becomes critical in areas with low human traffic and obscured visibility.



In-Rack Sprinklers are Often Essential:

Ceiling-only sprinklers may be insufficient due to the height and density of storage, requiring multiple levels of in-rack sprinklers. Integrating these without interfering with ASRS machinery (robots, shuttles, cranes) is a significant design challenge requiring mechanical adjustments to the ASRS itself.



Specific ASRS Configurations: Different ASRS types (e.g., shuttle systems, crane-based systems, robotic cube storage) present distinct fire protection challenges requiring tailored solutions.

03 MITIGATING ASRS FIRE RISKS

THE ROLE OF INSURANCE AND THIRD-PARTY TESTING

Given the limitations of baseline standards for novel or complex ASRS, insurance providers play a pivotal role.

- **Insurers Drive Requirements:** To insure the facility and its valuable contents, insurers often dictate fire protection measures exceeding minimum code requirements. Their requirements are crucial for insurability.
- **Third-Party Testing Validates Solutions:** For unique storage configurations or commodity types not explicitly covered by existing standards or test data, large-scale fire testing by recognized third-party laboratories (e.g., UL, FM Global) may be necessary to prove the effectiveness of a proposed fire protection design. This validates adequacy. Early engagement with the intended insurer is critical.

NAVIGATING THE APPROVAL PROCESS: THE FIRE MARSHAL'S PERSPECTIVE

While insurers focus on property protection and insurability, the local Authority Having Jurisdiction (AHJ), typically the Fire Marshal or Fire Department, holds the ultimate sign-off authority for building occupancy. Their primary concerns revolve around:

Life Safety:

Ensuring safe egress for any occupants and safe operating conditions for emergency responders.

Firefighter Access:

Can responders reach the seat of a fire effectively and safely? This includes:

- ♦ **Access Points:** Sufficient perimeter access, designated entry points to automation zones.
- ♦ **Reaching the Fire:** Strategies for penetrating dense storage or accessing elevated fire locations. Smoke control and ventilation systems are key considerations.
- ♦ **Unique Hazards:** Training and awareness regarding ASRS-specific hazards like high-voltage systems, unexpected equipment movement (requiring robust lockout/tagout procedures during emergencies), and potential structural collapse in prolonged fires.

Water Supply:

Ensuring adequate water volume, pressure, and duration for the designed sprinkler system.

Early and ongoing communication with the local Fire Department and AHJ is essential to ensure the design meets their operational requirements and safety concerns.

DESIGN PRINCIPLE: PROTECT PEOPLE FIRST, PROPERTY SECOND

In any facility, life safety is paramount. In ASRS, where human presence is often minimal within the automated zones, the focus shifts heavily towards protecting firefighters responding to an event and minimizing property damage.

A well-designed fire suppression system aims to:

- **Control and Suppress:** Quickly control the fire's growth, limiting its spread.
- **Minimize Damage:** While some product loss is likely in a fire, effective suppression can significantly limit damage to the expensive ASRS equipment and the building structure, allowing for faster recovery and reduced business interruption.



INTEGRATING FIRE PROTECTION INTO ASRS DESIGN: A STRATEGIC PROCESS

A successful and safe ASRS facility requires fire protection to be considered integral to the design from day one, not an afterthought.

Our proven process involves:

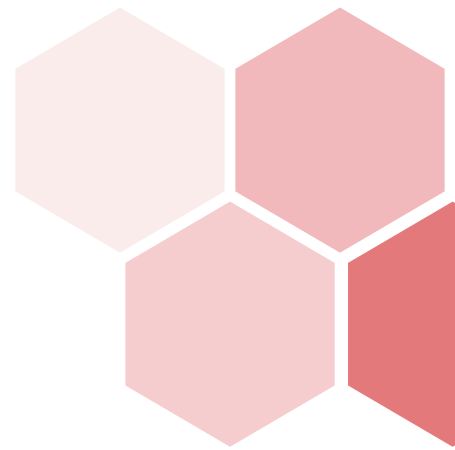
- 1. Understanding Requirements:** Deeply understanding the client's operational needs – storage capacity, throughput rates, types of goods handled.
- 2. Product Classification Analysis:** Rigorously determining the NFPA commodity classification(s) of all goods to be stored, including packaging variations (pallets, slip sheets, plastic totes – solid/closed bottom, perforated/open, etc.). This is fundamental to defining the fire hazard.
- 3. Conceptual System Design:** Developing the initial ASRS layout based on operational needs.
- 4. Expert Fire Protection Consultation:** Engaging qualified fire protection engineers (FPEs) specialized in storage and ASRS early. This consultation, guided by our expertise in ASRS implementation, determines the specific fire detection and suppression requirements (e.g., sprinkler types, placement, densities, water demand, detection methods) based on the product classification, storage configuration, and height.
- 5. Integrated Design & Adjustment:** This is where our core expertise lies. We work collaboratively with the FPEs and ASRS manufacturers to:
 - ♦ **Incorporate Fire Protection:** Strategically place sprinklers (in-rack and ceiling), detection devices, and piping within the ASRS structure.
 - ♦ **Mechanical Adjustments:** Modify the ASRS mechanical design (racking, supports, clearances) to accommodate fire protection hardware without compromising system performance or creating interference risks (e.g., ensuring sprinkler heads are safe from impact by shuttles or goods).
 - ♦ **Review Container Types:** Sometimes, minor changes to storage containers (e.g., specifying perforated bottoms for plastic totes instead of solid) can significantly impact fire protection requirements and costs. We identify these opportunities.
- 6. Cost Assessment:** The total system cost includes both the automation equipment and the integrated fire protection system. Early integration prevents costly retrofits or design changes later.
- 7. Coordination with Stakeholders:** Facilitating communication between the client, insurer, AHJ, FPEs, and ASRS provider throughout the design and installation process.

04 THE ECONOMICS OF INTEGRATED FIRE SAFETY DESIGN

Investing in expert ASRS design that includes integrated fire protection yields significant long-term economic benefits:

- **Reduced Risk of Catastrophic Loss:** Preventing major fires protects valuable inventory, expensive automation equipment, and the facility itself.
- **Minimized Business Interruption:** Effective fire protection limits damage, allowing for quicker resumption of operations after an incident.
- **Optimized Insurance Premiums:** A well-designed, potentially insurer-approved system can lead to more favorable insurance terms and premiums.
- **Avoiding Costly Redesigns:** Addressing fire protection requirements proactively prevents discovering late in the project that the initial ASRS design is inadequate or non-compliant, which can lead to significant delays and budget overruns.
- **Enhanced Resilience:** A safe facility is a reliable facility, contributing to supply chain stability.

Conversely, underestimating fire protection needs in dense ASRS environments can lead to uninsurable facilities, denied occupancy permits, or devastating losses that far exceed the cost of proper upfront design. The cost impact of dense storage systems is directly mitigated by effective, integrated fire protection planning.



LEARNING FROM EXPERIENCE: FOUR ASRS FIRE CASE STUDIES

Several high-profile incidents underscore the unique fire risks in automated warehouses and provide valuable lessons:

Ocado Warehouse Fire (Andover, UK, 2019):



- ♦ **Cause:** An electrical fault in a robot battery charging unit initiated the fire.
- ♦ **Key Issues:** Compounding factors led to total loss. Reports indicated potential issues with detection systems and, critically, the sprinkler system was turned off prematurely by staff attempting to manage the fire. The fire reignited, eventually exhausting the dedicated on-site water supply tank. Firefighters faced immense difficulty accessing the seat of the fire within the large, complex structure, and the fire burned for four days, destroying the facility (£110m loss).
- ♦ **Lessons:** Underscores the absolute necessity of robust safety protocols for charging systems, reliable detection, strict operational procedures preventing premature shutdown of suppression systems, ensuring sufficient water supply duration, and pre-planning firefighter access strategies.

Ocado Warehouse Fire (Erith, UK, 2021):



- ♦ **Cause:** A collision between three robots resulted in a lithium-ion battery fire.
- ♦ **Outcome:** In contrast to Andover, the fire suppression system activated as designed and successfully controlled the fire. Damage was limited to a very small section of the ASRS grid (reportedly less than 1%), and operations resumed relatively quickly.
- ♦ **Lessons:** Demonstrated that well-designed, properly functioning fire suppression systems can effectively manage challenging ASRS fires, including those involving lithium-ion batteries. Highlights the value of integrated protection in ensuring business resilience and reinforces the need for robust collision avoidance and battery safety management.

Lineage Logistics Fire (Finley, WA, US, April 2024):



- ♦ **Context:** A massive fire occurred at a large cold storage warehouse (often highly automated).
- ♦ **Key Issues:** The fire proved extremely difficult to extinguish, smoldering for nearly two months and creating vast plumes of smoke impacting nearby residents. Access was severely hampered as the structure collapsed. Lack of nearby hydrants necessitated trucking in millions of gallons of water. Environmental contamination became a major concern. Cold storage materials added complexity.
- ♦ **Lessons:** Highlights extreme firefighting access challenges in large, potentially collapsed structures, the critical importance of adequate water supply planning, and potential severe community/environmental impacts.

Canadian Tire Distribution Centre Fire (Brampton, ON, Canada, March 2023):



- ♦ **Context:** A major fire occurred at a large distribution center utilizing an Attabotics 3D robotic ("cube") storage system.
- ♦ **Cause:** Specific cause under investigation/dispute; however, the incident highlighted operational risks in large DCs.
- ♦ **Damage & Impact:** Significant disruption and financial losses (\$67.7 million reported in Q1 2023).
- ♦ **Lessons:** Demonstrates the immense financial vulnerability of critical distribution hubs. Underscores the need for rigorously tested fire protection strategies for novel ASRS configurations like dense cube storage, where fire dynamics differ from traditional racking.

05 CONCLUSION

OUR COMMITMENT: YOUR PARTNER IN SAFE AND EFFICIENT AUTOMATION

Chang Robotics is uniquely qualified to guide manufacturing, distribution, and order fulfillment companies through the complexities of designing and implementing safe, efficient, and resilient automated storage facilities. Our deep expertise lies specifically in understanding ASRS technology, its operational demands, and how to seamlessly integrate comprehensive, effective fire protection strategies from the outset.

We bridge the gap between operational goals, ASRS system design, fire protection engineering, insurance requirements, and AHJ approval.

Our process ensures that:

- **With a Chang Robotics feasibility assessment and plan, risks are Identified Early:** We analyze your products, processes, and chosen automation to pinpoint specific fire hazards.
- **Solutions are Integrated, Not Added:** Fire protection becomes part of the core system design, optimizing safety and minimizing potential conflicts or costly retrofits.
- **Compliance and Insurability are Addressed Proactively:** We facilitate engagement with insurers and AHJs, incorporating their requirements into the design.
- **Long-Term Value is Maximized:** By getting the design right upfront, we help you avoid the catastrophic costs of fire incidents, minimize insurance premiums, ensure operational continuity, and protect your people and investments – saving money into perpetuity.

Developing an ASRS solution without fully integrating fire protection considerations based on expert assessment can lead to wasted time, exceeded budgets, and ultimately, a system that fails to meet the comprehensive needs of the end-user because it cannot be adequately protected or insured. Our experience prevents these pitfalls.

BUILDING RESILIENCE INTO THE FUTURE OF STORAGE

Advanced automated warehouses are essential components of modern, efficient supply chains and manufacturing. However, their unique characteristics demand a paradigm shift in how fire safety is approached. Standard guidelines provide a foundation, but true resilience requires a specialized, integrated design process driven by expertise in both ASRS technology and advanced fire protection principles.

Early engagement with experts who understand the intricacies of ASRS, commodity risks, insurance expectations, and regulatory requirements is not just advisable – it is critical for project success and long-term operational viability. By prioritizing integrated fire safety design, companies investing in ASRS can protect their personnel, safeguard their substantial investments in automation and inventory, ensure business continuity, and build facilities prepared for the future.

Are you planning an advanced manufacturing or distribution facility with automated storage?

Ensure its safety, insurability, and resilience from day one.

Contact us to connect with our team and learn how an ASRS feasibility study can help you get fire safety planning right the first time - saving you time, cost, and risk in the long run.

www.changrobotics.ai/contact

ABOUT THE AUTHOR

Philip Blackwelder is a senior automation expert with more than 25 years of hands-on experience across system engineering, field service, commissioning, software integration, and project management. With a degree in mechanical engineering, Philip has led automation projects around the globe—designing and implementing systems that are efficient, intuitive, and resilient. At Chang Robotics, he applies this deep technical expertise to help clients across industries optimize complex automation systems, including ASRS, with a focus on seamless integration, operational safety, and long-term performance.

