INSTALLATION OF SPRINKLER SYSTEMS

INTRODUCTION

National Fire Protection Association (NFPA) documents describe a level of fire protection agreed on by persons representing a variety of interests working in a volunteer consensus-based committee. The guidance in these documents typically does not reflect unique conditions or special considerations, such as system performance under adverse conditions. Nor does NFPA guidance reflect the increased system reliability that AXA XL Risk Consulting recommends for high-valued business-critical properties. AXA XL Risk Consulting and its predecessors have been a member of this committee since its inception in 1896 and are aware where additional guidance for high value property of business resilience is warranted.

This PRC Guideline takes a position on provisions of NFPA 13 that AXA XL Risk Consulting believes require clarification or changed protection. To understand these positions, this document should be read in conjunction with the associated NFPA documents. The provisions of NFPA documents are not repeated.

Also protect storage occupancies covered by NFPA 13 in accordance with PRC.10 series documents. Some general storage protection requirements are also covered in NFPA 1. The use of FM Global Data Sheets is an acceptable option except as outlined herein.

While NFPA 13 generally does not apply to facilities and equipment prior to the effective date of the version, it is AXA XL Risk Consulting position that in many cases new technology, testing, research, and/or real-world performance statistics provide data indicating prior versions may not provide acceptable protection. AXA XL Risk Consulting typically defaults to the most current version of a standard for analysis. This is especially true if revisions in a newer standard have the potential to reduce risk or loss due to improved protection recommendations.

APPLICATION OF DEFINED TERMS

Quick Response (QR) Sprinkler

Do not use quick response sprinklers to protect areas where there is a potential for a fast-spreading fire (i.e. oil spray, flammable liquids, or lint dust) due to the possibility that too many sprinklers will operate, reducing the effectiveness of the protection system.

Closed VS Open Array

Consider a storage array to be an open array unless the arrangement is as described for the closed array fire tests described in NFPA 13, i.e., 6 in. (150 mm) or less longitudinal flues and no transverse flues, and the arrangement is consistently maintained throughout the warehouse.

Bin Box Storage

By NFPA definition, bin boxes cannot be constructed of plastic. Protect all shelf storage in boxes constructed of a Group A plastic as an exposed Group A plastic commodity. Bin box storage does not include open top tote boxes used for movement of commodities.

Pile Stability

Pile stability had a sizable effect on the ability of sprinklers to control the test fires. In some tests, early collapse of the pile resulted in control of the fire by very few sprinklers. In tests where the same or similar commodities did not collapse, a greater number of sprinklers operated. Consider all piling as stable unless testing has proven the commodity to be consistently unstable. In practice, unstable piles rarely exist because they can also collapse under ordinary storage conditions and pose a safety threat.

Solid Shelving

The definition states that shelves of wire mesh, slats or other materials more than 50 percent open and where the flue spaces are maintained shall be defined as open racks. This type of shelving can allow random storage with the potential to block transverse flues. Maintain all flues in order for mesh or slatted shelves to be treated as open shelves.

CLASSIFICATION OF OCCUPANCIES AND COMMODITIES

The use of exposed foamed plastics on interior or exterior walls, ceilings, or both was not anticipated in occupancy classifications and could make the provisions of this standard inadequate. These materials significantly increase fire loading and smoke generation. All plastic materials used in construction, finishes, and decorating should be considered in occupancy classification.

Light hazard design is not considered adequate for occupancies with combustible walls, partitions, or, ceiling assemblies. Structures with these features require a minimum protection system design equivalent to Ordinary Hazard (Group 1) Occupancy due to increased combustible loading.

Protection for occupancies beyond the scope of NFPA 13 can be found in other NFPA standards such as NFPA 30, NFPA 30B, NFPA 101 and NFPA 5000, as well as other PRC Guidelines.

Table 1 contains a list of occupancies where AXA XL Risk Consulting deems the hazard to higher than NFPA 13.

TABLE 1

Occupancies Where AXA XL Risk Consulting Deems The Hazard To Higher Than NFPA 13

Occupancy	NFPA 13 Category	AXA XL Risk Consulting Recommendation
Hospitals	Light Hazard	Only Patient Rooms are Light Hazard, the remainder is OH1
Office Buildings	Light Hazard	OH1 unless the fire load is unusually light
Museums	Light Hazard	OH1 unless the fire load is unusually light
Libraries (except large stack rooms	Light Hazard	OH1
Bakeries	OH1	OH2
Electronic Plants	OH1	OH2
Laundries	OH1	OH2
Wood Machining	OH2	EH1

Tables 2 and 3 contain lists of occupancies not currently addressed NFPA 13.

TABLE 2

Additional Ordinary Hazard Group 1 Occupancies Not Currently Addressed in NFPA 13

Abrasives Manufacturing
Airport Terminals
Aluminum Casting
Aluminum Machining
Alumina/Bauxite Refining
Boiler Houses
Brick or Tile Manufacturing
Bus Terminals
Cement or Plaster Manufacturing
Computer Rooms (Except tape processing and library areas)
Casting and refining
Electric Appliance Assembly (No or limited plastic parts)
Ice Manufacturing
Incandescent Lamp Manufacturing
Jewelry Manufacturing
Metal Plating (No plastics)
Mining Properties
Mirror Manufacturing
Optical Works
Parking Garages
Pottery Manufacturing
Shipyards (Steel hulls)
Slaughter Houses
Smelting
Steel Mill Roof Area, pickling/ galvanizing (Except oil cellars and rolling/stripping mills)
Stone Quarrying
Water Pumping Stations
Wineries

TABLE 3

ADDITIONAL ORDINARY HAZARD GROUP 2 OCCUPANCIES NOT CURRENTLY ADDRESSED IN NFPA 13

Acid Plants
Aircraft Assembly
Amusement (Game rooms)
Amusement Parks
Artificial Flowers (Plastic/ Synthetic) Manufacturing
Automobile Supply Stores
Bags, Luggage Manufacturing
Battery Manufacturing
Bowling
Broom Brush Manufacture
Cameras, Photo Equipment Assembly
Candy Manufacturing
Carpet Manufacturing
Casino Areas
Chemical Laboratories - Class B
Chemical Laboratories - Class C
Coffee Manufacturing
Computer Tape Process Area
Confectionery Plants
Copper, Tin, Zinc Operations
Engine Fabrication
Engraving
Fertilizers
Fiber Products
Flour Mills
Food Products
Fur Processing
Glove Leather Tanneries
Glue Manufacturing
Grain Terminals
Grist Mills
Grocery Stores
Gum Manufacturing
Hair Products Manufacturing (No aerosols)
Hardware Stores
Hat Manufacturing
Iron Fabrication
Knitting Operations
Lamp Shade Manufacturing
Linen Mills
Lithographing
Magnesium Fabrication
Mail Order Houses
Mattress Manufacturing (No foam plastics)
Metal Machining (Limited hydraulic fluids).
Metal Product Fabrication (Limited hydraulic fluids)
Metal Working (Limited hydraulic fluids)
Millinery Plants
Motion Picture Studios and Stages
Paper Coating (No flammables)
Radio and TV Studios
Research Laboratories
Rice Mills
Rope, Cordage, and Twine
Rug and Carpet Stores
Rug Manufacturing
Sales Rooms (Automotive)
Self-Service Stores
Semiconductor Plants
Shoe Accessories
Shoe Manufacturing
Shoe Stores
Silk Mills
Spice Processing
Starch Manufacturing
Steel Fabrication
Stock Storerooms (12 ft max.)
Sugar Processing
Synthetic Fiber Extrusion
Tanneries
Upper Leather Tanneries
Vehicle Assembly
Wallpaper
Waste, Batting Mills
Wool Scouring
Woolen Mills

Extra Hazard Occupancies

Protect areas containing machinery that uses combustible hydraulic fluid under pressure (except those listed as less flammable) for Extra Hazard (Group 1). Use a design area of at least 5000 ft² (465 m²) with 165°F (74°C) rated sprinklers. The area of application can be reduced to 3000 ft² (279 m²) when 286°F (140°C) rated sprinklers are used. See PRC.9.2.4

Table 4 contains a list of occupancies not currently addressed NFPA 13.

TABLE 4
Extra Hazard Occupancies

Additional Extra Hazard Group 1 Occupancies Not Currently Addressed In NFPA 13

Automobile Paint Shops
Bat Manufacturing
Blending (Combustible liquids)
Box Manufacturing (Wood)
Candle Manufacturing
Carding
Casket Mfg.
Chemical Laboratories - Class A
Computer Tape Libraries - Less than 6 ft (1.8 m) in height
Cork Mfg.
Die Casting
Drug Manufacturing
Excelsior
Fiber Cutting
Flock Printing
Garneting
Heels, Lasts
Linoleum and Oil Cloth
Manufacturing using Combustible lubricating Oils (Including cold rolling, and PVC calendaring)
Match Manufacturing
Napping Operations
Paint Manufacturing (Latex)
Paint Shops
Particle Board Manufacturing
Picture Frames Manufacturing
Sash, Doors, and Blind
Shade Cloth Manufacturing
Soap Manufacturing
Synthetic Rubber
Tire Recapping and Repair
Toys (Wood)
Waste Recovery and Handling
Wood Flour

Additional Extra Hazard Group 2 Occupancies Not Currently Addressed In NFPA 13

Asphalt Plants
Boat Manufacture/Assembly (Wood and FRP)
Chemical Plants
Cottonseed Oil Plants
Essential Oil Plants
Flammable Liquids Handling
Oil Cellars
Oil Storage Rooms
Paint Manufacturing (Oil or solvent base)
Plastics Manufacturing
Refineries (Animal oil)
Refineries (Vegetable oil)
Rocket Fuel Manufacture
Solvent Extraction
Varnish Manufacturing
Waste Paper Recovery (Solvent de-inking)
Wax Manufacturing
Woodworker Finishing Rooms

Note: Foam-water systems will provide improved protection for many occupancies that handle flammable or combustible liquids.

Alphabetized Listing of Commodity Classes

NFPA 13 in the 2016 edition revised the commodity classification layout, added some products and removed some others that were previously included in the list. With ongoing testing of different products by various testing laboratories, this list will change.

AXA XL Risk Consulting has classified additional commodities, has clarified the type of plastics. or else does not agree with NFPA's classification on some commodities. It also clarifies which type of plastic to use when the commodity is classified as a plastic. Those differences are included here.

COMMODITY – form, packaging	COMMODITY CLASS OR REFERENCE
ALFALFA - bulk storage	Not Applicable (NOTE 1)
ASPHALTS (solid blocks in cartons)	Class IV
AUTOMOTIVE AIR BAGS in cartons	Cartoned Unexpanded Group A Plastics
BARLEY	
- bulk storage	Not Applicable (NOTE 1)
- packaged, in cartons	Class III
BARRELS	
Any size, empty	
- wood and fiberboard	Class II
- plastic	Exposed Unexpanded Group A Plastic
BOXES, CRATES	
- empty, wood, slatted	Same as Idle Wood Pallets (NOTE 2)
BUTTER - packaged in cartons	Class III
CANDLES (packaged, cartoned)	Cartoned Unexpanded Group A plastic
CARBON FIBERS - on wood spools in cartons	Class III
CARPETS	See PRC.10.2.2
CARTONS (empty, corrugated) plastic coated	Class IV
CHARCOAL (bagged) - quick light	Exposed Unexpanded Group A
COD LIVER OIL (bottled, cartoned)	Class IIIB Liquid
CORK (baled)	Class IV
CORN (bulk storage)	Not Applicable (NOTE 1)
CORN OIL (bottled, cartoned)	Class IIIB Liquid
COTTONSEED OIL (bottled, cartoned)	Class IIIB Liquid
DIAPERS - disposable with plastics and non woven fabric uncartoned but plastic wrapped	Exposed Unexpanded Group A plastic
DRUMS (see BARRELS)	
ELECTRONIC EQUIPMENT	Group A plastic (NOTE 3)
FIBERBOARD	Class III
FIRELOGS in cartons	Exposed Unexpanded Group A plastic
FLAVORING EXTRACTS up to 20% alcohol	
- glass containers, cartoned	Class I (NOTE 4)
- plastic containers, cartoned	Class III (NOTE 4)

COMMODITY – form, packaging	COMMODITY CLASS OR REFERENCE
FLOUR	
- bulk bags on pallets	Class II
- retail packaged, cartoned	Class III
FOAMED PLASTIC	See PRC.10.2.3
- Ametek Micro Foam	Class IV
GYPSUM WALLBOARD	Not Applicable (NOTE 1)
HAIRSPRAY (in pump containers) in Cartons	
- glass container and $\leq$ 50% alcohol	Class IV (NOTE 4)
- plastic container and $\leq$ 50% alcohol	Cartoned Unexpanded Group A plastic (NOTE 4)
- greater than 50% alcohol	Class I or II Liquid depending on the flash point.
HANGING GARMENTS	See PRC.10.2.5
INKS-Solvent based paste in metal cans	Class IIIB Liquid
KEVLAR	
- raw fibers	Class II
LARD (packaged, cartoned)	Class IIIB Liquid
LARD OIL (bottled, cartoned)	Class IIIB Liquid
LEATHER GOODS	Class III
LIQUOR - 100 proof or less,1 gal (3.8 L) or less, cartoned- glass (racked)	Class III (NOTE 4)
LINOLEUM PRODUCTS (See Vinyl Floor Coverings)	
MALT (bulk storage)	Not Applicable (NOTE 1)
MARGARINE	
- 50% oil, 50% aqueous solution or less in plastic tubs	Class III
- Over 80% oil (in any packaging)	Class III
MATCHES (packaged, cartoned) - wood	Cartoned Unexpanded Group A plastic
MATTRESSES - foam (in finished form)	Cartoned Expanded Group A plastic
MEAT, MEAT PRODUCTS- frozen, plastic trays	Class II
MENHADEN OIL (Pogy Oil)	
- bottled, cartoned	Class IIIB Liquid
MILK	
- waxed paper containers	Class II
- plastic containers	Class I
- containers in solid plastic crates	Exposed Unexpanded Group A plastic
- containers in open plastic crates	Class I
- empty laminated cardboard containers in cartons	Cartoned Unexpanded Group A plastic
NAIL POLISH 1 oz - 2 oz (29.6 ml - 59.1 ml) plastic bottles cartoned	Cartoned Unexpanded Group A plastic

COMMODITY – form, packaging	COMMODITY CLASS OR REFERENCE
NONWOVEN MATERIAL	
High Loft	
- finished goods, cartoned	Cartoned Expanded Group A plastic
- finished goods, exposed	See PRC.10.2.12
- rolls	See PRC.10.2.12
Fabric	
- cartoned, ≤ 10% synthetic fibers	Class III
- cartoned, ≤ 25% synthetic fibers	Class IV
- cartoned, > 25% synthetic fibers	Cartoned Unexpanded Group A plastic
- rolls	See PRC.10.2.12
Nuts (in plastic lined paper bags)	Class II
OATS (bulk)	Not Applicable (NOTE 1)
OILS	
Cooking, bottled, cartoned	Class IIIB Liquid
Motor	
- in plastic containers	Class IIIB Liquid
- in paper/metal containers in cartons	Class IIIB Liquid
Olive oil - bottled/canned, cartoned	Class IIIB Liquid
PAILS (See Barrels)	
PAINTS (friction top cans, cartoned)	
- water-based (latex)	Class III
- oil-based	Class IV
- lacquers, low flash solvents	See PRC.8.1.0
- waterborne < 20% solvents in plastic containers	Class III
PAPER, BALED (scrap paper)	Class IV
PAPER PRODUCTS	
- plastic coated paper, cartoned tissue products	Class IV
- tissue products, uncartoned and plastic wrapped	Exposed Unexpanded Group A Plastic
PERFUMES (See Hairspray)	
PET BOTTLES	(NOTE 5)
PHARMACEUTICALS	
(non-flamm. liquids) - plastic containers, cartoned	Class III
PHOTOGRAPHIC	
- paper & Polaroid film	Class III
- film, 35 mm in metal cartridges in polyethylene cans in cardboard boxes and rolls in polycarbonate plastic cassettes, bulk wrapped in cardboard boxes	Class IV
- motion picture or bulk rolls in metal cans in cartons	Class II

COMMODITY – form, packaging	COMMODITY CLASS OR REFERENCE
PLASTIC CONTAINERS (except PET)	
- noncombustible liquids or semiliquids (such as Ketchup) in plastic containers less than 5 gal (18.9 L) capacity in cartons	Class III
- noncombustible liquids or semiliquids (such as Ketchup) in plastic containers more than 5 gal (18.9 L) capacity in cartons	Cartoned Unexpanded Group A Plastic
- noncombustible powders in plastic containers less than 5 gal (18.9 L) capacity in cartons	Class IV
- noncombustible powders in plastic containers more than 5 gal (18.9 L) capacity in cartons	Cartoned Unexpanded Group A Plastic
POLYISOCYANURATE insulation board	Cartoned Unexpanded Group A plastic
- Celotex “Therm check”	Class IV
POLYVINYL ALCOHOL (PVA) resins	
- bagged	Class IV
POLYVINYL CHLORIDE (PVC)	
- bagged resins	Class III
- flexible (e.g., coated fabric) > 10% plasticizer	Exposed Unexpanded Group A plastics
- rigid (e.g., pipe, pipe fittings) < 2% plasticizer	Class III
- semi rigid - between 2 and 10% plasticizer	Class IV
POLYURETHANE FOAM	(NOTE 6)
POULTRY PRODUCTS	
- frozen, waxed paper containers	Class II
- frozen, plastic containers	Class III
PROPANE CYLINDERS	
- up to 2-1½ lb (1 kg) water capacity	Level 3 Aerosol
- greater 2-1½ lb (1 kg) water capacity	See NFPA 58 (NOTE 5)
PULP, WOOD (baled, rolled)	Class III
RECORDS, LP (packaged, cartoned)	Class IV
ROOFING PAPER (rolled, asphalt coated, fiberglass and impregnated felt)	
- horizontal storage	Class IV
- vertical storage	Stable Exposed Unexpanded Group A Plastic
SHINGLES - Owens Corning laminated fiberglass shingles	Class I
STARCH, in plastic bag	Class III
STRAW HATS (cartoned)	Class IV
SUGAR	
- raw bulk	See PRC.10.2.10
- bulk bags on pallets	Class II
- refined, retail packaged, cartoned	Class III
SYRUP	
- drummed	Class I
- barreled, wood	Class II

COMMODITY – form, packaging	COMMODITY CLASS OR REFERENCE
TOBACCO - hogsheads	Class II
VINYL COATED FABRIC	Unexpanded Group A plastic
WAX COATED paper; cups, plates	
- boxed or packaged inside cartons	Class IV
- loose inside large cartons	Cartoned Unexpanded Group A plastic
WOOD PRODUCTS	
- solid piles (irregular edges)	Class IV
- stuck lumber-(1 in, [25.4 mm] spacers)	See PRC.17.8.1
- stuck lumber-spaces in horizontal and vertical	Same as Idle Pallets (NOTE 2)
WOOL	
- baled	Class II

Note 1 Automatic sprinkler protection is not necessary to protect the commodity but will be necessary if it is stored in a combustible building.

Note 2 Treat as idle pallets.

Note 3 Check the amounts and types of plastic in product and packaging, could be Class III or Class IV.

Note 4 These commodity classifications are based on alcohol content. Testing is ongoing to determine the appropriate classification. Contact the Research Department for additional guidance.

Note 5 Full-scale tests of PET (polyethylene terephthalate or thermoplastic polyester) beverage bottles have indicated that PET can be protected as a Group B rather than Group A plastics. Exposed, empty PET bottles on paper slip sheets and wood pallets stored to a maximum height of 25 ft (7.6 m) in a maximum 30 ft (9.1 m) high building can be protected with a density of 0.25 gpm/ft² (10.2 L/min/m²) over the most hydraulically remote 2000 ft² (186 m²) area using 286°F (141°C) sprinklers.

Note 6 Store and protect foamed, flexible, open-cell polyurethane and foamed rubber in accordance with PRC.10.2.3. Testing has shown that foamed, flexible, open-cell polyurethane and foamed rubber cannot be protected by the methods outlined for Group A plastics.

Note 7 In-rack sprinklers must be installed where storage is over 15 ft (4.6 m).

SPRINKLER PIPING

Plastic Sprinkler Pipe

Several manufacturers have obtained UL listings for plastic piping systems made from chlorinated polyvinyl chloride (CPVC) materials. The materials:

- Are combustible;
- Are heat sensitive;
- Have less mechanical strength.

Listed plastic pipe may be used per the manufacturer's specifications but should also include the following requirements:

- Be limited to "dwelling units" and light hazard occupancies only. Do not use in storage rooms or other ordinary hazard areas incidental to the light hazard occupancy.
- Be limited to wet pipe systems installed on the interior of buildings only.
- Include pipe protection against fire exposure through gypsum board encasement or other means. UL listed CPVC pipe must be protected. This protection typically consists of ⅛ in. (9.5 mm) gypsum wallboard, ½ in. (12.5 mm) plywood soffits, or acoustical ceiling panels having a weight of not less than 0.35 psf (1.7 kg/m²) and classified as to fire resistance (see

UL product categories BYIT (Acoustical Material Ceiling Panels) and CIKV (Framing Members) on the UL Online Certifications Directory). Plastic fire sprinkler pipe must be framed and encased properly. CPVC sprinkler pipe may be installed in a plenum area when installed in accordance with the manufacturer's instructions and any listing restrictions.

Do not install the pipe in a combustible concealed space except where:

- Systems in soffits as outlined above.
- Systems in combustible concealed spaces protected by listed/approved Combustible Concealed Space Specific Application Sprinklers or equivalents, and piped with a CPVC piping system that has been specifically listed by UL for use in open wood truss interstitial concealed spaces. AXA XL Risk Consulting will accept the use of these sprinklers and CPVC piping system in combustible concealed spaces when designed and installed in accordance with the UL listing.

Do not penetrate fire rated walls, ceilings, or floor assemblies with a pipe unless the opening is protected with a listed firestopped assembly tested specifically for the piping involved.

Recognize that even when a fire has been successfully controlled, it is possible that some sections of piping may need replacement, i.e., leaks may develop.

Unexposed plastic sprinkler pipe will only be reviewed for acceptance in occupancies listed in this PRC Guideline as light hazard when all requirements and restrictions of the listing and this guide are satisfied.

Galvanized Steel Piping

Galvanized steel piping should not be used in wet pipe systems nor with foam additive systems. It can be used for trim such as the piping to a water-motor gong, test lines, etc.

There have been several explosions due to the reaction of water and the galvanized steel piping that created an explosive gas. These explosions have occurred while the sprinkler system was being tested.

Pipe Joining

Couplings And Unions

Couplings 2½ in. (65 mm) and larger are to be of the threaded, roll or cut groove, or welded flange type. Loss experience has shown that plain end couplings fail if the bolts are not properly torqued, resulting in significant water damage with the larger pipe sizes. Permit exceptions only for listed types where a visual inspection will verify proper installation, i.e., have breakaway lugs or other auto-torqueing feature.

Reducers And Bushings

Bushings are not be used to effect a change in pipe size merely as an expedient or because the installer may not have the proper fitting in stock.

Do not permit bushings where the reduction is less than ½ in. (15 mm) because the wall thickness of the bushing would then be so thin that it would weaken the system piping beyond safe limits.

Do not insert more than one bushing in an outlet at any time. For example, do not use one bushing to reduce from 2½ in. (65 mm) to 2 in. (50 mm) pipe, then a second bushing to reduce from 2 in. (50 mm) to 1½ in. (40 mm) pipe.

Threaded Pipe And Fittings Of Lightweight Pipe

UL classifies lightweight piping from several manufacturers as suitable for fabrication of sprinkler systems using threaded joints.

Careful thread cutting is important because there is less tolerance for imperfect threads. Poor threading procedures, dull dies, or out-of-round pipe may produce threads with reduced joint strength

or which may leak or have a drastically reduced service life. UL acknowledges this by requiring that threading requires the use of thread gauges conforming to the dimensions of ANSI B1.20.1.

When threaded lightweight pipe is used, each thread must be checked with a thread gauge. This is critical in areas subject to earthquakes, in systems with long drops to sprinklers, and in areas that are highly sensitive to water damage.

Welded Pipe And Fittings

The term “shop welded” means welded either on the sprinkler contractor’s own premises or in a properly supervised and safeguarded area on the facility site, sufficiently remote from the place of installation and located so as not to present any exposure hazard to important buildings. Prohibit on-site welding inside the buildings being protected; however, use of a properly arranged and protected welding shop is acceptable.

Sections of welded piping may consist of branch lines, cross and feed mains, or a combination of both. Make the size and configuration of the welded sections such that modifications, extensions, maintenance, or repairs may be accomplished without the use of cutting torches.

No “in-place” welding is permitted if fire sprinklers are out-of-service and combustible material or construction is present.

When sections of a sprinkler system are to be welded, the drawings are to clearly indicate the location of the welded fittings and include the make and model of all fittings used.

Welded piping is the preferred method of joining branch line piping in areas subject to earthquakes.

Razed And Soldered Joints

Brazing normally requires the use of open-flame techniques. Therefore, fabricate brazed joint tubing systems off-site with restrictions equivalent to those for welded systems. Prohibit open-flame brazing inside buildings that are being protected. The use of flameless resistance soldering tools for soldering joints is recommended. Adherence to hot work procedures is required.

Other Joining Comments

When sprinklers are installed in chemical facilities or similar sites with explosion hazards where a high degree of reliability is needed to meet loss prevention performance objectives, only the use of welded flanged fittings on lines over 2-½ in. (65 mm) should be permitted to limit the potential for damage. (See PRC.12.2.1.2.)

PROTECTION OF PIPING AGAINST FREEZING

Design sprinkler systems to prevent water filled piping from being exposed to freezing conditions. The use of insulation or other “reliable means” as allowed by this section is not recommended unless no other solution is available. Supervise heat-tracing systems, when installed, so that a system failure can be detected. Provide temperature supervision so that freezing or excessive heating can be detected.

PROTECTION OF PIPING AGAINST CORROSION

Although not required by this standard, AXA XL Risk Consulting recommends using Schedule 40 or heavier unthreaded pipe when such a corrosive condition may exist. Specialty pipe paints or coatings designed to resist corrosion are also recommended to prolong system service life.

UL has established that some specially listed piping products may have a corrosion resistance less than Schedule 40 pipe. The corrosion resistance ratio (CRR) is marked on each piece of pipe to alert users to its lower corrosion resistance.

Examples of occupancies where Schedule 40 pipe is recommended include some chemical plants, bleacheries, dye houses, metal plating plants, animal pens, areas of high humidity and any area containing corrosive vapors.

Piping in dry pipe systems is sometimes galvanized on the inside to inhibit corrosion and tuberculation. AXA XL Risk Consulting does not require internally galvanized piping in dry systems. Do not use internally galvanized pipe when temperatures can exceed 140°F (60°C). The combination of high heat and humidity can lead to accelerated corrosion of galvanized piping.

The requirement in the internal corrosion section to have a CRR of one or more is meant to recommend against the use of most thin wall products. Similarly, if schedule pipe is used, a minimum Schedule 30 pipe should be utilized. The thinner the pipe wall, the quicker pipe failure can occur. This should be considered when threadable thinwall pipe is utilized in such locations. Threading thinwall pipe creates relatively thin sections of pipe wall at the points where the threads are cut. Experience has shown that these are major areas of pipe failure for the reasons mentioned.

During installation, keep piping clean and clear of dirt, debris, sediment, and particulate matter. Particulate matter can carry bacteria that could establish microbial colonies and ultimately cause pinholes in steel pipe when filled with water after only a few years of service.

TYPES OF VALVES AND SPRINKLER INSTALLATION RULES

Dry Pipe Systems

Delivery Time Requirements

AXA XL Risk Consulting recommends all dry systems, regardless of volume, deliver sustained water flow to the inspector's test connection within 60 s of opening the inspector's test connection.

All systems in excess of 500 gal (1890 L) should be provided with a quick opening device.

Meeting required delivery times could be achieved by two methods:

New Systems - Limit the volume of the system to a size that will allow delivery of water within the required time or use a listed quick opening device (QOD), installed at the dry-pipe valve. QOD's (accelerators or exhausters) are normally listed by UL for systems with a capacity of not over 750 gal (2840 L). Devices used on systems with larger capacities may not operate as fast as originally intended.

When quick opening devices are used on systems with capacities in excess of 750 gal (2840 L), the speed of operation can be increased by enlarging the volume of the trapped air chamber of the QOD. This can be accomplished by installing a supplemental chamber, whose volume is determined by the following formula:

$$V = \frac{V_1 \times V_2}{V_3} - V_2$$

where:

$V =$ Minimum volume of the supplemental chamber in ft^3 (L)

$V_1 =$ Capacity of the new system in gal (L)

$V_2 =$ Trapped volume in the QOD in ft^3 (L)

$V_3 =$ Normal system capacity, 750 gal (2840 L)

To ensure that the QOD will operate satisfactorily, the supplemental chamber always has a volume greater than the minimum indicated by *V*.

Existing Systems – QOD's can be used, or flow control devices designed to function as exhausters may be installed, at the ends of cross mains or other locations when all of the following conditions are met:

- Listed devices are used.
- The devices are installed in locations readily accessible for inspection and maintenance.
- The building owner recognizes and accepts the responsibility for the increased maintenance these installations require.

Looped Dry Pipe Systems

Looped dry systems are not specifically prohibited, but AXA XL Risk Consulting does not recommend the use of looped dry pipe systems since a delay in sustained waterflow can also be expected with these systems as well. These can be considered if delivery time is proven by a listed hydraulics calculation program.

Location And Protection Of Dry Pipe Valves

Locate dry pipe valves in a heated room or closet and provide sufficient heat to prevent freezing.

Do not heat-trace dry pipe valves. The combination of heat tracing and insulation can lead to extremely high temperatures; i.e., 150°F (65°C) or higher, which could be difficult to detect. This may lead to rapid evaporation of the priming water and leave mineral deposits that could impair valve operation, or the heat could cause the rubber clapper facing to stick to the metal valve seat.

During cold weather, inspect dry pipe valve enclosures daily. When electronic supervision is provided, monitor the temperature of dry pipe valve enclosures and the air pressure on dry pipe valves.

Shop Air Supply

Do not use open connections to "shop air" to make up for system leakage unless the air system is connected through an acceptable automatic air maintenance device. Shop air systems usually have enough capacity to maintain system air pressure and prevent the dry valve from tripping even though a sprinkler may have operated.

System Air Pressure

The air pressure maintained on the dry valve is not to be greater than that needed to eliminate false trips of the valve, as recommended by the manufacturer. Excessive air pressure can cause damage to the valve clapper and can greatly increase time required to obtain a constant flow of water from operating sprinklers.

Preaction Systems

Supervision Of Preaction Systems

Supervise all preaction systems, not just those with 20 or more sprinklers.

Preaction System Configuration

Gridded double interlock preaction systems, like gridded dry systems, are not allowed due to the extended water delivery time caused by the activation of both a detection system and sprinklers before the system would be charged with water. This restriction does not apply to single interlock systems or non-interlock systems because the detection system will activate and charge the system with water reducing the time between sprinkler activation and water discharge.

Refrigerated Spaces

Do not install a control valve above a dry pipe valve to isolate the dry pipe valve from freezer piping. See PRC.12.0.2 for AXA XL Risk Consulting's recommendations concerning testing of dry pipe valves in areas constantly below freezing.

System Protection Area Limitations

When a sprinkler system riser supplies sprinklers on more than one floor, do not exceed the total building floor area protection limitations unless:

- Floor openings are protected as specified in the standard or by materials equivalent to the floor construction and
- The sprinklers on each floor are provided with a separate control valve.

Mezzanines In Protection Area

Treat large mezzanines of 5000 ft² (465 m²) or more as floors, and the floor area included when determining the total area covered by a single system.

Extended Coverage Sprinklers

Extended coverage (EC) sprinkler heads may be used to protect Light Hazard occupancies for building construction is either Type I or II as described in NFPA 220, and has noncombustible exterior walls, interior walls, interior finish, ceilings and partitions.

For Ordinary Hazard Occupancies EC sprinklers can be used subject to the following:

- Calculations are for a minimum of 9 operating sprinklers.
- Building heights are limited to a maximum of 30 ft (9.1 m).
- Consult with the AXA XL Risk Consulting's Account Consultant for the use of EC sprinklers in dry systems.

Obstructions At Or Near Ceiling

This section applies to both continuous and isolated obstructions that prevent development of the sprinkler pattern. With continuous obstructions (e.g., beam at ceiling), their width is easily determined. However, the obstruction potential of an isolated obstruction depends on its orientation and location relative to the sprinklers. An obstruction has an effect on the discharge pattern if it is within the sprinkler's area of operation. See Figure 1 for example of isolated obstruction at ceiling.

For isolated obstructions, use the following guidance if the criterion in NFPA 13 cannot be met.

- A sprinkler should be installed below an isolated obstruction if its width and length is 2 ft (0.6 m) or greater.
- A sprinkler is not required below an isolated obstruction affecting four sprinklers if its length or width is less than 2 ft (0.6 m) provided the distance from the centerline of the obstruction to the sprinklers does not exceed one-half the allowable distance (the ideal case is if the obstruction is centered between 4 sprinklers). See Figure 2.
- A sprinkler is not required below an isolated obstruction affecting two sprinklers if its dimension in the plane of the two sprinklers is less than 2 ft (0.6 m) provided the distance from the centerline of the obstruction to the sprinklers does not exceed one-half the allowable. See Figure 3 for unobstructed example and Figure 4 for obstructed example.

Figure 1: Isolated Obstruction

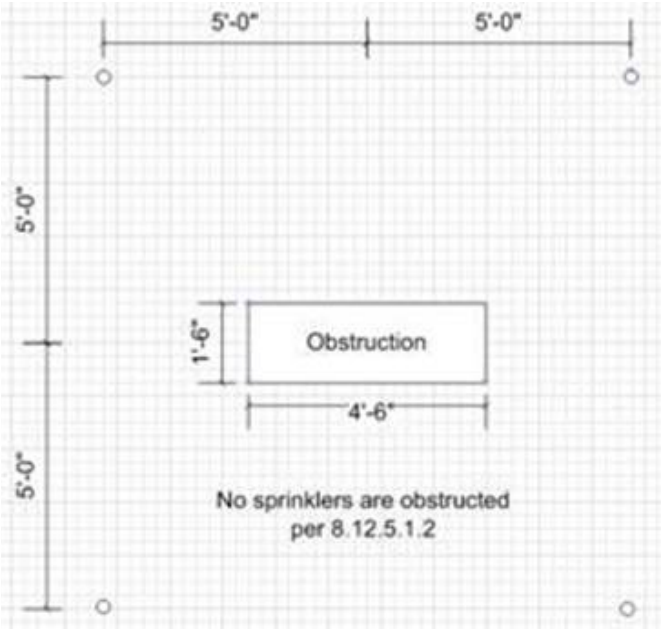

Figure 2: Obstruction Centered Between 4 Sprinklers

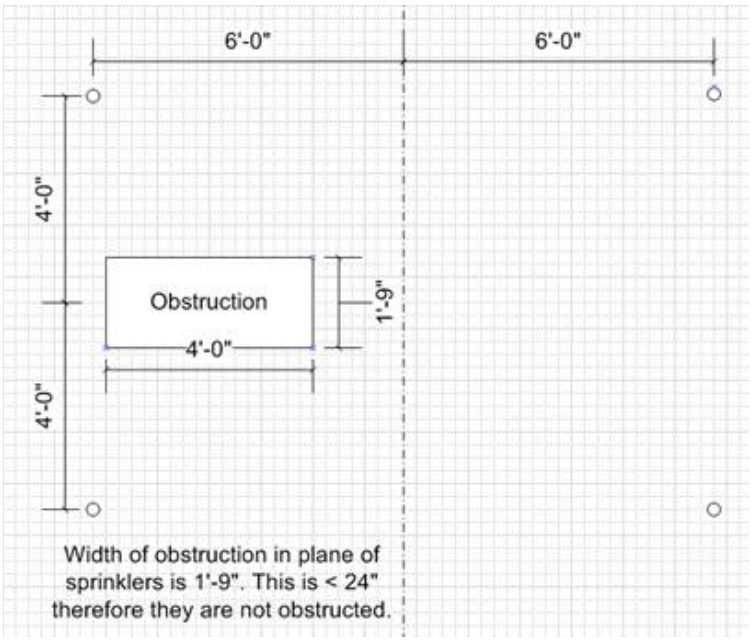

Figure 3: Unobstruction Sprinklers

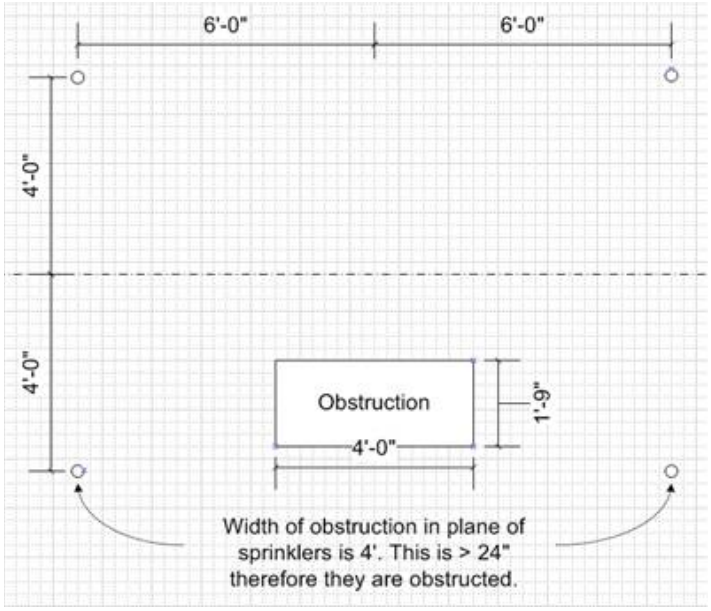

Figure 4: Obstruction Sprinklers

Concealed Spaces Requiring Sprinkler Protection

Protect all combustible concealed spaces with sprinklers.

The judicious use of fire stops and noncombustible insulation or both can eliminate the need for extending sprinklers into many concealed spaces.

The omissions allowed in NFPA 13 recognize the difficulty and expense of installing sprinklers in these areas, but do not consider the significance of fire spreading undetected and unchecked throughout the concealed space.

Provide sprinkler protection if the spaces formed by studs or framing members extend vertically more than 12 ft (3.7 m) or pass through a floor.

Spaces when the ceiling is directly attached to the wood joist and there is limited access do not require sprinklers

Testing has shown that standard spray upright and pendant sprinklers installed in accordance with the NFPA 13 do not perform well in shallow horizontal concealed spaces of combustible construction. Use only special sprinklers specifically listed for these shallow spaces in accordance with this section.

Control Valves

The potential water damage to contents due to accidental sprinkler system operation should be considered when determining which form of valve supervision is appropriate for a facility.

The decisions in this section should consider the potential risk of added water damage caused by a delay in closing a locked sprinkler system control valve where a key is not readily available. Restrict the use of hard shank locks to sites where prompt response to emergencies at all times is expected by full-time security, maintenance, and/or fire protection department. As an additional precaution, bolt cutters or other devices capable of quickly severing locks in emergency situations should be available to staff responsible for responding to related incidents such as broken sprinklers or severed pipes from forklifts.

Control Valves With Check Valves

Provide an accessible valve on the supply side of the check valve in addition to the one provided by the waterworks. The availability of this additional valve is desirable so that the connection can be shut off quickly in an emergency, particularly when the public water department cannot respond on short notice. Often the waterworks valve is useless because it has been paved over, or is temporarily inaccessible because it is located under a parked vehicle. In addition, with this valve installed, it will be possible to inspect, clean or repair the check valve without having to call the public water department.

Where the check valve is located inside of a building, install a wall-type indicator valve or a post indicator valve on the supply side.

Control Valve Accessibility

Provide access to control valves. It is common practice to locate public water supply control valves and other valves in frost proof pits with access provided through an access hole. Valve pits are subject to contamination from many sources. They also may contain an oxygen deficient atmosphere. As a result, valve pits are considered “confined spaces,” as defined by the Occupational Safety and Health Administration (OSHA), and valves located within them will not always be accessible.

Access to control valves located in confined space pits may be delayed during an emergency due to required pre-entry safety precautions. Therefore, control valves located in pits should have valve extensions and an indicator post. Other means to allow operation of the valve without entering the pit may be acceptable when a permanent indicator post cannot be installed.

Design new installations to avoid the use of valves in pits. Consider installing check valves, meters and backflow preventers above grade in suitably designed enclosures. If these are installed in pits, establish maintenance procedures that include proper confined space entry procedures.

Pressure Reducing Valves

Design fire protection water supplies, especially for high rise buildings, to function within acceptable parameters without the use of pressure reducing valves. Design sprinkler systems for high-rise buildings in zones as recommended in PRC.17.6.1 so that pressure reducing valves are not required to limit the pressure on sprinklers or branch lines. Problems during fires in Philadelphia and Los Angeles, where fire-fighting efforts were severely hampered by pressure regulating devices, reinforce concerns.

Some pressure reducing valves are designed to proportionally reduce the inlet pressure rather than control the maximum outlet pressure as would a pressure-regulating valve. These valves respond to inlet pressures and are often referred to as “direct acting type.” Under conditions where the inlet

pressure is less than the original design, e.g., before the fire pump starts, these valves continue to reduce the inlet pressure even when the inlet pressure is less than 175 psi (12 bar). This can cause a substantial reduction in sprinkler density in the early stages of a fire. Do not use this type of pressure reducing valve.

Other pressure reducing valves respond to the downstream pressure and act like pressure-regulating valves. These valves will open fully when the pressure on the outlet side of the valves falls below the set pressure, providing they are set correctly.

All pressure reducing valves will allow excess pressure to develop downstream under conditions of little or no flow.

Exercise and maintain pressure-reducing valves (when installed) in accordance with the manufacturer's instructions.

Automatic Breach Control Valves

Do not install automatic breach control valves (ABCVs) in sprinkler systems. If an ABCV is required, the breach-flow shut-off setting for an ABCV shall be the higher value of either:

1) 200% of the maximum flowrate expected from the least hydraulically remote demand area for the sprinkler system located downstream of the ABCV, or
2) 100% of the desired shut-off flow, calculated by a registered professional engineer, based on objectives agreed to by the authority having jurisdiction.

The least hydraulically remote demand area is the demand area that is typically closest to the water supply source, or sprinkler riser, and results in the highest flowrate for the required demand area protected by the sprinkler system.

Where an ABCV is required on a main riser that services both a sprinkler system and a standpipe, the ABCV's breach-flow shut-off setting should be at 200% of the maximum flowrate expected from the least hydraulically remote demand area for the sprinkler system located downstream of the ABCV and include a minimum additional flow of 500 gpm (1,900 L/min) for hose demand. Where an ABCV is installed on a main riser that services both a sprinkler system and a standpipe system, the minimum ABCV's breach-flow shut-off setting is intended to prevent premature closure of the ABCV if sprinklers and hose streams are flowing simultaneously.

An ABCV is a waterflow control valve designed to automatically shut off the flow of water downstream of the valve when a sudden pressure reduction is sensed, such as when a sprinkler pipe connection might catastrophically fail. The intent is to preserve water for other fire protection systems within the building that are still intact. However, if the flow setting is not properly set, there is concern that the valve could prematurely shut off the flow of water to a sprinkler system protecting an active fire event.

The desired shut-off flow is a flow quantity determined by either the building owner or the authority having jurisdiction. Note that not all building owners or authorities having jurisdiction may specify such a value.

As an example, the desired shut-off flow is based on a scenario where the sprinkler system is damaged by a backpack bomb brought into the building. An engineering analysis by a registered professional engineer determines that this given scenario would result in a flow of 750 gpm (2850 L/min); this is the flow calculated in number 2 above. This value would then be compared to flow calculated for the least hydraulically most remote sprinkler system demand as indicated in number 1 above. If the least hydraulically most remote sprinkler system demand flow is calculated to be 250 gpm (950 L/min), then the shut-off flow setting would be 500 gpm (1900 L/min), which is 200% of 250 gpm (950 L/min). For this example, the setting for the breach-flow shut-off would then be 750 gpm (2850 L/min) as this flow rate is the higher of the two calculated values.

Post Indicating Valves

Post indicator valves are preferred as they are easy to locate and remain accessible under all but the most unusual of conditions.

Do not use roadway box type, non-indicating valves for sprinkler system control due to the following:

- Roadway box valves are often covered by dirt, ice, and snow or paving materials making them difficult to locate.
- Care is needed to prevent dirt and water from entering the cover and preventing valve operation. During the winter months any water in the valve box may freeze.
- “T” wrenches are required for valve operation and are often misplaced. Valve covers can be difficult to remove. These can result in delayed operation during an emergency.
- Roadway box valves are difficult to supervise.

When roadway box valves must be used for sprinkler system control:

- Provide a “T” wrench for each valve and locate it nearby, i.e., on an adjacent building wall or in a marked cabinet.
- Provide a sign to clearly indicate the location of the valve in the road, e.g., 10 ft (3 m) north of building wall.
- Verify that roadway box valves are wide-open after all major work and implement a valve plate seal program (or install locking lids where appropriate).

Control valves must be accessible. A 40 ft (12 m) separation from a building wall usually ensures the valve will not be exposed to radiant heat in the event of a fire, and will remain accessible in the event of a building wall collapse. When the distance is reduced, the exposure to the valve must be evaluated to determine if additional precautions need be taken to maintain valve accessibility. Do not use wall post indicator valves unless wall collapse is unlikely. A blank non-load bearing masonry wall exposed by a Light or Ordinary Hazard Group 1 or 2 Occupancy would not be expected to fail catastrophically. One exception to this would be when there is little space between the property line and the building wall, thus requiring a choice between outside accessibility and the less desirable alternative of an OS&Y control valve on the riser inside the building.

Sectional Valves

Sectional control valves are necessary to limit the amount of protection out of service with a main break, or when repairs or extensions are made to the system. Provide sectional control valves as follows:

- On each side of all supply connections.
- Within main sections so the number of fire protection units (sprinkler system, hydrant or other connection) located between sectional control valves does not exceed five.
- On each side of a river, canal, building or railroad tracks that fire protection mains pass under or through. It is AXA XL Risk Consulting’s normal recommendation to abandon fire mains in the way of building additions and to replace with mains that are clear of the proposed expansion.
- At the intersection of major loop sections.

Tie-In Drains For Wet Pipe And Preaction Systems Not Subject To Freezing

While tie-in drains for wet systems are not required, a system can be drained more easily if they are installed. Consider installing them in areas where occasional freezing temperatures may be expected or where building heat may be shut off as a result of energy shortage. Provide tie-in drains for center feed systems in peaked roof buildings having branch lines terminating at a level below the cross main.

Auxiliary Drains For Dry Pipe And Preaction Systems Subject To Freezing

NFPA 13 allows trapped sections with a capacity of less than 5 gal (19 L). This permits a cross main to be located at the peak of a double-pitched roof (so that all branch lines are trapped) rather than at the eaves of the roof. Do not accept this design approach for new dry-pipe or preaction sprinkler systems. Experience has demonstrated that it is difficult to drain all the water because the small diameter tie-in drain lines are subject to plugging by sediment and loose scale from the branch lines.

Fire Department Connection Arrangement

For a multi-building campus with a common municipal water supply connection, a single fire department connection (FDC) supplying the entire site is the preferred arrangement. Experience has shown that multiple FDC's can have negative effects as follows:

- During a fire, confusion can result where emergency responders connect to the wrong FDC. This can be due to poor labeling of FDC's or uncertainty concerning the exact area of the fire or the area protected by a specific sprinkler system.
- The operation of multiple sprinkler systems requires the fire department to discharge into several connections, tying up equipment and personnel.
- The FDC does not remain accessible when located in a nonrated building wall.
- Access to individual FDC's within a campus could be limited because of closely spaced structures, fences, and parking lots or landscaping.
- Individual connections may be remote from an adequate suction source and require extensive hose layouts.

Several water supply connections are desirable in a large industrial or commercial complex. When this is the case, a separate FDC should be installed at each public water supply connection.

When underground pipe is used between a freestanding FDC and standpipe or riser, the FDC check valve should be located as close to the FDC as possible. This will allow pressurization (integrity supervision) of the underground pipe. Freeze protection must also be considered (i.e. locating the check valve underground at the base of the FDC).

Provide a public hydrant with pumper connection within 50 ft (15 m) of FDC(s).

Hose Connections

Do not obstruct or block hose connections, no matter where they are located. In the warehouse, this may necessitate 3 ft (0.9 m) breaks or passageways in the rack or pile to permit proper deployment of hose.

Alarm Test Connections

AXA XL Risk Consulting prefers alarm test connections be located at the most remote point of the system as was required in earlier editions of NFPA 13. Flow from the most remote location provides a worst-case test situation, replicating pressure and flow conditions at the end of the system where response would typically be most delayed.

Earthquake Reinforcement

Unsupported Armover Length

Unsupported armovers are very vulnerable to damage where subject to earthquakes.

Lateral sway bracing requirements - rods less than 6 in. (150 mm) in length

Pipe hangers with rods less than 6 in. (150 mm) in length cannot be considered equivalent to lateral bracing. Loss experience has shown that the rigidity of these rods can cause them to snap.

Powder-Driven Fasteners

In both the 1989 Loma Prieta and 1994 Northridge earthquakes, powder-driven studs used for both hangers and bracing had high failure rates. If utilized, use only listed fasteners for this specific use and concrete pull testing shall be completed as part of the installation. AXA XL Risk Consulting experience has shown that contractors may not always adhere to this required testing.

Underground pipe

Pipe type and class

When selecting the proper pipe for an installation, the size of pipe, working pressure, laying condition and depth of cover must be considered.

Select ductile iron pipe in accordance with the applicable ANSI standard. Ductile iron pipe with a thickness Class of 50 will be acceptable provided the depth of bury does not exceed 15 ft (4.5 m), the pipe size does not exceed 20 in. (500 mm) and the working pressure is less than 350 psi (24 bar).

Select plastic, cement asbestos and reinforced concrete pipe in accordance with its listing and installed in accordance with the manufacturer's instructions and NFPA 13.

Transition plastic pipe to ductile iron pipe prior before entering the footprint of the building.

Lining Of Buried Pipe

Use only lined ductile iron pipe in accordance with AWWA C104. All cast iron, ductile iron or steel, underground fire main components are to have polyethylene encasement in accordance with AWWA C105, unless a soil test demonstrates the area where the underground will be installed has a CIPRA score less than 10. The "10 Point" CIPRA soil test evaluation procedure assigns from one to ten points for the results of each of five areas of soil characteristics that contribute to corrosivity. These are resistivity (ohm/cm), ph, redox potential, sulfides, and moisture content. The point score in each area is summed to arrive at a CIPRA score. A score of 10 or more is regarded as corrosive to ductile iron pipe. Protection can also be achieved by suitable coating of the pipe; however, care is needed to prevent damage to the pipe coating during handling and installation. Cathodic protection can be used to prevent corrosion, but the systems are costly and require high maintenance.

Where external corrosion is anticipated, polyvinyl chloride, fiberglass reinforced epoxy resin, cement asbestos or reinforced concrete pipe may offer improved corrosion resistance.

Certain organic solvents, such as ketones and aromatic hydrocarbons, affect polyvinyl chloride. The long-term effects of other hydrocarbons are not known. Until test data is available for specific solvents, do not use plastic piping, including the necessary gaskets, in soil that is or may become saturated with these materials. Give similar considerations to locations where the water supply is or may be contaminated by these solvents, e.g., a chemical plant where the fire pump suction supply is from a cooling tower basin.

Pipe Joint Assembly

Standard bolts coated with nylon or Teflon are acceptable however best practice suggests underground pipe bolts be of a material known as core-10 and coated with nylon or Teflon. Proper coating is critical.

Thrust Blocks

When sizing thrust blocks, use 1000 lb/ft² (4900 kg/m²) for maximum lateral bearing strength of soil. Calculate the thrust pressure at 50 psi (3.4 bar) above the hydrostatic pressure with a minimum of 250 psi (17 bar) thrust pressure. Higher thrust pressures may be required if pipe is subject to large water hammers or has a history of blowouts. If the ground contains soluble sulfates, use a sulfate resistant concrete.

Restrained Joint Systems

Use conventional tie rods, pipe clamps, restrained mechanical joints and thrust blocks to anchor sprinkler risers to underground piping rather than other "approved devices," such as mechanical retainer glands with setscrews.

Because of the location of sprinkler riser piping in relation to building foundations and floors, **avoid the use of mechanical retainer glands in or near buildings and fire pump houses**. They may be used inside fire pump houses if the setscrews have the "break-away" type heads to assure application of the necessary torque.

When mechanical retainer glands are used to anchor other components of the underground system, strictly adhere to the following requirements:

- Torque wrenches must be used for tightening setscrews in accordance with the manufacturer's installation instructions.
- The specific location of each retainer gland is to be clearly indicated on the contractor's drawing so it can be determined that sufficient glands are being used, and they are properly located.
- Where unstable soil conditions are involved, provide a second method of anchorage in addition to the mechanical retainer gland.
- Mechanical retainer glands shall not be used where the soil is suspected to be corrosive.

Several types of retainer glands (couplings) are suitable for underground use only. Do not use them for aboveground unless specifically listed for aboveground use and provided with setscrews having breakaway heads to assure the application of the needed torque.

In the past, the use of mechanical joint retainer glands has been accepted in lieu of conventional tie rods, clamps and concrete blocking to anchor tees, plugs, caps, bends and hydrants. However, there have been several losses where pipe separation has occurred because of the contractor's failure to properly tighten setscrews to the specified torque as recommended by the manufacturer's installation instructions and required by the UL listing; the use of torque wrenches is required.

When using PVC pipe, the rods used for restraining devices either should be stainless steel or be afforded a bitumen coating.

Fans

High Volume Low Speed (HVLS) Fans

For palletized/solid pile storage over 12 ft (3.6 m) high, HVLS fans should be interlocked to shut down upon activation of an engineered early warning smoke detection system. Generic detection has not shown to be adequate for the early shutdown we seek. Water flow shutdown is not acceptable because sprinkler operation delay may have already taken place. Flame detectors are unlikely to "see" the flame before plume distortion occurs.

For rack storage over 12 ft (3.6 m) high, interlock all HVLS fans to shut down upon waterflow alarm activation.

For sorting and staging areas, HVLS fans can be used if all the following criteria are met:

- no arrays larger 2 pallet loads deep by 2 loads wide by 2 loads high or greater exist,
- water flow fan shutdown or manual shutdowns at exits are provided,
- idle pallet stacks are limited to 4 ft (1.2 m) high with pile size limited to 2 stacks wide by 2 stacks deep,
- a sprinkler design area of at least 3000 ft² (279 m²) with the appropriate density for the area is provided.

If these conditions cannot be met, then the standard storage recommendations should be followed.

In the Research Foundation test of high pile storage, the test barely passed. Damage was severe and 20 sprinklers (the limit) opened. Even ignoring this test, waterflow shutdown pushes protection to its limit. This is not consistent with HPR. The smoke detection tests did much better.

Wall/Sideway Mounted Fans

For storage over 12 ft (3.6 m) high, fans should be interlocked to shut down upon activation of an engineered early warning smoke detection system. Generic detection has not shown to be adequate for the early shutdown we seek. Water flow shutdown is not acceptable because sprinkler operation delay may have already taken place. Flame detectors are unlikely to "see" the flame before plume distortion occurs.

Fire modeling has shown an airflow velocity of 10 ft/s (3.05 m/s) from a wall mounted fan can cause the heat from the fire to shift and not activate the sprinklers over the fire.

Water Demand Requirements

Density/Area Curves

The densities and areas of application subject to the following limitations:

- For Light Hazard and Ordinary Hazard Group 1 occupancies, the minimum area of application is 1500 ft² (140 m²), except for combustible construction where AXA XL Risk Consulting recommends that a 3000 ft² (279 m²) area be protected.
- For Ordinary Hazard Group 2 occupancies, use a minimum area of application of 3000 ft² (279 m²).

Hose Demand And Duration Requirements

Table 5 list the inside hose demand, the total hose demand (inside and outside hose) and the estimated duration of the sprinkler system based on the occupancy.

TABLE 5
Water Demand Requirements

Occupancy Classification	Inside Hose (gpm)	Total Hose (gpm)	Duration (min)
Light Hazard	100	500	90
Ordinary Hazard 1 and 2	150	500	120
Extra Hazard 1	250	500	180
Extra Hazard 2	250	750	180

SI Units: 1 gpm = 3.785 L/min

Sprinkler Orifice Sizes

The minimum sprinkler orifice size in respect to density (for new and / or retrofit systems) shall be subject the following and applies to all applications (storage & non-storage):

- With densities of 0.20 gpm/ft² (8.2 mm/min) or less, sprinklers with a K factor of K-5.6 (80) or larger shall be permitted.
- With densities of greater than 0.20 gpm/ft² up to 0.34 gpm/ft² (8.2 mm/min to 13.9 mm/min), sprinklers with a nominal K-factor of K-8.0 (115) or larger shall be used.
- With greater than 0.34 gpm/ft² (13.9 mm/min), sprinklers with a K-factor of K-11.2 (161) or larger shall be used.

Note: This is not required to apply to modifications to existing systems, using sprinklers with K factors of K-8.0 (115) or less; however, should be considered. Contact your AXA XL Risk Consultant or Account Consultant who will provide further guidance.

Installation / applications for other than general property (building) & storage systems (i.e., oil spray fires, etc.), where there exists the potential of opening many large orifice sprinklers. Contact your AXA XL Risk Consultant or Account Consultant who will provide further guidance.

Use Of Quick-Response Sprinklers

Apply the reduction in design area allowed by this section only to Light Hazard occupancies. Do not apply the reduction to Ordinary Hazard occupancies due to higher levels of combustible loading and continuity of combustibles.

Room Design Method

Sprinkler systems are expected to perform under reasonably adverse conditions. The calculation of a single room allows for only “ideal” conditions and is not recommended.

Exposure Protection

Design sprinklers for exposure protection systems provide 3 gpm per lineal ft (38 L/min per linear m). Space sprinklers a maximum of 10 ft (3 m) apart horizontally. The vertical distance protected by a single line of sprinklers is not to exceed 15 ft (4.5 m), however, a single story building with a 20 ft (6 m) height may be protected by a single line of sprinklers. Include all of the sprinklers facing the exposure in the calculation.

STORAGE

Where ESFR sprinklers are installed and heat and smoke venting is provided, non-automatic vents are preferred. If automatic vents are required by the local codes, they must be of the gravity type and operated by minimum 360°F (180°C) standard response fusible elements.

CMSA sprinklers should use a 20-sprinkler design rather than the NFPA 13 design in the following situation:

- Idle wood pallets 20 ft (6.1 m) high under a 30 ft (9.1) ceiling protected with K 11.2 (160) sprinklers.
- Solid Pile Plastic and Rubber in cases NFPA recommends 15.
- Single, double-, and multi-row racks without solid shelves of Class I - IV and Plastics commodities stored up to and including 25 ft (7.6 m) in height in cases NFPA recommends 15.
- Rubber Tires
- Roll paper in cases NFPA recommends 15.

Storage Water Supply Duration Recommendations

Minimum duration for all storage is 2 h, excluding ESFR sprinklers. Public fire authorities are spending more and more time on size-up and are often sending a reduced response to waterflow alarms. This combined with the time needed for final extinguishment can exceed one hour. For ESFR sprinklers the minimum duration is 1 h.

Durations exceeding NFPA 13 requirements are outlined elsewhere in this document.

Use a hose demand of 500 gpm (1890 L/min) and water supply duration of 3 h for all CMSA sprinkler designs. For Class IV Commodities over 20 ft (6.1 m) high increase the hose stream demand to 750 gpm (2840 L/min).

For Group A plastics and rubber tire storage, increase water supply duration to 3 h for storage over 5 ft (1.52 m) in height. Increase hose demand to 750 gpm (2840 L/min) for storage over 25 ft (7.62 m) high.

Provide a 3 h water supply duration for all Class IV and Group A plastics rack storage 20 ft (6.1 m) and higher. Increase hose demand to 750 gpm (2840 L/min) for storage over 25 ft (7.62 m) high.

For roll paper storage with CMSA sprinklers and ESFR sprinklers, increase the hose stream requirement to 750 gpm (2840 L/min) for spray and CMSA sprinklers, or to 500 gpm (1890 L/min) for ESFR sprinklers when any one of the following conditions are encountered:

- Unfavorable firefighting circumstances, e.g., limited or poor access, limited public fire department or mutual aid response, inadequate manual smoke and heat venting;
- Mediumweight or lightweight paper is stored in open arrays over 15 ft (4.6 m) high;
- Tissue paper stored vertically over 10 ft (3 m) high in any type of array.

- Experience has shown that public fire authorities are likely to use more than the NFPA minimum hose stream allowances, especially in the form of unstaffed streams.

For aircraft engine test facilities, water supplies shall be capable of meeting the largest sprinkler system demand at the design flow rate plus 500 gpm (1890 L/min) hose stream demand for 2 h.

Fire Protection For Steel Columns

When CMSA, ESFR, or in rack sprinklers are provided, additional protection for building columns is not needed.

Otherwise, column protection is needed for following situations where columns are located in the storage array:

- All rubber tire storage,
- Class I-IV and Group A plastics, idle pallets, tissue paper over 15 ft (4.5 m) high.
- Medium and Heavyweight paper over 20 ft (6.1 m).

When any of the above are present, column protection should be one of the following:

- One hour fire-proofing
- Sidewall column sprinklers, hydraulically designed to deliver a discharge density not less than 0.25 gpm/ft² (10.2 L/min/m²) over the wetted area. The number of columns to be included in the ceiling remote area calculation is to equal the number of columns found in an area equal to the area of application of the ceiling sprinklers.

Arrange column sprinkler protection and supply piping so that they are not susceptible to being struck when stock is being moved. Locating the sprinkler between the flanges of the building column is effective, particularly if a deflection plate is welded or fastened across the flanges where the sprinkler.

High-Expansion Foam Systems

The overall acceptability of high-expansion foam must be carefully studied on the basis of possible contamination of the product being stored, unacceptable discoloration, delamination or other damage to containers. It has been demonstrated that high-expansion foam can cause failure of carton joints sealed without waterproof glue and can result in the need to repackage the stored product. Besides the potentially undesirable moisture problem with the package and contents, the residue left by the foam may also be unacceptable from the standpoint of appearance or potential contamination of the product. Food products, empty glass bottles or tin cans, pharmaceuticals, and electronic parts or equipment are particularly susceptible to such residue contamination.

High expansion foam is not acceptable for tissue because the rapid spread of fire and buildup in intensity could jeopardize the structural steel before the foam could begin to exert control. In addition, the entire contents would probably absorb water and all would have to be scrapped and recycled.

Consider reliability of power supply and pollution problems in disposing of the foam. Review any request for the use of high-expansion foam systems with the assigned AXA XL Risk Consulting's Risk Consultant.

Protection Of Idle Pallets

Protection Of Idle Wood Pallets In Racks

Protect storage of idle wood pallets in racks with CMDA sprinklers as follows:

- Store pallets in dedicated racks with no other commodity storage in the area.
- Install solid barriers over each level of storage, including over flue spaces, at a maximum vertical spacing of 5 ft (1.5 m).
- Install face in-rack sprinkler protection designed for eight K-5.6 (80) or K-8.0 (115) sprinklers operating at 30 psi (2.1 bar) at each level using quick response, 165°F (79°C) rated sprinklers.

- Space in-rack sprinklers at 8 ft (2.5 m) in each direction. Design ceiling sprinkler system for a density of 0.30 gpm/ft² over 3000 ft² (12.2 L/min/m² over 279 m²) using 286°F (141°C) rated sprinklers. Include a hose allowance of 500 gpm (1890 L/min) and water supply duration of 3 h.

Storage Of Idle Plastic Pallets

AXA XL Risk Consulting recommends storage of idle plastic pallets in the following order of preference:

- Outside storage, 50 ft (15 m) from any structures.
- Inside of a cut off room with sprinkler protection in accordance with NFPA 13 and this guideline.

Miscellaneous Storage 12 FT (3.7 M) Or Less In Height

For Group A plastic, rubber tires, and roll paper, limit the contiguous areas of such storage are limited to 250 ft² (23 m²) and maintain at least 25 ft (7.6 m) of separation. The roll paper entries in the table include all rolled paper arrays.

- Do not use miscellaneous storage allowances for exposed Group A plastic, tires stored in single row portable or fixed rack configurations, or idle pallets.
- Protect storage of all heavyweight and medium weight roll paper up to 8 ft (2.4 m) in height with sprinklers designed for Extra Hazard Group 1. For storage heights from 8 ft (2.4 m) to 10 ft (3.1 m) high, design sprinklers for 0.30 gpm/ft² (12.2 L/min/m²) over the most remote 2000 ft² (186 m²) area.
- Protect rolled tissue paper as Extra Hazard Group 2.

Protection For Palletized, Solid-Piled, Bin Box, Shelf, Or Back-To-Back Shelf Storage Of Class I To Class IV Commodities

The reduction in area of operation assigned to 286°F (141°C) sprinklers for any density as expressed in Figure 14.2.4.2 is justified mainly when the storage arrangement is conducive to vertical flame propagation, e.g., has well-defined vertical flues. However, with clamp-type or other solid pile arrangements that have wide, i.e., over 6 in. (152 mm), vertical flues that are not interrupted by pallets, the initial fire plumes can have greater than average intensity and thus require higher density. Conversely, when vertical flue spaces are restricted (2 in. [50 mm] or less) or virtually nonexistent, the fire may be slow developing and likely to spread more horizontally before sprinkler actuation occurs.

With these two conditions in mind, Table 6 identifies modifications, if any, which are to be made to the density or area of application derived from the curves in NFPA 13

TABLE 6

Sprinkler System Design Adjustments

Storage Type	Figure 14.2.4.1	Figure 14.2.4.2
Clamp-Type (6 in. [152 mm] or greater flues - no pallets)	Acceptable but increase density from curves by 33 ⅓%*	Preferred but increase density from curves by 33 ⅓%*
Palletized or solid pile with small flue spaces (2 in. [50 mm] or less flues)	Preferred and use density and area from curves	Not acceptable. Use density and area from curves in Figure 14.2.4.1
All other storage arrangements	Acceptable	Acceptable

*Use 3000 ft² (279 m²) as the starting area

.

For storage of Class I though IV commodities, where aisles less than 8 ft (2.4 m) wide cannot be avoided, increase the recommended density in accordance with Figure 5.

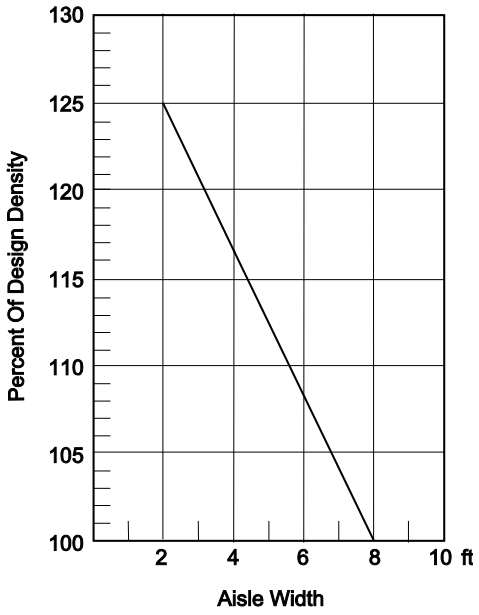

Figure 5: Aisle Width Correction Factors.

SI Units: 1 ft = 3.048 m

Solid Shelving

Treat all cantilever racks as having solid shelves.

Blockage or elimination of flue spaces reduces the effectiveness of ceiling sprinkler protection. Large-scale fire tests demonstrated the inability of ceiling sprinklers alone to control fires in double row racks when all flues were blocked or when transverse flues occurred only at 8 ft – 10 ft (2.4 m – 3.0 m) intervals. FM Global now makes some allowance for this but has flue width rules that must be rigidly adhered to.

When no flues exist, install in-rack sprinklers at every tier level. Test work did not delineate how much in-rack sprinkler protection was needed if some transverse flues existed.

Open-Top Containers

Loss experience and large-scale fire tests indicate a greater hazard with open-top combustible (paper, cardboard, or wood) containers. The major factor appears to be the capture and retention of ceiling sprinkler discharge within the open-top container and less water flow down the flue and aisle faces. This does not apply to open-top containers with mesh sides.

Provide in-rack sprinkler protection at approximately 10 ft (3 m) vertical intervals, i.e., above the tier of storage closest to that level, with sprinklers spaced a maximum 9 ft (2.7 m) apart and designed for an operating pressure of 30 psi (2.1 bar). No additional credit can be given for the installation of these in-rack sprinklers.

ESFR Sprinklers cannot be used with open top containers except under very limited circumstances outlined in FM Global Data Sheet 8-9. These requirements are difficult to implement and enforce.

In-Rack Sprinklers

Quick response in rack are recommended.

Obstructed sprinklers cannot be expected to control developing fires involving rack storage. Figure 6 shows a longitudinal flue in-rack sprinkler incorrectly installed with deflector above the bottom of the load beam. In this position, the load beam will clearly block the majority of the sprinkler’s discharge.

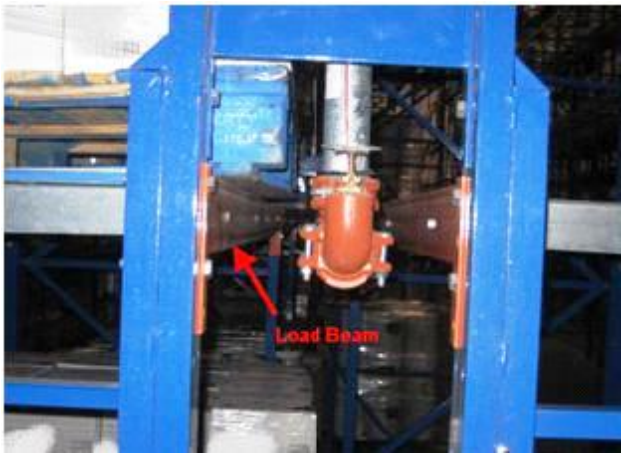

Figure 6:. In-Rack Sprinkler Position.

Single, Double, And Multi-Row Row Rack Storage Up To And Including 25 FT (7.6 M) Without Solid Shelves

Use NFPA 13 tables subject to the following conditions and exceptions:

- One level of in-rack sprinklers is recommended for nonencapsulated Class IV commodities stored above 15 ft (4.6 m) in height.
- One level of in-rack sprinklers is recommended for nonencapsulated Class II, III commodities stored over 20 ft (6.1 m) and up to 25 ft (7.6 m) in height in single and double row racks. Provide one level for Class I commodities in multi-row racks.
    - The original testing indicates that additional protection is needed. To allow for “curve fitting”, the NFPA 13 criteria reflects less protection than was required to control the test fires.
    - An alternative is to provide ceiling only protection in accordance with FM Global Data Sheet 8-9.
- Tests have shown that when clearance between the ceiling sprinklers and the top of storage is increased beyond 10 ft (3 m), the effectiveness of the ceiling sprinklers is considerably reduced. Therefore, in high bay areas when storage is 15 ft (4.6 m) or more in height and the clearance between top of stock and ceiling sprinkler deflectors is greater than 10 ft (3 m), provide additional protection in the form of a horizontal barrier with sprinklers under the barrier.
- The horizontal barrier, which will act as a false ceiling, may be supported by the rack structure. The distance between the top of stock and bottom of the barrier must be sufficient so there will be at least 6 in. (152 mm) clearance between the top of stock and the sprinkler deflectors.
- The exception to this arrangement is where ESFR and CMSA sprinklers are used. Protection with these types of sprinklers is based on the height of the building rather than storage height. Protection would be the same for storage up to and including the maximum height allowed by this standard and in accordance with the approval listing of the specific sprinkler being used.
- When determining the need for in-rack sprinklers, the maximum width of a longitudinal flue space in a double-row rack is 24 in. (610 mm). This situation could occur when there is a building column in the flue. When the flue width is more than 24 in. (610 mm), AXA XL Risk Consulting considers it to be an “aisle” and each of the racks would require a separate line of IRAS since it would be unreasonable to expect a single line of IRAS to operate promptly and discharge water to the face of the rack.

Strict application of the design curves could permit a density below 0.20 gpm/ft² (8.1 L/min/m²). Do not use such a low level of protection because:

- There were no fire tests conducted using densities below 0.20 gpm/ft² (8.1 L/min/m²).

- Protection afforded to steel roof members is questionable with densities below 0.20 gpm/ft² (8.1 L/min/m²).

Although the design curves indicate a possible 2000 ft² (186 m²) area of application using standard spray sprinklers, AXA XL Risk Consulting considers this too marginal. Tests have shown that total sprinkler operation can be markedly influenced if:

- One or two sprinklers over the initial fire area fail to operate, become plugged or the orifice caps hang up.
- The source of ignition is greater than that used in the tests.
- Ignition occurs at some other location than that used in the test, i.e., in the aisle.

Use an area of application of not less than 3000 ft² (279 m²). When conditions are encountered that require a larger area of application than indicated in Curves E and G use the same density indicated for the maximum area shown in the Figure, i.e., Curve E shows 0.45 gpm/ft² (18.3 L/min/m²) for 2400 ft² (223 m²). For 3000 ft² (372 m²), use the same 0.45 gpm/ft² (18.3 L/min/m²) density.

Special Design For Rack Storage Of Class I Through Class IV Commodities Stored Up To And Including 25 FT (7.6 M) In Height With Slatted Shelves

This section is based on large-scale fire tests conducted by the retail sales industry. Note that the requirements are very specific as to the type of sprinkler heads that can be used, their hydraulic design, the class and packaging of the commodities that can be protected, type of shelving that can be used and how it must be installed and rack arrangement. While it may be possible to achieve all the specifications upon installation, maintaining them will be very difficult. The racks used in the large-scale test were limited in length and there was burning, to limited degrees, to the ends of the racks. Therefore, the exception can be used for rack lengths up to 50 ft (15 m).

Protection Criteria For Rubber Tire Storage Using Control Mode Density/Area Sprinklers

Use a minimum 3000 ft² (279 m²) area of application for storage over 10 ft (3 m) high when clearance between the top of the stock and the sprinklers exceeds 5 ft (1.5 m). Tables 18.4(a) and 18.4(b) show areas of application as small as 2000 ft² (186 m²). This area of application is considered too marginal when sprinkler clearances exceed 5 ft (1.5 m).

Examples:

A 10 ft (3 m) high pile of rubber tires on side in palletized portable racks requires a density of 0.32 gpm/ft² (13.0 L/min/m²) using ordinary temperature sprinklers. Instead of the 2000 ft² (186 m²) from Table 12.4.2(b), use an application area of 3000 ft² (279 m²) when clearance to sprinklers exceeds 5 ft (1.5 m).

A 15 ft (4.6 m) high pile of rubber tires on side in palletized portable racks requires a density of 0.50 gpm/ft² (20 L/min/m²) over 3700 ft² (344 m²) using ordinary temperature sprinklers, or over 2300 ft² (214 m²) using high temperature sprinklers. When high temperature sprinklers are used and clearance to sprinklers exceeds 5 ft (1.5 m), use an area of application of 3000 ft² (279 m²).

Roll Paper

Submit the storage of waxed or synthetic papers, or palletized storage to the assigned AXA XL Risk Consulting's Account Consultant for review.

Encapsulated roll paper large-scale fire tests were conducted in 1987 on rolls of metal banded heavyweight paper encapsulated in polyethylene film and arranged in a standard array. The tests showed that this particular storage required no additional protection. It is not known if this holds for other weights of paper or other storage situations, particularly open arrays.

Protect horizontal roll storage of lightweight hard and tissue paper as vertical storage.

Protect storage of wrapped rolls of lightweight or tissue paper based on the weight of the basic roll, not the wrapper.

For heavyweight and mediumweight storage heights from 8 ft – 10 ft (2.4 m – 3.1 m) high, design sprinklers for 0.30 gpm/ft² (12.2 L/min/m²) over the most hydraulically remote 2000 ft² (186 m²) area.

Protect storage of roll tissue paper less than 10 ft (3.1 m) in height with sprinklers designed for Extra Hazard, Group 2 occupancies.

Existing Roll Paper Storage Facilities

The tables recognize densities of less than 0.30 gpm/ft² (12.2 L/min/m²) and second, they encompass storage up to 30 ft (9.1 m) high. Tables A.19.1.2(a) and A.19.1.2(b) can be used to evaluate existing situations. Ceiling sprinkler protection alone for storage heights above 25 ft (7.6 m) is debatable. Submit any such proposal to the AXA XL Risk Consulting's Account Consultant for review.

Although some arrays of heavyweight and mediumweight paper up to 15 ft (4.6 m) high can possibly be protected by K-5.6 (80) sprinklers at densities of 0.20 or 0.25 gpm/ft² (8.1 or 10.2 L/min/m²), the NFPA Technical Committee felt that, for new installations the better design is to use K-8 (115) sprinklers at a minimum density of 0.30 gpm/ft² (12.2 L/min/m²). The additional 100 gpm – 200 gpm (380 L/min – 760 L/min) of water required is minimal and the greatly improved protection allows for unforeseen adversities such as a sloping roof, structural obstructions, a plugged sprinkler, etc.

No fire tests were conducted with storage 30 ft (9.1 m) high. The indicated protection for such storage in Tables A.19.1.2(a) and A.19.1.2(b) is speculative and marginal, particularly where the same density is used for 30 ft (9.1 m) as for 25 ft (7.6 m).

Apply the sprinkler densities and areas of application for the indicated commodity classifications for the rack storage of roll paper as follows:

- Rolls are unbanded **and** stored vertically on pallets in racks:
  - Heavyweight paper – Class III
  - Mediumweight paper and lightweight hard paper – Class IV
  - Tissue paper – Group A plastic (cartoned)*
- Rolls are banded or stored on sides on pallets in racks:
  - All classes of paper except tissue – Class III
  - Tissue paper – Group A plastic (cartoned)*
- Rolls (banded or unbanded) stored on horizontal mandrels in double row or single row racks:
  - Heavyweight paper – Class III
  - Mediumweight and lightweight hard paper – Class IV
  - Tissue paper – Group A plastic (cartoned)*

*Provide in-rack sprinklers with 10 ft (3 m) vertical spacing for storage above 15 ft (4.6 m).

For tissue paper, increase the area of application by 50% if dry pipe sprinkler systems are used. The very rapid fire development associated with lightweight hard and tissue papers makes dry pipe systems highly undesirable. Where they cannot be avoided, the additional adjustment in the area of application is certainly warranted.

For single interlock preaction systems, use an area of application equivalent to that for wet systems in protecting heavyweight and mediumweight roll paper storage. For lightweight hard and tissue papers, where fire development is rapid, apply a 30% increase in the area of application (over that required for wet pipe systems).

Use malleable iron fittings. In a large-scale fire test conducted at UL involving tissue paper rolls and simulated dry pipe system operation, a cast iron fitting ruptured when cold water entered the piping over the fire.

Use sprinklers with 286°F (141°C) temperature rating for all new roll paper installations including storage down to 10 ft (3.1 m) in height. For existing installations with 165°F (74°C) sprinklers, such

protection is acceptable if the area of application includes the recommended 67% increase. For example, if Table 19.1.2.1.3 (a) recommends an area of operation of 3000 ft² (279 m²), the area of application for 165°F (74°C) sprinklers is 3000 times 1.67 or 5000 ft² (465 m²). Treat sprinklers rated at 212°F (100°C) as 165°F (74°C) sprinklers.

Special Designs Of Storage Protection - Sprinkler Design Criteria For Storage And Display Of Class I Through Class IV Commodities, Cartoned Nonexpanded Group A Plastics And Nonexpanded Group A Plastic In Retail Stores

This section is based on large-scale fire tests conducted by the retail sales industry. Note that the requirements are very specific as to the type of sprinkler heads that can be used, their hydraulic design, the class and packaging of the commodities that can be protected, type of shelving that can be used and how it must be installed and rack arrangement. While it may be possible to achieve all the specifications upon installation, maintaining them will be very difficult. The racks used in the large-scale fire tests were limited in length. The protection criteria can be used for various storage configurations matching those tested. Any change in the storage configuration, such as longer racks or closer exposures, may have an adverse effect and must be reviewed. Provide a 3 h water supply duration.

PROTECTION OF SPRINKLERS IN SPRAYING AREAS

Tests have shown that even very thin paper or plastic bags increase operating time by about one minute. Furthermore, residue thickness as little as 0.015 in. (0.4 mm) is capable of affecting sprinkler operation. To alleviate these difficulties with closed head systems, quick response heads may be used. Replace coverings on all closed heads when residue buildup is measurable. Do not cover open heads or nozzles.

DESIGN REQUIREMENTS FOR SOLVENT EXTRACTION PLANTS

The density of 0.25 gpm/ft² (10.2 L/min/m²) for water spray or deluge systems, and 0.16 gpm/ft² (6.5 L/min/m²) for foam-water sprinkler or deluge systems is not adequate for the protection of the solvent extraction process. Provide protection in accordance with PRC.17.23.1.14.

DESIGN REQUIREMENTS FOR LABORATORIES USING CHEMICALS

Due to the quantities of flammable and combustible liquids that may be present in the various classes of laboratories, an increase in the sprinkler densities is required. Provide sprinkler protection for Class A laboratories in accordance with Extra Hazard Group 1. Provide sprinkler protection for Class B, C and D laboratories in accordance with Ordinary Hazard Group 2.

TYPES OF SYSTEMS FOR COUNTERFLOW COOLING TOWERS

Deluge systems are preferred as they provide a higher degree of protection.

DESIGN REQUIREMENTS FOR MARINE TERMINALS, PIERS, AND WHARVES

The ever-changing commodities and storage configurations in the areas covered by this section make it difficult to specify the proper sprinkler protection. To insure adequate protection, the automatic sprinkler system design should be based on the maximum available storage height of a Group A Plastic commodity. Long-term storage areas can be designed for specific commodities and storage arrangements. See PRC.9.2.1.2 for the protection of flammable and combustible liquids on piers, docks, and wharves.

CALCULATION PROCEDURE - DENSITY/AREA METHOD

Evaluation of fire test data indicates the potential for sprinklers to operate in a rectangular pattern. In addition, the fire that starts along a wall may open sprinklers in a semicircular area. For these reasons, the dimension parallel to the branch line is 1.4 times the square root of the area of sprinkler operation, or a rectangle that is approximately twice as long as it is wide. For more on this topic, see PRC.12.1.1.1.

SPRAY SPRINKLERS AND CMSA SPRINKLERS ABOVE AND BELOW OBSTRUCTIONS

Where spray sprinklers and CMSA sprinklers are located above and below obstructions such as overhead doors, oversized ducts, or other obstructions, the hydraulic calculations are to include the sprinklers both above and below such obstructions.

While the standard is clear regarding the need to provide sprinklers above and below obstructions, it does not require the calculation of both the above and below sprinklers when spray or CMSA sprinklers are installed. The heat from a fire will operate both the sprinklers at the ceiling and those below the obstruction that effectively attack the fire. Thus, both sprinklers are to be included in the hydraulic calculations.

PRESSURES (VELOCITIES)

Restricting the velocity in sprinkler piping promotes avoids the high pressure losses associated with excessive velocities. Note that systems designed with high velocities, i.e., near 32 ft/sec (9.8 m/s) are subject to a severe reduction in the density available at the most remote sprinkler if an additional head opens on the branch line beyond those calculated. Avoid velocities in excess of 20 ft/sec (6 m/sec) in branch line piping.

WATER SUPPLIES

Size Of Fire Mains

Provide a minimum 4 in. (100 mm) pipe for a connection from the distribution system to the sprinkler riser for either pipe schedule or hydraulically designed systems. The designed riser may be less than 4 in. (100 mm) pipe diameter. Size underground mains in accordance with PRC.14.1.2.0.

All ferrous pipe is to be lined. Within the intent of this guideline, lined pipe shall mean pipe with a cement-mortar lining of a thickness not less than 1⁄16 in. (1.6 mm) for 3 in. – 12 in. (80 mm – 300 mm) pipe, and 1⁄32 in. (2.4 mm) for 14 in. – 24 in. (350 mm – 600 mm) pipe, and with a bitumastic seal coat as per AWWA C 104, or an Enamel lining. Listed cement-asbestos and plastic pipe may be considered equivalent to lined pipe.

When designing private fire protection distribution systems:

- Size mains to take full advantage of the water supplies available. Large water supplies are wasted if the water distribution system cannot or only marginally delivers the water to the desired area.
- Size looped systems meet the demand with one leg of the loop out of service.
- Use 6 in. (150 mm) mains to supply individual sprinkler system risers or one or two fire hydrants.
- Use 8 in. (200 mm) mains to supply two or more sprinkler systems or three or four fire hydrants.
- Limit the use of 8 in. (200 mm) mains for general distribution to small facilities and areas of larger facilities containing light hazard occupancies where the water demands will not exceed 1000 gpm (3790 L/min).

- Use 10 in. (250 mm) mains in industrial facilities of moderate hazards (Ordinary Hazard Group 1 or 2 Occupancies as defined in NFPA 13.
- Use 12 in. (300 mm) and larger mains where the water demands are high (over 2000 gpm [9460 L/min]), or the facility is large and water must be transported over significant distances.

Meters And Pressure Regulating Valves

Use UL listed (HDRT) fire flow meters designed for minimal friction loss in fire protection mains.

Do not use pressure regulating valves on supply connections. However, pressure regulating valves may be accepted where the public water supply pressure exceeds 150 psi (10.4 bar), or where the local authority requires them.

Where pressure regulating valves are installed, the following is recommended:

- The valve is to be of the pilot-operated fixed pressure type.
- Provide a bypass around the pressure regulating valve.
- Provide a pressure relief valve on private fire mains to protect equipment from excessive pressure. Locate the valve above grade or where adequate drainage can be provided.
- Provide a means to test the operation of the pressure regulating valve. Provide a 2 in. (50 mm) drain pipe or 2½ in. (65 mm) hose connection to drain the test water. Test the valve monthly.
- Flush the supply piping thoroughly prior to installation. When the valve is installed on a dead end main or a raw water supply, strainers may be necessary to prevent plugging of the pilot operator.

Install meters and check valves downstream of the pressure regulating.

Pressure regulating valves are commonly installed on municipal water systems. In this application, the valves are exercised frequently and have proved to be reliable. When installed on fire protection mains, the valves are not routinely exercised and can become sluggish in operation. In addition, under little or no flow conditions it is possible for the pressure downstream of the valve to creep up to the supply pressure.

Care must be used when selecting the size of a pressure regulating valve. Most valves have a minimum and maximum recommended flow rate. When operating near the minimum rate, these valves are almost closed and prolonged operation near this minimum flow rate is to be avoided to prevent damage to the valve due to chatter. When such conditions are likely to be encountered, install two valves each designed for a specific flow range in parallel.

CROSS-REFERENCE INDEX