

High-Piled Combustible Storage Warehouses and Water-Based Fire Protection

By Assistant Chief Ronald R. Spadafora, Chief of Fire Prevention



Bush Terminal warehouses located in Brooklyn are large dimensional buildings with heavy fire loading.

Recent Fires

Warehouse fires are some of the most challenging blazes for FDNY members to extinguish. In April of 2016, a five-alarm fire in a Brooklyn cold storage, restaurant supplies warehouse, located at 640 Parkside Avenue in the Prospect-Lefferts Gardens section of Brooklyn, completely destroyed the building. A January 31, 2015, records storage fire, also in Brooklyn (5 North 11th Street, Williamsburg), near the East River, went to seven alarms, requiring more than 200 Firefighters employing both land and fireboat resources.

Commodity Classification

According to the Fire Code, high-piled combustible storage features ignitable materials arranged in a closely packed configuration on the floor of the occupancy or on pallets, in racks or on shelves, where the top of the storage area is greater than 12 feet in height. It also includes certain high-hazard commodities where the top of the storage area is greater than six feet. Stored materials are classified as Class I, Class II, Class III, Class IV or high-hazard. A generalized overview of these classifications follows.

Class I—noncombustible products on wooden or non-expanded polyethylene solid deck pallets, in single-layer, corrugated cartons or in ordinary paper wrappings. Class I commodities are allowed to contain a limited amount of Group A (heat of combustion much higher than ordinary combustibles and burning rate higher than Group B) plastics. Examples of Class I commodities include gypsum board, cement bags, ceramics, frozen foods, alcoholic beverages (less than or equal to 20 percent alcohol) and glass.

Examples of Group A plastics include natural rubber (foamed/expanded), polyethylene, polypropylene, polystyrene, polyurethane and polyvinyl chloride or PVC (plasticized to produce liners, film, packaging, wire and cable insulation jackets and many other products that require flexibility and resistance to tear, puncture and abrasion).

Examples of Group B plastics include cellulose acetate, natural rubber (non-expanded), nylon and more rigid forms of PVC.

Class II—includes Class I products in slatted wooden crates, solid wooden boxes or paperboard cartons with or without pallets. Class II commodities also are allowed to contain a limited amount of Group A plastics. Examples of Class II commodities include foods in combustible containers, alcoholic beverages (less than or equal to 20 percent alcohol) in combustible containers, incandescent or fluorescent lightbulbs in cartons and fine wire on reels or in cartons.

Class III—commodities of wood, paper, natural fiber cloth or Group C (heat of combustion and burning rate similar to ordinary combustibles) plastics with or without pallets. Group A plastics are limited. Examples of Class III commodities include aerosol products with a relatively low heat of combustion (Level 1), food in plastic containers, fertilizer bags, lumber, mattresses (excluding foam rubber and foam plastics), paints (oil base in metal cans) and plywood.

Examples of Group C plastics include cellulose acetate, natural rubber (non-expanded), nylon and rigid forms of PVC.

Class IV—are Class I, II or III products containing Group A plastics in ordinary corrugated (pleated) cartons and Class I, II and III commodities with Group A plastic packaging, with or without pallets. Free-flowing (thermoplastic) Group A plastics and Group B (heat of combustion and burning rate higher than ordinary combustibles, but not as high as those of Group A) plastics also are included in this classification. Examples of Class IV commodities include aerosol products with a relatively moderate heat of combustion (Level 2), materials made from combustible metals (solid), alcoholic beverages exceeding 20 percent, but less than 80 percent alcohol in cans or bottles in cartons, linoleum products, paints (oil base) in combustible containers and asphalt shingles.

High-hazard—are products that present special fire hazards be-

yond that of the other four classifications. Examples of high-hazard commodities include aerosol products with a relatively high heat of combustion (Level 3), alcoholic beverages exceeding 80 percent alcohol in bottles or cartons, lubricating or hydraulic fluid in plastic containers, foam rubber or foam plastic mattresses, idle (empty) combustible pallets, rubber tires and vegetable oil in plastic containers.

Note: Upon catching fire, aerosol containers can travel (rocket) long distances across a warehouse, igniting combustibles all along their path. Separation areas, chain-link fence enclosures, fire walls and supplemental automatic sprinkler protection may be required, commensurate with the number of containers being stored and chemical content. Moreover, hazardous materials (explosives, oxidizers, poisons and reactive substances, for example) will have additional fire prevention safety requirements per the Fire Code.

Fire Protection Design

Fires in storage buildings and occupancies present a unique challenge to fire protection engineers. They generate a tremendous amount of heat over a short period of time and spread rapidly. This is particularly true when the fire involves commodities, such as flammable and combustible liquids, paper products and plastics. Sprinkler systems are engineered to cover a particular commodity classification in a specific storage configuration. Using a different packaging material, rearranging stock within the racks, modifying the dimensions of the pallets or changing from metal to plastic pallets can increase the hazard classification and decrease the chances of the sprinkler system successfully controlling the fire. The Fire Code uses the combination of commodity hazard classifications, size of storage area (square footage), maximum storage height, material handling methods and storage configurations to determine sprinkler density, as well as aisle widths, building access for the fire service, smoke and heat removal systems, draft curtains and fire walls.

High-pile storage arrangements require uniquely designed fire protection systems since the materials are maximally exposed to fire, allowing for the greatest amount of heat transfer. It is essential that sprinkler systems conform to the facility's stacking and racking patterns. Automatic sprinkler research and development during the past 150 years have upgraded ceiling-level sprinkler systems where they now can protect stored materials under ceilings as high as 45 feet. Higher than 45 feet, sprinkler manufacturing companies acknowledge the limitations relating to solely utilizing ceiling-level sprinkler protection, necessitating the use of in-rack sprinklers. Improvements in response times, the increase in size of the sprinkler head orifice and deflector design are just a few of the enhancements. In-rack sprinklers typically are needed, howev-



Commodities stacked on wooden pallets (foreground) and metal rack storage in the rear.

er, when the water penetration from ceiling-level sprinklers to the base of the storage array is impeded by solid shelving or requires a significant period of time, which is often the case for high-storage arrangements. An in-rack sprinkler head will operate at 30 gpm. As a general rule, storage should be maintained at least 18 inches below sprinkler head deflectors or 24 inches below the ceiling (for buildings without sprinklers).

In-rack sprinklers typically will reduce the risk of life loss, contain the fire to a localized area, limit fire damage and lessen facility downtime. They are modular in design. If the storage capacity of a warehouse is increased and expanded, the system can be extended to cover the additional stock. Conventional ceiling-mounted fire protection sprinklers, on the other hand, necessitate a custom design and, therefore, expansion could require reconstructing the entire system. In-rack fire suppression systems also are used in mechanized (automated) structures controlled by a computer for loading and removing material. Fires originating in the middle of a rack can be controlled prior to the fire spreading to surrounding materials on other shelves or adjacent racks.

In-rack sprinkler system installations are becoming more popular as the cost factor is lowered. This has come about through the work of FM Global (formerly Factory Mutual Insurance Company), a Rhode Island-based mutual insurance company that specializes in loss prevention services through engineering analysis. FM Global conducted a three-year, in-rack sprinkler research project beginning in 2011. During this time, officials performed small-, intermediate- and full-scale fire tests, strategically coupled with computer modeling, to help identify potential protection solutions. This approach demonstrated that by using larger orifice sprinkler heads and higher water flow rates, the number of in-rack sprinklers needed for an installation and the water capacity requirements could be greatly reduced.

ESFR Sprinkler Systems

In the 1980s, ESFR (Early Suppression, Fast Response) sprinkler systems were developed as a viable alternative to in-rack systems or supplemental fire protection system, depending on ceiling height, storage configurations and building construction. Unlike conventional sprinkler systems that are designed only to control a fire, ESFR fire protection is intended to extinguish a fire. A typical ESFR sprinkler head will discharge 100 gpm. This is two to three times the amount of water from a conventional sprinkler head. ESFR heads also emit larger droplets of water than conventional



In-rack sprinkler protection.



ESFR (Early Suppression, Fast Response) sprinkler system installed at ceiling level.

sprinklers. This feature gives the water greater momentum, allowing it to reach the seat of the fire. In general, ESFR systems can be used in warehouses with storage that do not exceed 40 feet in overall height and with a ceiling height of less than 45 feet. There are, however, sprinkler system protection schemes that will allow storage above these heights when a combination of ESFR with in-rack sprinklers are installed.

ESFR systems are designed to protect a wide array of commodities. This provides more flexibility in warehouse operations when compared to conventional sprinkler systems. If the warehouse requires in-rack sprinklers to be installed in conjunction with conventional sprinklers, building owners may choose (depending upon Code requirements) to change their conventional system to ESFR, thereby eliminating the need for the in-rack system. Advantages include removing the worry about damaging in-rack sprinkler heads during normal storage operations and the likelihood of having to remove or replace in-rack sprinklers with each new tenant.

Summary

Codes are designed to achieve a minimum level of safety for building occupants, as well as protect property from fire. In general, fire inspectors are watching for housekeeping-type hazards (accumulation of debris/rubbish, locked/blocked exits, blocked aisles, damaged sprinkler heads and piping, malfunctioning exit lights, fire

DEFINITIONS

Commodity—A combination of products, packing materials and containers.

Draft curtain—A structure arranged to limit the spread of smoke and heat along the underside of the ceiling or roof.

Expanded plastics—Manufactured using a foaming process that creates tiny bubbles inside the plastic. Much lower in density than unexpanded plastics and, therefore, have a higher heat release rate.

Fire wall—A fire-resistant barrier used to passively prevent the spread of fire and subdivide a building into separated fire areas. Fire walls also are built between or through buildings.

Heat of combustion—Total energy released as heat when a substance undergoes complete combustion with oxygen under standard conditions.

Pallet—A flat structure that supports commodities in a stable fashion while being lifted by a forklift, pallet jack, front loader or crane. Commonly constructed of wood; also can be made of plastic, metal and recycled materials.

Plasticized—Additive (most commonly esters) process used in PVC applications, giving this material improved flexibility and durability.

Solid shelving—Dense design that obstructs sprinkler discharge into the racks.

Thermoplastic—A plastic polymer that when heated, will melt into a liquid. In a fire situation, thermoplastics readily can feed and spread the blaze once ignited. Polyethylene is a type of polymer that is thermoplastic.

Unexpanded plastics—High-density materials formed into different shapes and configurations.

extinguishers missing or improperly maintained, etc.). Researching commodity classifications in the Fire Code and/or working with a fire protection engineer at the Bureau of Fire Prevention will assist the fire inspector on a subsequent visit in evaluating the hazard classifications of commodities stored, as well as verifying the engineering specifications of the sprinkler system. The goal should be to accurately determine the level of fire protection a storage warehouse requires.

References

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About the Author

Assistant Chief Ronald R. Spadafora has served the FDNY since 1978. He is the Chief of Fire Prevention. He holds a Master's degree in Criminal Justice from LIU-C.W. Post Center, a BS degree in Fire Science from CUNY-John Jay College and a BA degree in Health Education from CUNY-Queens College. He is an Editorial Advisor and regular contributor to *WNYF*.