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WAREHOUSE PROPERTY PROTECTION

Among the most challenging occupancies from a property loss control viewpoint are warehouses, distribution centers and large retail businesses referred to as "big box" establishments.

"Warehouses represent a unique fire challenge to both fixed fire suppression systems and the manual firefighting forces that are called upon to deal with a fire. Modern warehouses and storage occupancies are especially subject to rapidly developing fires of great intensity, because complex configuration of storage and building layout are usually conducive to fire spread, presenting numerous obstacles to manual fire suppression efforts. The only proven method of controlling a warehouse fire is with properly designed and maintained automatic sprinkler systems. If sprinkler protection is not provided, the likelihood of controlling a fire in a warehouse is minimal, at best."[1]

In this publication, we will examine critical elements you must consider when developing a comprehensive risk mitigation strategy to protect your facilities. These elements include:

- Commodity classification
- Common storage configurations
- Various protection schemes
- Hazards associated with some of the common types of warehouses
- Loss prevention guidelines for minimizing the frequency and severity of a loss

Mirriam-Webster defines a warehouse as "a structure or room for the storage of merchandise or commodities." Warehouses can thus range from several hundred to more than a million square feet and can include among other occupancies storage garages, refrigerated storage facilities, isolated storage buildings, underground storage locations and air-supported structures.

Big box retail facilities typically have large footprints, many of which approach or exceed 100,000 square feet in area. A variety of commodities are displayed and stored within these facilities, including soft goods (clothes, bedding materials, etc.), furnishings of

all types, paints, home repair and building materials, chemicals and plastics. Moreover, big box retail spaces often have ceiling or roof heights in excess of 16 feet and, in many cases, as high as 35-40 feet. Using rack storage configurations, these types of retail stores will typically display products at lower elevations and use the higher elevations for product storage.[2]

COMMODITY CLASSIFICATION

So how do we determine what we are protecting? Commodities are classified taking into account three factors:

1. The specific item or product
   - Its heat of combustion
   - Its rate of heat release
   - Its rate of flame spread

2. The packaging of the specific item or product including the type of pallet the item is stored on.
   - Interior and exterior packaging components (e.g., type of carton or container as well as the material inside the carton or container)

3. The individual storage units
   - The commodity classification shall be determined based on the makeup of individual storage units (e.g., a unit load or a pallet load)*
   - As a general guideline, Table 1 outlines the Commodity Classes and Classification of Plastics, Elastomers and Rubber

It is critically important to properly identify the correct commodity class, as this will serve as the foundation for determining the appropriate fire sprinkler protection scheme.

Table 1: Commodity Classes and Classification of Plastics, Elastomers and Rubber	
Class I	Noncombustible product that meets one of the following criteria: 1. Placed directly on wooden pallets 2. Placed in single-layer corrugated cartons, with or without single-thickness cardboard dividers, with or without pallets 3. Shrink-wrapped* or paper wrapped as a unit load with or without pallets
Class II	Noncombustible product that is in slatted wooden crates, solid wood boxes, multiple layered corrugated cartons, or equivalent combustible packaging material, with or without pallets.
Class III	Product fashioned from wood, paper, natural fibers, or Group C plastics with or without cartons, boxes or crates and with or without pallets. A Class III commodity shall be permitted to contain a limited amount (5% by weight or volume or less) of Group A or Group B plastics.
Class IV	Product, with or without pallets, that meets one of the following criteria: 1. Constructed partially or totally of Group B plastics 2. Consists of free-flowing Group A plastic materials 3. Contains within itself or its packaging an appreciable amount (5% to 15% by weight or 5% to 25% by volume) of Group A plastics
Group A	ABS, Acetal, Acrylic, Butyl Rubber, EPDM, FRP, Natural Rubber Nitrile Rubber, PET, Polybutadiene, Polycarbonate, Polyester Elastomer, Polyethylene, Polypropylene, Polystyrene, Polyurethane, PVC, SAN, SBR
Group B	Cellulosics, Chloroprene Rubber, Fluoroplastics (ECTFE, ETFE, FEP), Natural Rubber, Nylon, Silicone Rubber (Group B and Class IV are considered equivalent)
Group C	Fluoroplastics (PCTFE, PTFE), Melamine, Phenolic, PVC, PVDC, PVDF, PVF, Urea (Group C and Class III are considered equivalent)

* In accordance with National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler System*, Section 3.9.1.8 of NFPA 13 states: **Encapsulation**. A method of packaging consisting of a plastic sheet completely enclosing the sides and top of a pallet load containing a combustible commodity or a combustible package or a group of commodities or combustible packages. Combustible commodities individually wrapped in plastic sheeting and stored exposed in a pallet load also are to be considered encapsulated. Totally non-combustible commodities on wood pallets enclosed only by a plastic sheet as described are not covered under this definition. Banding (i.e., stretch-wrapping around the sides only of a pallet load) is not considered to be encapsulation. Where there are holes or voids in the plastic or waterproof cover on the top of the carton that exceed more than half of the area of the cover, the term encapsulated does not apply.

The term encapsulated does not apply to plastic-enclosed products or packages inside a large, non-plastic, enclosed container.

In addition, plastic storage is further classified as expanded or unexpanded. Expanded plastics are generally a low-density product and are commonly called foam plastics such as polystyrene foam coffee cups, polystyrene foam packaging material, and polyethylene and polypropylene foam packaging material. Unexpanded plastics are a solid high-density product such as polyethylene film, polystyrene toys, polyester and polystyrene plastic tote bins, and polyethylene 55 gallon (209 l) drums or smaller.

STORAGE CONFIGURATION

Generally speaking, storage arrangements include bulk storage, solid piling, palletized pile storage, shelf storage and rack storage. The differences among the five arrangements that affect the behavior of fire and the difficulty of fire control are in the flues; i.e., horizontal and vertical air spaces created by the storage configurations.[3]

- **BULK STORAGE** consists of piles of unpackaged material in loose, free-flowing condition, such as powder, granules, pellets or flakes – such materials as can be found in silos, bins, tanks or in large piles on the floor of storage buildings.

- **SOLID PILING** consists of cartons, boxes, bales, bags, etc., in direct contact with each other.

- **PALLETIZED STORAGE** consists of unit loads placed on pallets.

- **SHELF STORAGE** consists of items on a structure where solid shelves are less than 30-inches deep, measured from aisle to aisle and usually less than 2 feet apart vertically.

- **RACK STORAGE** FM Global Data Sheet 8-9 *(Storage of Class 1, 2, 3, 4 and Plastic Commodities)* defines rack storage as storage in racks that use combinations of vertical, horizontal and diagonal members, with or without solid shelves, to support stored material. Racks may be fixed-in-place or portable. Loading may be either conducted manually by using lift trucks, stacker cranes or hand placement, or automatically by using machine-controlled storage and retrieval systems. Typical rack storage configurations include:
  - Open-frame single-row rack
  - Open-frame double-row racks
  - Double-row racks with solid shelves
  - Double-row racks with slatted shelves
  - Automatic storage rack
  - Multiple-row rack
  - Flow-through pallet rack
  - Drive-in rack, two or more pallets deep
  - Flow-through and portable racks
  - Cantilever rack

Care should be taken to avoid water damage to any items stored directly on the floor of a building. The use of pallets may help.

Furthermore, Data Sheet 8-9 classifies flue spaces as the spaces between rows of storage. In rack storage, the longitudinal flue spaces are perpendicular to the direction of loading, and transverse flue spaces are parallel to the direction of loading. Flue spaces that are less than a net 3 in. (75 mm) wide are not considered flue spaces for fire protection purposes. In addition, any space between rows of storage that exceeds 24 in. (600 mm) horizontally is considered an aisle for fire protection design purposes. In solid-piled and palletized storage, flue spaces may run in either direction.

FIRE PROTECTION DESIGN CHALLENGES

When designing the fire protection system(s) for warehouse-type occupancy, in addition to commodity classification and storage configuration, there are many other variables

to consider, such as storage height versus building height, aisle width, and specific design features of automatic sprinkler systems (including temperature rating, orifice size, response time and in-rack sprinklers).

STORAGE HEIGHT VS. BUILDING HEIGHT

"Other than the fire properties of the commodities themselves, probably no other condition has a more profound influence on the progress of fire in a storage occupancy and on the difficulty of fire control than storage height."[4] Rack storage to heights of 40 feet or higher in buildings with ceiling or roof height of 45 feet or above is common. One can also find automated storage and retrieval systems which use computer-controlled robots for material handling operations to be as tall as 100-feet with very narrow aisles!

NFPA 13, *Installation of Sprinkler Systems*, defines **clearance** as the distance from the top of storage to the ceiling sprinkler deflectors. Generally speaking, 18 to 36-inches is the amount of space necessary to allow the spray pattern to develop and provide an effective distribution pattern. Conversely, excessive clearance from the top of storage to sprinkler deflectors will prevent the spray pattern from reaching the hazard.

AISLE WIDTH

Aisle width is determined by the horizontal distance between the faces of the storage in the racks. Aisles are usually four to eight feet wide, and the aisles allow for water from the ceiling sprinklers to reach a fire, help keep a fire from jumping from rack to rack and provide egress for firefighters and their equipment.

SPRINKLER SYSTEMS

Many different models and styles of automatic sprinklers are available. It is critical that the type of sprinkler head you select is approved by a nationally recognized testing agency and installed for the specific application.

Sprinklers are divided into two categories based on the mechanisms by which they are designed to attack a fire. **Control mode** sprinklers rely on cooling and pre-wetting, allowing the fire to continue to burn in the area of ignition while controlling roof and ceiling temperatures and preventing fire spread until firefighters arrive or the fuel is consumed and the fire goes out. These types of sprinklers are characterized by a relatively large area of operation (e.g., 15-50 sprinklers). **Suppression mode** or **Early Suppression Fast Response** (ESFR) sprinklers rely on penetration to stop fire growth quickly and drastically reduce heat release. Usually six or fewer of this type of sprinkler is required.[5]

Section 3.6.1 in NFPA 13 outlines the characteristics of a sprinkler that define its ability to control or extinguish a fire.

a. **THERMAL SENSITIVITY** A measure of the speed with which the thermal element operates as installed in a specific sprinkler or sprinkler assembly. One measure of thermal sensitivity is the response time index (RTI) as measured under standardized test conditions.

b. **TEMPERATURE RATING** Usually ranges from 165° F to 286° F.

c. **ORIFICE SIZE** The opening through which the water flows depending on the amount of water (density) needed to protect the occupancy. They can range from one-half-inch to as much as one inch in diameter.

d. **INSTALLATION ORIENTATION** Sidewall, pendent and upright.

e. **WATER DISTRIBUTION CHARACTERISTICS** Application rate, discharge pattern.

f. **SPECIAL SERVICE CONDITIONS** Dry sprinklers, corrosion resistant, rack storage sprinklers.

As stated in FM Global Data Sheet 8-9, in-rack storage sprinklers are sprinklers typically having a K-factor[10] of K5.6 (K80), K8.0 (K115) or K11.2 (K160) and are non-storage sprinklers equipped with an attached water shield over the top of the thermal

sensing element. The water shield prevents wetting of the thermal sensing element by water from sprinklers at a higher elevation in the rack or at ceiling level. **NOTE:** the water shield is not a heat collector and has virtually no effect on how fast the in-rack sprinkler will operate.

In-rack sprinklers are classified as either longitudinal in-rack sprinklers or face in-rack sprinklers. Both types of sprinklers are meant to be located within the transverse flue spaces of the storage array and positioned so that water can be delivered into the flue spaces they are intended to protect. If in-rack sprinklers are not located at every transverse flue space intersection, then the in-rack sprinklers must also be positioned such that they can discharge water across the top of any storage at the level the in-rack sprinklers are provided. Longitudinal in-rack sprinklers are located within the longitudinal flue spaces of a double-row or multiple-row rack, or down the middle of a single-row rack. Face in-rack sprinklers are located within the rack storage array at transverse flue spaces no more than 18 in. (450 mm) horizontally from the face of the rack. Both longitudinal and face in-rack sprinklers need to be positioned within 3 in. (75 mm) horizontally of their designated transverse flue space intersection.

Longitudinal in-rack sprinklers help prevent horizontal fire spread down the length of the rack. Face in-rack sprinklers help prevent horizontal fire spread down the length of the rack as well as provide a water curtain between two adjacent racks to hinder fire jump across the aisle.

The factors determining whether or not in-rack sprinklers are needed are usually the storage height and/or the solid shelving in the rack structure. Solid Shelving is fixed-in-place, solid, slatted (fixed or non-fixed), grated (less than 70% open), or other types of shelves located within racks. Solid shelving can promote horizontal fire spread and negatively impact the amount of sprinkler water that can reach the entire vertical height of the rack.

Water Supply Finally, as with any sprinkler system, it is imperative that an adequate and reliable water supply is in place to ensure that design requirements are met for ceiling sprinklers, in-rack sprinklers, hydrants, standpipes and hose systems. In the case of suppression mode sprinklers, it is not uncommon for water supply requirements to exceed 1,500 gallons per minute. A booster fire pump as well as a redundant or supplemental water supply is often required.

BUILDING CONSTRUCTION

Buildings used for both manufacturing and warehousing/distribution should have a good barrier wall (preferably a bona fide fire wall) between these components. The goal is to limit the spread of smoke and fire to other areas within a structure, a concept called compartmentation. It is crucial that any penetrations within these walls are fire stopped at all times to limit the spread of smoke and fire. Furthermore, steel columns within storage racks over 15 feet high in which there are no in-rack enclosed sprinklers need to be fireproofed,

protected by one or two sidewall sprinklers or under high-density ceiling sprinklers.[6] However, this may not be needed with ESFR or other special application sprinklers.

HAZARDS

Assuming that all fixed protection is designed, installed and maintained in proper fashion, as with any occupancy, there are several additional hazards unique to warehouses, distribution centers and big box retail establishments.

INDUSTRIAL LIFT TRUCKS

In most cases, material handling systems, such as industrial lift trucks, are used extensively throughout the facility. LP-Gas-powered forklifts are common, making precautions regarding the use and storage of LP-Gas tanks necessary. LP-Gas vapors are heavier than air and tend to collect in low floor areas. Special precautions might be needed if they are used or stored in a concentrated area (such as explosion-proof electrical equipment or used in an area where other heat/ignition sources are present). When battery-powered lift trucks are in use, special attention must be given to the battery charging area. Due to the fumes that may be released from gassing batteries during charging, this area may need ventilation, gas detection, as well as explosion-proof electrical equipment.

Combustible storage should be located away from the battery charging stations by a minimum separation distance of five feet. In addition, battery charging stations are not recommended within rack storage areas.

HIGH INTENSITY DISCHARGE (HID) LIGHTING SYSTEMS

Lighting systems utilizing HID lamps have existed for several years and are widely used in warehouse occupancies. Although commonly recognized as a safe means of providing high quality lighting, one type of HID lighting is suspected of being the source of ignition for several major fires. The three main types of HID lamps are metal halide lamps, mercury vapor lamps and high-pressure sodium lamps. These systems are typically found in newer facilities or as part of a refurbishment program at older facilities. Such systems appear to be most appropriate for the more open settings found in occupancies with high ceilings, but may certainly be found in other applications.

Metal halide lights consist of an assembly of a conical outer fixture housing, a replaceable bulb (lamp) within the fixture and, in most designs, a fixture lens cover or light diffuser. Some fixtures are approved for use with a specifically designed lamp that may not require the lens cover/diffuser. Otherwise, the lens cover/diffuser is constructed of such materials as tempered glass or high temperature, high impact plastic that will contain the fragments of a ruptured arc tube (filament) within the bulb, which would be part of the lamp. The normal pressure within a metal halide lamp can reach 70 psi and interior temperatures can be over 1,000° C (1,832° F). Sudden internal failure can cause lamp rupturing and result in the forceful spraying of hot fragments into the general area below the fixture. These hot fragments are capable of igniting any combustibles within the area. The hot fragments can fall within the storage and generate a fire some time later. When replacing lamps, use Type "O" lamps in open fixtures which are a shielded lamp that may prevent an inner arc tube rupture from spewing hot metal and glass. *If possible, install HID lights over aisle spaces and not over storage areas.*

PALLET STORAGE

Proper protection regarding the use and storage of wood and plastic pallets is essential. Based on fire tests, pallets are divided into two groups for determining the level of protection needed for their storage.

Group I

1. Wood pallets with slatted and/or solid top and/or bottom

2. Pallets made of combinations of solid sheets of corrugated paperboard, separated by either polystyrene blocks of short rolls of corrugated paperboard edge

3. Non-expanded, high-density polyethylene pallets with solid deck

4. Approved plastic pallets

Group II
All other plastic pallets.

Since pallets in **Group I** are a lesser fire hazard than those in Group II, their storage is permitted in the following areas:

1. A cut-off room located anywhere in the building

2. Any storage area with no cut-offs between pallet storage and other storages (storage in such areas should be limited to a maximum height of 20 ft (6.0 m))

Group II Pallets
The locations, in order of preference, for idle plastic pallet storage are:

1. Outdoors, a safe distance from important buildings

2. A detached low value building at least 20 ft. (6.0 m) from important buildings

3. A cut-off room located along the exterior wall and outside of the building

4. A cut-off room located along the exterior wall and inside of the building
5. A non-cut-off area (4 ft. (1.2 m) maximum storage height)

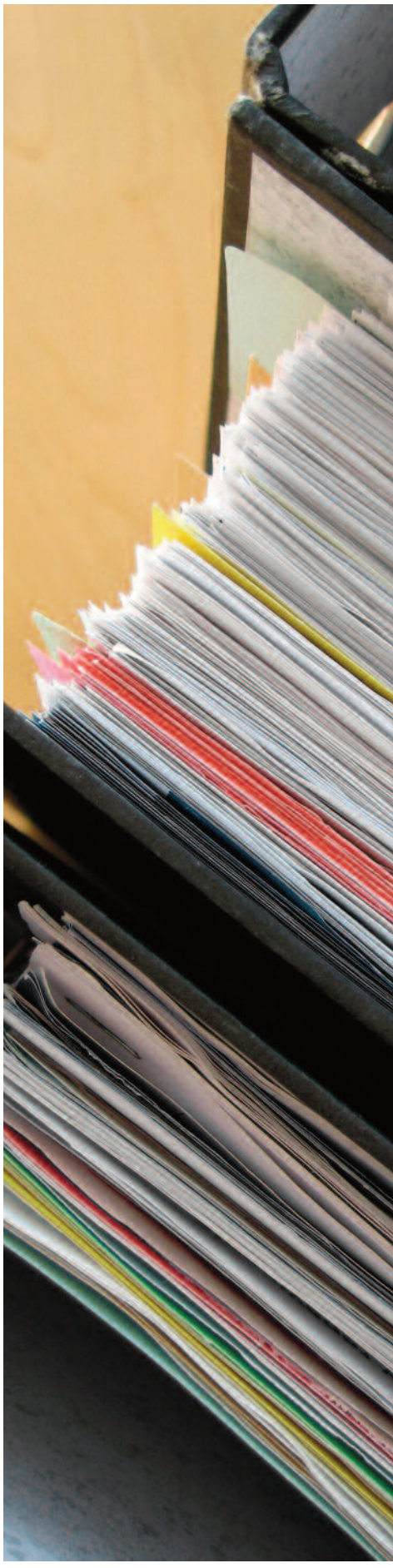
For indoor pallet storage, specific sprinkler design and storage requirements are needed in order to provide adequate protection.

If pallets must be stored indoors, they should be kept no higher than 6 ft., stored in piles not exceeding four stacks and in piles separated by a distance of 8 ft. from one another or by 25 ft. of commodity. Idle pallet height also depends on the sprinkler design.

MULTI-TENANTED FACILITIES
Off-site and third-party warehousing are commonly used to accommodate spillover storage and for distribution purposes. Although these facilities offer operational flexibility, this is often at the cost of accepting lower fire prevention and control standards. Furthermore, products may be stored adjacent to your storage which may be higher hazard or non-compatible products significantly increasing exposure to a serious fire, which is often not evaluated.

All third-party warehousing contracts should specify standards of both fire prevention and control that are in place and utilized. You should undertake regular audits to ensure standards are maintained.

SPECIAL HAZARDS
Items such as rubber tires, rolled paper, carpet, baled fibers, hazardous materials and other commodities require particular attention. Because of their unique



burning characteristics and storage arrangements, protecting these items is especially challenging. For example, on more than one occasion, fires have occurred resulting in total destruction of the warehouse due to the presence of aerosols. This has led to special protection requirements, including the storage of these items in a segregated and fenced-in area within a structure.

Flammable or combustible liquids, oxidizers, and other chemicals or hazardous materials may be located in a warehouse or storage environment as well. These products may be kept in metal, plastic and fiber drums, small pales, 55-gallon drums or bulk containers. Depending on the hazard involved, a dedicated storage area may be required which could include the need for drainage in the event of a spill or leak, ventilation and enhanced fire protection systems.

COLD STORAGE WAREHOUSES

Cold storage warehouses are used primarily for long-term storage of food products at temperatures that reduce the chances of spoilage. Other products such as medicine and chemicals may also require refrigeration and humidity control. Depending on the products, temperatures may range from -35° F to 65° F.

Polyurethane and polystyrene foam are two common insulation materials used to aid in maintaining cold temperatures. When used in walls or ceilings, these materials should be protected by an approved thermal barrier or by a half-inch coat of cement plaster on metal lath attached to the building framing. For polystyrene, the barrier also may be either half-inch Type X gypsum wallboard or three-quarter-inch fire-retardant plywood supported by studs or furring attached to the framing.[7]

A cold storage warehouse should be protected by an automatic sprinkler system. However, for this particular occupancy, the sprinkler system must be designed not to freeze. In chill rooms and coolers, preaction type sprinkler systems are preferred over dry-pipe systems. In freezers, systems should combine deluge and dry pipe systems. In this case, a combination dry-pipe valve and deluge valve replaces the usual wet-pipe sprinkler system.

The systems should be designed to be easily inspected and disassembled for the removal of ice plugs. According to FM Global Data Sheet 8-29, Refrigerated Storage, ice plugs can form rapidly inside piping systems in freezers unless proper precautions are taken to prevent them. When warm air enters the freezer and rapidly cools, moisture present in the air condenses and accumulates in the interior of the piping. To locate ice plugs, the traditional method has been to disassemble the piping and visually inspect for internal ice formation. The use of tees and caps will help assist in disassembling the pipe. When inspecting for ice plugs you need to look on both sides of the freezer wall starting on the warm side and continuing to a point beyond where the sprinkler pipe is insulated. The piping also can be inspected using ultrasound technology without the need for disassembling the piping system. To remove ice plugs, piping should be disassembled and brought to a warm area to thaw. If ice plugs are small they can be broken up by hammering and then removed from the pipe. Heating the pipe with a torch or open flame is not suggested.

The installation of regenerative air dryers capable of reducing the pressure dew point to at least 20°F (-6.7°C) below the lowest freezer temperature will help reduce the potential for ice plugs. Existing regenerative air dryers should be checked for proper operation and for discolored desiccant (drying agent). Bypass valves around the air dryers should be sealed closed.

METAL BUILDING SYSTEMS

A Metal Building System (also known as Pre-engineered Buildings) is defined by the Metal Building Manufacturers Association as “a complete integrated set of mutually dependent components and assemblies that form a building. It includes the primary and secondary framing, covering, and accessories, all of which are manufactured to permit

inspection on site prior to assembly or erection." These buildings can be totally comprised of steel, or their appearance can be enhanced, completely or partially, by the use of other cladding materials, such as masonry, EIFS[8], pre-cast, cast-in-place, or tilt-up concrete wall systems.

Many of these buildings utilize standing/lap seam roof coverings. The standing/lap seam roof cover generally consists of 22, 24 or 26-gage exterior metal sheets or panels, field seamed to adjacent sheets by a special roll-forming machine to create an upstanding seam (rib) of folded metal along the sheet sidelaps. This folded sidelap is secured by a panel clip which contains metal tabs roll-formed into the panel seam. The heavy gage clip is secured to the building's structural framework.[9] This light gage roof cover is highly susceptible to wind damage if not properly secured and to collapse due to excessive weight from heavy snowfall or roof mounted equipment.

HIGH-VOLUME LOW-SPEED (HVLS) FANS

The use of HVLS fans in warehouses has significantly grown in popularity over the past few years. However, research indicates that these fans may cause inadequate sprinkler system performance.

These fans are widely used in the summertime since HVLS fans "cool" by increasing the rate at which perspiration is evaporated from the skin's surface. In some cases, fans make the surrounding area feel between 8 - 16° F cooler. In the winter time, HVLS fans distribute the heat trapped at the ceiling down to the floor, letting the heating system cycle less frequently, significantly reducing heating bills.

Several live fire tests were conducted in conjunction with the Property Insurance Research Group (PIRG) and were directed through the National Fire Protection (NFPA) Fire Protection Research Foundation. The PIRG is comprised of several insurance companies which gather knowledge for issues regarding the property insurance industry. Based on the completed fire tests, the following is suggested:

A means should be provided to automatically shut down the power to the HVLS fan within 90 seconds after the first sprinkler operates. To achieve this, smoke detectors, heat detectors and water flow alarm devices are acceptable.

PREMISES SECURITY

In addition to burglar alarms, closed circuit television (CCTV) and on-site watch services, there are several other protection schemes available to protect the building and its contents from burglary, theft, arson and civil disturbance.

Adequate exterior lighting is critical, especially on either sides of fences and at all building entrances. Windows that can be easily entered at ground level should be locked or boarded up altogether. Fences should be even with the ground and tall enough to prevent people from climbing over. Yard storage should be adequately protected or kept to a minimum and trailers that are stored on site with merchandise or material in them should be provided with king pin locks. These locks cover semi-trailers' king pins preventing unauthorized coupling.

When businesses are affected by labor problems (strikes, layoffs, work stoppages) or civil unrest, the probability of an arson fire is significantly increased. For example, rioters in London apparently set Sony's Enfield-based DADC (Digital Audio Disc Corporation) facility ablaze, reducing the disc distribution center to flames and smoke. The massive multi-story, 20,000 square meter building would have likely contained stock tied to multiple mediums, ranging from music labels to video games to movies and more.

CONCLUSION

"Even with adequate fire control by sprinklers, manually fighting storage fires presents significant challenges. A well-planned fire protection system should simplify manual firefighting tasks. Automatic alarms to the fire department from operating sprinkler systems, as well as adequate hydrants, 24-hour emergency access, audible/visual indication of which sprinkler system is operating, and clear identification of sprinkler valves, hydrants, interior small-hose stations, and Siamese pumped connections, all contribute to successful fire-fighting operations. Pre-fire inspections and planning are also strongly recommended."[11]

Years of live fire testing and volumes of standards and guidelines have clearly proven the challenges involved with adequately protecting warehouses, distribution centers and big box establishments. With ongoing research, as well as continued changes in commodity classification, the importance of developing adequate protection schemes cannot be emphasized enough. Extensive consultation and plan review is needed before any work commences, whether it appears to be a simple change in storage configuration, a complete renovation or new construction. Willis looks forward to working with you to ensure these projects are properly designed.

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[1] Arthur E. Cote, P.E., et al., *Fire Protection Handbook, Seventeenth Edition* (Quincy: National Fire Protection Association, 1992), pp. 8-26.
[2] Ed Schultz, "Big Box Retail: A Building and Fire Code Perspective," *Fire Protection Engineering*, Winter 2006 (2006), pp. 42-44.
[3] Cote, op. cit., pp. 8-35.
[4] Cote, op. cit., pp. 8-38.
[5] James Golinveaux and Joe Hankins, "Meeting the Challenges of an Ever-Changing Storage Industry", *Fire Protection Engineering,* Winter 2006 (2006), pp. 32-40.
[6] Cote, op. cit., pp. 8-51.
[7] Cote, op. cit., pp. 8-53.
[8] EIFS (Exterior Insulation Finish System) is a system which uses sheets of expanded polystyrene or polyisocyanurate attached to the exterior of the buildings. The expanded plastic is covered by a material that looks and feels like concrete. EIFS can be installed over concrete blocks or panels, or on wood, gypsum board or metal panels. The insulation can be mechanically fastened, clipped or adhered with adhesive to the wall system. A reinforcing mesh (mostly polypropylene) is troweled into a base coat applied to the insulation board to add additional strength and to minimize damage to the assembly. A finish coat of either a thin portland cement or acrylic is applied over the base coat. The finish coat can be textured to look like concrete or stucco.
[9] *FMRC Approval Guide – Building Materials*, (Norwood: Factory Mutual Research Corporation, 1999), pp. 2-68.
[10] K-factor, also known as the discharge coefficient, is a numerical value representing the orifice size of the sprinkler in combination with the expected flow through the sprinkler orifice at a given pressure value.
[11] Arthur E. Cote, P.E., et al. *Fire Protection Handbook, Eighteenth Edition* (Quincy: National Fire Protection Association, 1997), pp. 9-131.