FIRE SPRINKLER SYSTEM

Fundamentals of Design & Installations

What will You learn after Completion of this Module.....?

- ❑ Understanding Sprinkler Operation and Its Different Types
- ❑ About Pendent Type Sprinklers
- ❑ About Recessed and Concealed Pendent Type Sprinklers
- ❑ About Sidewall Type Sprinklers
- ❑ **How to Conduct Pipe Sizing Calculations?**
- ❑ Understanding the Different Types of Sprinkler Pipes
- ❑ **How to Perform Sprinkler Flow Calculation?**
- ❑ How to Estimate Sprinkler Coverage Distance?
- ❑ How to Install a Sprinkler System?

SECTION 01

SYSTEM FUNDAMENTALS

Automatic Fire Sprinkler System Myths and Realities

MYTHS	REALITY
All sprinkler heads operate simultaneously	With the exception of the deluge type of sprinkler system, sprinkler heads operate independently; only the sprinkler head(s) in the fire area—not every head in the building—activates to control or suppress a fire.
Sprinkler heads activate for no reason.	Sprinkler heads undergo numerous tests by third-party testing and certification organizations to ensure that they maintain stability when standing ready to operate. It is rare that a sprinkler head accidentally activates unless it has suffered mechanical damage, exposure to freezing conditions, or excessive heat not related to a fire.

Automatic Fire Sprinkler System Myths and Realities

MYTHS	REALITY
The amount of water discharged from a sprinkler system is enough to cause a flood or drown a person.	The amount of water discharged from a residential sprinkler head is about the same as that from a showerhead, a minimal amount when compared to that discharged from a manual fire hose stream. A manual fire hose stream delivers 10 to 100 times more water than one sprinkler head during a fire event and could cause substantially more collateral damage. A commercial sprinkler head is able to discharge considerably more water, but it is uniformly distributed over a number of square feet of area and is still less than most manual fire hose stream applications.

Automatic Fire Sprinkler System Myths and Realities

MYTHS	REALITY
Expenses related to water damage from sprinkler systems are higher than those related to fire damage.	Fire sprinkler systems deliver as little water as required to control and, in numerous cases, extinguish a fire; and, in many cases, property can be salvaged from the water exposure more easily than it could from exposure to fire and smoke. In addition, sprinklers limit the spread of fire and smoke, therefore limiting the amount of fire and smoke damage.

MYTHS	REALITY
The activation of a smoke detector will cause the sprinkler head to operate.	The vast majority of smoke detectors operate independently of fire sprinkler systems. Although there are some smoke detectors that integrate with specialized fire suppression systems, they do not activate sprinkler heads; instead, the detectors send a signal to a panel that releases water into the piping system.
New homes are safer because smoke alarms are required to be installed on all levels and that provides sufficient protection.	Properly installed and maintained smoke alarms will alert occupants that there is a fire, but because many new homes are built with lightweight construction materials that burn and fail faster, and the newer furnishings are made of synthetic materials that increase fuel load, burn faster, and emit toxic by-products, the amount of time available to escape once the alarm sounds can be reduced, whereas a fire sprinkler system will apply water to control or possibly extinguish a fire before the fire department arrives.

Determine Requirement of Sprinkler System

Understanding General Occupancy Classifications

+

Occupancy Classification for the application of Sprinkler system

&

Determining Requirement of Sprinkler System based on Occupancies

Occupancy Classification

The ICC codes and the NFPA codes divide the occupancy classifications slightly differently. However, the 10 most common occupancy classifications used throughout the various building and life safety codes.

- Assembly occupancies
- Business occupancies
- Educational occupancies
- Factory or Industrial occupancies
- Hazardous occupancies
- Institutional occupancies
- Mercantile occupancies
- Residential occupancies
- Storage occupancies
- Utility or Miscellaneous occupancies

Comparison of Occupancy Classifications

Occupancy Classification	ICC *International Building Code*	NFPA *Life Safety Code* and *NFPA 5000*
ASSEMBLY	A-1 Assembly, Theaters (Fixed Seats) A-2 Assembly, Food and/or Drink Consumption A-3 Assembly, Worship, Recreation, Amusement A-4 Assembly, Indoor Sporting Events A-5 Assembly, Outdoor Activities	A - Assembly (variations noted by occupant load)
BUSINESS	B- Business	B –Business AHC- Ambulatory Health Care
EDUCATIONAL	E- Educational (includes some day care)	E- Educational
FACTORY/INDS	F-1 Factory Industrial, Moderate Hazard F-2 Factory Industrial, Low Hazard	I- Industrial, General Industrial, Special Purpose Industrial, High Hazard
HAZARDOUS	H-1 Hazardous, Detonation Hazard H-2 Hazardous, Deflagration Hazard or Accelerated Burning H-3 Hazardous, Physical or Combustible Hazard H-4 Hazardous, Health Hazard H-5 Hazardous, Hazardous Production Materials (HPM)	(Included in Group I)
INSTITUTIONAL	I-1 Institutional, Custodial Care OL* >16 I-2 Institutional, Medical Care I-3 Institutional, Restrained (includes various Sub-conditions I-5) I-4 Institutional, Day Care Facilities	D-I Detentional/Correctional (includes various sub-conditions I-V) H- Health Care DC -Day Care

Comparison of Occupancy Classifications

Occupancy Classification	ICC *International Building Code*	NFPA *Life Safety Code* and *NFPA 5000*
MERCANTILE	M Mercantile	M-A Mercantile, > 3 levels or > 30,000 SF (2800 SM) M-B Mercantile, ≤ 3 stories or > 3000 SF (280 SM) and ≤ 30,000 SF (2800 SM) M-C Mercantile, 1 story ≤ 3000 SF (280 SM)
RESIDENTIAL	R-1 Residential, Transient R-2 Residential, Multi-Dwelling Unit R-3 Residential, One and Two Dwelling Units R-4 Residential, Care and Assisted Living Facilities OL > 5 ≤16	R- Residential, Hotels and Dormitories Residential, Apartment Buildings Residential, Lodging or Rooming Houses Residential, One- and Two-Family Dwellings Residential, Board and Care
STORAGE	S-1 Storage, Moderate Hazard S-2 Storage, Low Hazard	S Storage
UTILITY/ MISCELLANEOUS	U Utility and Miscellaneous	Special Structures and High-Rise Buildings

Requirement of Sprinkler System

[F] 403.3 Automatic sprinkler system. Buildings and structures shall be equipped throughout with an *automatic sprinkler system* in accordance with Section 903.3.1.1 and a secondary water supply where required by Section 403.3.3.

IBC 2018 CH. 04 , HIGH RISE BUILDING

Requirement of Sprinkler System

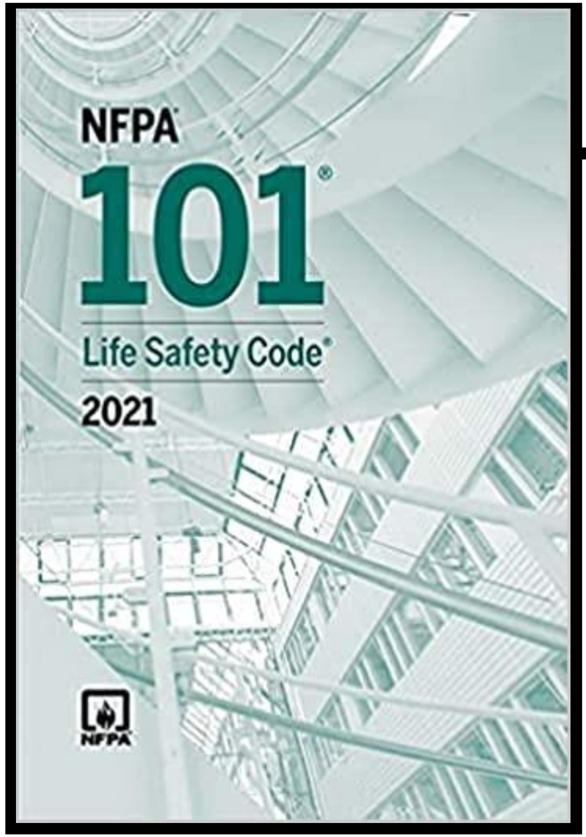
12.3.5 Extinguishment Requirements.

12.3.5.1 The following assembly occupancies shall be protected throughout by an approved, supervised automatic sprinkler system in accordance with 9.7.1.1(1):

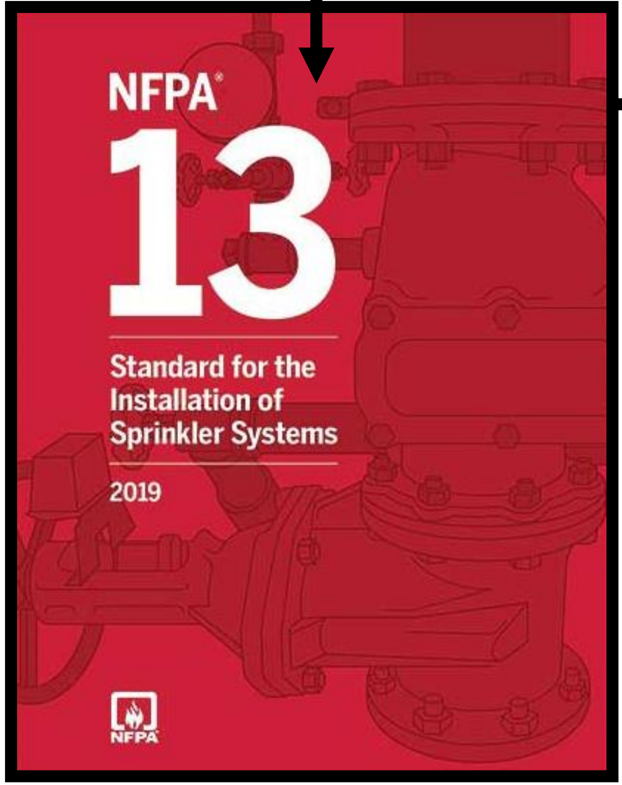
(1) Bars with live entertainment
(2) Dance halls
(3) Discotheques
(4) Nightclubs
(5) Assembly occupancies with festival seating

NFPA 101, 2009,CH. 12 , ASSEMBLY OCCUPANCIES

WHEN TO DO IT



HOW TO DO IT



WHAT TO DO

REFERENCE PRODUCT STANDARDS AND TEST PROTOCOL

The Hierarchy of Reference Documents

Educational Occupancy Thresholds

NFPA 101, Life Safety Code®	1. New buildings a. Protection throughout (Exceptions: Non-relocatable and relocatable buildings 1000 ft^2 or less; non-relocatable single classroom buildings; relocatable buildings 30 ft or more from another building) b. Portions below level of exit discharge c. Unprotected openings d. As required by other provisions within the chapter 2. Existing buildings a. Student occupied and unoccupied floors below level of exit discharge (Exceptions: If approved by the approving authority and rescue windows and ventilation provided) b. Unprotected openings c. As required by other provisions within the chapter

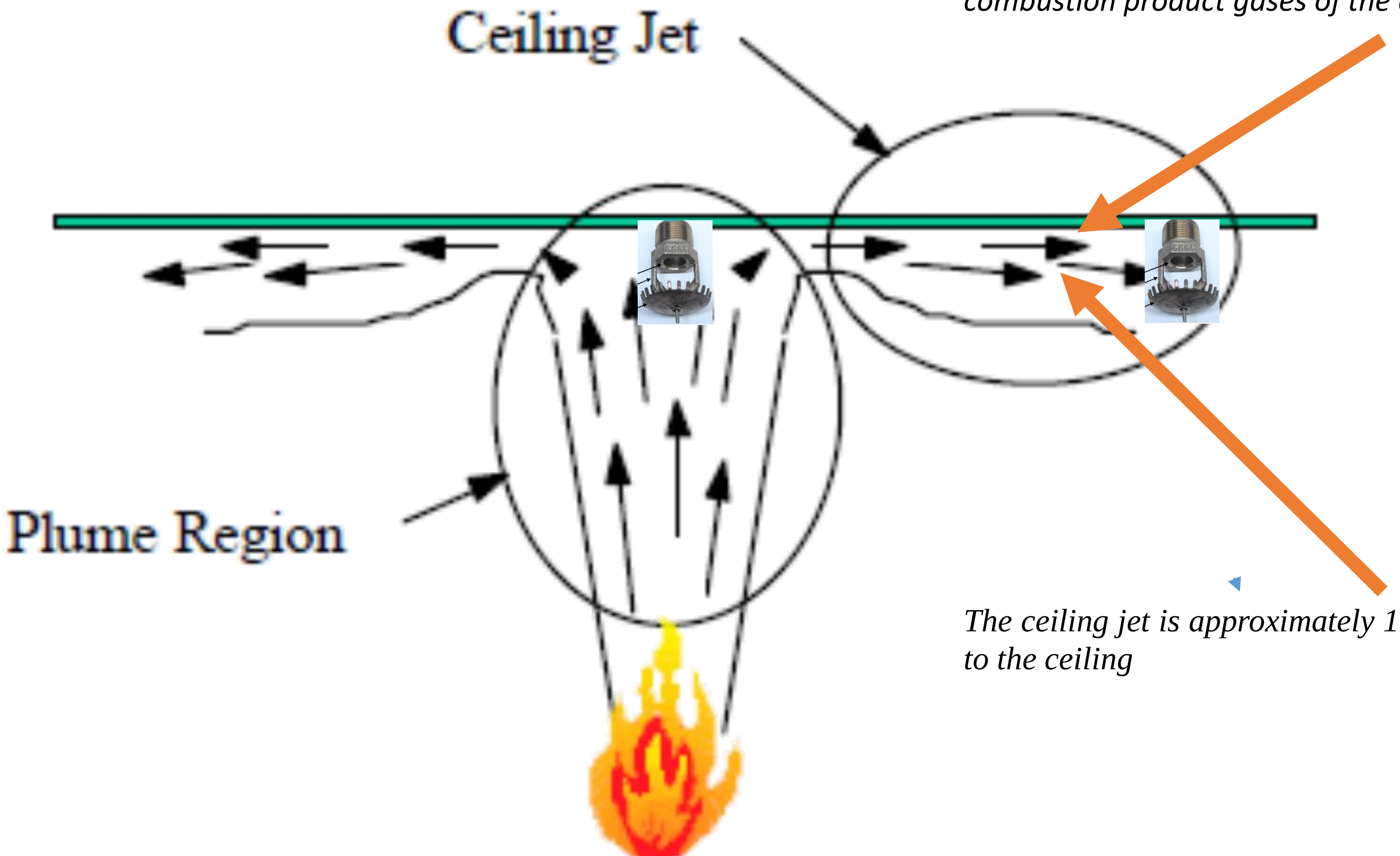
Mercantile Occupancy Thresholds

NFPA 101, Life Safety Code®	1. New buildings a. Three or more stories in height b. Gross area exceeds 12,000 ft^2 c. Stories below the level of exit discharge exceeding 2500 ft^2 used for sale, storage, or handling of combustible goods and merchandise d. Multiple occupancies protected as mixed occupancies where conditions a, b, and c apply to mercantile

Understanding Sprinkler Operation and Its Different Types

Convective Heat Flow in Fires

Approximately 92 percent to 98 percent of the heat that a heat detector/Sprinklers receives is carried to the detector/sprinkler in the hot air and combustion product gases of the ceiling jet created by the fire

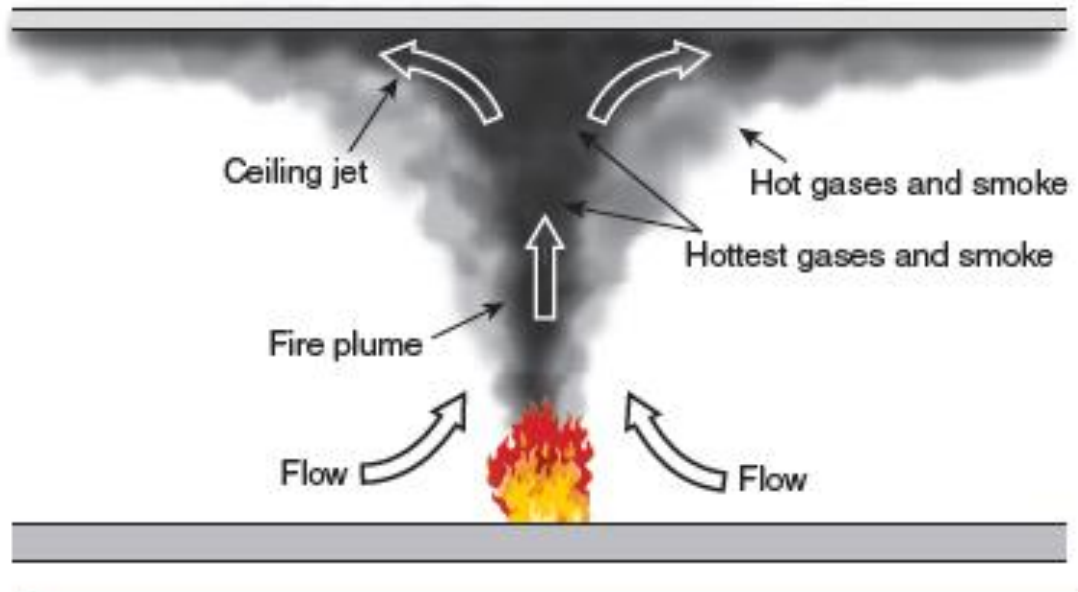


The ceiling jet is approximately 10 percent of the distance from the base of the fire to the ceiling

Convective Heat Flow in Fires

Primary Purpose of Sprinkler Spray

1. It delivers water to the burning material and reduces the combustion rate by preventing further generation of combustible vapor.
2. It wets the surrounding material which reduces the flame spread rate
3. It cools the surrounding air by evaporation and displaces air with inert water vapor.



Sprinkler Design Purposes

1. Sprays from sprinklers located directly above the fire must have sufficient vertical momentum to penetrate the fire plume and reach the burning commodity.
2. Spray from sprinklers located in the ceiling jet must have sufficient horizontal momentum to counteract the ceiling jet flow and reach the burning commodity positioned between sprinklers
3. The spray must absorb enough heat from the plume and ceiling jet to lower the temperatures to an acceptable level

Sprinkler Design Purposes

Spray pattern is a crucial characteristic of fire sprinklers. The way they spray water determines how effective they are at different jobs. There are two main variables in fire sprinkler spray patterns: **droplet size** and **spray angle**.

Droplets, as *Kenneth Isman* explains, come in three sizes and perform three separate functions:

1. **Small droplets** provide cooling, absorbing the heat of a fire.
2. **Medium droplets** are useful for pre-wetting combustible materials near a fire.
3. **Large droplets** penetrate a fire plume where smaller droplets would vaporize. These directly attack a fire.

What is a Sprinkler System

- A *fire sprinkler system* is an **ACTIVE** fire protection measure, consisting of a water supply system, providing adequate pressure and flow of water through a distribution piping system, onto which fire sprinklers are connected,

- Sprinkler systems have been around since the late 1880's,

- In 1874, H.S. Pamelee patented the first practical automatic sprinkler,

Sprinkler System Components

- ❑Pipe and Fittings
- ❑Gauges
- ❑Valves
- ❑Pipe Supports
- ❑Sprinkler Heads

Pipe and Fittings

Not all pipe or tubing that meets these standards is *also* listed for fire sprinkler service. Pipes that are “listed” have been rigorously tested and found to meet the safety standards of a third-party certification agency. Metal pipes are listed to UL 852 and thermoplastic pipes are listed to UL 1821.

****If listed materials differ from Table 7.3.1.1, NFPA 13 permits their use as long as installers adhere to any limitations in the listing

Table 7.3.1.1 Pipe or Tube Materials and Dimensions

Materials and Dimensions	Standard
Ferrous Piping (Welded and Seamless)	
Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use	ASTM A795/A795M
Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless	ASTM A53/A53M
Welded and Seamless Wrought Steel Pipe	ASME B36.10M
Standard Specification for Electric-Resistance-Welded Steel Pipe	ASTM A135/A135M
Copper Tube (Drawn, Seamless)	
Standard Specification for Seamless Copper Tube	ASTM B75/B75M
Standard Specification for Seamless Copper Water Tube	ASTM B88
Standard Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube	ASTM B251
Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube	ASTM B813
Specification for Filler Metals for Brazing and Braze Welding	AWS A5.8M/A5.8
Standard Specification for Solder Metal, Section 1: Solder Alloys Containing Less Than 0.2% Lead and Having Solidus Temperatures Greater than 400°F	ASTM B32
Alloy Materials	ASTM B446
CPVC	
Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)	ASTM F442/F442M
Brass Pipe	
Standard Specification for Seamless Red Brass Pipe, Standard Sizes	ASTM B43
Stainless Steel	

Table 7.4.1 Fittings Materials and Dimensions

Materials and Dimensions	Standard
Cast Iron	
Gray Iron Threaded Fittings, Classes 125 and 250	ASME B16.4
Gray Iron Pipe Flanges and Flanged Fittings, Classes 25, 125, and 250	ASME B16.1
Malleable Iron	
Malleable Iron Threaded Fittings, Classes 150 and 300	ASME B16.3
Steel	
Factory-Made WroughtButtwelding Fittings	ASME B16.9
Buttwelding Ends	ASME B16.25
Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service	ASTM A234/A234M
Pipe Flanges and Flanged Fittings, NPS ½ through NPS 24 Metric/Inch Standard	ASME B16.5
Forged Fittings, Socket-Welding and Threaded	ASME B16.11
Copper	
Wrought Copper and Copper Alloy Solder Joint Pressure Fittings	ASME B16.22
Cast Copper Alloy Solder Joint Pressure Fittings	ASME B16.18
CPVC	
Standard Specification for Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80	ASTM F437
Standard Specification for Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40	ASTM F438
Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80	ASTM F439
Bronze Fittings	

Pipe and Fittings

The pipe schedule or type indicates the thickness of the pipe wall

Summation of Variables Affecting Fire Sprinkler Pipe Selection				
	Pipe or Tube Type			
Property	Steel Sch. 40	Typical lightwall steel	Copper Type M	CPVC SDR 13.5
color	black	silver	copper	bright orange
weight of the DN25 (1 in.) size (kg/m)	2.5	1.8	0.7	0.4
melting point (MP) or heat distortion temperature (HDT)	(MP) 1427-1538°C (2600-2800°F)	(MP) 1427-1538°C (2600-2800°F)	(MP) 1082°C (1980°F)	(HDT) 103°C (217°F)
damage susceptibility	low	low	low	high with UV exposure and impacts
corrosion susceptibility design C factor	high/ 120	high/ 120	moderate/ 150	low/ 150
occupancy classification NFPA standards	not limited	not limited	not limited	NFPA 13 light hazard, 13D, 13R, concealed and restricted exposure NFPA 90A
maximum ambient temperature	not limited	not limited	not limited	66°C (150°F)
flexibility/hanger spacing for the DN25 (1 in.) size (m)	not flexible/ 3.7	not flexible/ 3.7	slightly flexible/ 2.4	flexible/ 1.8
expansion concerns/solutions	negligible	negligible	negligible	yes/offsets direction changes, loops
fitting type	threaded grooved flanged plain-type	threaded grooved flanged plain-type	soldering brazing grooved	primer/solvent cement
compatible antifreeze	not limited*	not limited*	not limited*	glycerine*

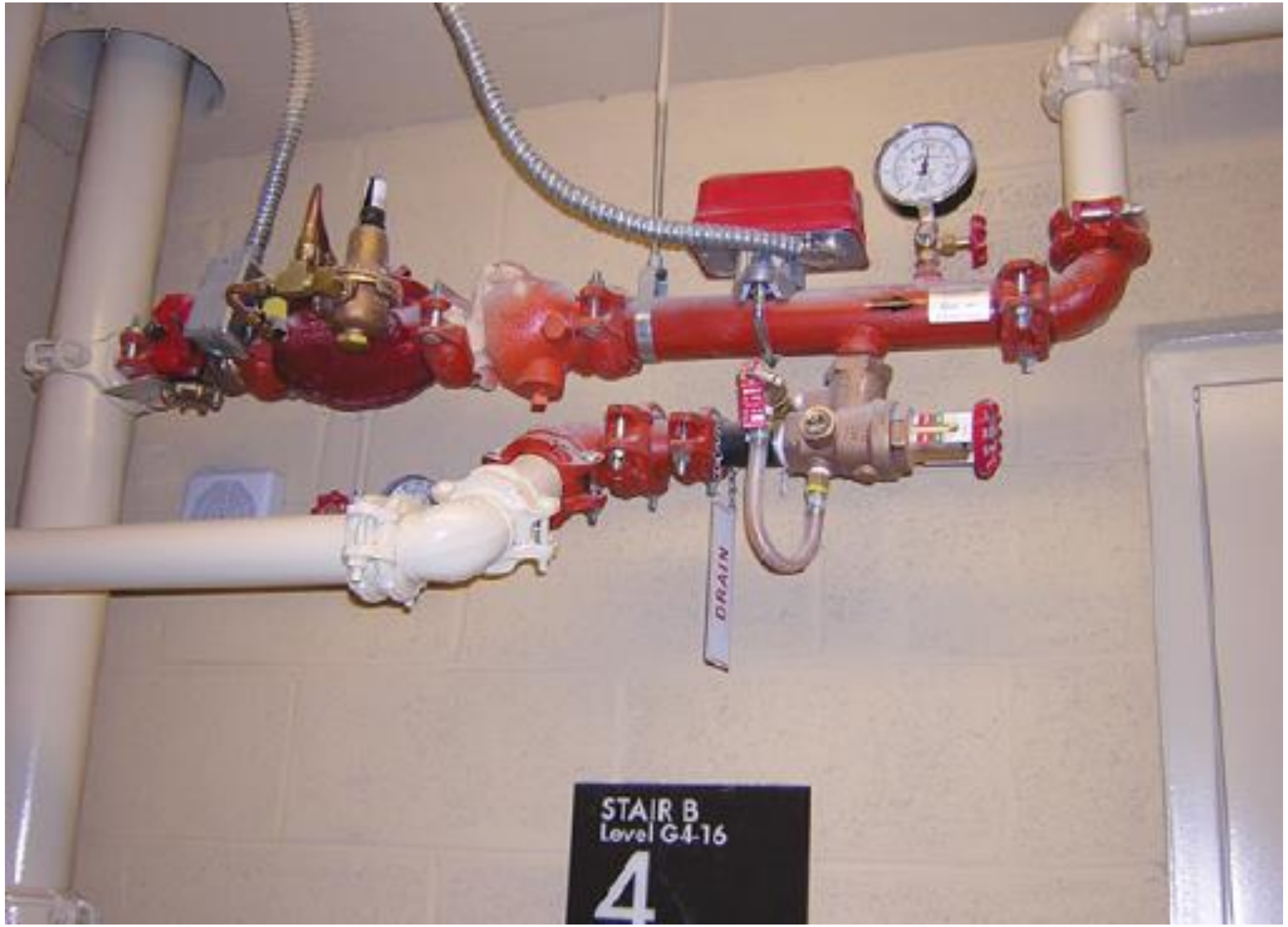
Gauges

- Pressure gauges are a small but important component of the fire sprinkler system. Some systems only have water gauges, but others also have air gauges. Gauges help fire fighters, sprinkler system contractors, and building maintenance workers to determine the available water or air pressure at the gauge location.
- In addition, a gauge can help to determine whether there is a problem with the system if the gauge reading is outside the normal or expected pressure readings.
- Water gauges are typically installed on the supply and system sides of the various fire sprinkler system valves and fire pumps, at the tops of standpipes, at the main drain, at each floor level when feeding a sprinkler system from a standpipe, and on each side of pressure-regulating devices. Air gauges are installed on the system side of certain fire sprinkler valves, on system air sources, on air supply lines, and on quick-opening devices.
- Gauges should not be subject to freezing temperatures, should have a shut-off valve, and should be capable of draining.

Valves

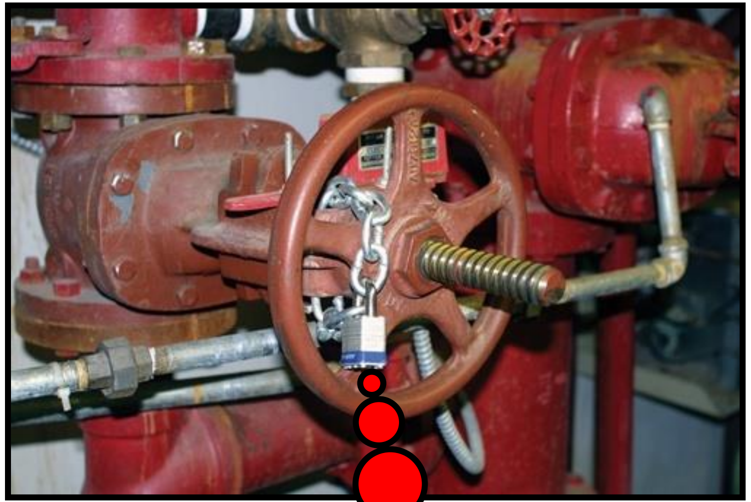
- All automatic fire sprinkler system control valves must be indicating-type valves so that a person can look at the valve and determine if the valve is open, partially open, or shut. In addition, these valves require identification with a permanent metal or rigid plastic weatherproof sign, which must identify the area of the building served by that valve (National Fire Protection Association 2019, *NFPA 13,* Section 16.9.12.1).
- All indicating valves must be able to handle 175 psi or carry an appropriate rating for an anticipated pressure above 175 psi. Fully open indicating valves shall not close in less than 5 seconds when operated at maximum possible speed (National Fire Protection Association 2019, *NFPA 13,* Section 7.6.1). Indicating valves in fire sprinkler systems are usually 2 in. or larger and include the outside screw and yoke (OS&Y) valve, butterfly indicator valve, wall post indicator valve (WPIV), and post indicator valve (PIV)

Control Valves

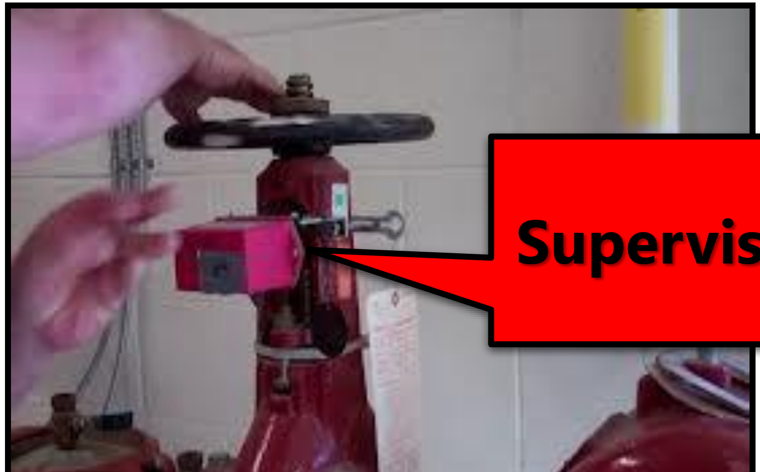


Control Valves

- OS&Y Valve
- Post Indicator Valve (PIV)
- Post Indicator Valve Assembly (PIVA)
- Operating Valves

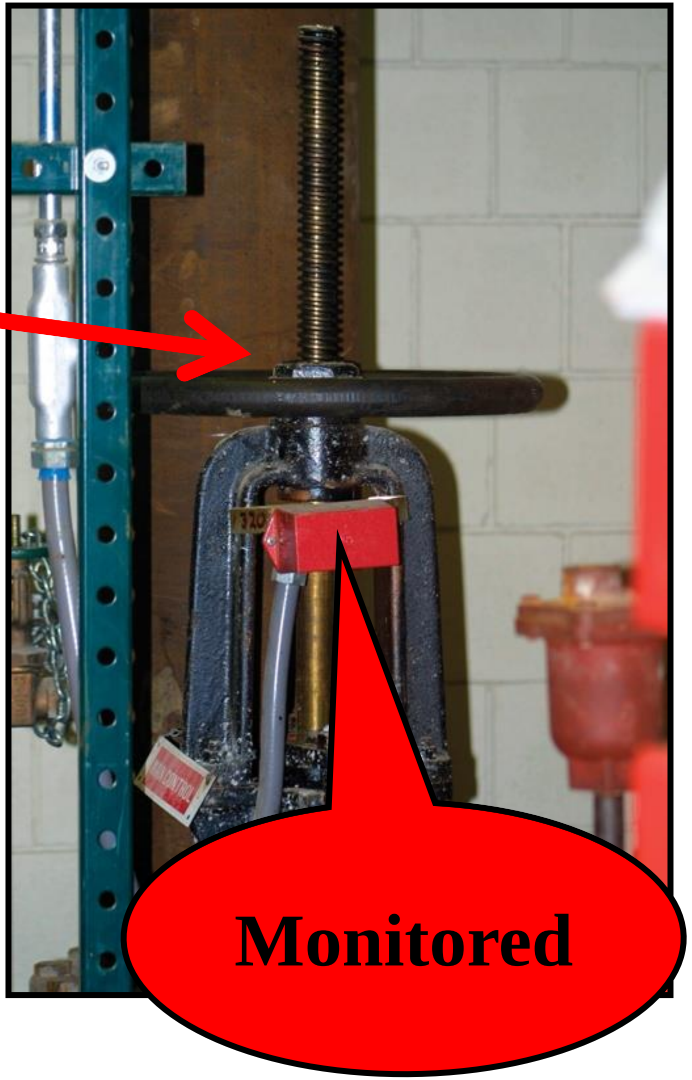


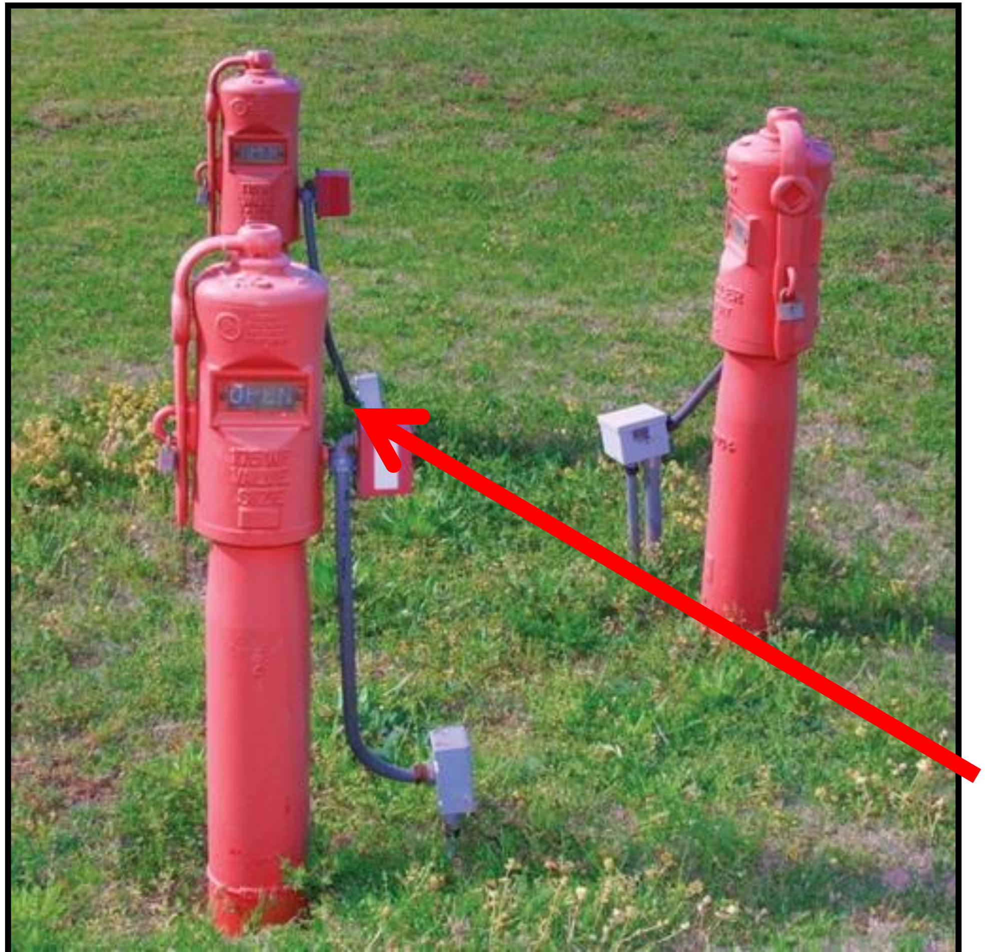
OS&Y secured in open position by chain & lock



Supervised control

❑ Outside Screw and Yoke (OS&Y) Valve





❑ Post Indicator Valve (PIV)

❑ Wall Post Indicator Valve (WPIV)

❑ Post Indicator Valve Assembly (PIVA)

Waterflow Alarms

- Hydraulic or Electrical;
  - warn of water movement in system,
  - hydraulic alarm sounds local,
  - electrical alarm sounds local and fire alarm system.

Pipe Support and Stabilization Assemblies

- The majority of sprinkler piping runs horizontally across a building's ceilings; in order to ensure that it stays in place and does not fall or move too much, hangers, bracing, supports, guides, restraints, and different types of fasteners are used. Bracing, guides, and restraints hold the pipe in position and prevent movement in an unwanted direction. A typical hanger assembly consists of a fastener or clamp, threaded rod, and a ring that holds the pipe. Fasteners secure the other components to the structure and are available for many different materials and installation situations.
- Fasteners can be attached by hammering, screwing, power driving, or drilling, but it is extremely important that the correct type of fastener attach to the compatible building material to ensure that the assembly carries the load for the type and size of the pipe. For piping that runs vertically, riser-type clamps hold the pipe in position and prevent upward and downward movement. These support and stabilization assemblies hold the weight of the sprinkler system pipe and water by attaching to the structure or providing a place for the pipe to rest on

Hanger Loads

- There is a difference between the safety factors applied to the hanger versus those for the building structure. In general, the hanger components are expected to support five times the weight of the water-filled piping plus a load of 250 lb (114 kg) at any point of piping support.

Hanger Distance

TABLE 16.4.5 Maximum Distance Between Hangers (ft-In.)

	Nominal Pipe Size (in.)											
	¾	*1*	*1¼*	*1½*	*2*	*2½*	*3*	*3½*	*4*	*5*	*6*	*8*
Steel pipe except threaded lightwall	NA	12-0	12-0	15-0	15-0	15-0	15-0	15-0	15-0	15-0	15-0	15-0
Threaded lightwall steel pipe	NA	12-0	12-0	12-0	12-0	12-0	12-0	NA	NA	NA	NA	NA
Copper tube	8-0	8-0	10-0	10-0	12-0	12-0	12-0	15-0	15-0	15-0	15-0	15-0
CPVC	5-6	6-0	6-6	7-0	8-0	9-0	10-0	NA	NA	NA	NA	NA
Polybutylene (IPS)	NA	3-9	4-7	5-0	5-11	NA	NA	NA	NA	NA	NA	NA
Polybutylene (CTS)	2-11	3-4	3-11	4-5	5-5	NA	NA	NA	NA	NA	NA	NA
Ductile Iron Pipe	NA	NA	NA	NA	NA	NA	15-0	NA	15-0	NA	15-0	15-0

Sway Bracing Placement

lateral Bracing

Longitudinal Bracing

4 way Bracing

Sprinkler Heads

Once activated, a sprinkler head develops a water spray pattern that covers a certain area below the head.

Sprinkler Heads

- Sprinkler heads are the key components of the system,
  - Heads must be suitable in design, performance, application and temperature for type of property it is protecting,
  - Standard heads are marked with ***SSU*** (standard sprinkler upright) or ***SSP*** (standard sprinkler pendent) on the deflector,
  - Side wall heads may be pendent, upright, or horizontal,

frangible bulb

Sprinkler Heads

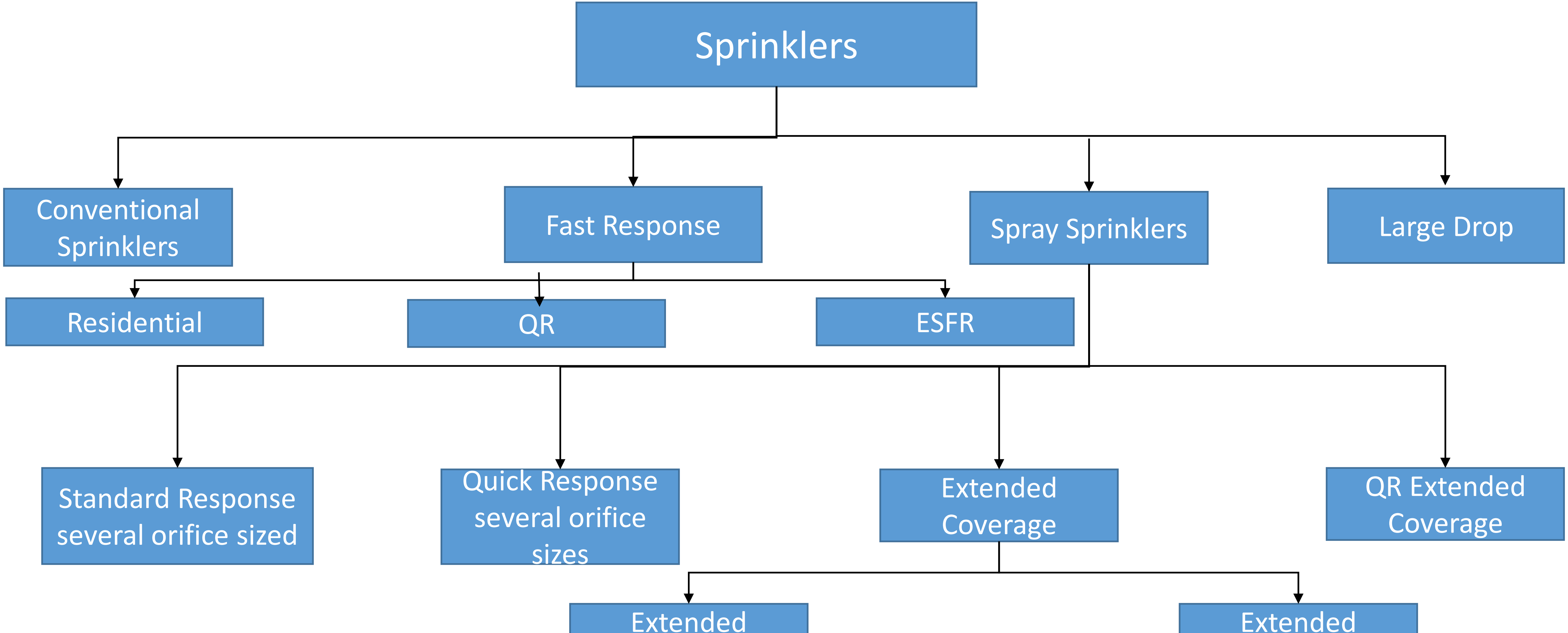
fusible link

- The typical sprinkler head is activated by heat (temperature),
  - opens when a triggering action occurs,
  - a frangible bulb breaks (color indicates temperature setting),
  - a fusible link melts,
  - water flows when head is opened,
  - water is manually shut off,
  - once activated, head must be replace,

Sprinkler Heads

- *Types*;
  - Upright
  - Pendant
  - Sidewall
  - Recessed heads

Application of Sprinkler Types



Sprinklers Temperature Rating

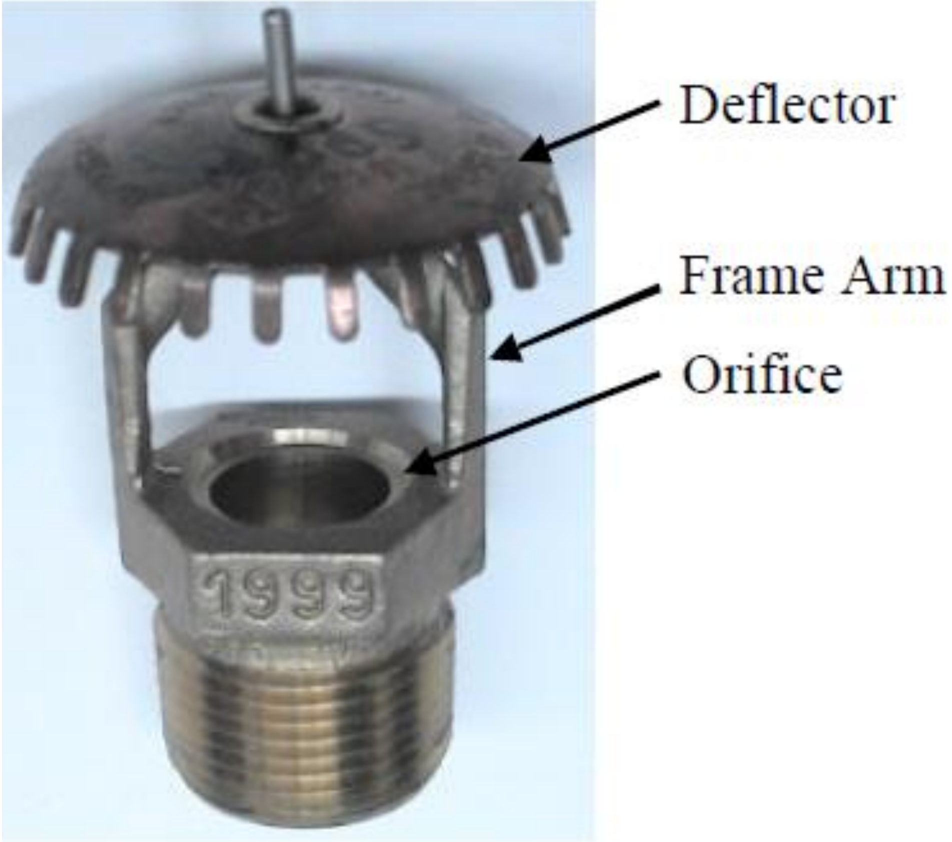
This Liquid may contain

Toluene, xylene, n-decane, cyclohexane, trichloroethylene, tetrachloroethylene, ethyl acetoacetate, acetone, methyl ethyl ketone, methanol, ethanol, isopropanol, glycerol or ethyl acetate, or mixtures thereof

The size of the bubble and the expansion rate of the liquid establish the operating temperature of the sprinkler.

 # 6.2.5.4-The frame arms of bulb-type sprinklers shall not be required to be color coded.

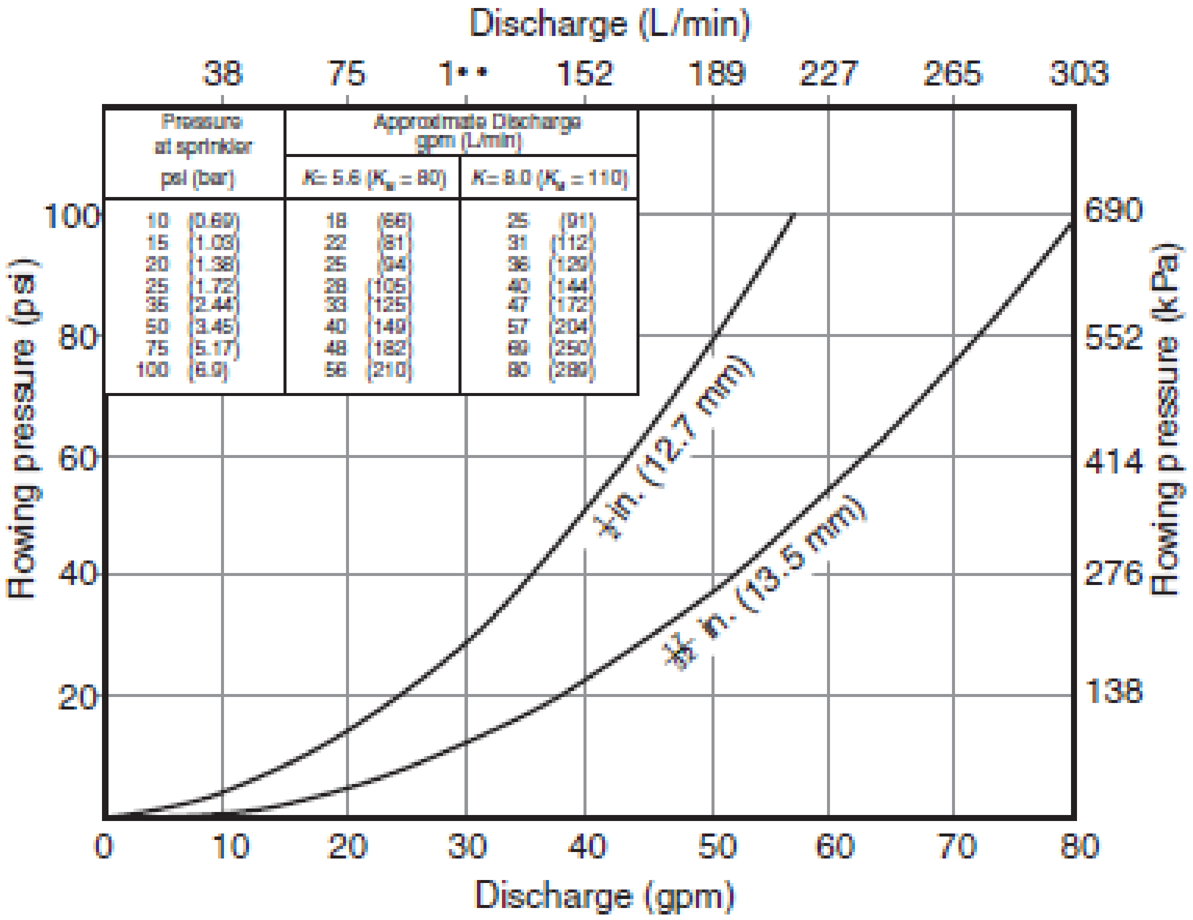
Typical Sprinkler Design



Automatic Sprinkler

Legend	
1	Escutcheon
2	Orifice seat
3	Orifice cap
4	Frame arms
5	Fusible element
6	Deflector

Deflector Design



Pressure at sprinkler psi (bar)	Approximate Discharge gpm (L/min)	
	$K = 5.6$ ($K_s = 80$)	$K = 8.0$ ($K_s = 110$)
10 (0.69)	18 (66)	25 (91)
15 (1.03)	22 (81)	31 (112)
20 (1.38)	25 (94)	36 (129)
25 (1.72)	28 (105)	40 (144)
35 (2.44)	33 (125)	47 (172)
50 (3.45)	40 (149)	57 (204)
75 (5.17)	48 (182)	69 (250)
100 (6.9)	56 (210)	80 (289)

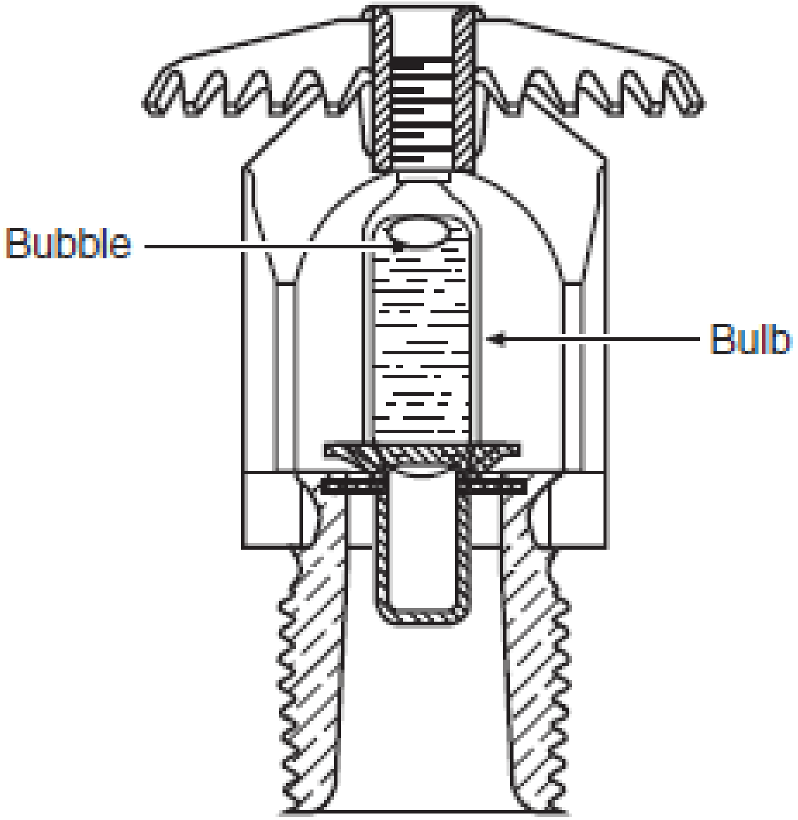


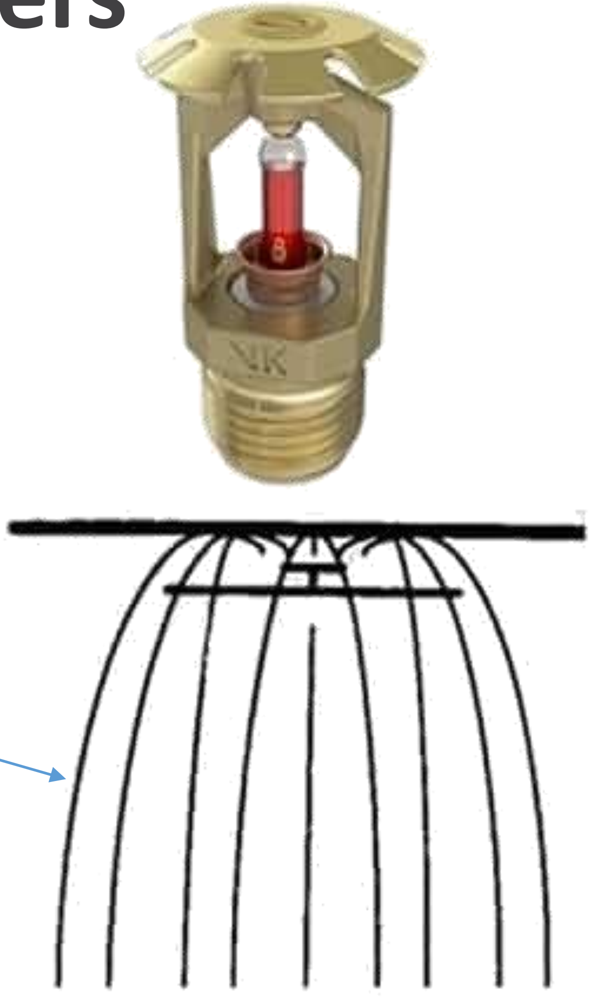
FIGURE 16.2.4 Water Discharge Rates of Typical Nominal

Sprinkler Heads

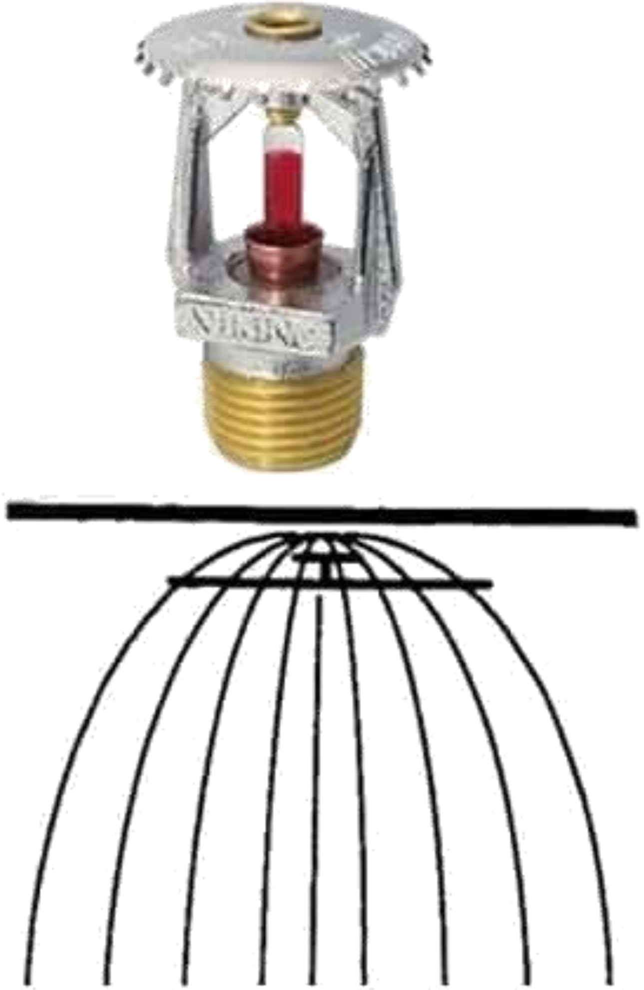
- **Storage Cabinet;**
  - Extra heads
  - Sprinkler wrench
- Cabinets hold a minimum of six sprinklers and sprinkler wrench in accordance with NFPA® 13.
  - Less than 300 heads min 6 spares
  - 300 – 1,000 heads min 12 spares
  - More than 1000 heads min 24 spares

The Difference Between Standard Response and Quick Response Sprinklers

Until 1953, fire sprinklers had what we now call “conventional” or “old-style” deflectors, which would throw between 40 and 60% of their discharged water initially upwards rather than downwards.



Upright old-style sprinkler



Upright spray sprinkler and

The Difference Between Standard Response and Quick Response Sprinklers

NFPA 13 defines “fast-response” and “standard-response” sprinklers based on these RTI values (**3.3.205.4**):

•**Fast response** sprinklers have RTIs of **50 or less**.

•**Standard response** sprinklers have RTIs of **80 or less.**

Standard vs QR vs Residential

Standard-Response Pendent VK1021 | **Quick-Response Pendent VK3021** | **Residential (Fast-Response) Pendent VK468**

What is the Hydraulic Advantage of QR Spr.

Because QR sprinklers open faster and thus may control fires sooner, **NFPA 13 encourages designers to use them** instead of standard response sprinklers in certain conditions. Specifically, designers can employ QR sprinklers where (**19.3.3.2.3.1**):

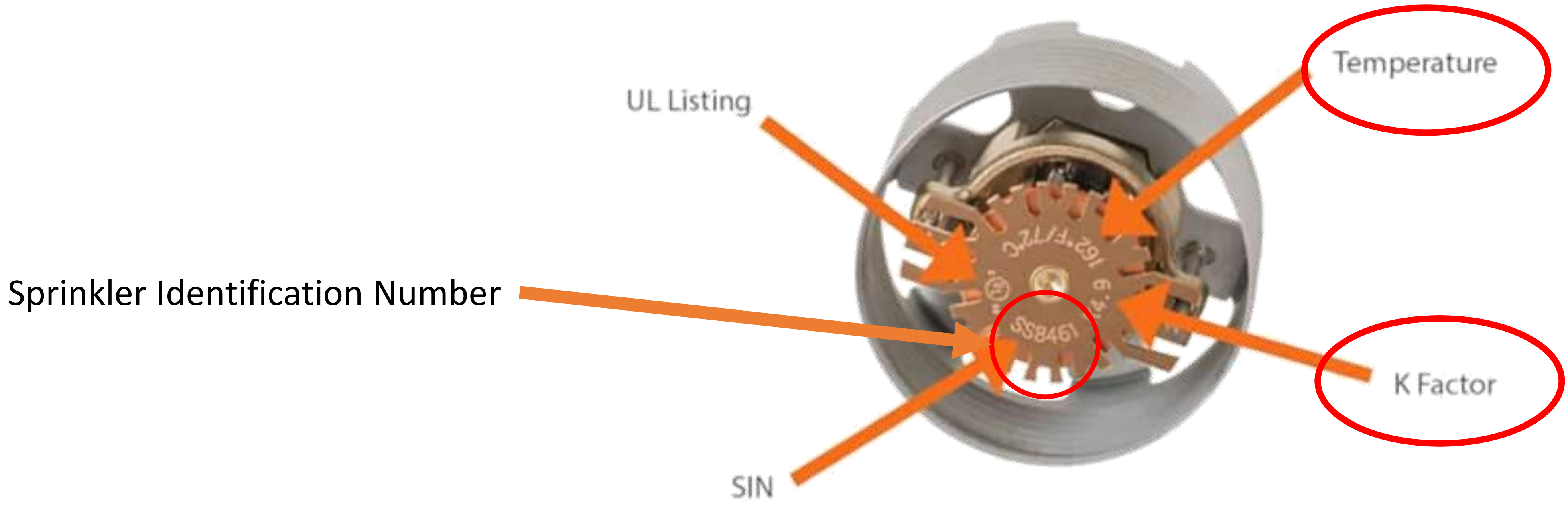
- The occupancy is light or ordinary hazard (the only time QR is allowed)
- The sprinkler system is wet-pipe
- The ceiling is no more than 20 feet high
- There are no unprotected ceiling pockets covering more than 32 ft.^{2}
- There are no unprotected areas above cloud ceilings

What is the Hydraulic Advantage of QR Spr.

Without Quick-Response	With Quick Response
Design density: 0.15 gpm/ft.2	Design Density: 0.15 gpm/ft2
Design area: 1500 ft.2	Design area: 900 ft.2
Required flow in design area: 225 gpm	Required flow in design area: 135 gpm

Sprinkler Identification

All sprinklers shall be permanently marked with one or two English uppercase alphabetic characters to identify the manufacturer, immediately followed by three or four numbers, to uniquely identify a sprinkler as to K-factor, deflector characteristic, pressure rating, and thermal sensitivity



Sprinkler Identification

- All of this information is important, but the type of head, temperature rating, and K-factor are critical to the design process. Installing a head that has the wrong temperature rating for the installation conditions could lead to unwanted activation, delayed activation, or no activation.

Sprinkler Identification

- For calculation and design purposes, *the K-factor establishes the mathematical relationship between the pressure and flow from a sprinkler head*. With Q being the discharge in gallons per minute, K being the discharge coefficient for the orifice of the sprinkler head, and P being the water pressure in pounds per square inch, the relationship for determining flow is expressed in the following formula:

$$Q = K \sqrt{P}$$

- Each size orifice has a K-factor value that applies when performing hydraulic calculations. For example, a ½-in. orifice has an applied nominal K-factor of 5.6, a ¾-in. orifice has a nominal K-factor of 14.0, and a 1-in. orifice has a nominal K-factor of 25.2

Sprinkler Identification

Sprinkler head orifices with K-factors of 25.2, 14.0, and 5.6 (from left to right).

Table 7.2.4.1 Temperature Ratings, Classifications, and Color Codings

Maximum Ceiling Temperature		Temperature Rating		Temperature Classification	Color Code	Glass Bulb Colors
°F	°C	°F	°C			
100	38	135–170	57–77	Ordinary	Uncolored or black	Orange or red
150	66	175–225	79–107	Intermediate	White	Yellow or green
225	107	250–300	121–149	High	Blue	Blue
300	149	325–375	163–191	Extra high	Red	Purple
375	191	400–475	204–246	Very extra high	Green	Black
475	246	500–575	260–302	Ultra high	Orange	Black
625	329	650	343	Ultra high	Orange	Black

Table 7.2.2.1 Sprinkler Discharge Characteristics Identification

Nominal K-Factor [gpm/(psi)$^{1/2}$]	Nominal K-Factor [L/min/(bar)$^{1/2}$]	K-Factor Range [gpm/(psi)$^{1/2}$]	K-Factor Range [L/min/(bar)$^{1/2}$]	Percent of Nominal K-5.6 Discharge	Thread Type
1.4	20	1.3–1.5	19–22	25	½ in. (15 mm) NPT
1.9	27	1.8–2.0	26–29	33.3	½ in. (15 mm) NPT
2.8	40	2.6–2.9	38–42	50	½ in. (15 mm) NPT
4.2	60	4.0–4.4	57–63	75	½ in. (15 mm) NPT
5.6	80	5.3–5.8	76–84	100	½ in. (15 mm) NPT
8.0	115	7.4–8.2	107–118	140	¾ in. (20 mm) NPT or ½ in. (15 mm) NPT
11.2	160	10.7–11.7	159–166	200	½ in. (15 mm) NPT or ¾ in. (20 mm) NPT
14.0	200	13.5–14.5	195–209	250	¾ in. (20 mm) NPT
16.8	240	16.0–17.6	231–254	300	¾ in. (20 mm) NPT
19.6	280	18.6–20.6	272–301	350	1 in. (25 mm) NPT
22.4	320	21.3–23.5	311–343	400	1 in. (25 mm) NPT
25.2	360	23.9–26.5	349–387	450	1 in. (25 mm) NPT
28.0	400	26.6–29.4	389–430	500	1 in. (25 mm) NPT

Note: The nominal K-factor for dry-type sprinklers are used for sprinkler selection. See 27.2.4.10.3 for use of adjusted dry-type sprinkler K-factors for hydraulic calculation purposes.

Types of Systems

Sprinkler Installation Type		Installed where
1	Wet Pipe System	Occupancies with temperature 95°C > X > 0°C
2	Dry Pipe System	Occupancies with risks of temperature X < 0° and X > 95° C
3	Deluge Systems	Occupancies with rapid fire spread
4	Preaction Pipe Systems	In occupancies where water damage is not accepted by accidental activation

Types of Systems

There are ***four*** ***major*** types of sprinkler systems;

- The **Wet Pipe** system,
- The **Dry Pipe** system,
- The **Deluge** system and
- The **Pre-Action** system.

Types of Systems

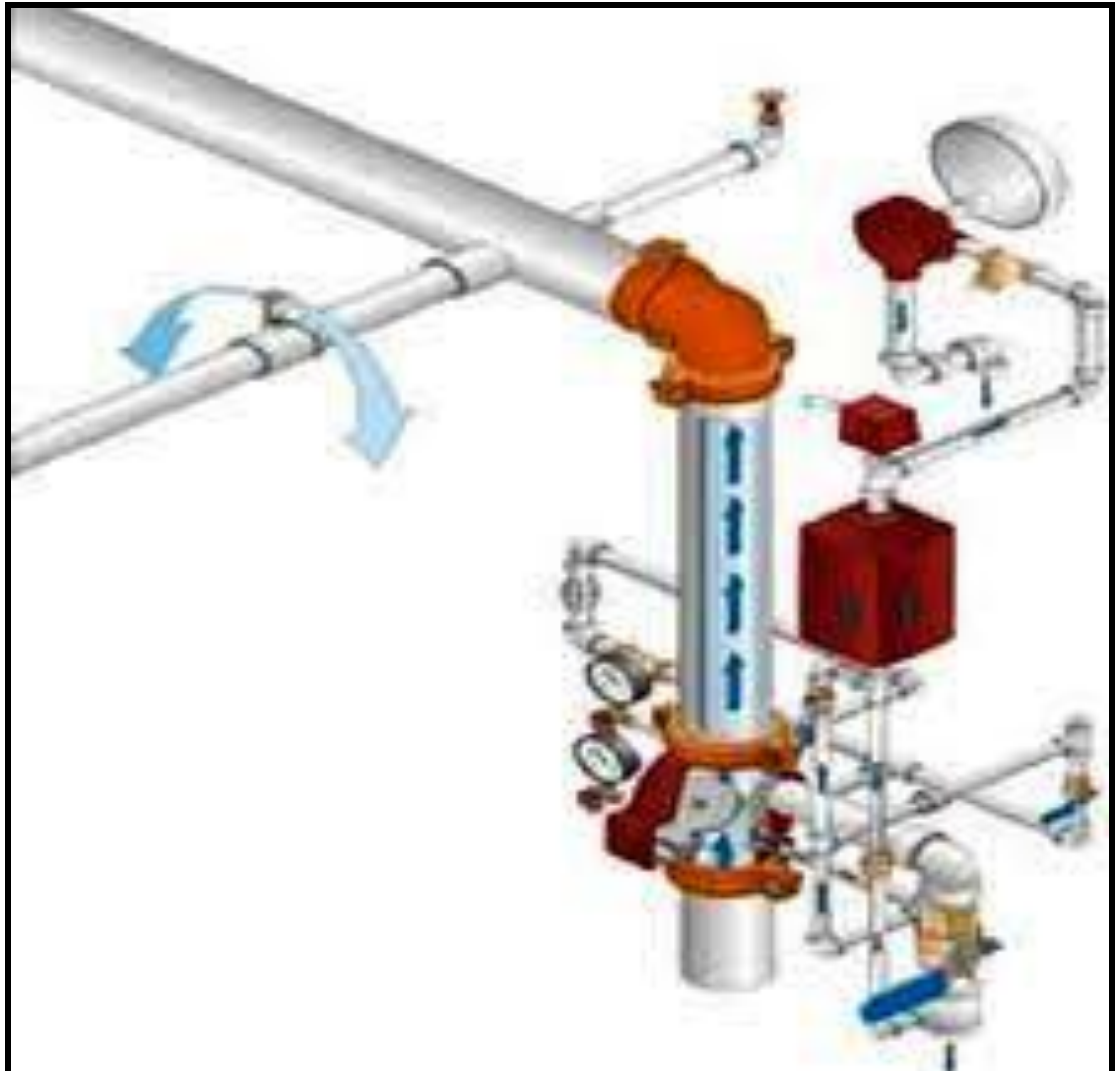
Wet pipe ---------- *by far the most common,*

Dry-pipe ---------- *where water freezing is possible,*

Deluge ------------- *for high hazard applications,*

Pre-Action -------- *where concerns over water damage.*

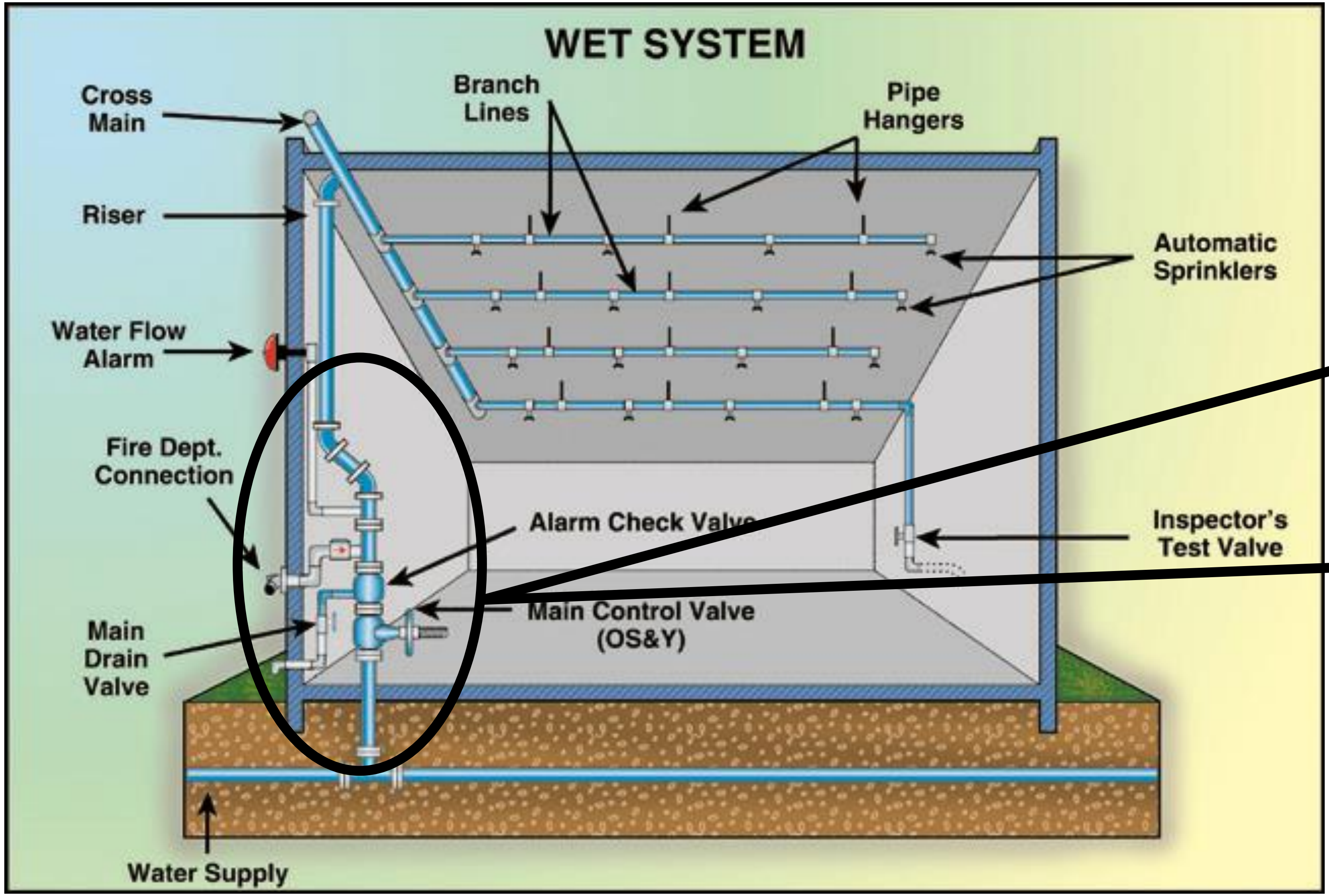
Wet Pipe Sprinkler

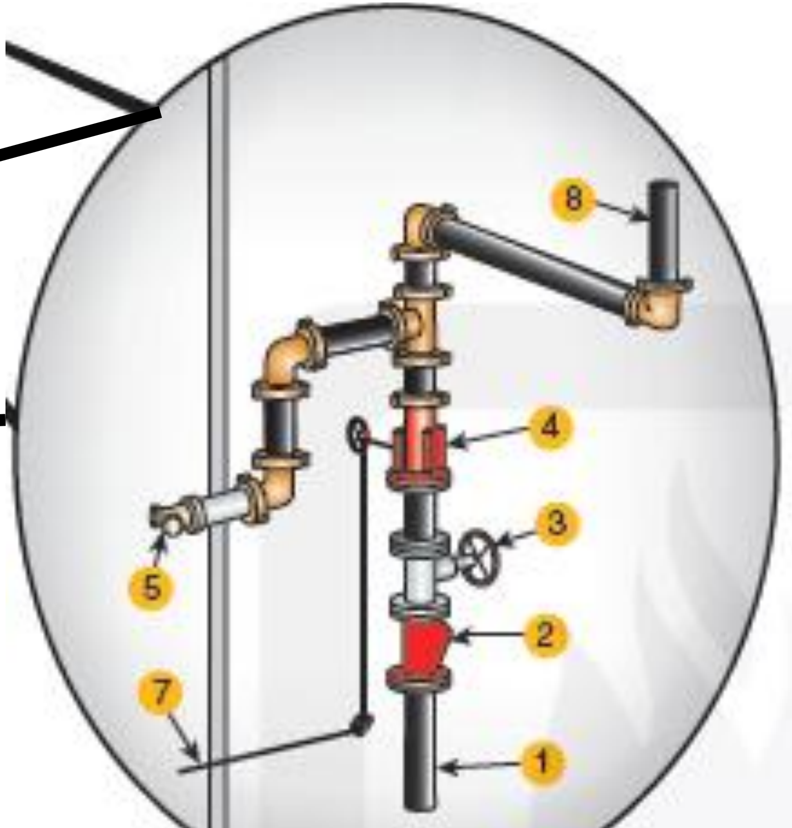


Wet Pipe Sprinkler

- Pipes are always filled with water. Heat from fire opens a sprinkler head,
- Usually only one or two heads open,
- Water flows until it is shut off,
- The open sprinkler head(s) is replaced and the system is reset.

An opening sprinkler head triggers the system





Wet Pipe Sprinkler

- A one-way clapper prevents water from re-entering the water supply,
- Gauges on both sides of the main valve, register pressure on the supply and system sides,
- A retard chamber prevents sudden pressure surges which could cause a false alarm,
- An *alarm check valve* detects water flow and activates the alarm system,

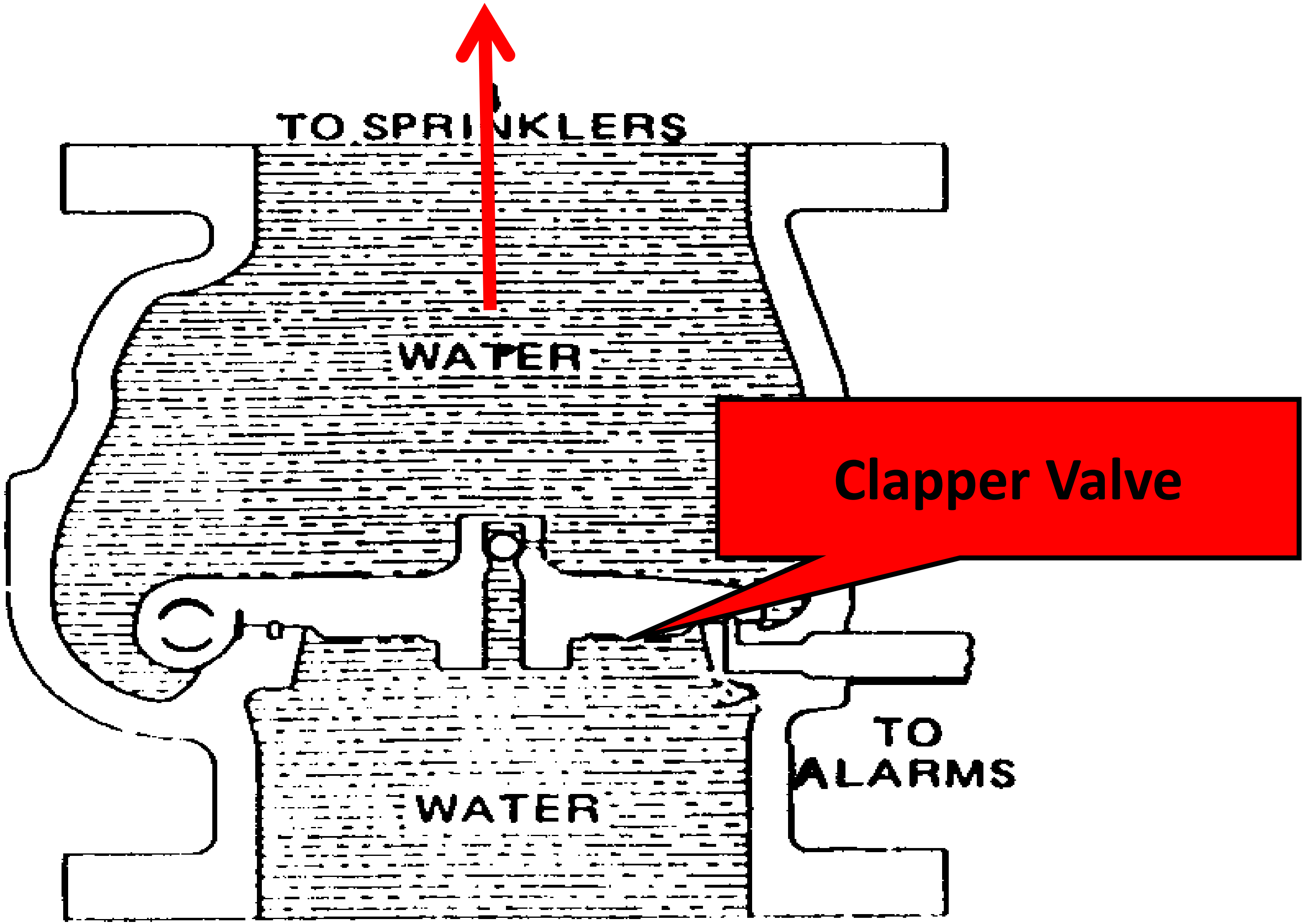
Wet Pipe Sprinkler

- There is a control valve to shut off the system, normally an *O.S.&Y.* (Outside Stem and Yoke) or (Outside Screw and Yoke),

- There is a *main drain valve* which drains the system for service,

- And an *Inspectors Test Valve*, usually at the end of the system, used to simulate flow from a single head and to measure the system response.

Typical wet pipe sprinkler valve



Wet Pipe Sprinkler

- ***Restoration of the System, Liability Issues;***

  - Some occupancies have **required** systems for life safety, i.e., public assembly, hotels and high-rises,

  - Does your FD allow restoration of the system?

  - If Not, then require a FIRE WATCH or EVACUATE THE BUILDING…..

  - Or at least, shut off the closest control valve and leave the rest of the system operational,

Wet Pipe Sprinkler

- If your SOP allows restoration;
  - after the fire is completely under control, the closest sectional water control valve should be closed,
  - the main control valve should not be closed unless there are no sectional valves,

Wet Pipe Sprinkler

- ***Restoration of the System;***

  - shut down any water source supplying the system,

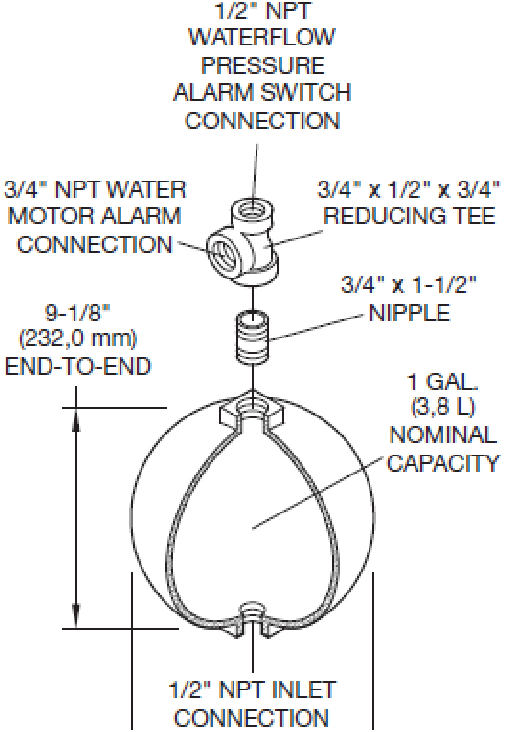
  - the sprinkler head(s) are replaced with an identical one from the spares in the sprinkler control room,

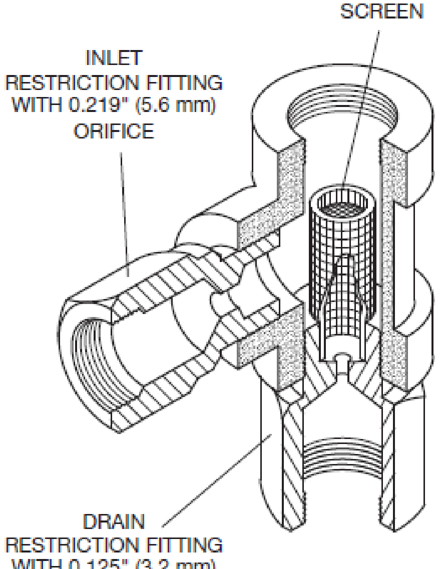
  - re-open any closed control valves,

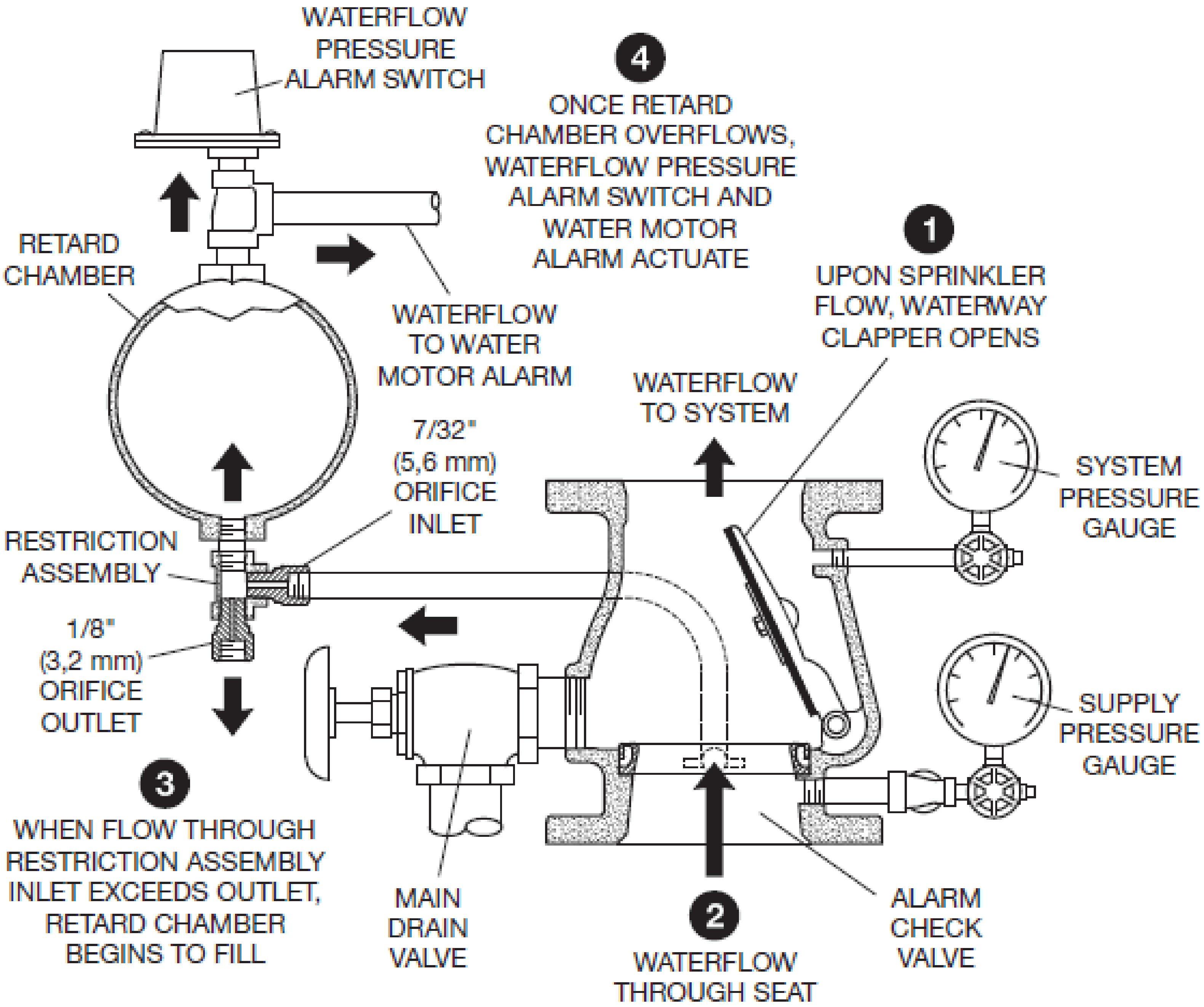
  - open the Inspectors Test Valve to ensure water is flowing to the topmost sprinkler.

Wet Pipe Sprinkler System


SHIELD FIRE, SAFETY AND SECURITY LTD.
28TH FLOOR REGUS SUITE, ONE CANADA SQUARE
CANARY WHARF, LONDON, E14 5DY, UK
SHIELD
RETARDING CHAMBER
MODEL - RC9
RATED PRESSURE - 250 PSI
LISTED
FM
APPROVED


1/2" NPT WATERFLOW PRESSURE ALARM SWITCH CONNECTION
3/4" NPT WATER MOTOR ALARM CONNECTION
3/4" x 1/2" x 3/4" REDUCING TEE
3/4" x 1-1/2" NIPPLE
9-1/8" (232,0 mm) END-TO-END
1 GAL. (3,8 L) NOMINAL CAPACITY
1/2" NPT INLET CONNECTION

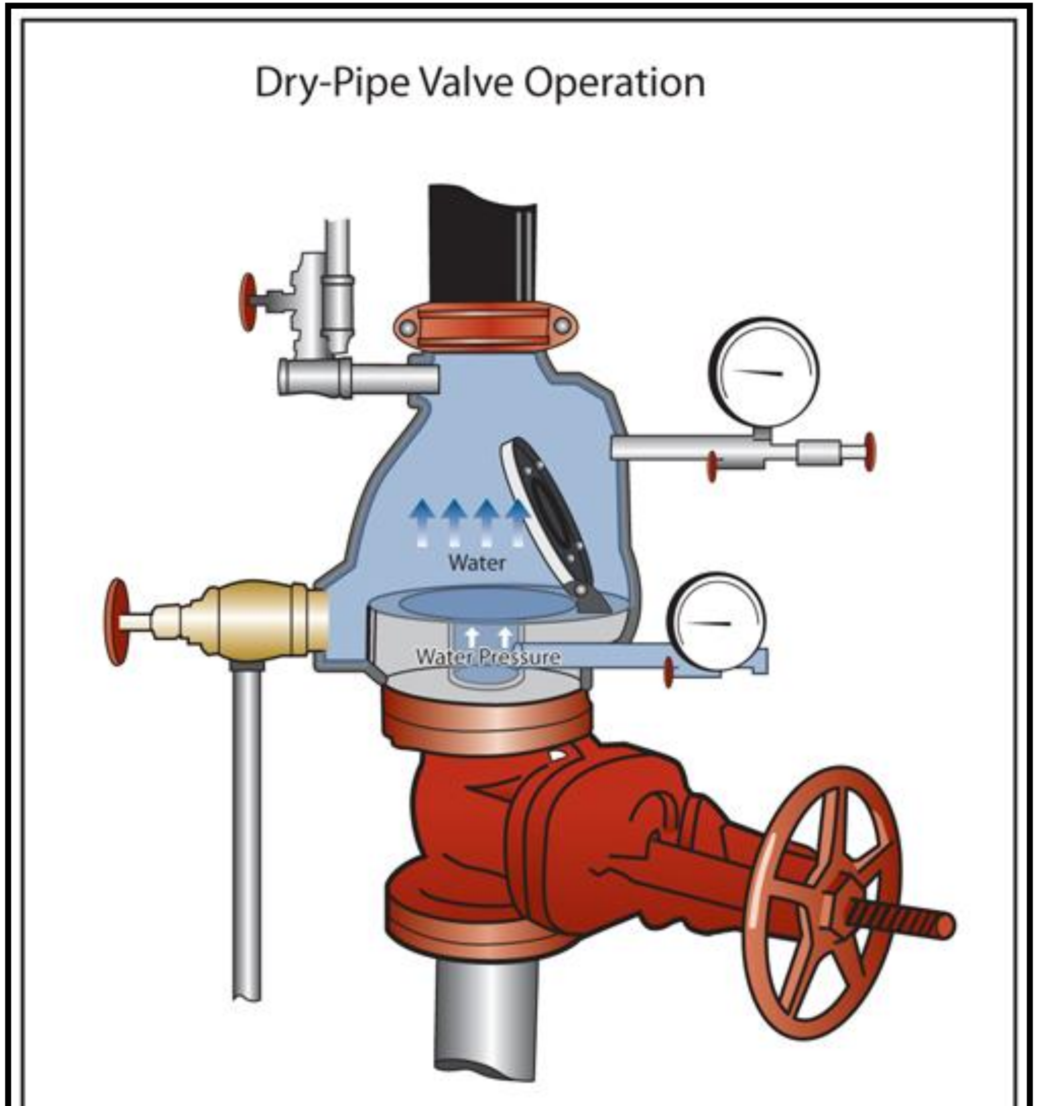

SCREEN
INLET RESTRICTION FITTING WITH 0.219" (5.6 mm) ORIFICE
DRAIN
RESTRICTION FITTING


WATERFLOW PRESSURE ALARM SWITCH
4
ONCE RETARD CHAMBER OVERFLOWS, WATERFLOW PRESSURE ALARM SWITCH AND WATER MOTOR ALARM ACTUATE
RETARD CHAMBER
WATERFLOW TO WATER MOTOR ALARM
1
UPON SPRINKLER FLOW, WATERWAY CLAPPER OPENS
WATERFLOW TO SYSTEM
7/32" (5,6 mm) ORIFICE INLET
SYSTEM PRESSURE GAUGE
RESTRICTION ASSEMBLY
1/8" (3,2 mm) ORIFICE OUTLET
SUPPLY PRESSURE GAUGE
3
WHEN FLOW THROUGH RESTRICTION ASSEMBLY INLET EXCEEDS OUTLET, RETARD CHAMBER BEGINS TO FILL
MAIN DRAIN VALVE
2
WATERFLOW THROUGH SEAT
ALARM CHECK VALVE

Per NFPA 25

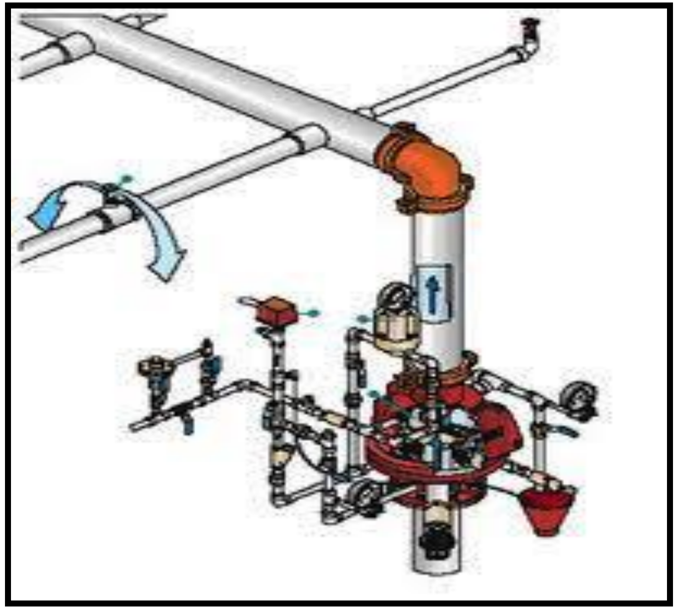
Alarm Test

Dry Pipe Sprinkler System



Dry Pipe Sprinkler

❑ Dry pipes systems are used in unheated buildings, but the valve room <u>must</u> be heated,



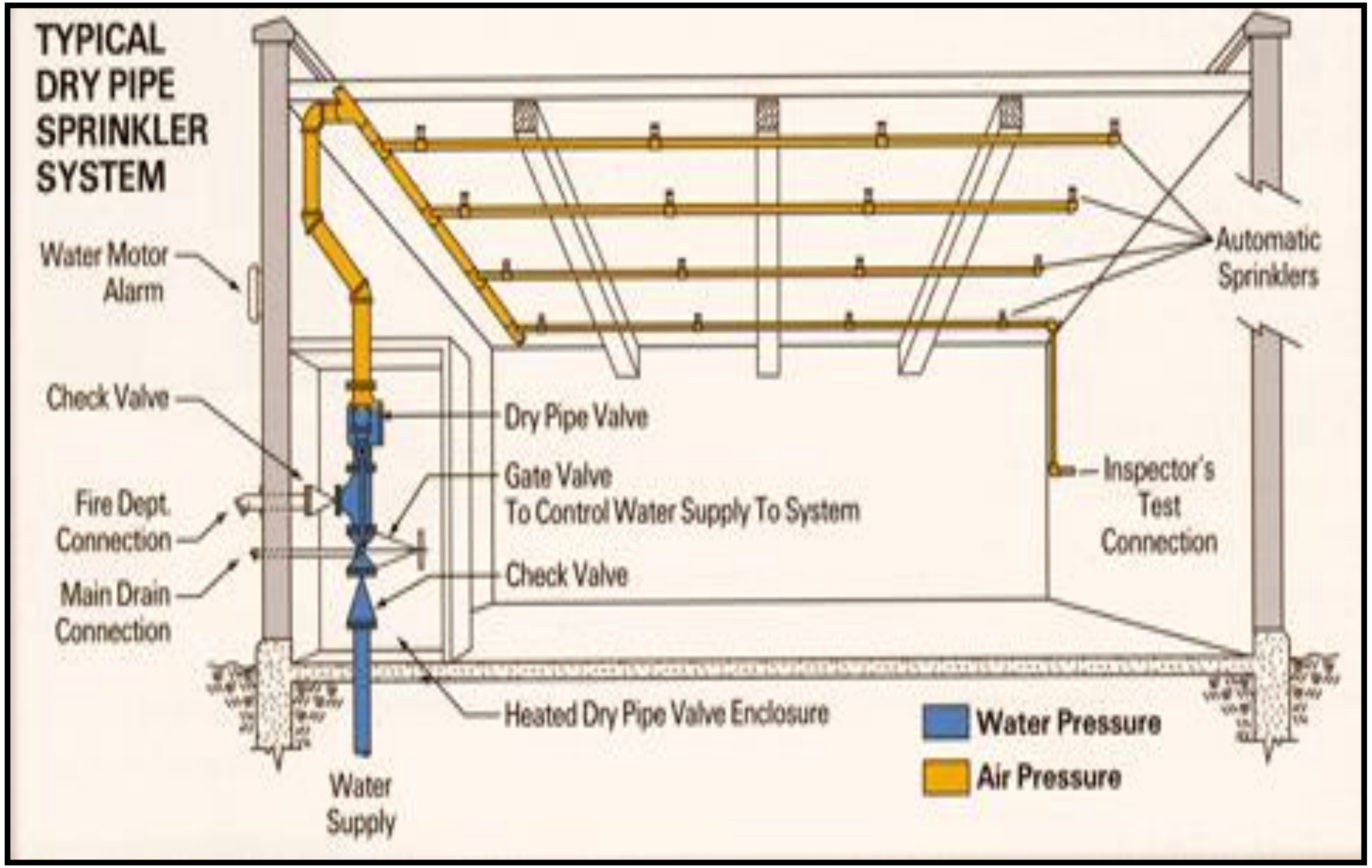
❑ Dry pipe systems are more difficult to design than wet pipe systems and are harder to restore,

Dry Pipe Sprinkler

- Pipes are not filled with water (but with pressurized gas or air)
- Heat from a fire opens a sprinkler head,
- Usually only one or two heads open,
- Air pressure drops in the piping and opens a water valve (the dry-pipe valve)

Dry Pipe Sprinkler

- Water fills the pipes and exits through an open sprinkler head(s),
- Water flows until shut off,
- Open sprinkler head is replaced,
- System is reset,



❑ Pipes in protected space are filled with air or inert gas; an opening sprinkler head, triggers the system by releasing the air or gas, which allows water to flow into the pipes and then out through the open sprinkler head.

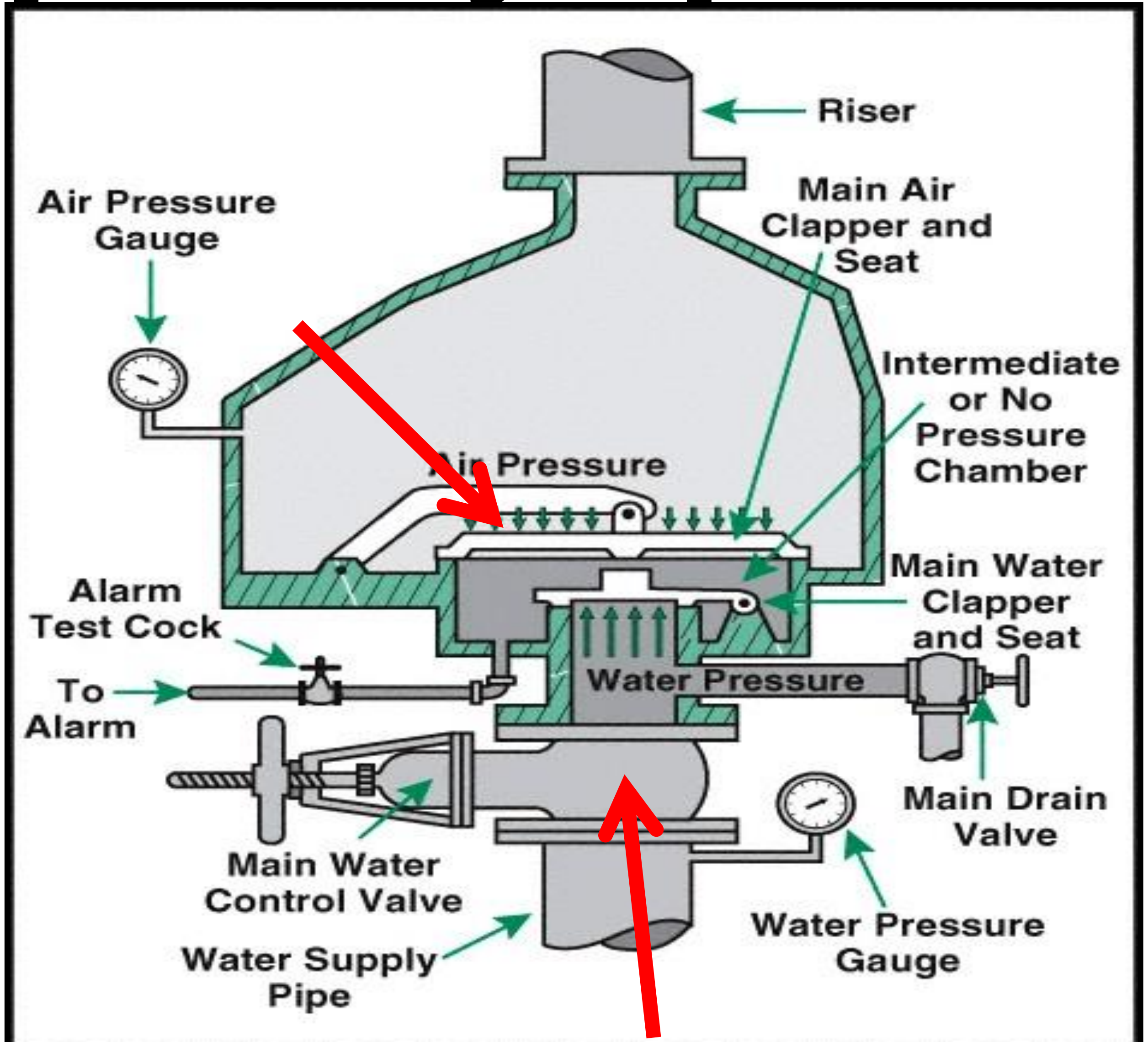
Dry Pipe Sprinkler

- A *dry pipe valve* keeps pressurized air above the supply water pressure,

- The *clapper valve* has a locking mechanism to keep the clapper open until it is reset, by draining the system, opening the dry pipe valve cover and resetting the lock,

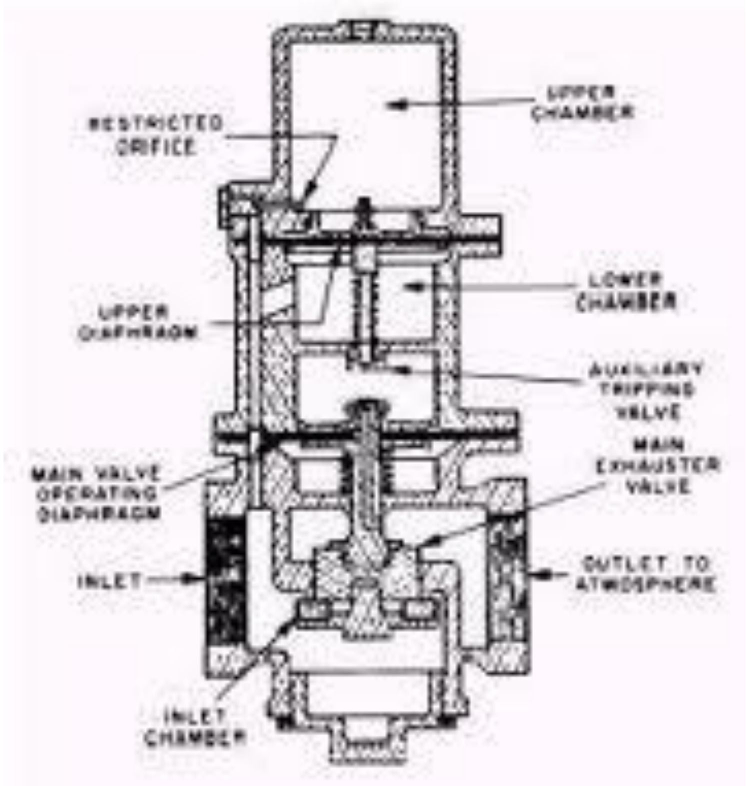
- Dry pipe systems are a little slower to activate than wet pipe systems, so most have either an *Exhauster* or *Accelerator* to speed up the system operation,

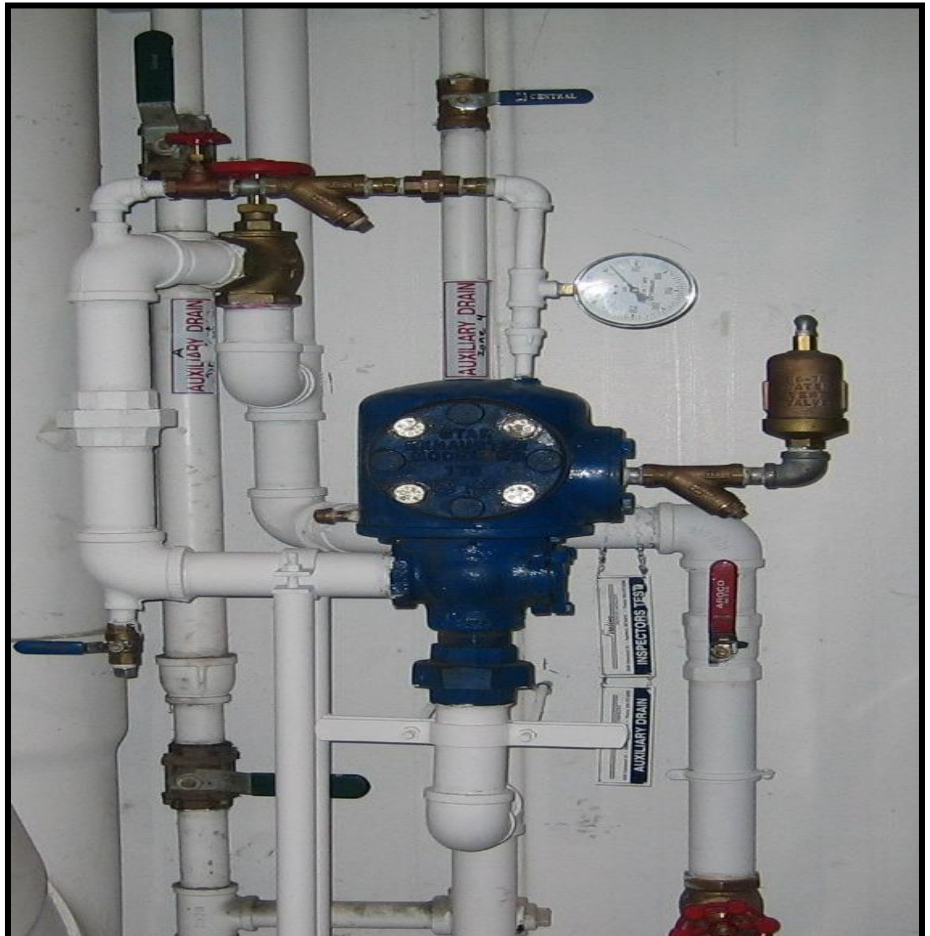
Typical Dry Pipe Valve



Dry Pipe Sprinkler

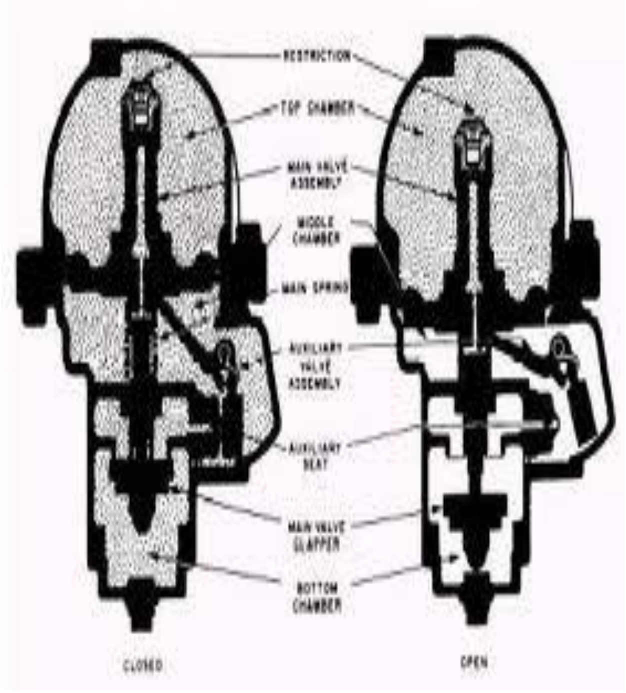
- The ***Exhauster*** detects decrease in air pressure and helps bleed off air,





Dry Pipe Sprinkler

- The ***Accelerator*** detects decrease in air pressure and pipes air pressure below the clapper valve, to speed up it’s opening,



Typical Dry Pipe Sprinkler set up

SYSTEM OPERATION AND PERFORMANCE

When dry pipe sprinkler systems are ‘trip tested’ for acceptance, the following events occur after the inspectors test valve is opened.

1. Air pressure begins to drop in the system as a result of the open inspectors test valve. The loss of air pressure in the system causes the dry pipe valve to trip at its designed air/water ratio, or when an optional accelerator trips the valve on loss of air pressure.

2. When the valve trips, water begins to fill the system by compressing trapped air and forcing air from the inspector’s test connection.

3. Water reaches the test connection and a steady water discharge is established.

The dry pipe valve trip pressure

- Different models of dry pipe valves trip at different water to air pressure ratios.
- A typical Water to Air Pressure Ratio = 5.5 : 1

Q) Static Water Pressure = 75 psi

Determine Trip Pressure for DPV ?

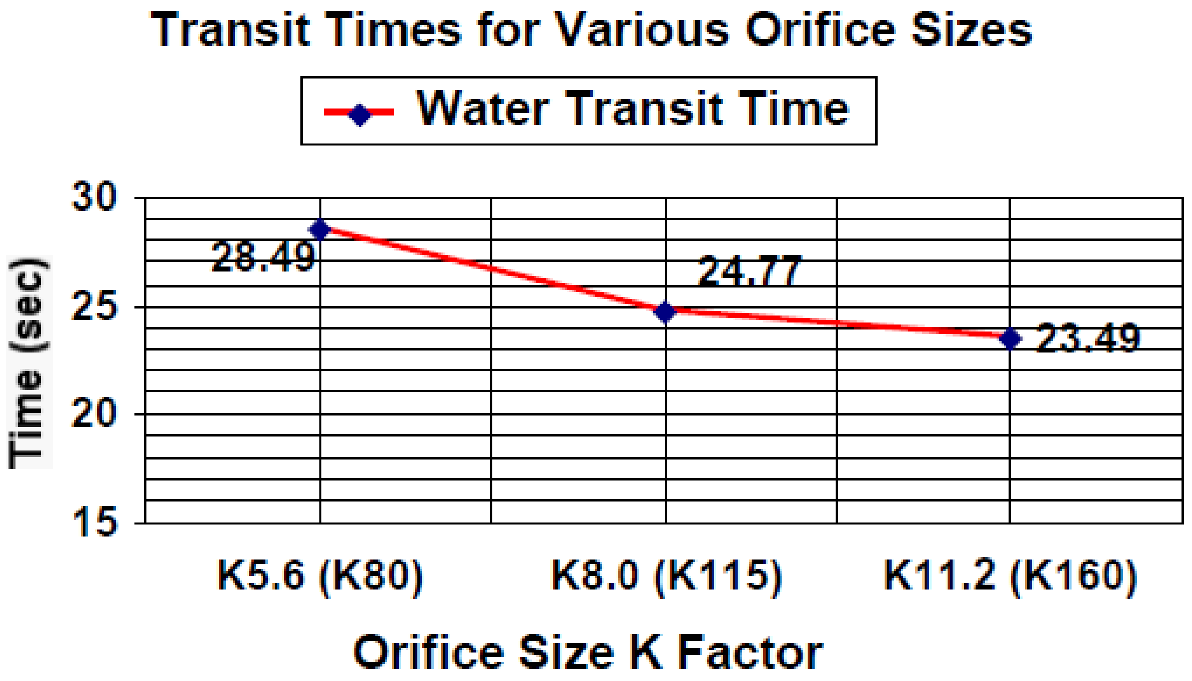
Determine Max. Set Air Pressure for DPV

Use of an accelerator

- Shortens the time required to trip a dry pipe valve since they are very sensitive to pressure changes and significantly reduce the effect of system volume
- Typically trip a dry pipe valve in 4 to 10 seconds from the opening of the inspectors test valve.
- The activation time is dependent on the system volume, system configuration and test orifice size.

Water transition time

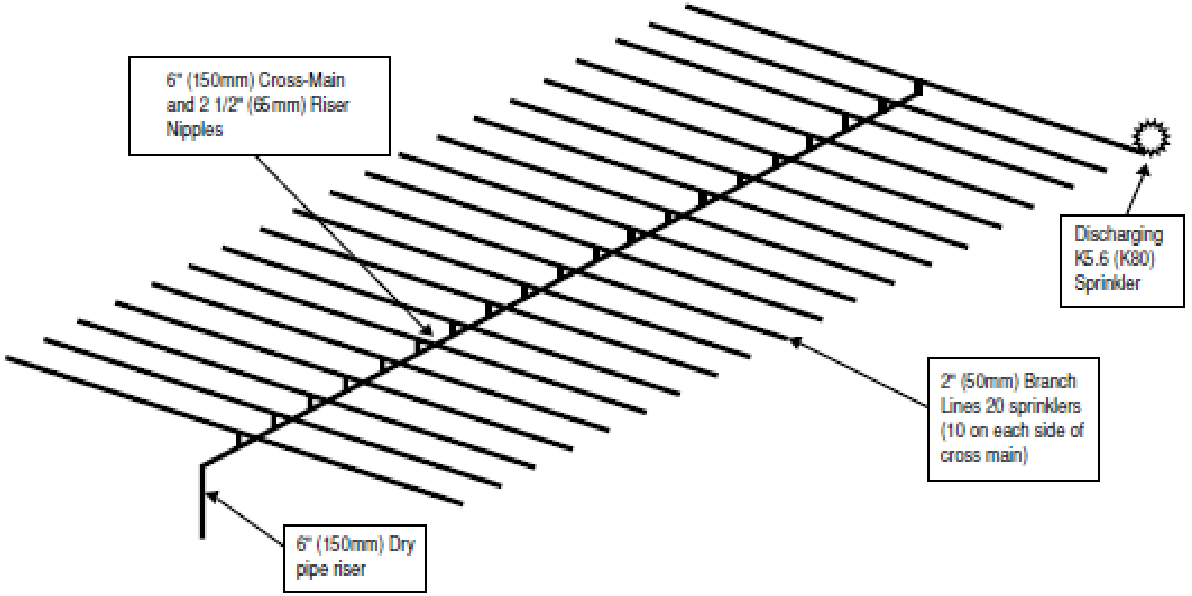
- This is the time required after tripping of the dry pipe valve for water to displace air in system piping and begin water flow from the test orifice.



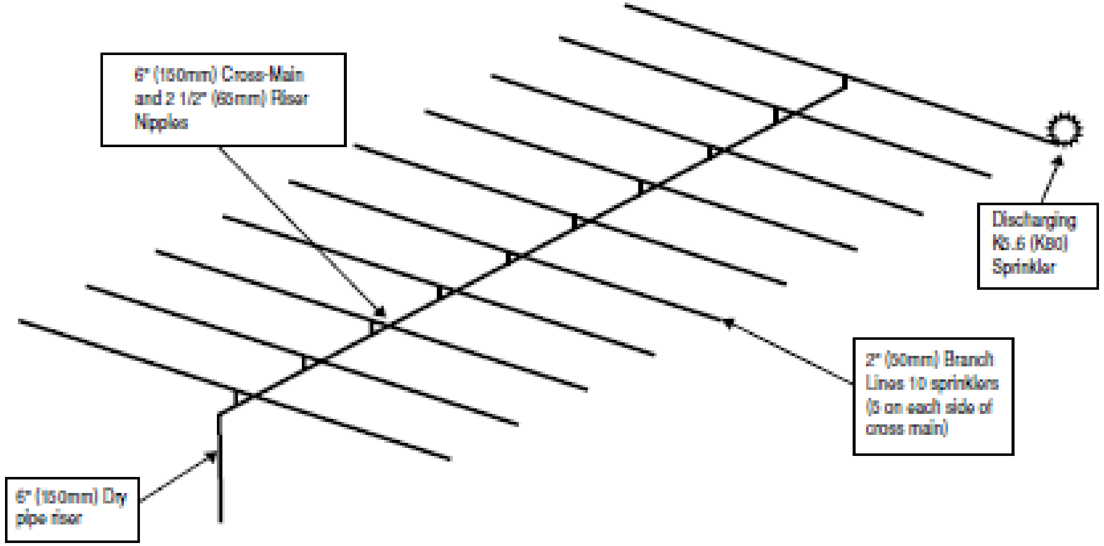
System Actuation Time

- Total Actuation Time = DPV Trip Time + Water Transition Time

Effect of System Volume on Transition Time

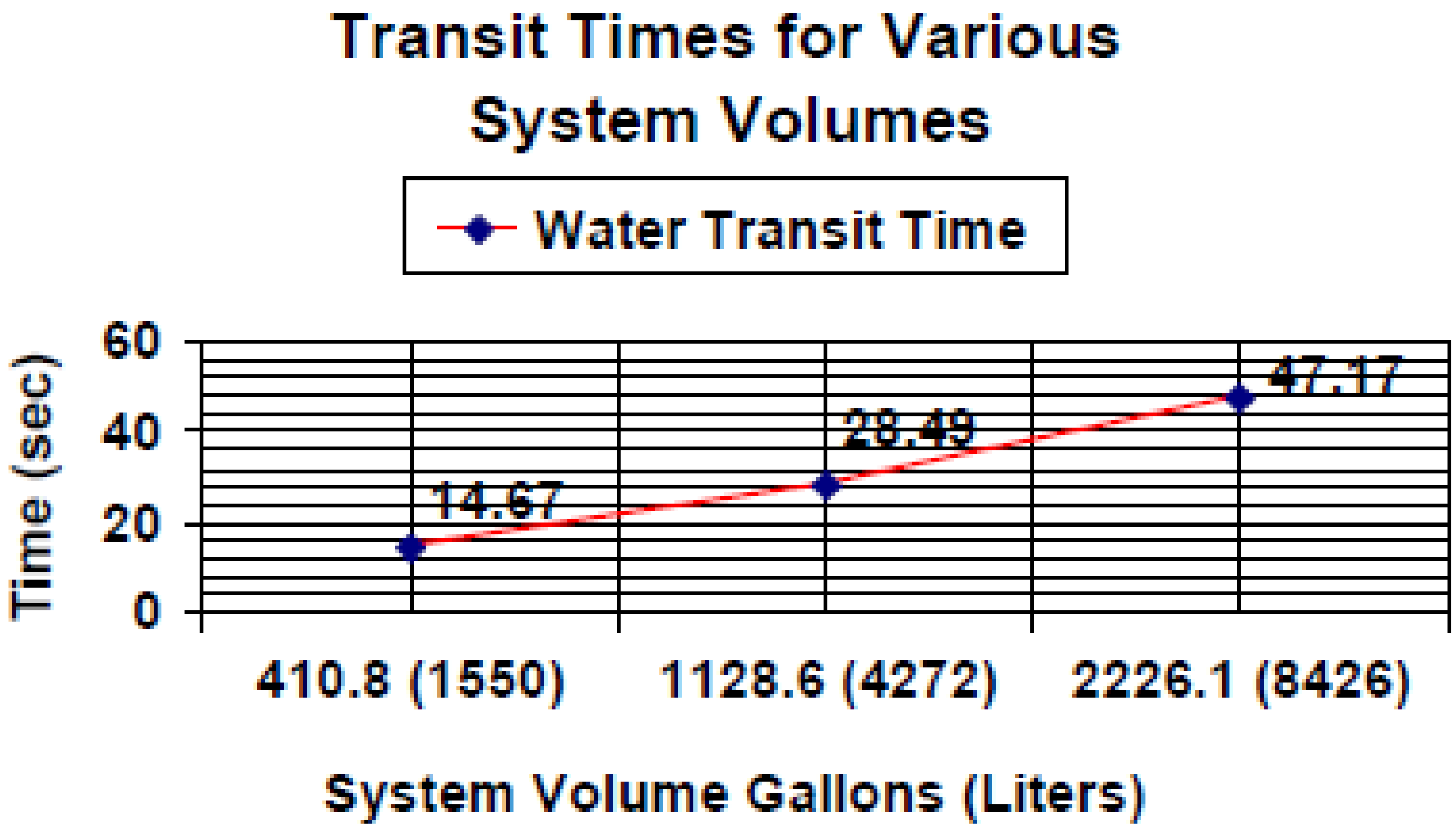


1128.6 gallon (4272 liter) capacity (20 lines by 20 lines sprinklers)



410.8 gallon (1555 liter) capacity (10 lines by 10 lines sprinklers)

Effect of System Volume on Transition Time



Effect of System Volume on Transition Time

- All of the trapped air in the system has to be vented from the sprinkler prior to water arrival.
- In the smaller system, there are no pockets of air to compress, or non-flowing volumes for the water front to push the air except out of the open sprinkler.
- The single open sprinkler cannot exhaust air as fast as the 6"(150mm) riser can fill the system causing back pressure of air and slowing the fill rate of water.

DPV System Water Delivery – NFPA 13

- Cl. 7.2.3.1.1 - For dry pipe systems protecting dwelling unit portion of any occupancy, system size shall be such that initial water is discharged from the system test connection in not more than 15 seconds, starting at the normal air pressure on the system and at the time of fully opened inspection test connection
- Cl. 7.2.3.2 System size shall be such that initial water is discharged from the system test connection in not more than 60 seconds, starting at the normal air pressure on the system and at the time of fully opened inspection test connection

DPV System Water Delivery – NFPA 13

Cl. 7.2.3.3 A system size of not more than 500 gal (1893 L) shall be permitted without a quick-opening device and shall not be required to meet any specific water delivery requirement to the inspection test connection.

Cl. 7.2.3.4 A system size of not more than 750 gal (2839 L) shall be permitted with a quick-opening device and shall not be required to meet any specific water delivery requirement to the inspection test connection.

DPV System Water Delivery – NFPA 13

Hazard	Number of Most Remote Sprinklers Initially Open	Maximum Time of Water Delivery (seconds)
Light	1	60
Ordinary I	2	50
Ordinary II	2	50
Extra I	4	45
Extra II	4	45
High piled	4	40

Dry Pipe Sprinkler

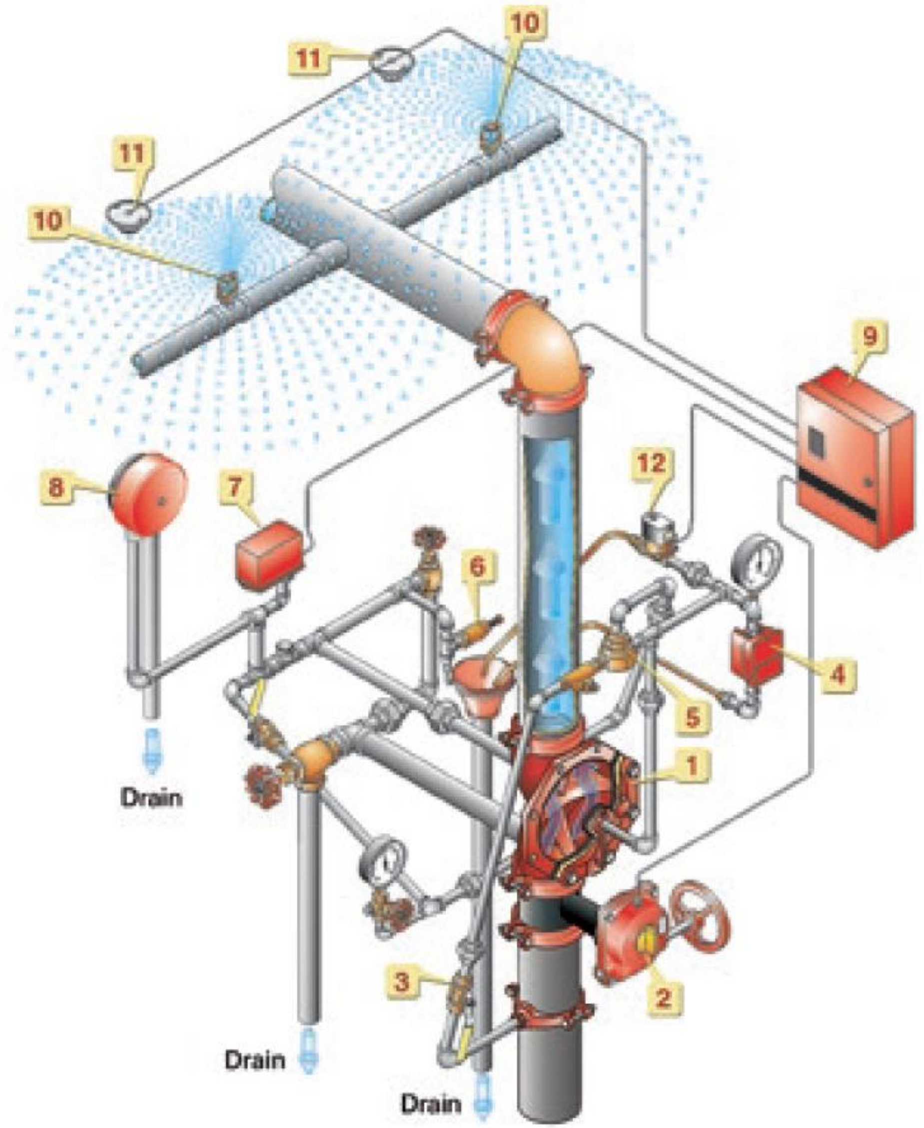
- ***Restoration of the System;***
  - resetting is <u>not</u> usually performed by FD personnel,

  - notify the property owners that the system has activated,

  - the system has to be drained and the dry pipe valve has to be reset, this is a complex procedure,

  - in mild weather, the system can stay in a wet condition.

Deluge System

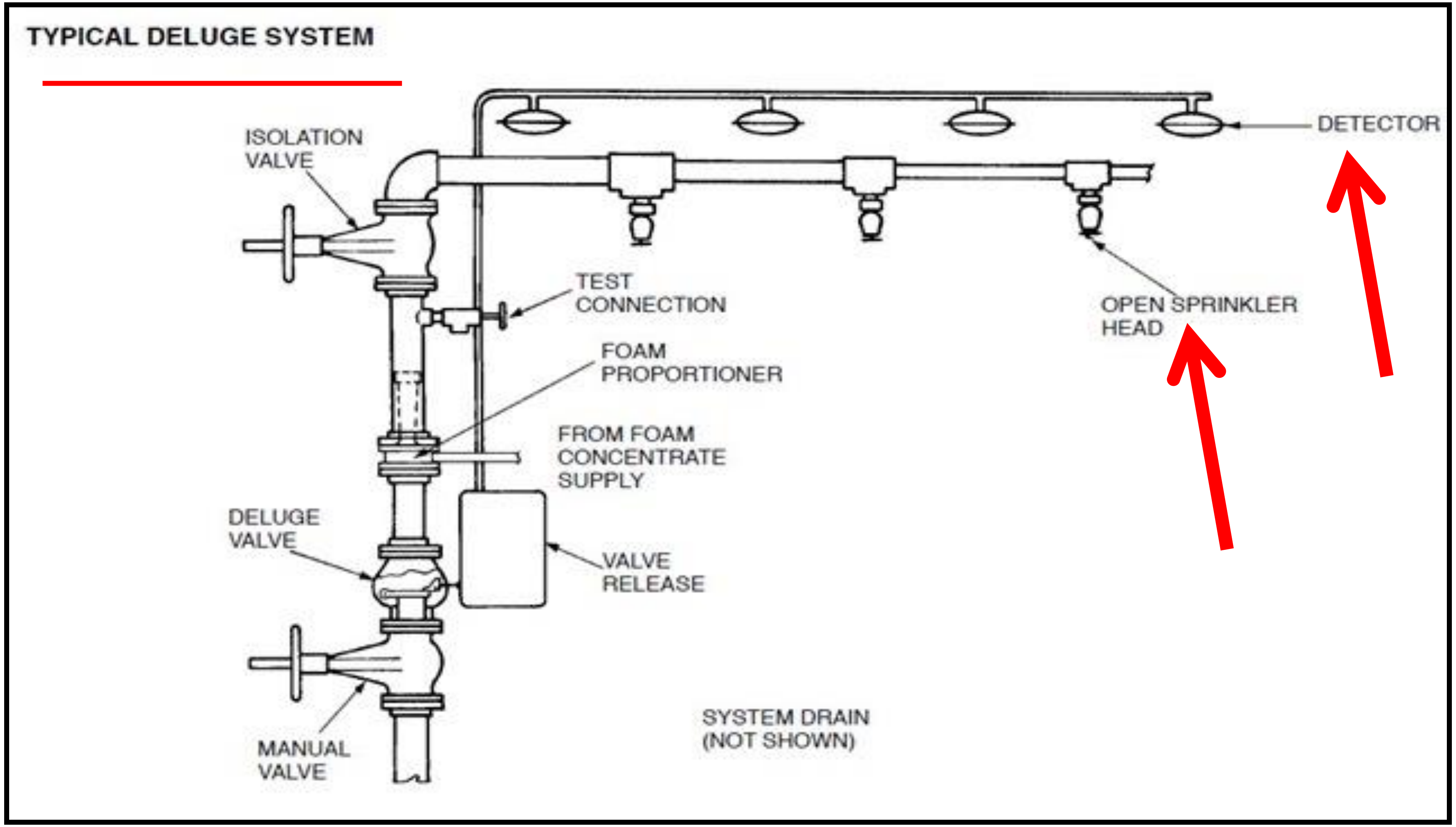


Deluge Sprinkler

- Pipes are not filled with water (or gas),
- All sprinkler heads are pre-opened,
- A signal from a detection device mechanically opens a water valve,
  - water fills the pipes and flows from all heads,
  - water flows until shut off,
  - system is reset.

Deluge Sprinkler

- Primarily installed in special hazard areas that have fast spreading fire, (i.e. petroleum facilities, hazardous materials),
- Are also used to apply protein and AFFF foams,
- Activation will cause great quantities of water or foam to flow,
- Usually requires several detectors to activate before dischargir



- Pipes in protected area are empty; a detector signal triggers the system, allowing water/foam to enter pipes and flow from all sprinkler heads (which are already open),

Deluge System

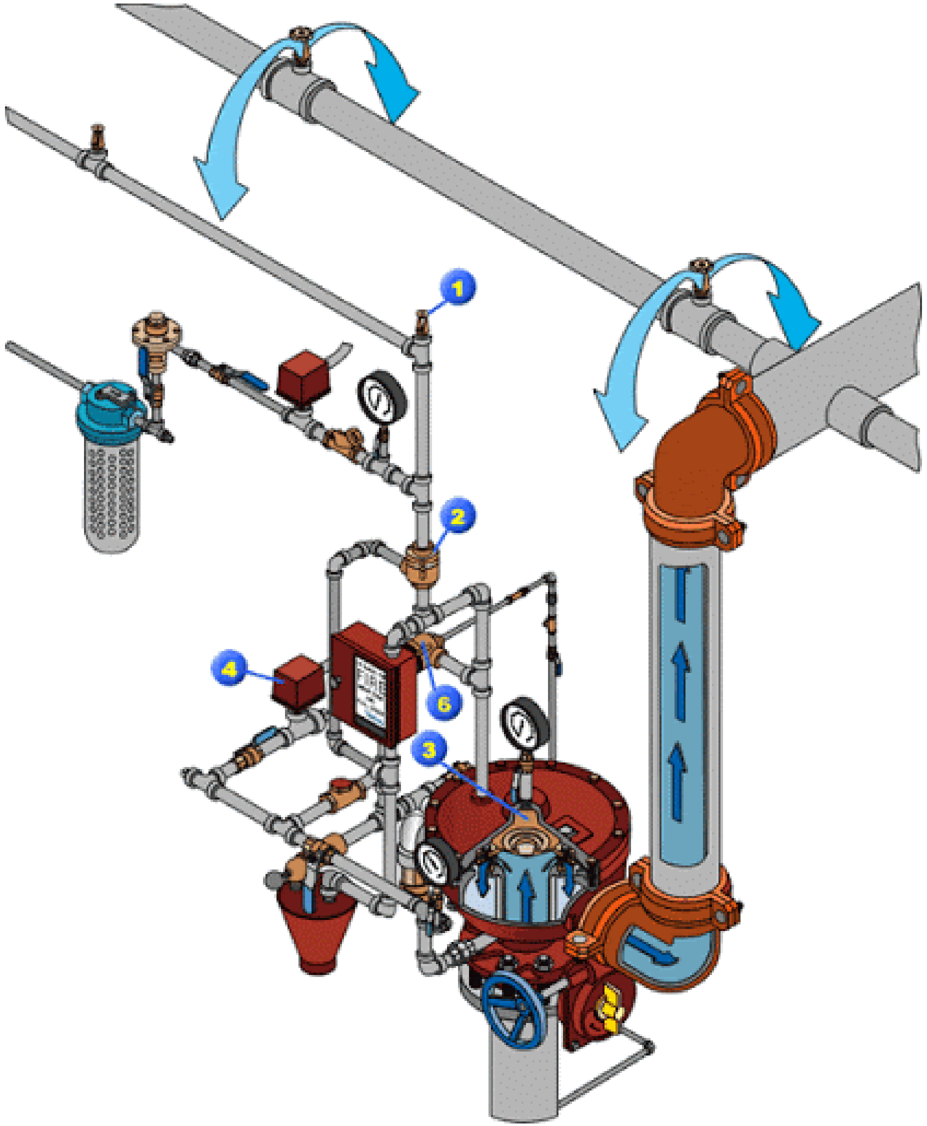
- ***Restoration of the System;***

  - the deluge clapper valve must be manually reset with the latching mechanism in place,

  - the detection system is re-activated,

  - because of these procedures, it is not recommended for the FD to restore the system, leave it to the professionals.

Pre-Action System



Pre-Action Sprinkler

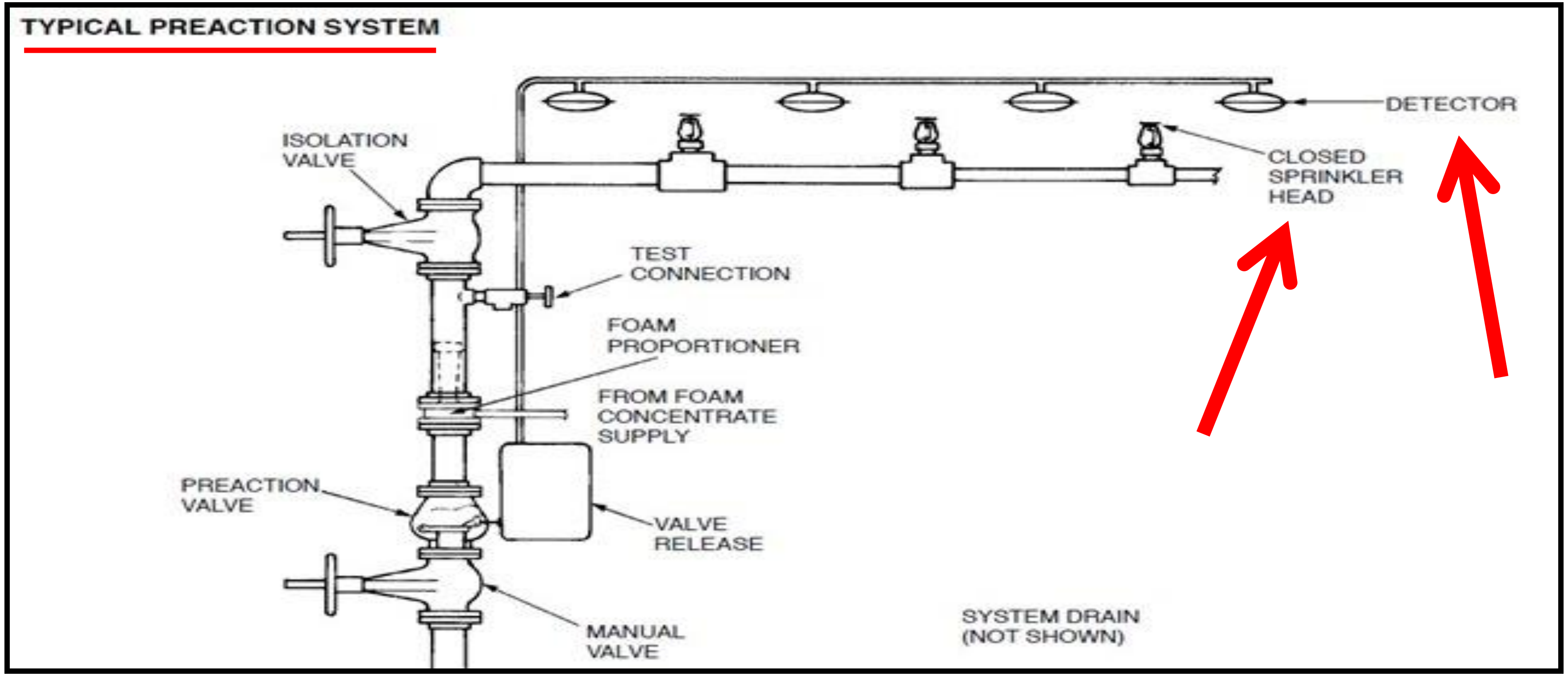
- ❑ Pipes are not filled with water,
- ❑ All sprinkler heads are of the standard type (they are closed),
- ❑ A detection device opens a water valve,
- ❑ Water fills the pipes,
- ❑ Water only flows from a sprinkler head *if it is opened* by heat from a fire,
- ❑ Water flows until shut off and system is reset.

Pre-Action Sprinkler

- Used primarily to protect property where water could severely damage facilities or equipment, (historical items)

- Similar to dry-pipe and deluge system;
  - closed piping,
  - little or no air/gas pressure,
  - water does not flow to the sprinkler heads until detector activates,
  - water on fire after sprinkler head fuses,

- Turns into a wet system, but allows personnel to check/fight fire before head fuses,



- Pipes in protected area are empty; a detector signal triggers the system, allowing water to enter pipes and flow into piping network; heat from a fire may then open a sprinkler head; accidental damage to a head will not result in water flow.

Pre-Action Sprinkler

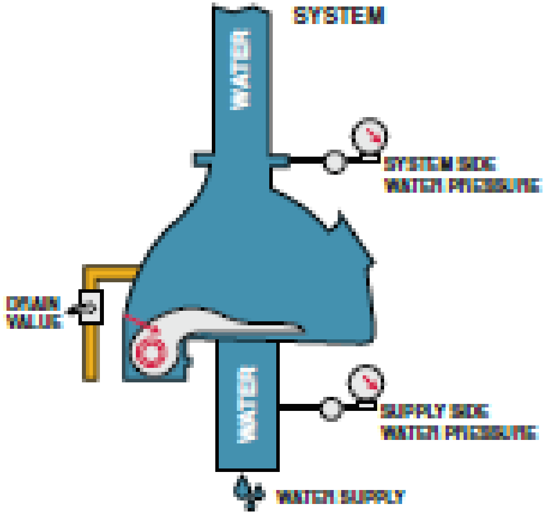
- ***Restoration of the System;***

  - the deluge clapper valve must be manually reset with the latching mechanism in place,

  - the detection system, with supervisory features is re-activated,

  - because of these procedures, it is <u>not</u> recommended for the FD to restore the system, leave it to the professionals.

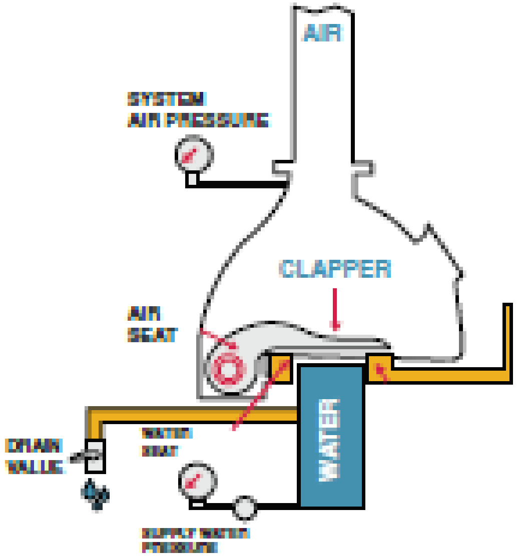
Summary of Sprinkler System



WET PIPE SYSTEM

Wet Pipe Sprinkler System

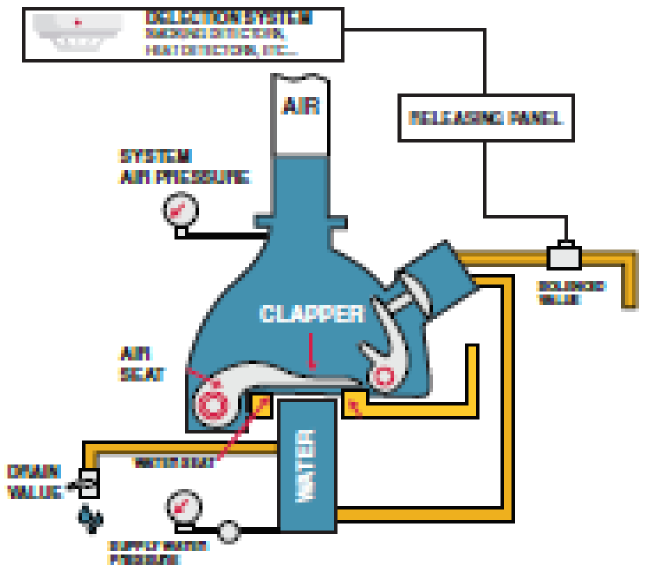
A wet pipe sprinkler system utilizes automatic sprinklers attached to piping that contains water and is connected to a water supply. Water is discharged immediately from the automatic sprinklers once they activate. Wet pipe sprinkler systems are the most common type of sprinkler systems.



Dry Pipe Sprinkler System

A dry pipe system utilizes automatic sprinklers attached to piping containing air or nitrogen under pressure. Upon activation of the automatic sprinkler, the release of the air or nitrogen from the piping will open a valve and permit the piping to be filled with water and discharge from the opened sprinklers. Dry pipe systems are used in areas where the system is subject to freezing temperatures below 40° F (4° C) (parking garages, unheated warehouses, etc).

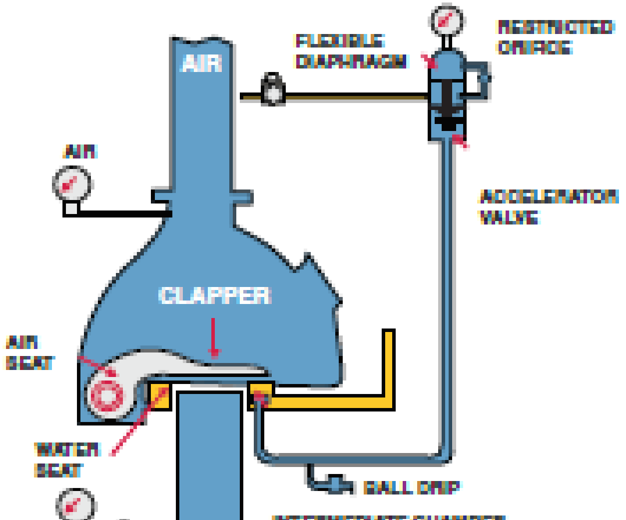
Summary of Sprinkler System



PRE-ACTION SYSTEM

Pre-Action Sprinkler System

A pre-action system utilizes automatic sprinklers attached to piping containing air or nitrogen that may or may not be under pressure. Water is only permitted to be released into the piping after a combination of automatic sprinkler activation and the activation of a detection system. Pre-action systems are used in areas where protection from accidental activation is required (data centers, museums, etc.).



Deluge Sprinkler System

A deluge sprinkler system utilizes open sprinklers attached to piping that does not contain any water with water held back by a valve. The valve, which is opened by the activation of a detection system, will allow water to discharge from all of the open sprinklers in the system. Deluge systems are used to protect against fires that spread quickly or for exposure protection.

SECTION 02

DESIGN FUNDAMENTALS

How to Conduct Pipe Sizing & Flow calculation

Occupancy Classification – NFPA 13

- Light Hazard
- Ordinary Hazard Group-1
- Ordinary Hazard Group-2
- Extra Hazard Group -1
- Extra Hazard Group -2

Role of Owners Certificate

OWNER'S INFORMATION CERTIFICATE

Name/address of property to be protected with sprinkler protection:

Name of owner:

Existing or planned construction is:

- ❑ Fire resistive or noncombustible
- ❑ Wood frame or ordinary (masonry walls with wood beams)
- ❑ Unknown

Describe the intended use of the building:

Note regarding speculative buildings: The design and installation of the fire sprinkler system is dependent on an accurate description of the likely use of the building. Without specific information, assumptions will need to be made that will limit the actual use of the building. Make sure that you communicate any and all use considerations to the fire sprinkler contractor in this form and that you abide by all limitations regarding the use of the building based on the limitations of the fire sprinkler system that is eventually designed and installed.

Is the system installation intended for one of the following special occupancies:

Aircraft hangar	❑ Yes	❑ No
Fixed guideway transit system	❑ Yes	❑ No
Race track stable	❑ Yes	❑ No
Marine terminal, pier, or wharf	❑ Yes	❑ No
Airport terminal	❑ Yes	❑ No
Aircraft engine test facility	❑ Yes	❑ No
Power plant	❑ Yes	❑ No
Water-cooling tower	❑ Yes	❑ No

If the answer to any of the above is "yes," the appropriate NFPA standard should be referenced for sprinkler density/area criteria.

Indicate whether any of the following special materials are intended to be present:

Flammable or combustible liquids	❑ Yes	❑ No
Aerosol products	❑ Yes	❑ No
Nitrate film	❑ Yes	❑ No
Pyroxylin plastic	❑ Yes	❑ No
Compressed or liquefied gas cylinders	❑ Yes	❑ No
Liquid or solid oxidizers	❑ Yes	❑ No
Organic peroxide formulations	❑ Yes	❑ No
Idle pallets	❑ Yes	❑ No

If the answer to any of the above is "yes," describe type, location, arrangement, and intended maximum quantities.

Study of Water

- Hydraulics
  - The science which defines the mechanical principles of water at rest or in motion.
- Hydrostatics
  - The scientific laws that define the principles of water at rest.
- Hydrokinetics
  - The study of water in motion.

Hydraulic Focus

- Pressure
- Flow

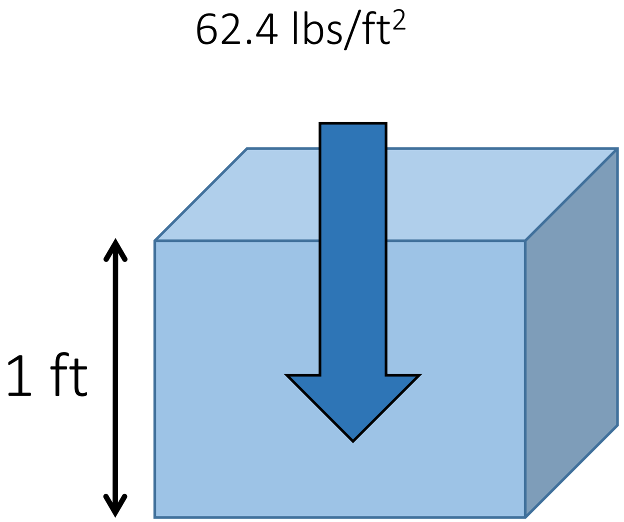
Pressure Types

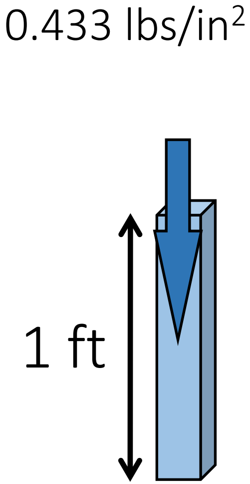
- Atmospheric Pressure
  - Caused by the weight of air, varies with altitude
    - Lower at high altitudes, higher at low altitudes
    - 14.7 psi at sea level
- Gage Pressure
  - The actual reading on a gage, does not account for atmospheric pressure. (psig)
- Absolute Pressure
  - The sum of atmospheric pressure and gage pressure. (psia)

Pressure Types (continued)

- Static Pressure (P_s)
  - The potential energy available within a system when no water is flowing.
  - Pressure is created by elevating water above a source, or it can be created mechanically with pumps or pressure tanks.

Elevation Pressure

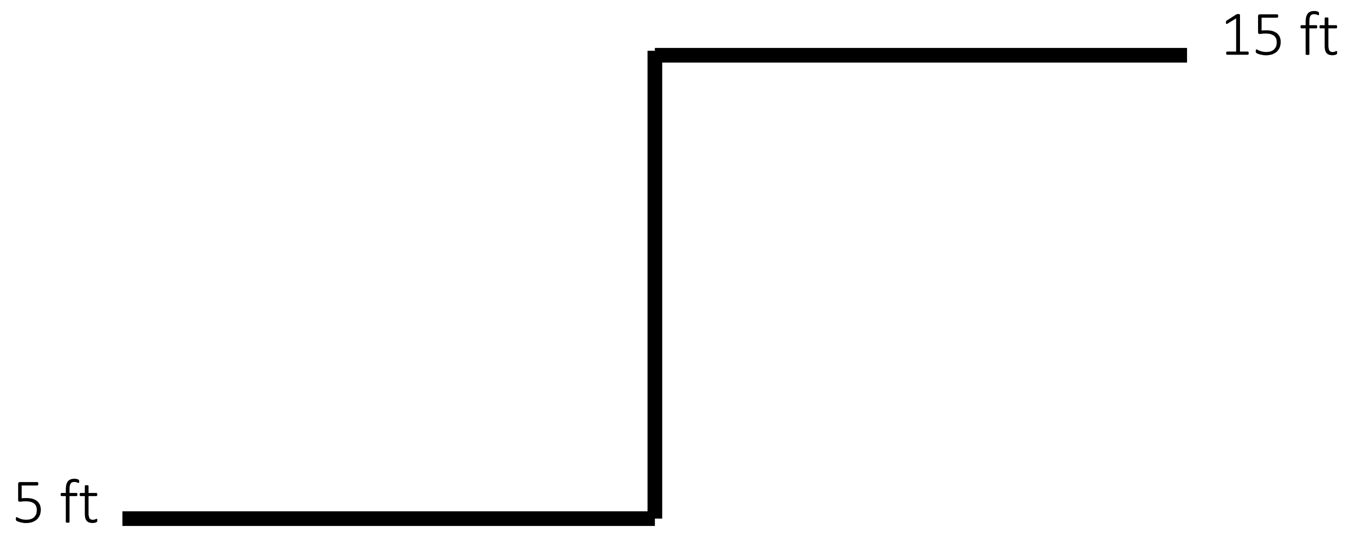




- A cubic foot of water results in a static pressure at its base of 62.4 lbs/ft^2
- Converted to square inches a column of water 1-foot high exerts a pressure of 0.433 lbs/in^2

Elevation Pressure (continued)

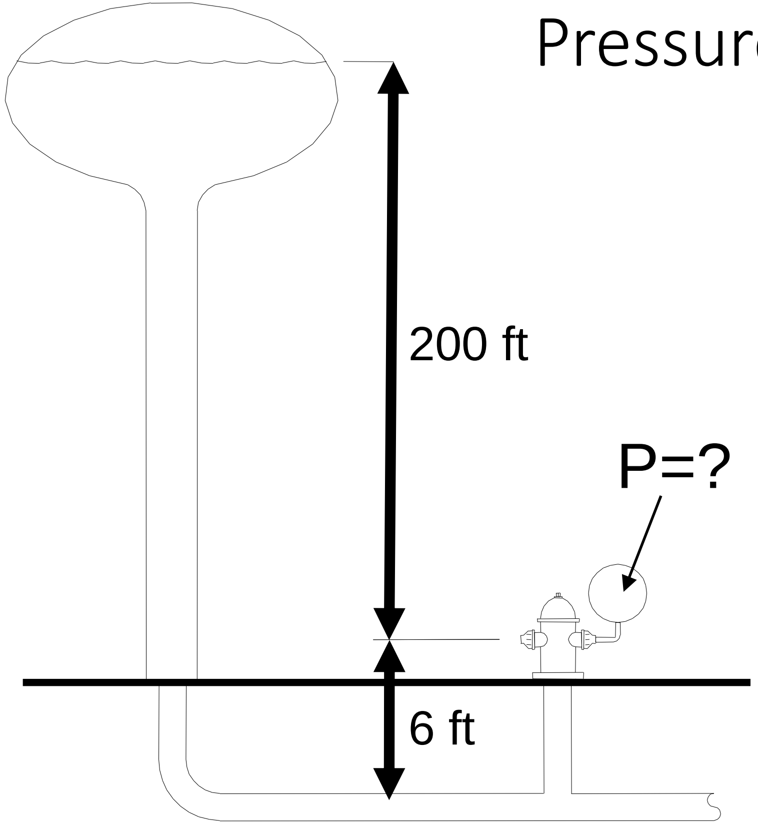
- Pressure (psi) = 0.433 X Elevation (ft)



What is the pressure difference?

Elevation Pressure Example (Continued)

- What is the pressure at the hydrant?



Pressure (psi) = 0.433 x Elevation (ft)

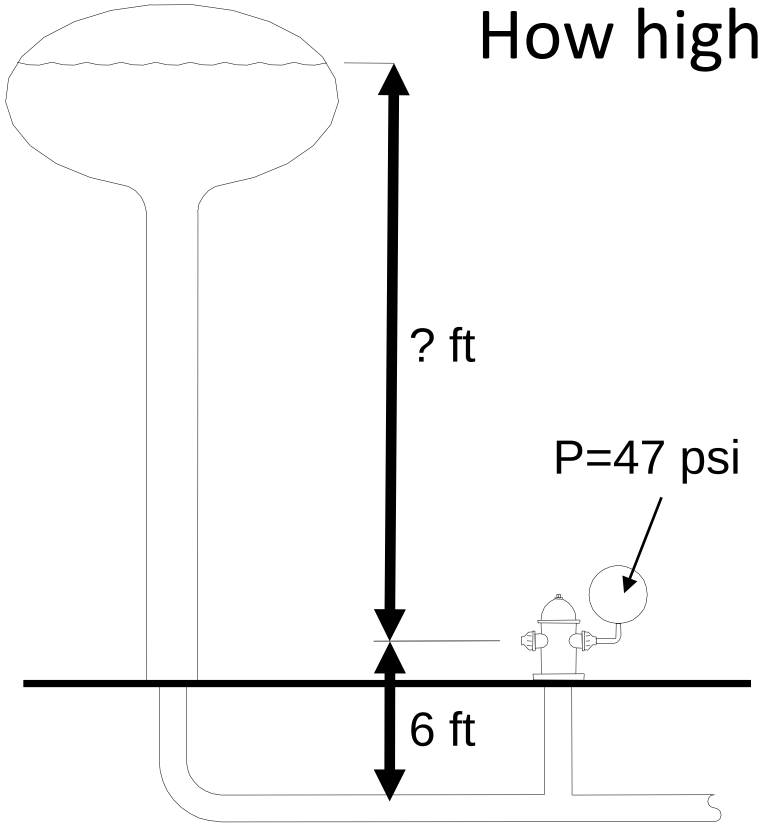
$$P = 0.433 x 200 ft$$

$$P = 90.93 psi$$

$$P \approx 91 psi$$

Elevation Pressure 2nd Example

- How high is the water?



$$\text{Pressure(psi)} = 0.433 \times \text{Elevation(ft)}$$

$$\text{Elevation(ft)} = \frac{\text{Pressure(psi)}}{0.433}$$

$$\text{Elevation(ft)} = \frac{47\text{psi}}{0.433}$$

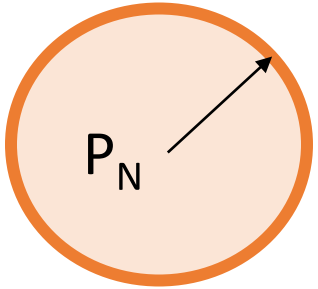
$$\text{Elevation} = 108.55\text{ft} \approx 109\text{ft}$$

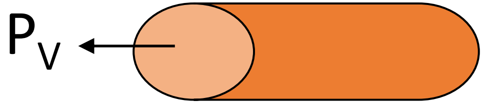
Pressure Types (continued)

- Residual Pressure (P_R)
  - The pressure at a given point in a conduit or appliance with a specific volume of water flowing.

Pressure Types (continued)

- Normal Pressure (P_N)
  - The pressure created on the walls of pipe or tanks holding water.
  - This is the pressure read by most gages.
- Velocity Pressure (P_V)
  - The pressure associated with the flow of water measured in the same direction as the flow.





Calculating Velocity Pressures

$$P_n = P_t - P_v$$

Where:

P_n = normal pressure (psi)

P_t = total pressure (psi)

P_v = velocity pressure (psi)

Velocity pressure can be found as follows:

$$P_v = \frac{0.001123Q^2}{d_i^4}$$

Using Velocity Pressure

- When velocities are high in a closed system the pressure needs to be accounted for in the calculations
- It can reduce the flows and pressures needed in a system 5-10 percent
- In most sprinkler systems velocities are low and their pressures create a minor effect, therefore velocity pressures can be ignored.
- It should be used at points where large flows take a 90-degree turn in the piping.

Flow (Q)

- The quantity (of water) which passes by a given point in a given period of time
- Generally measured in gallons per minute (gpm) or cubic feet per second (ft^3/sec)
- Uses the term “Q” in most equations

Flow Equation

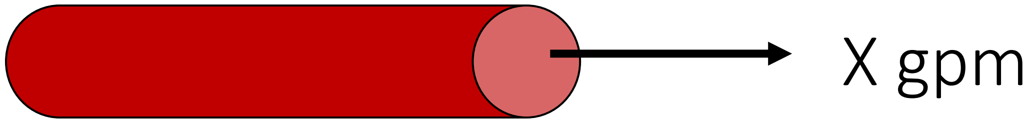
$$Q = A \times V$$

- Q = flow in **ft^3/sec**
- A = cross sectional area of pipe in **ft^2**
- V = water velocity in **ft/sec**

- Q is a constant for any given closed system.

Flow Equation (continued)

$Q = A \times V =$ constant flow

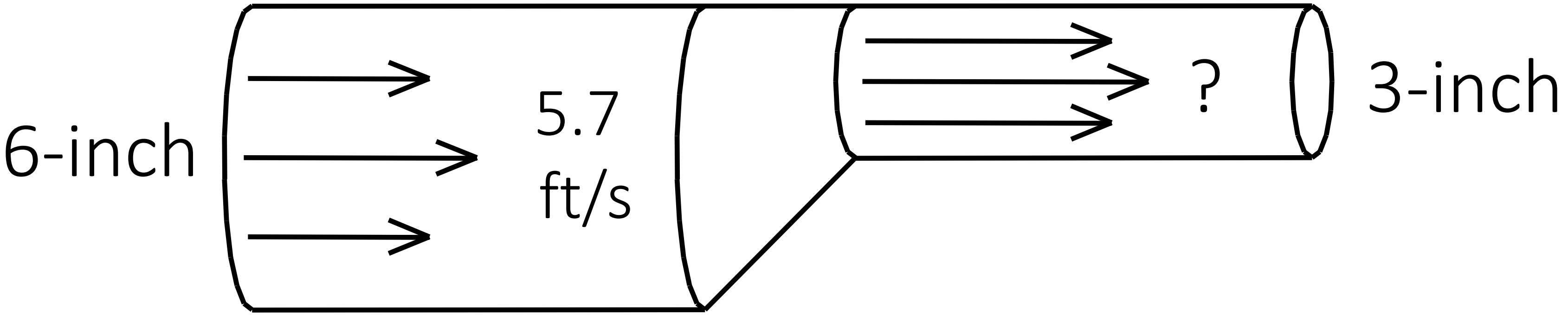


When the pipe size changes flow remains constant:

$$Q = A_1 \times V_1 = A_2 \times V_2$$

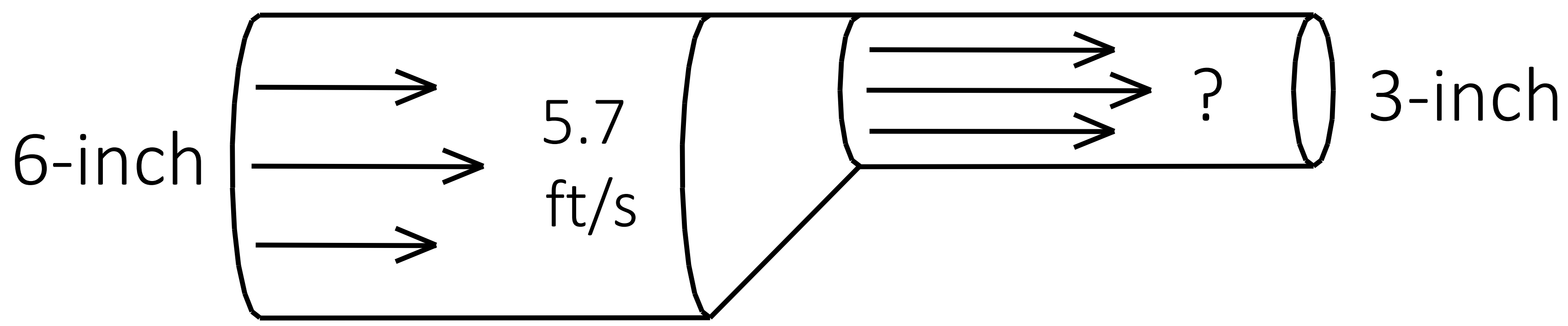
$$A_1 \times V_1 = A_2 \times V_2$$

Flow Example 1



- If water is flowing at 5.7 ft/sec in 6-inch pipe, how fast is it flowing when the pipe size is reduced to 3-inch?

Flow Example 1 Solution



How fast is it flowing when the pipe size is reduced to 2-inch?

$$A_1V_1 = A_2V_2 \qquad V_2 = \frac{A_1V_1}{A_2}$$

$$A_1 = \pi\ r^2 = \pi\ (3\ in)^2 = 28.3\ in^2$$

$$A_2 = \pi\ r^2 = \pi\ (1.5\ in)^2 = 7.1\ in^2$$

$$V_2 = \frac{(28.3in^2)(5.7ft/sec)}{7.1in^2} = 22.7ft/sec$$

Flow from an Outlet

- Dependent upon a number of factors
  - Size of the orifice
  - Construction of the device
  - Material used in the device
  - Other components near the device (e.g. screens)
- For a sprinkler, that ability is determined experimentally in a laboratory

Flow from an Outlet (continued)

$$Q = 29.83 \times d_i^2 \times \sqrt{P_v} \times C_D$$

- Where:
- Q is the flow (gpm)
- d_i is the diameter of opening (inches)
- P_v is the measured velocity pressure (psi)
- CD is the discharge coefficient of the device

- This is used when testing water supplies to determine the amount of flow

Flow from a Sprinkler

$$Q = k \times \sqrt{P}$$

Where:

Q is flow (gpm)

k is k-factor determined in the sprinkler listing (gpm/psi$^{1/2}$)

P is the pressure (psi)

- **The diameter of the opening and discharge coefficient are incorporated into the empirical determination of k-factor.**

Sprinkler Flow Example

- A sprinkler is being installed with a k-factor of 5.6. If the pressure at the sprinkler is 20 psi, how much water will exit the sprinkler?

$$Q = k\sqrt{P}$$

$$Q = 5.6\sqrt{20\,\text{psi}}$$

$$Q = 25.0\,\text{gpm}$$

Flow from a Sprinkler (continued)

- The flow equation can be rearranged to solve for pressure or k-factor:

$$Q = k \times \sqrt{P}$$

$$P = \left(\frac{Q}{k} \right)^2$$

$$k = \frac{Q}{\sqrt{P}}$$

Pressure Calculation Example

- What is the pressure for a sprinkler that has a k-factor of 17.6 and the expected flow is 83 gpm?

$$P = \left(\frac{Q}{k} \right)^2$$

$$P = \left(\frac{83\,\text{gpm}}{17.6} \right)^2$$

$$P = (4.716)^2 = 22.2\,\text{psi}$$

K-factor Calculation Example

- What is the K-factor for an outlet that is flowing 65 gpm at 30 psi?
-

$$k = \frac{Q}{\sqrt{P}}$$

$$k = \frac{65\,\text{gpm}}{\sqrt{30\,\text{psi}}}$$

$$k = \frac{65}{5.48} = 11.86$$

Friction Loss (P_L)

- Occurs when water flows in pipes, hoses, or other system devices
- Caused by water in contact with walls
- Used to account for losses in energy from water making turns or traveling difficult paths

Formulas for Calculating Friction Loss

- Hazen-Williams formula
  - Fire sprinkler systems
  - Water-spray systems
- Darcy-Weisbach formula
  - Anti-freeze systems
  - Water mist systems
  - Foam-water systems
- Fanning formula

Hazen-Williams Formula

- Most common for sprinkler calculations
- Assumes water is at room temperature but is still accurate with temperature variations
- Based on C-factor, flow, and pipe size
- Calculates the amount of friction loss in ONE FOOT of pipe

Hazen-Williams Formula

$$P_L = \frac{4.52Q^{1.85}}{C^{1.85}d_i^{4.87}}$$

- Where:
- PL = friction loss (psi/ft)
- Q = flow (gpm)
- C = roughness coefficient (based on pipe material)
- d_i = interior pipe diameter (inches)

You can see the above equation that if **Q** is raised to the power of 1.85 in the above equation this has the effect that if the flow is doubled and all other things remain constant the friction loss will increase by almost 4 times if the flow was to triple the friction loss would almost be 9 times greater. You can also see that the pipe diameter **D** is raised to the power of 4.87 and that it's in the denominator on the right-hand side of the equation. Therefore any increase in the pipe size will reduce the friction loss if all other factors remain the same. If the diameters double, the friction loss will be reduced by almost a factor of 1/32 likewise if the pipe diameter is tripled The friction loss would be reduced to about 1/243 of its original value.

Roughness Coefficient

Table 22.4.4.7 Hazen-Williams C Values	
Pipe or Tube	**C Value**
Unlined cast or ductile iron	100
Black steel (dry systems including pre-action)	100
Black steel (wet systems including deluge)	120
Galvanized (all)	120
Plastic (listed, all)	150
Cement-lined cast or ductile iron	140
Copper tube or stainless steel	150
Asbestos cement	140
Concrete	140

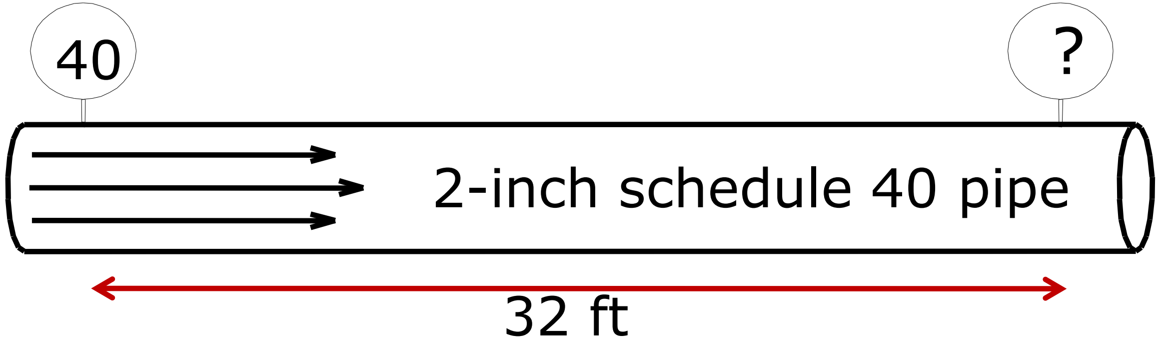
Inside Diameters (d_i)

List for steel and copper in Table A.6.3.2 and Table A.6.3.5

Nominal Pipe Size	Schedule 40	Schedule 10	Type K Copper	CPVC*
1-inch	1.049	1.097	0.995	1.101
1 ¼-inch	1.380	1.442	1.245	1.394
1 ½-inch	1.610	1.682	1.481	1.598
2-inch	2.067	2.157	1.959	2.003
2 ½-inch	2.469	2.635	2.435	2.423
3-inch	3.068	3.260	2.907	2.95
4-inch	4.026	4.260	3.857	N/A

Hazen-Williams Example

If a pressure gage is reading 40 psi at one end of a 32-foot section of 2-inch schedule 40 pipe (C = 120) flowing at 110 gpm, what will a gage at the other end read?

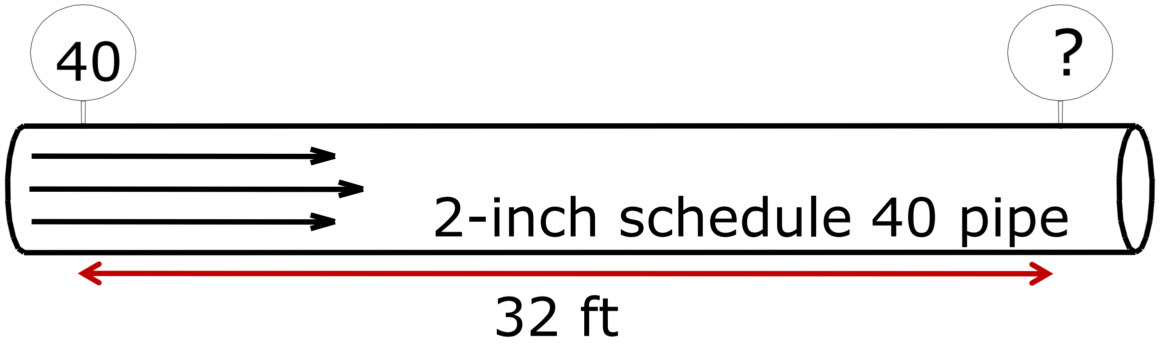


$$P_L = \frac{4.52Q^{1.85}}{C^{1.85}d_i^{4.87}} = \frac{4.52(110gpm)^{1.85}}{(120)^{1.85}(2.067in)^{4.87}}$$

$P_l = 0.112$ psi/ft

Hazen-Williams Example (continued)

- What will a gage at the other end read?



- PL = 0.112 psi/ft
- Friction Loss = 0.112 psi/ft x 32 ft = 3.6 psi
- Gage Pressure = 40 psi – 3.6 psi ≅ 36 psi

Fittings

- Energy losses through fittings are caused by turbulence in the water
- To determine losses through fittings "equivalent length" is used
- NFPA has a table to provide equivalent pipe lengths
- Table is based on schedule 40 steel in a wet pipe system with C Values of 120.

Equivalent Length Chart

Fittings & Valves	Fittings & Valves Expressed in Equivalent Feet of Pipe													
	¾ in	1 in	1 ¼ in	1 ½ in	2 in	2 ½ in	3 in	3 ½ in	4 in	5 in	6 in	8 in	10 in	12 in
45° Elbow	1	1	1	2	2	3	3	3	4	5	7	9	11	12
90° Standard Elbow	2	2	3	4	5	6	7	8	10	12	14	18	22	27
90° Long Turn Elbow	1	2	2	2	3	4	5	5	6	8	9	13	16	18
Tee/Cross	3	5	6	8	10	12	15	17	20	25	30	25	50	60
Butterfly Valve	-	-	-	-	6	7	10	-	12	9	10	12	19	21
Gate Valve	-	-	-	-	1	1	1	1	2	2	3	4	5	6
Swing Check	-	5	7	9	11	14	16	19	22	27	32	45	55	65

Adjusting Equivalent Lengths

- NFPA 13 table is based on schedule 40 steel pipe for a wet system
- All others need to be adjusted for:
  - Change in pipe material
    - C-factor other than 120
  - Change in interior diameter
    - Other than those for schedule 40 steel

Adjusting for C-Factor

Table 22.4.3.2.1 C Value Multiplier				
Value of C	100	130	140	150
Multiplying Factor	0.713	1.16	1.33	1.51

- Begin with the equivalent length value from the table
- Multiply the length by the factor above for the appropriate C-factor

Adjusting for Inside Diameter

$$\text{Factor} = \left(\frac{\text{Actual inside diameter}}{\text{Schedule 40 Steel Pipe inside diameter}} \right)^{4.87}$$

- Begin with the equivalent length value from the table
- Multiply the length by the factor above calculated for the inside diameter of the pipe being used

Fittings (continued)

- All fittings must be accounted for in the calculations
  - Including tees, elbows, valves, etc.
  - Some may have pressure loss or equivalent length values from manufacturer's listing information
- Special provisions:
  - Fittings connected directly to sprinklers
  - Fittings where water flows straight through without changing direction

Equivalent Length Exercise

- What is the equivalent pipe length of Type K copper tube which used for a 3-inch standard turn 90-degree elbow?

Equivalent Length Exercise Solution

- What is the equivalent pipe length of Type K copper tube which used for a 3-inch standard turn 90-degree elbow?
- NFPA 13 Table 23.4.3.1.1 :
  - 3-inch 90-degree elbow = 7 ft of pipe
- Adjustments are needed for:
  - Type K Copper
  - Interior diameter

Equivalent Length Exercise Solution
(continued)

- What is the equivalent pipe length of Type K copper tube which used for a 3-inch standard turn 90-degree elbow?
- Adjustment for material (C-factor)
  - Copper has a C-Factor of 150
  - Per Table 22.4.3.2.1: Multiplier = 1.51
- Adjustment for inside diameter
  - 3-inch copper has an inside diameter of 2.907-inch

$$\text{Factor} = \left(\frac{\text{Actual i.d.}}{\text{Schedule 40 Steel Pipe i.d.}} \right)^{4.87} = \left(\frac{2.907}{3.068} \right)^{4.87} = 0.77$$

Equivalent Length Exercise Solution
(continued)

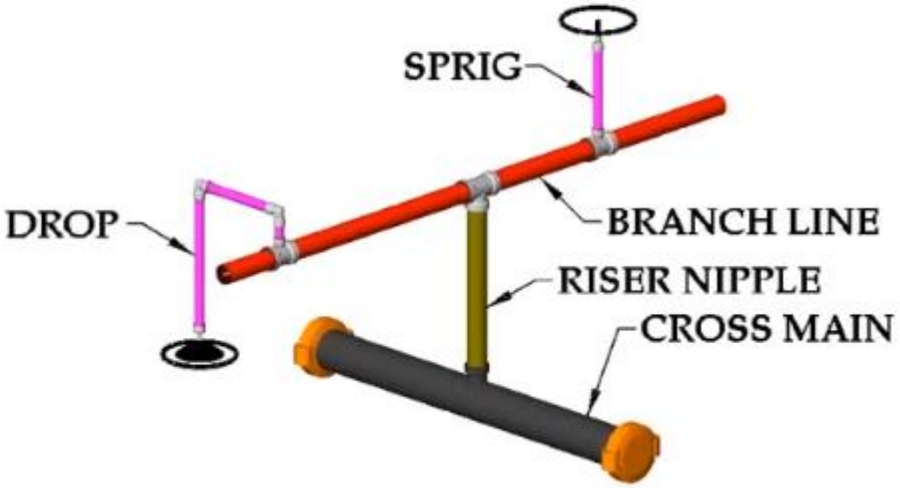
- What is the equivalent pipe length of Type K copper tube which used for a 3-inch standard turn 90-degree elbow?
- Apply the factors:
  - Equivalent pipe length per Table 22.4.3.1.1 = 7 ft
  - Adjustment for C-factor = 1.51
  - Adjustment for diameter = 0.77
- The equivalent length for a 3-inch Type K Copper standard turn elbow is:

$$7 \text{ ft} \times 1.51 \times 0.77 = 8.14 \text{ ft}$$

Hydraulic Calculation Principles

Design Elements

Component	Definition
Branch Lines	The pipes supplying sprinklers, either directly or through sprigs, drops, return bends, or arm-overs.
Cross Mains	The pipes supplying the branch lines, either directly or through risers.
Feed Mains	The pipes supplying cross mains, either directly or through risers.
Risers	The vertical supply pipes in a sprinkler system.
System Riser	The aboveground horizontal or vertical pipe between the water supply and the mains (cross or feed) that contains a control valve (either directly or within its supply pipe), pressure gauge, drain, and a waterflow alarm device.

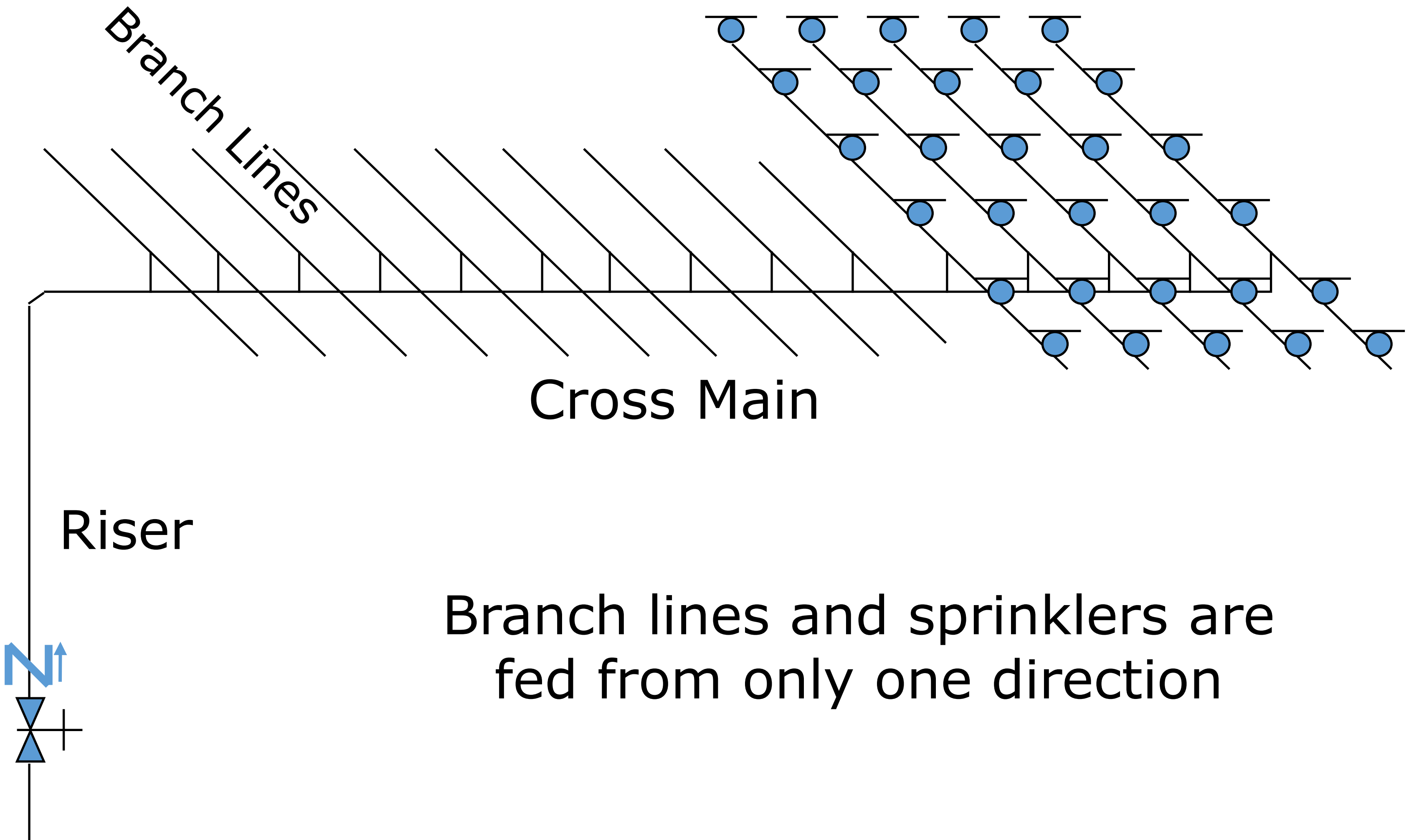


Design Elements- System Layout

Layout	Definition
Tree or Dead-End	A sprinkler system in which feed mains, cross mains and branch lines are supplied by and extend from a single system riser in a pattern in which pipe diameters get progressively smaller and branch lines are not tied together.
Gridded[1]	A sprinkler system in which parallel cross mains are connected by multiple branch lines, causing an operating sprinkler to receive water from both ends of its branch line while other branch lines help transfer water between cross mains.
Looped[1]	A sprinkler system in which multiple cross mains are tied together so as to provide more than one path for water to flow to an operating sprinkler and branch lines are not tied together.

Design Elements- System Layout

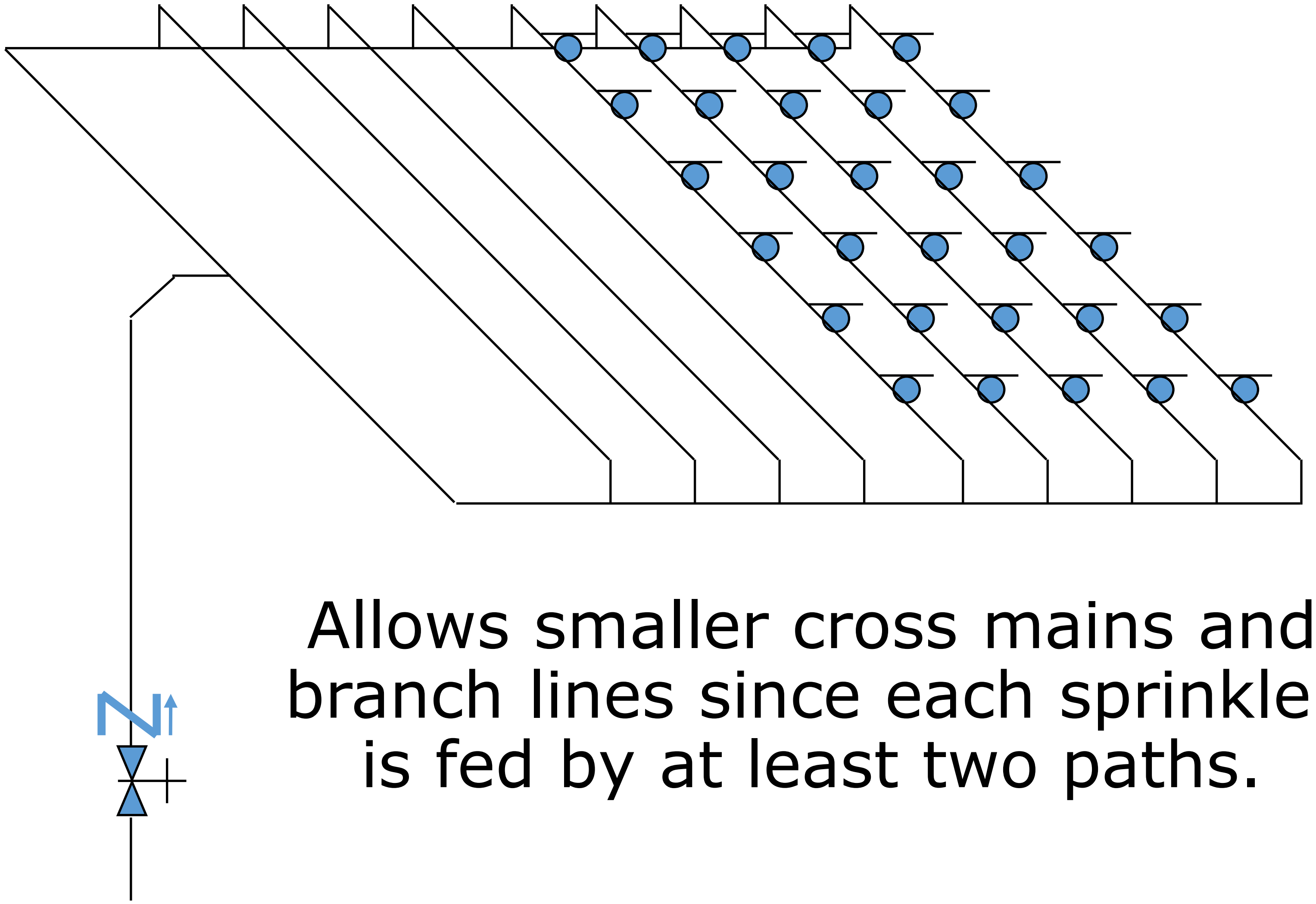
Tree System



Branch lines and sprinklers are fed from only one direction

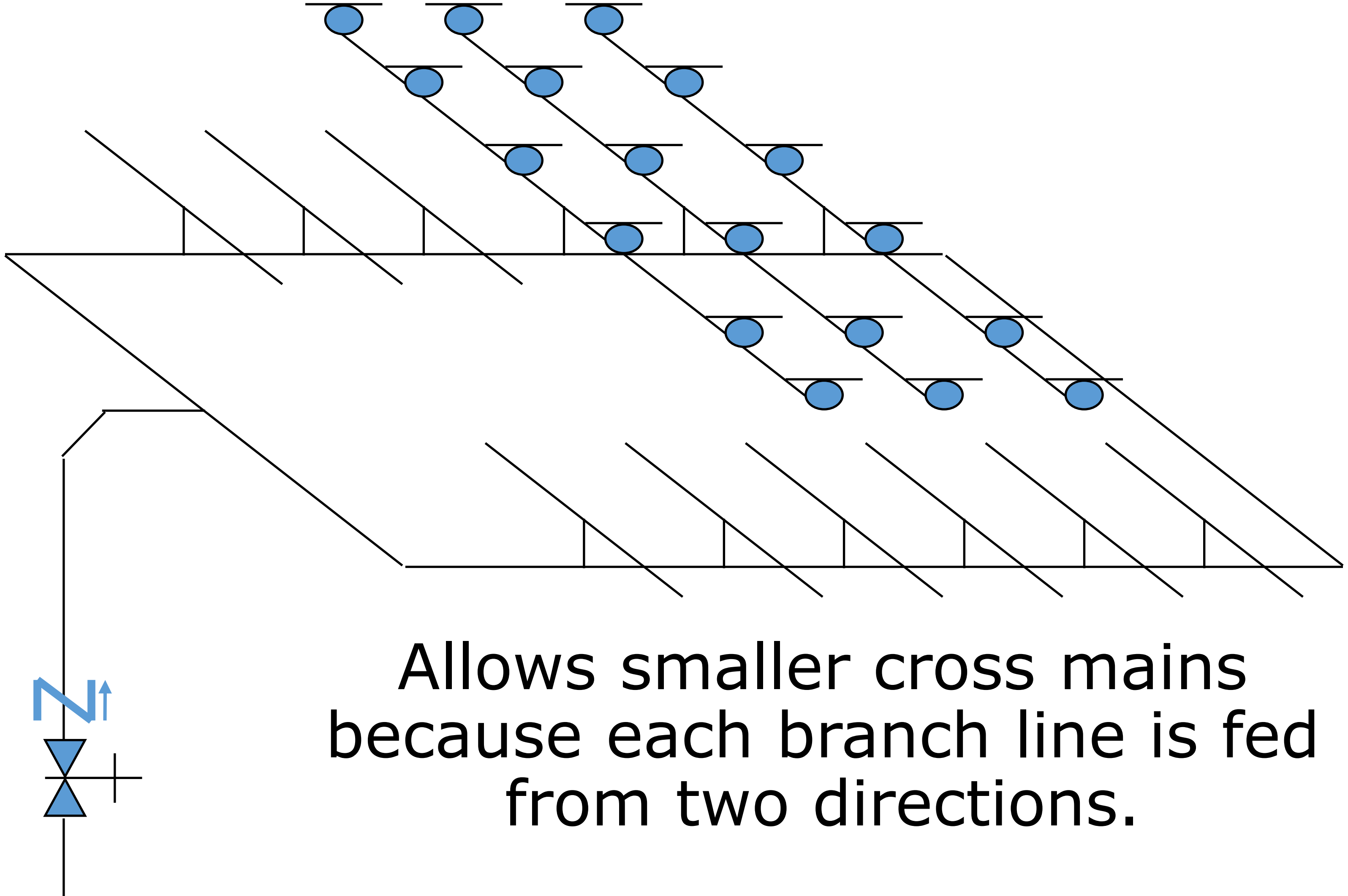
Design Elements- System Layout

Grid System



Allows smaller cross mains and branch lines since each sprinkler is fed by at least two paths.

Design Elements- System Layout –
Loop System



Allows smaller cross mains because each branch line is fed from two directions.

Hydraulic Calculation Method

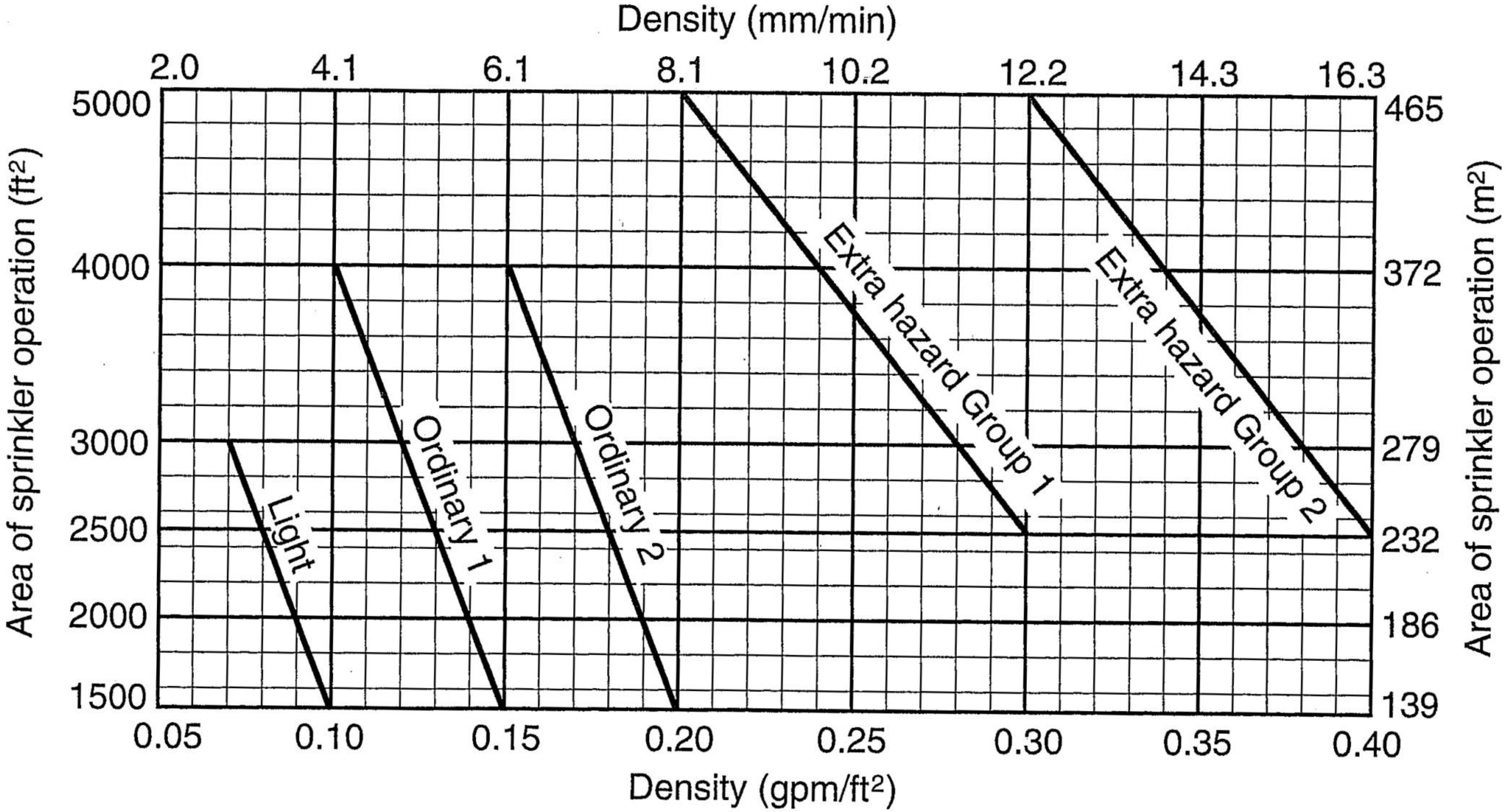
The Layout Process

1. Define the Hazard
2. Analyze the Structure
3. Analyze the Water Supply
4. Select the Type of System
5. Select the Sprinkler Type(s) and Locate Them
6. Arrange the Piping
7. Arrange Hangers and Bracing (where needed)
8. Include System Attachments
9. **Hydraulic Calculations**
10. Notes and Details for Plans
11. As-Built Drawings

Density/Area Method

- Density is the flow of water that lands in a single square foot under the sprinkler
- Measured in flow divided by unit area
  - English units: gpm/ft^2
- Flow required from a sprinkler is calculated by multiplying selected density by the coverage area

Density/Area Curves



Density/Area Example 1

- A sprinkler system has been installed with standard spray sprinklers spaced 10 feet by 11 feet 6 inches apart. If this is an Ordinary Hazard Group 2 occupancy and the discharge density is 0.2 gpm/ft^2, what is the minimum required flow from a sprinkler?
- Coverage Area:

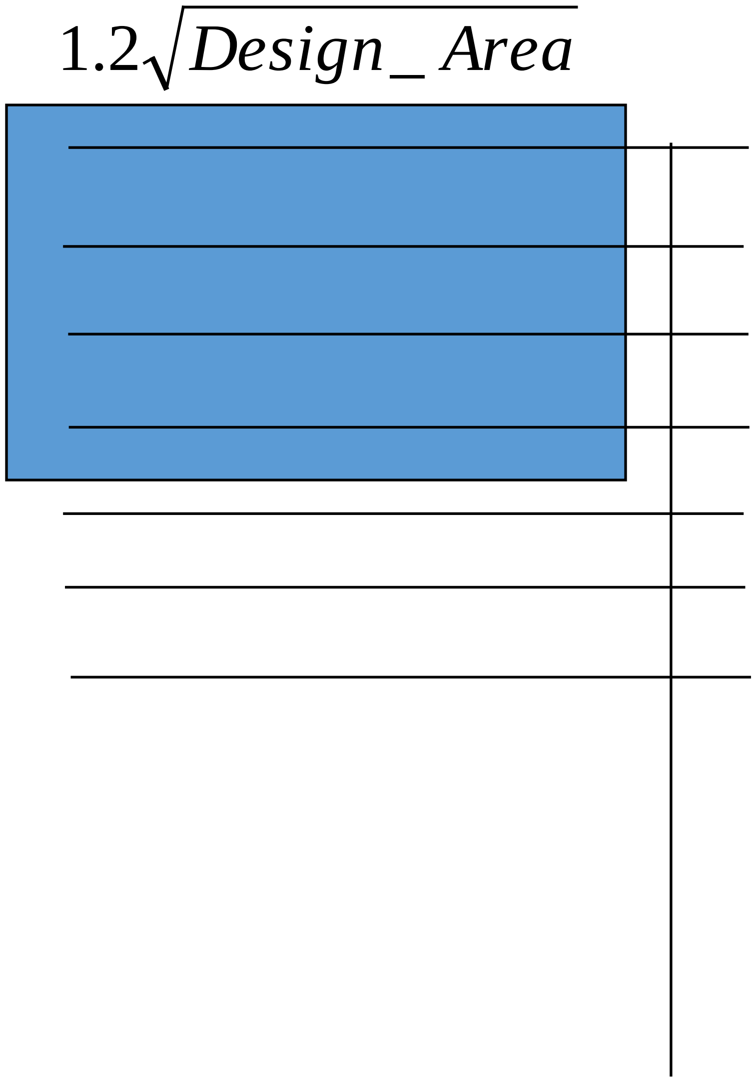
$$A = 10 \text{ ft} \times 11.5 \text{ ft} = 115 \text{ ft}^2$$

- Density times area equals flow:

$$0.2 \text{ gpm/ft}^2 \times 115 \text{ ft}^2 = 23 \text{ gpm}$$

Density/Area Method (continued)

- **Fire Rectangle**: "…the design area shall be a rectangular area having a dimension parallel to the branch lines at least 1.2 times the square root of the area of sprinkler operation used…"
- Different remote area geometry may be required by other authorities.



Density/Area Curves

- Total Number of Sprinklers to Calculate
  - Design Area ÷ Area Per Sprinkler
- Number of Sprinklers per Branch Line

$$\frac{1.2\sqrt{\text{Design Area}}}{S}$$

Where:

S is the distance between sprinklers on the branch line

Density/Area Example 2

- The sprinkler system in an OH2 occupancy has a discharge density of 0.2 gpm/ft^2 over 1500 ft^2 (selected from Figure 11.2.3.1.1), each sprinkler covers 115 ft^2, how many sprinklers will be in the design area?

$$1500 \text{ ft}^2 \div 115 \text{ ft}^2 = 13.04$$

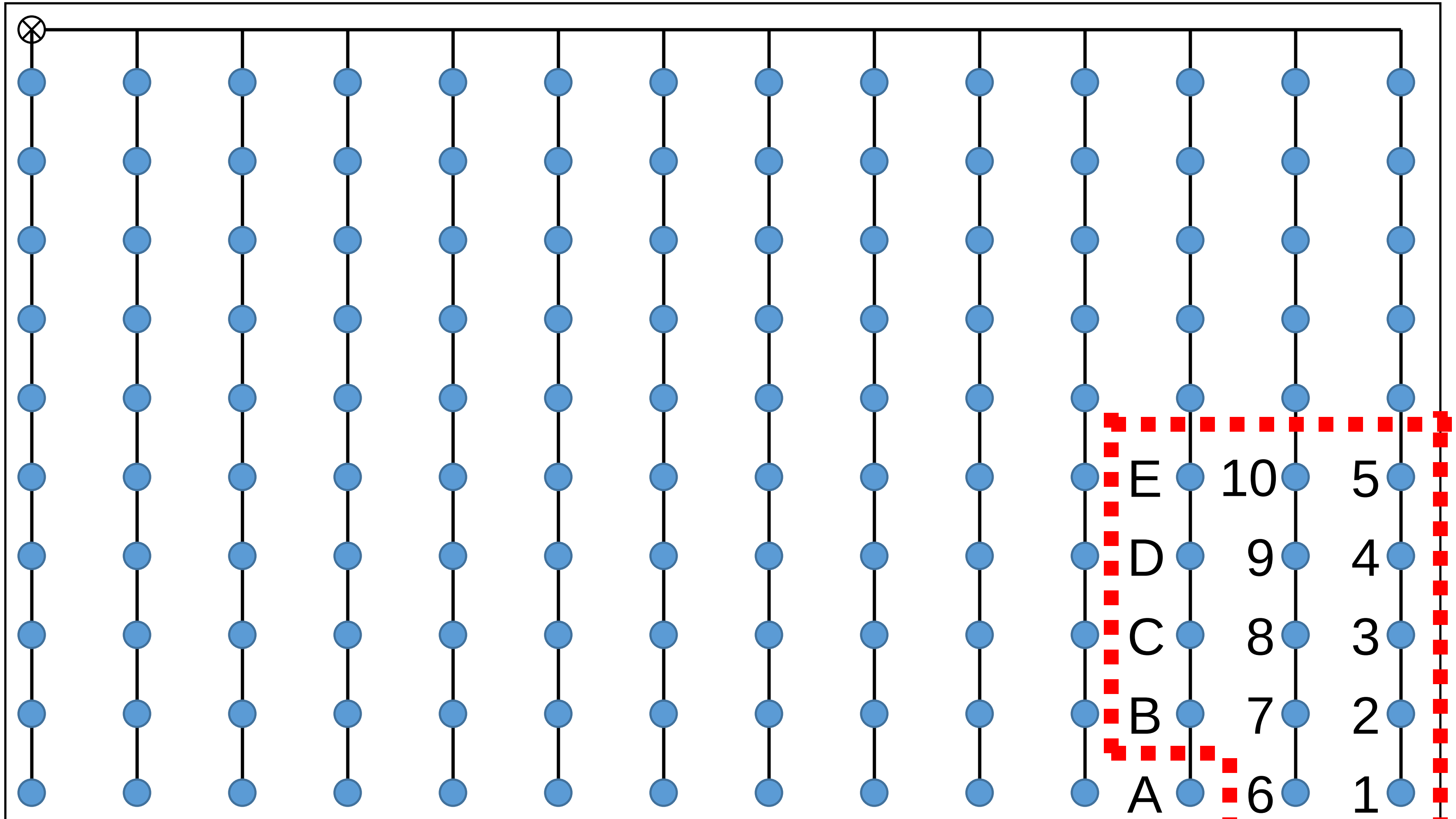
14 sprinklers

- If sprinklers along the branch line are 10 ft apart, how many sprinklers/line are calculated?

$$\frac{1.2\sqrt{1500\text{ft}^2}}{10\text{ft}} = 4.65 \cong 5 \text{ sprinkler/line}$$

Density/Area Example 2 (continued)

Which sprinklers on the 3rd line should be added?



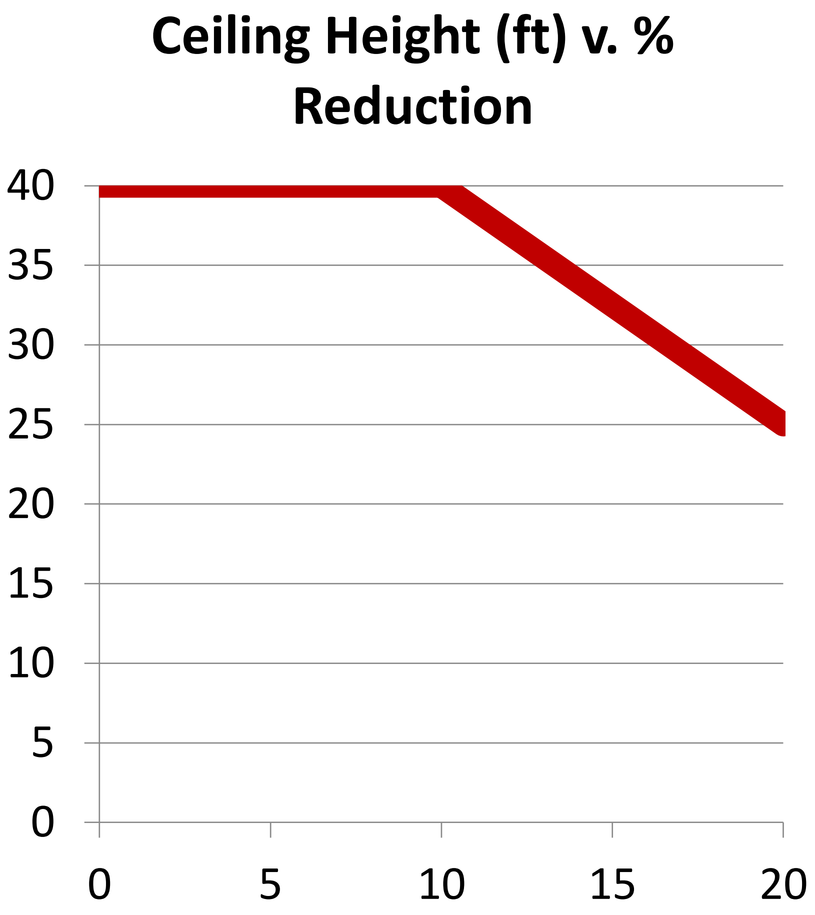
Area Adjustments

- Dry-Pipe Systems
  - Increase area 30% (Section 11.2.3.2.5)
- Double Interlock Pre-action Systems
  - Increase Area 30% (Section 11.2.3.2.5)
- Extra Hazard Occupancy with High Temperature Sprinklers
  - Decrease Area 25%, but minimum of 2000 ft^2 (Section 11.2.3.2.6)

Area Adjustments (continued)

- Quick Response Sprinklers (11.2.3.2.3)
  - Area of operation can be reduced 25 to 40% depending on ceiling height when:
    - Wet pipe system only
    - Light or ordinary hazards
    - 20 ft maximum ceiling height
    - No unprotected ceiling pockets
    - No less than 5 sprinklers in design area
  - Area may be less than 1500 ft^2

Quick Response Area Adjustment



- Ceiling Height <10 ft
  - Reduction is 40%
- Between 10 and 20 ft
  - Y = (-3x/2)+55
- Ceiling Height is 20 ft
  - Reduction is 25%
- Over 20 ft Ceiling Height
  - No reduction allowed

Area Adjustments (continued)

- Sloped Ceilings
  - Area of operation is increased by 30% if pitch exceeds 2 in 12 (rise in run). This is an angle of 9.46°

Multiple Adjustments Example 1

- Compound adjustments based on original area of operation selected from Figure 11.2.3.1.1.
  - Dry-pipe system installed under slope of 4 in 12
    - 30% increase for dry system
    - 30% increase for slope
    - Using 1500 ft^2 as the selected operation area
  - 1500 ft^2 x 1.3 x 1.3 = 2535 ft^2 design area
- There is no change in the density.

Multiple Adjustments Example 2

- Compound adjustments based on original area of operation selected from Figure 11.2.3.1.1.
  - QR sprinklers under 3 in 12 slope, ceiling height is 20 ft
    - 25% decrease for ceiling height
    - 30% increase for slope
    - Using 1500 ft^2 as the operation area
  - 1500 ft^2 x 0.75 x 1.3 = 1463 ft^2 design area
- There is no change in density.

Why examine only the most remote area?

The logic of examining only the set number of heads at the most remote portion of the building is as follows:

> Keeping pipe diameters and minimum water flow requirements the same throughout the building, because of physics and hydraulics, if the minimum required water pressure and gpm are met at the most remote section of the building, as you move closer to the riser, water pressure and gpm will automatically be greater

City Water Mains

- Information from the local water authority
- Flow testing near the site
- Need the following information:
  - Static Pressure
  - Residual Pressure
  - Residual Flow

Water Supply Summary

- If the system demand is NOT within the capacity of the water supply, alterations are need to the supply or to the system
- If the supply is too low on flow:
  - arrange a secondary water source (e.g. tank, lake, pond, etc.)
- If the supply is too low on pressure:
  - install a fire pump
  - use larger pipe to reduce friction loss
  - maintain higher water level in an elevated tank
  - install tank at higher elevation

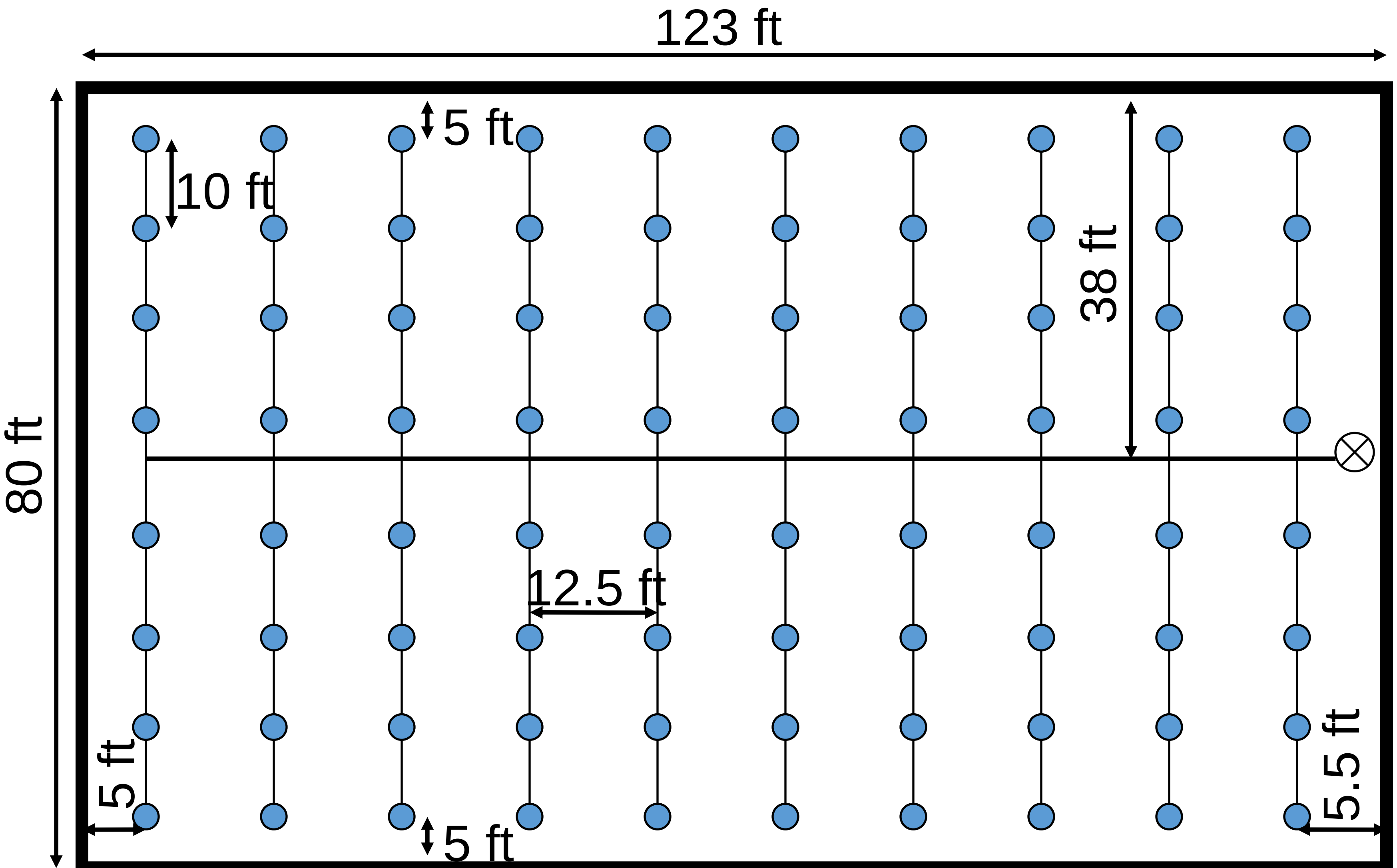
Step-by-Step Calculations

1. Identify hazard category
2. Determine sprinkler spacing
3. Determine piping arrangement
4. Calculate amount of water needed per sprinkler
5. Calculate number and location of open sprinklers in the hydraulically most demanding area
6. Start at most remote sprinkler and work towards the water supply calculating flows and pressures
7. Compare demand with supply

Example

- Ordinary Hazard Group 2 occupancy
- 12 ft ceiling height
- Quick Response standard spray sprinklers with a k-factor of 5.6
- Wet pipe sprinkler system
- Sprinklers on 10 ft x 12.5 ft spacing

Example: Plan View



Example (continued)

1. Select hazard category: **OH2**
2. Determine sprinkler spacing: **10 ft x 12.5 ft**
3. Determine piping arrangement: **Done**
4. Calculate amount of water per sprinkler
    a) Select **Density/Area Method**
    b) Pick point from density/area curve: **0.2 gpm/ft^2 over 1500 ft^2**
    c) 0.2 gpm/ft^2 x 125 ft^2 = **25 gpm/sprinkler**

Example (continued)

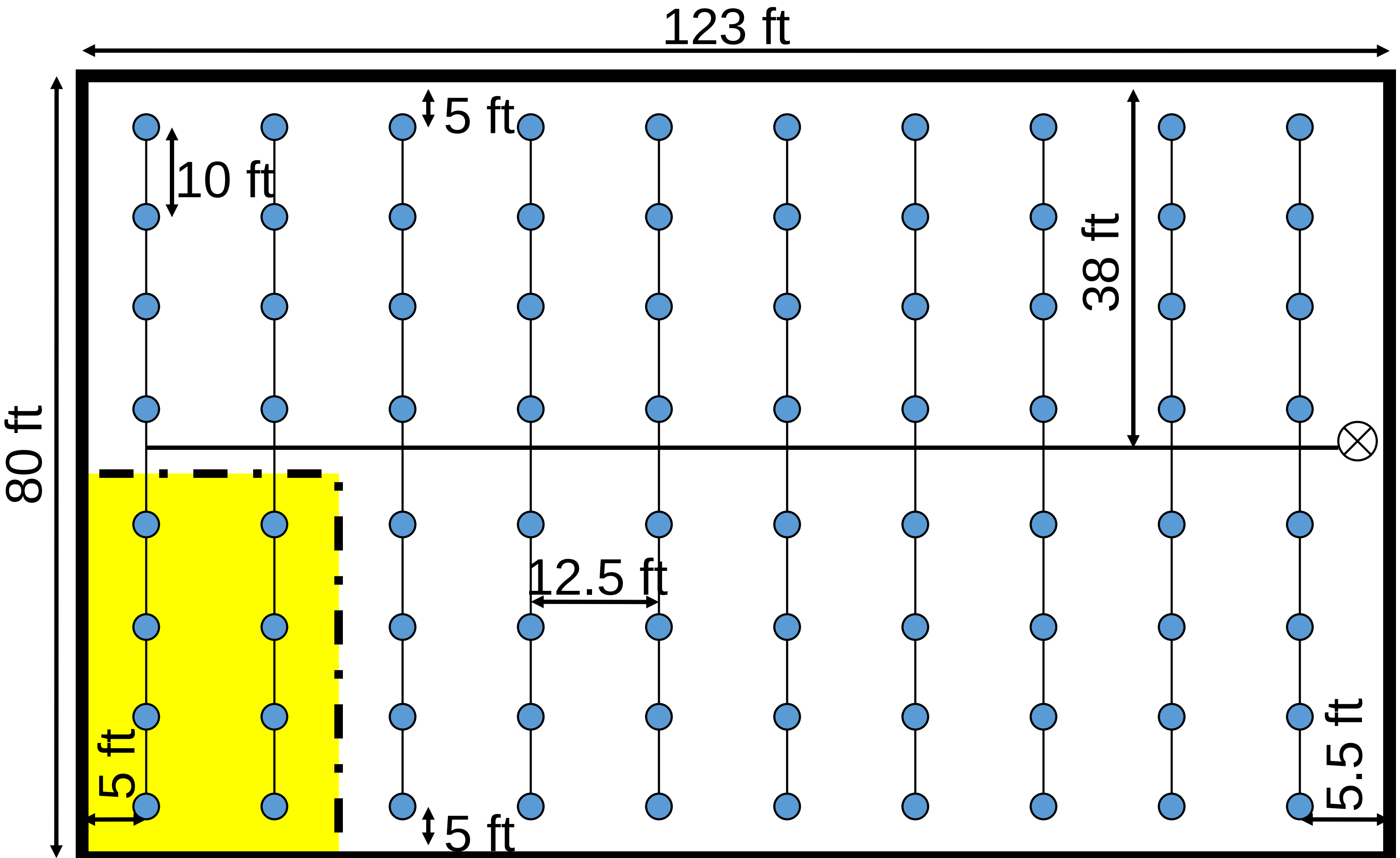
1. Select hazard category: **OH2**
2. Determine sprinkler spacing: **10 ft x 12.5 ft**
3. Determine piping arrangement: Done
4. Calculate amount of water per sprinkler: **25 gpm**
5. Calculate number & location of open sprinklers
   a) Area Adjustment(s):

      QR Reduction: % = (-3x/2) + 55 = [-3(12)/2] + 55 = 37%

      1500 ft^2 x 0.63 **= 945 ft^2**

   b) 945 ft^2 ÷ 125 ft^2 per sprinkler = 7.56 = **8 sprinklers**
   c) $1.2(945)^{0.5}/10$ = 3.7 = **4 sprinklers per branch line**

Example: Hydraulic Remote Area



Determine the Starting Pressure

- Most remote sprinkler needs 25 gpm
- Sprinkler k = 5.6

$$P = \left(\frac{Q}{k}\right)^2 = \left(\frac{25}{5.6}\right)^2 = 19.9\text{psi}$$

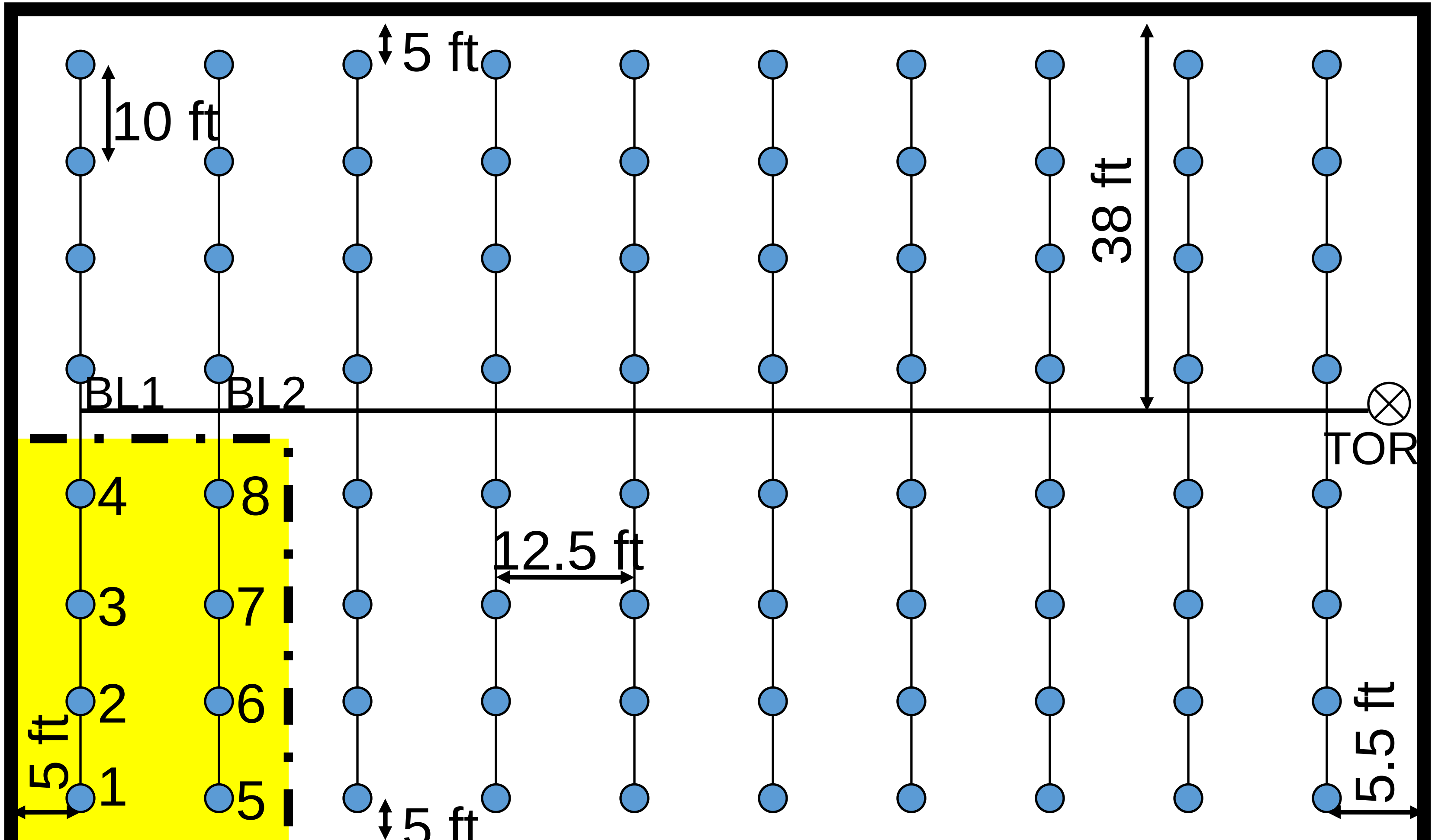
- Starting information for the first sprinkler:
  - **25 gpm at 19.9 psi**
- Next work back to the water supply adding pressure losses and flows throughout the system

Information Needed for Calculations

- Select initial pipe sizes
- Locate nodes on all places where:
    a. Flow (Q) takes place,
    b. Type of pipe or system changes (C), and
    c. Diameter (di) changes.
- Layout calculation paths starting with primary path then attachment paths
- Fill in hydraulic calculation sheets

Hydraulic Calculation Paths

Locate the system nodes:



Full System Hydraulic Calculation

- An electronics factory is being built.
- Water supply tests were done near the site and produced the following information:
  - Static pressure = 90 psi
  - Residual pressure = 60 psi
  - Flow at 60 psi = 1000 gpm

The Layout Process

1. Define the Hazard
2. Analyze the Structure
3. Analyze the Water Supply
4. Select the Type of System
5. Select the Sprinkler Type(s) and Locate Them
6. Arrange the Piping
7. Arrange Hangers and Bracing (where needed)
8. Include System Attachments
9. Hydraulic Calculations
10. Notes and Details for Plans
11. As-Built Drawings

Identify the Hazard

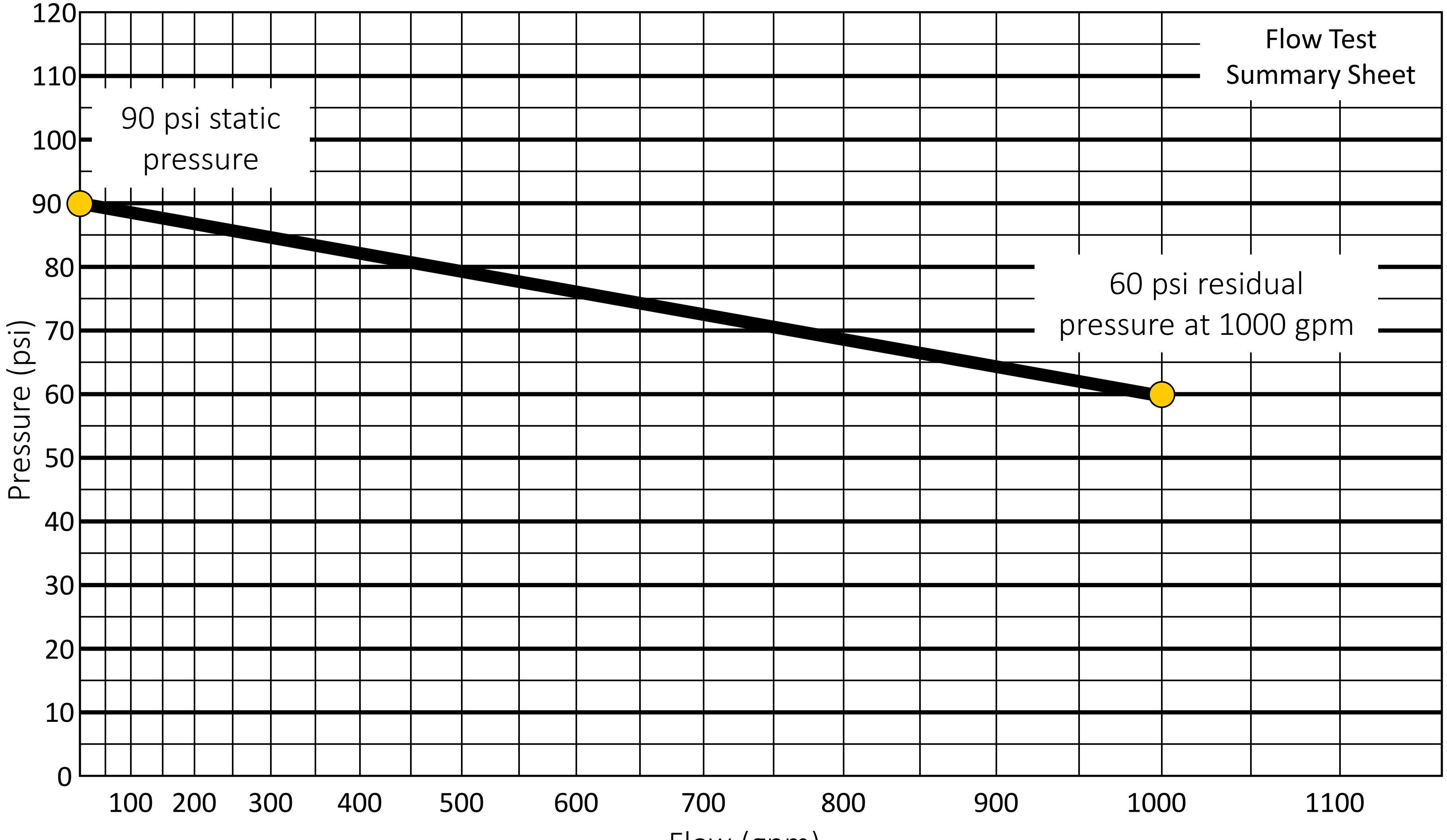
- In accordance with NFPA 13 hazard classifications, an **electronics factory** is classified as an **Ordinary Hazard Group I** occupancy.

The Layout Process

1. Define the Hazard
2. Analyze the Structure
3. Analyze the Water Supply
4. Select the Type of System
5. Select the Sprinkler Type(s) and Locate Them
6. Arrange the Piping
7. Arrange Hangers and Bracing (where needed)
8. Include System Attachments
9. Hydraulic Calculations
10. Notes and Details for Plans
11. As-Built Drawings

completed

Water Supply



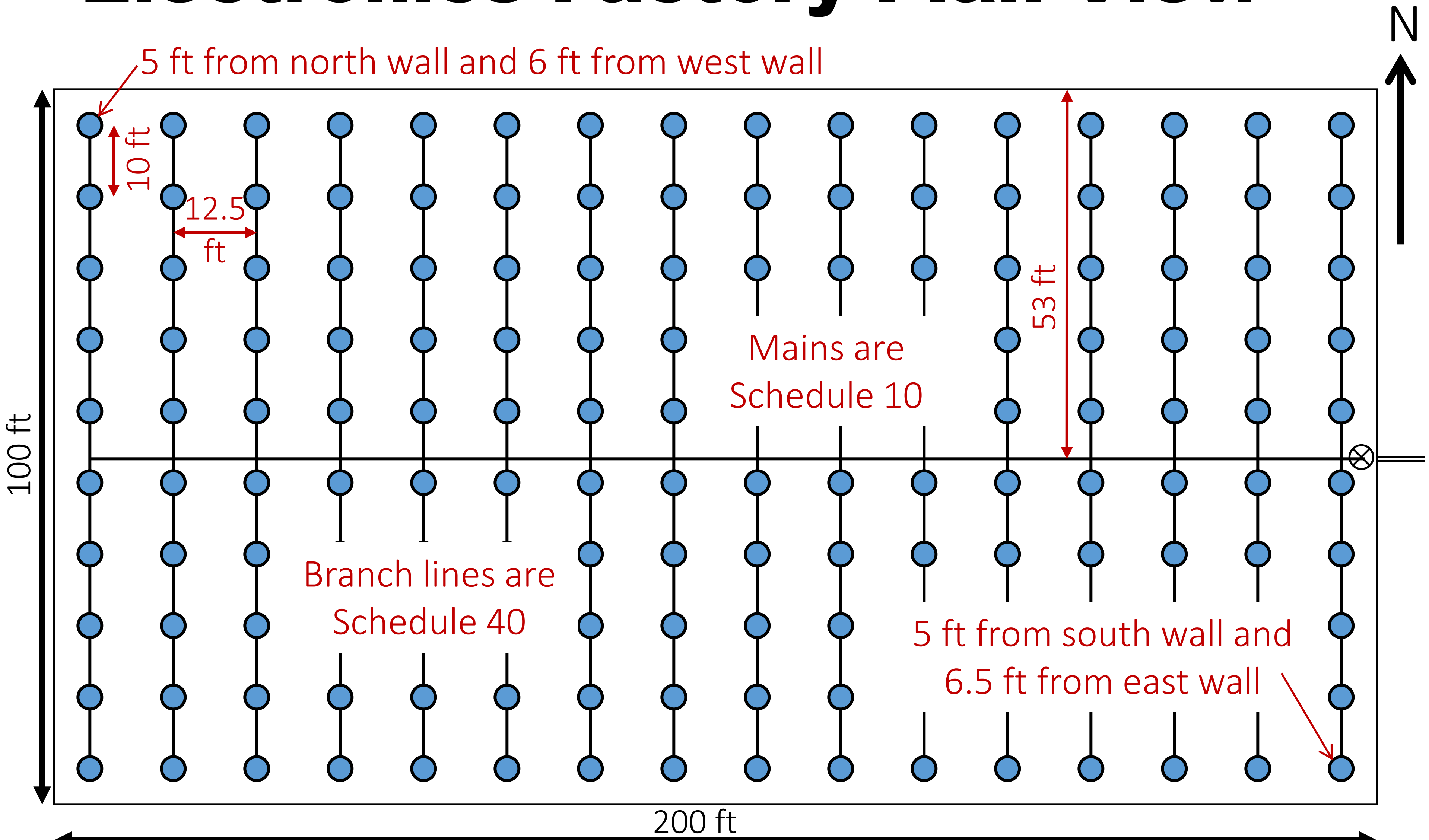
The Layout Process

1. Define the Hazard
2. Analyze the Structure
3. Analyze the Water Supply
4. Select the Type of System
5. Select the Sprinkler Type(s) and Locate Them
6. Arrange the Piping
7. Arrange Hangers and Bracing (where needed)
8. Include System Attachments
9. Hydraulic Calculations
10. Notes and Details for Plans
11. As-Built Drawings

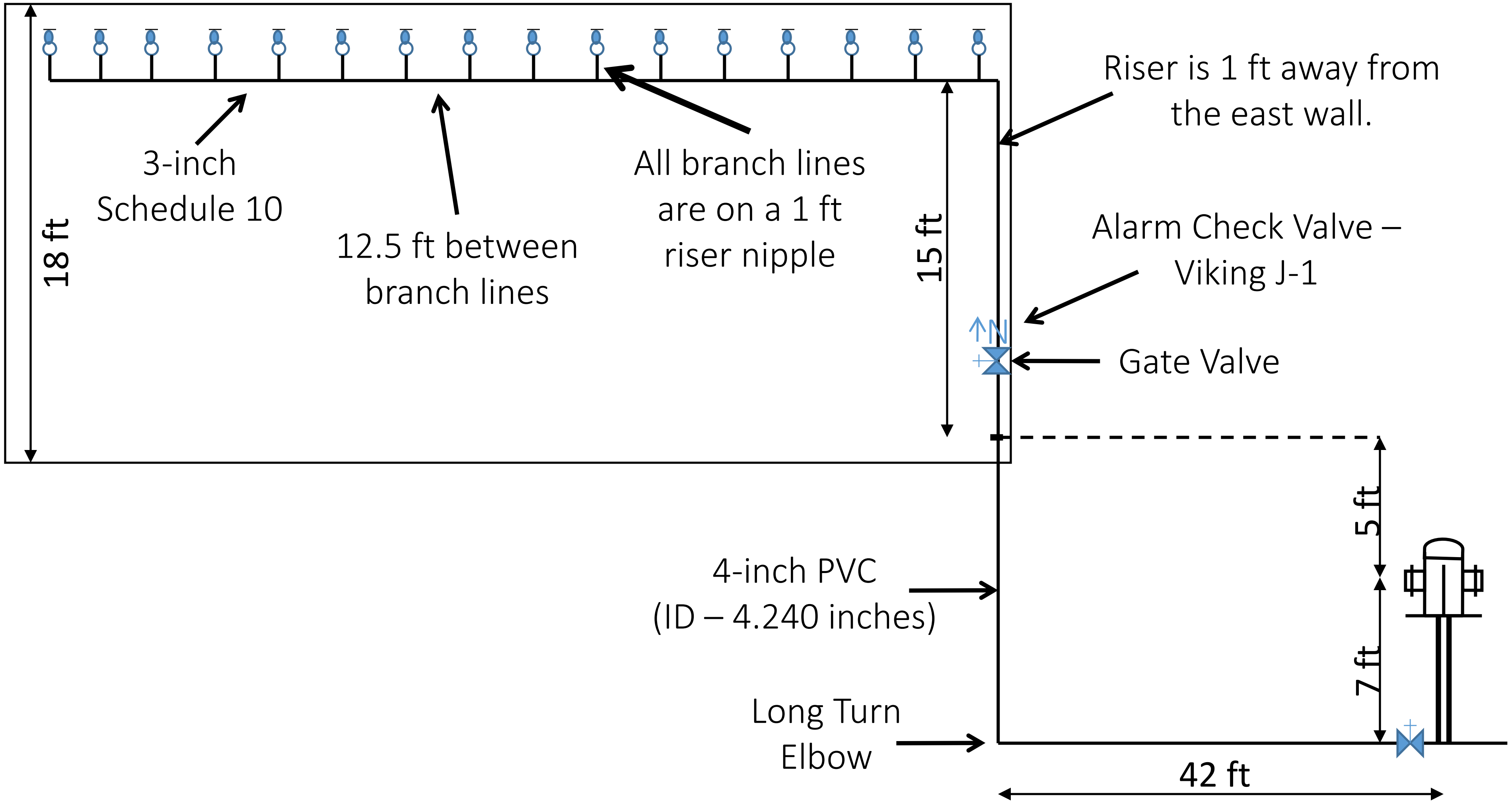
System Details

- Type of System:
  - Wet pipe system
- Type of Sprinkler: TY3121
  - Standard spray quick response upright sprinkler with a K-factor of 5.6
- Typical Sprinkler Spacing:
  - Sprinklers are 10 ft apart on the branch lines, and 12.5 ft between branch lines

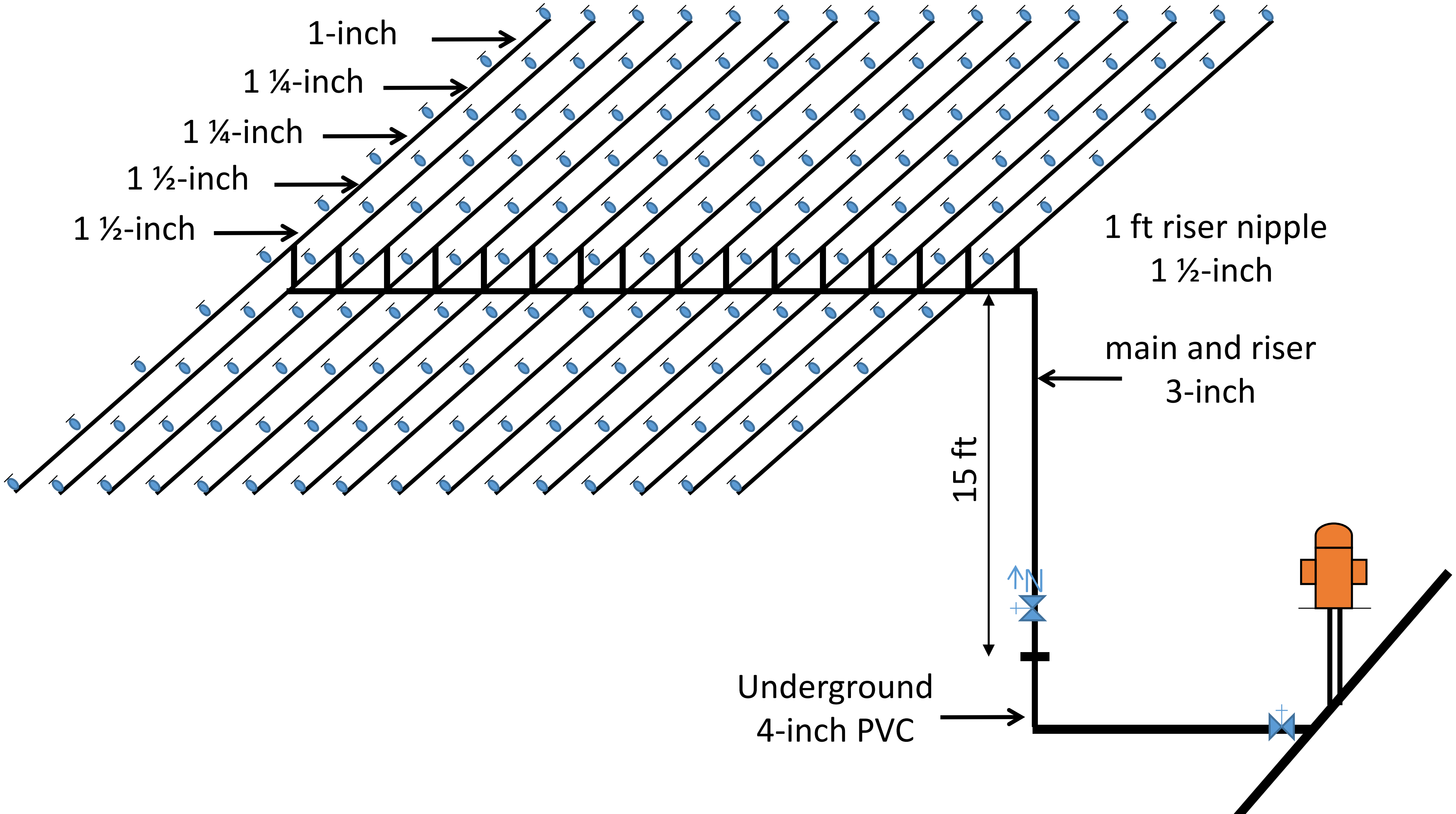
Electronics Factory Plan View



Electronics Factory Elevation View



Electronics Factory Isometric View

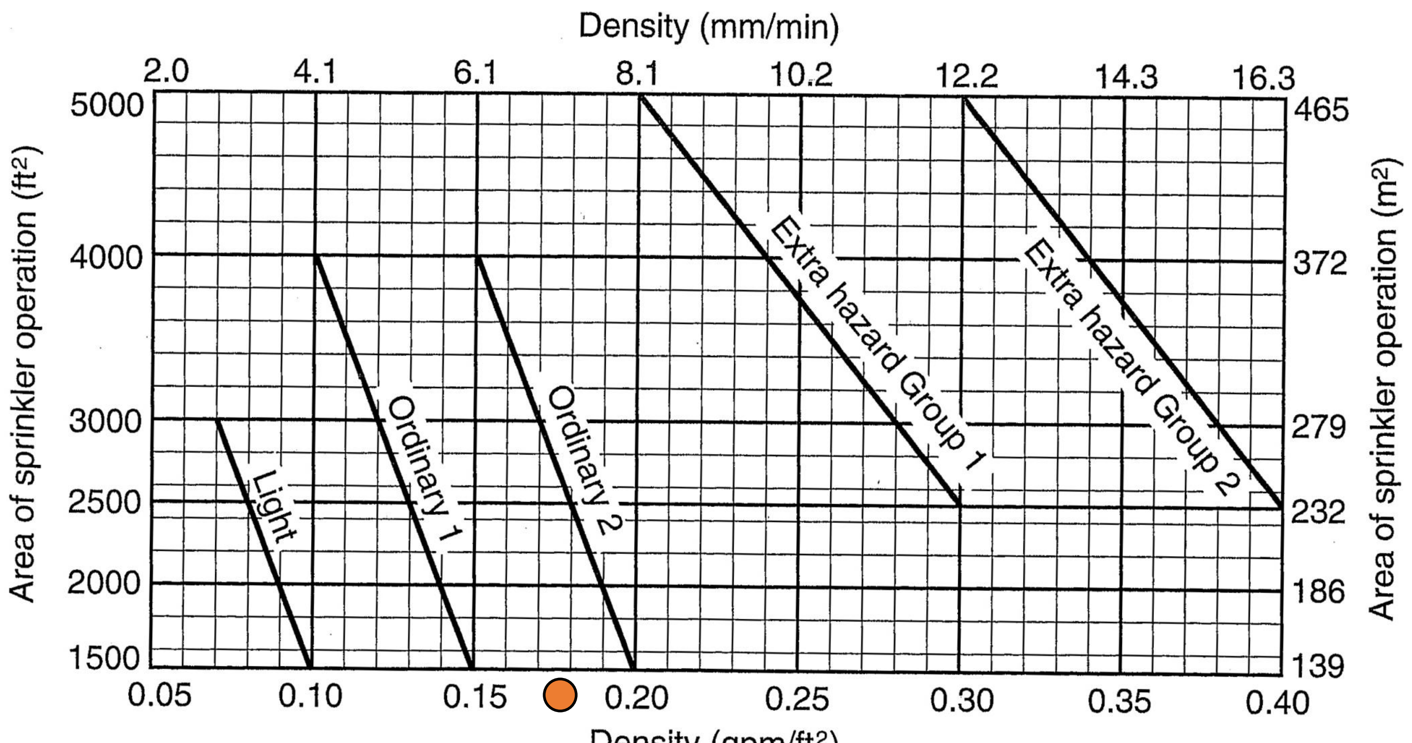


The Layout Process

1. Define the Hazard
2. Analyze the Structure
3. Analyze the Water Supply
4. Select the Type of System
5. Select the Sprinkler Type(s) and Locate Them
6. Arrange the Piping
7. Arrange Hangers and Bracing (where needed)
8. Include System Attachments
9. Hydraulic Calculations
10. Notes and Details for Plans
11. As-Built Drawings

Select a Design Approach

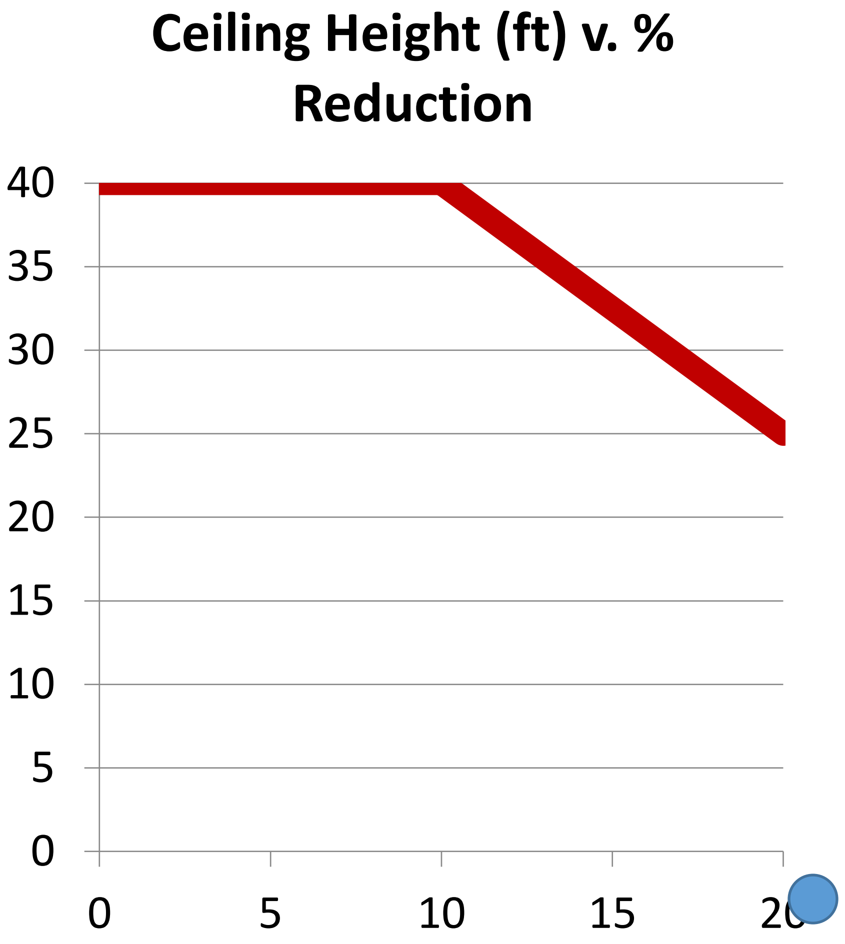
- Use the density/area method
- A point from the density/area curves need to be selected



Check for Area Adjustments

- Quick response sprinklers (in light hazard or ordinary hazard with wet pipe system, reduce design area based on maximum ceiling height, where it is less than 20 ft)
  - Original design area, from the area/density curve, is 1500 ft^2.
  - Wet pipe system, ordinary hazard, and a ceiling height of 18 ft

Area Reduction For QR Sprinklers



- y = % reduction in area
- x = ceiling height

$$y = \frac{-3x}{2} + 55$$

$$y = \frac{-3(18)}{2} + 55$$

$$y = \frac{-54}{2} + 55 = 28\%$$

Design Area (continued)

- Starting with 1500 ft^2 design area
- Applying the 28% reduction in area:

$$100\% - 28\% = 72\%$$

$$1500\ ft^2 * 0.72 = 1080\ ft^2$$

- New design area is **1080 ft^2**
- Density remains at **0.15 gpm/ft^2**

Design Area (continued)

- Design area is 1080 ft^2
- Each sprinkler, spaced 10 ft x 12.5 ft, is covering 125 ft^2
- **How many sprinklers are in the design area?**
- 1080 / 125 = 8.64 sprinklers = **9 sprinklers**

Forming the Design Area

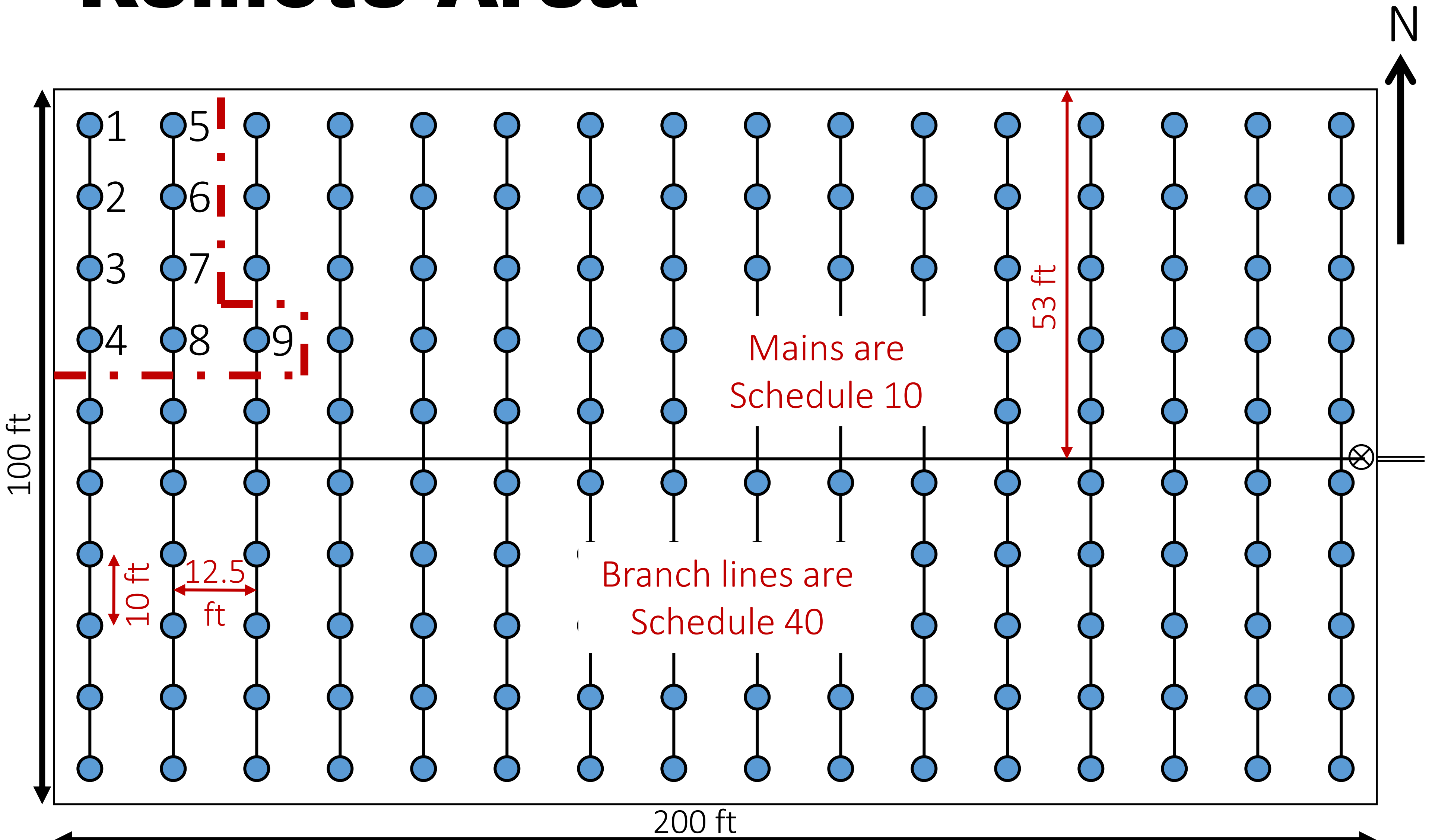
$$1.2\sqrt{\text{Design Area}}$$

parallel to the branch lines

$$\frac{1.2\sqrt{1080\,\text{ft}^2}}{10\,\text{ft}} = 3.94 \cong 4\ \text{sprinklers}$$

- Continue to add branch lines until 9 sprinklers are included

Remote Area



N
1
2
3
4
5
6
7
8
9
100 ft
10 ft
12.5 ft
53 ft
Mains are Schedule 10
Branch lines are Schedule 40
200 ft

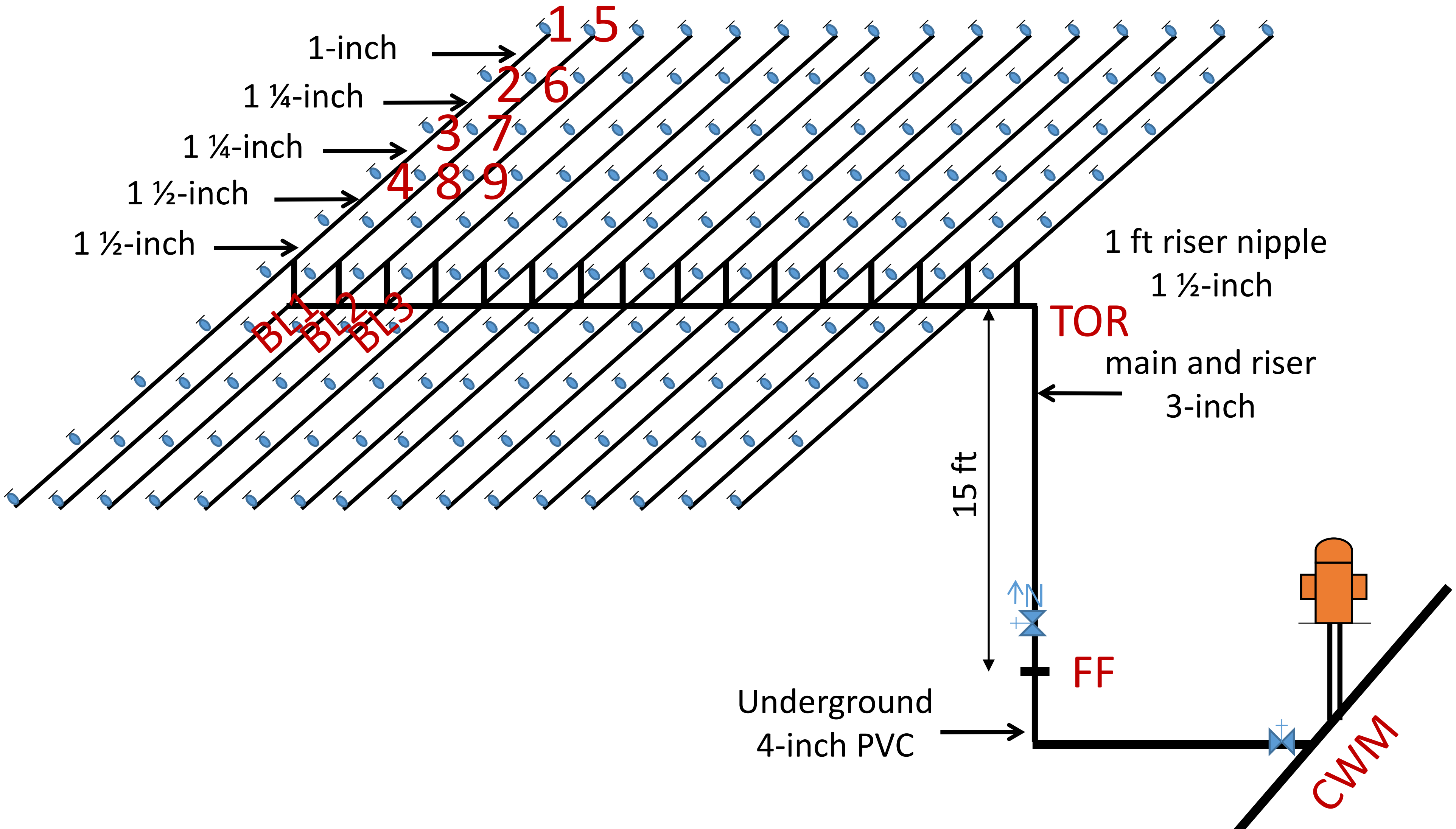
Information Needed for Calculations

1. Select initial pipe sizes

completed

2. Locate nodes on all places where:
   a) Flow (Q) takes place,
   b) Type of pipe or system changes (C), and
   c) Diameter (d_i) changes.
3. Layout calculation paths starting with primary path then attachment paths
4. Fill in hydraulic calculation sheets

Node Locations - Isometric

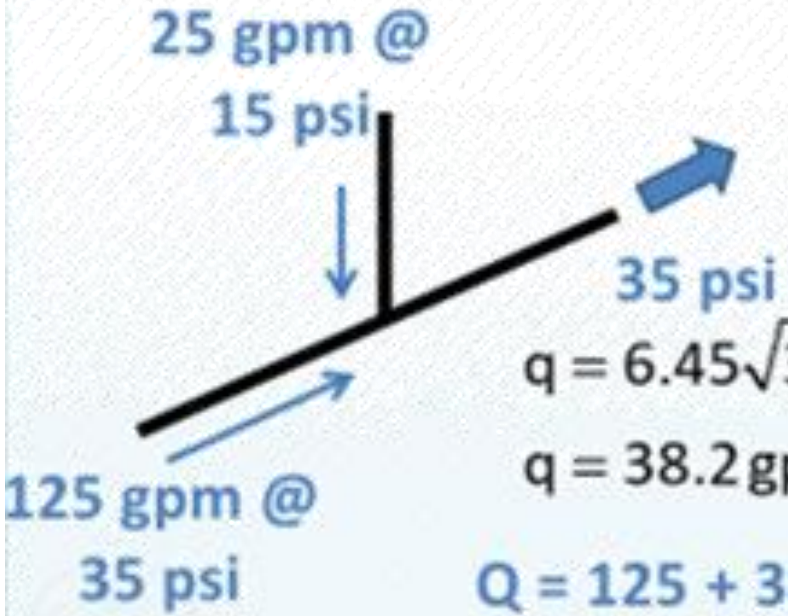


Information Needed for Calculations

- Select initial pipe sizes
- Locate nodes on all places where:
  - Flow (Q) takes place,
  - Type of pipe or system changes (C), and
  - Diameter (di) changes.
- Layout calculation paths starting with primary path then attachment paths
- Fill in hydraulic calculation sheets

Balancing Flows

$$K = \frac{Q}{\sqrt{P}} = \frac{25}{\sqrt{15}} = 6.45$$



$$q = 6.45\sqrt{35}$$

$$q = 38.2\,gpm$$

$$Q = 125 + 38.2$$

$$Q = 163.2\ gpm$$

- Only one pressure is inside the pipe
  - Use the higher pressure
- Calculate an equivalent K-factor for the portion of the pipe with the lower pressure
- Calculate the actual flow using the K-factor and the new pressure.

Obstruction Rules

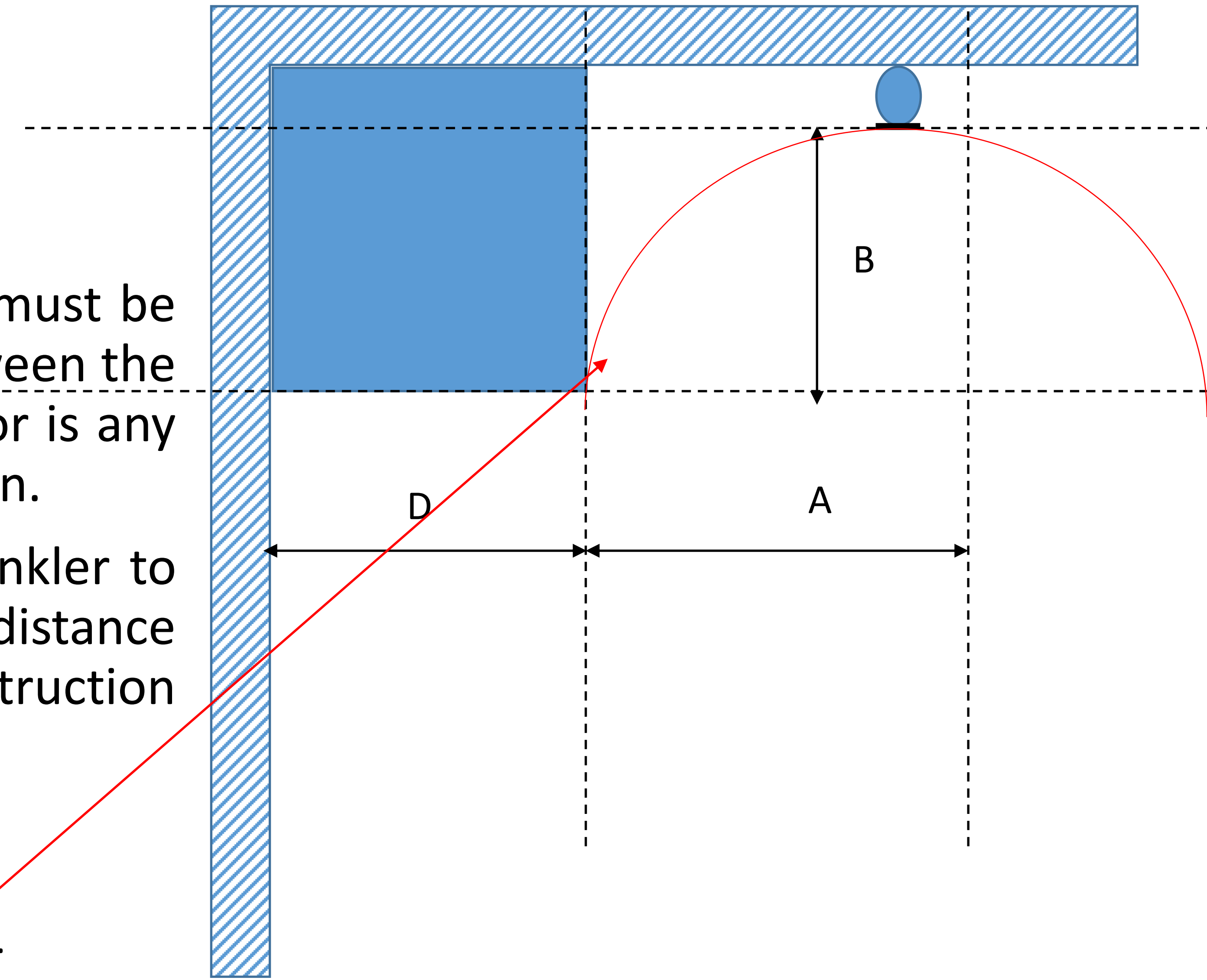
1. The Beam Rule
2. The Three Time Rule
3. The Four foot & wide obstruction Rule

Obstruction Rules

The Beam Rule :

In short the "beam rule" states that there must be at least 1 foot (0.3048 m)of separation between the sprinkler and the obstruction if the deflector is any distance above the bottom of the obstruction.

As the distance (A) increases from the sprinkler to the obstruction the greater the Allowable distance from the deflector to the bottom of the obstruction (B)



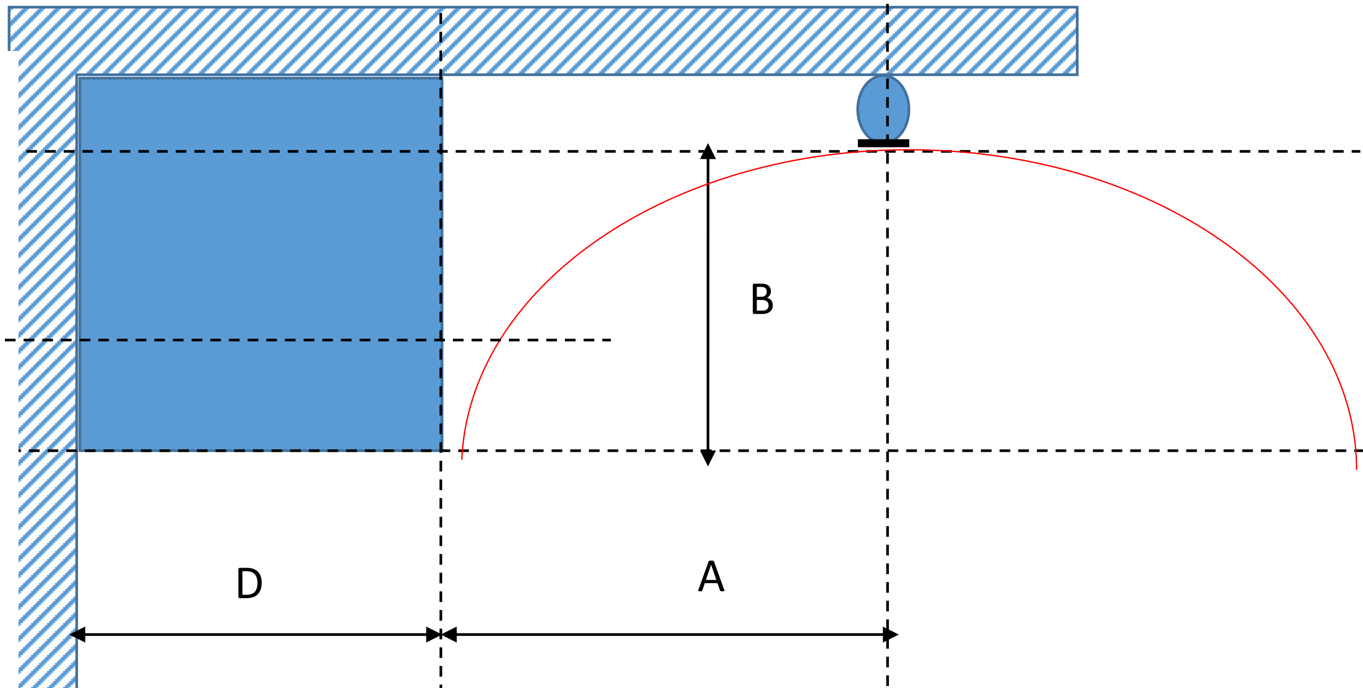
Spray Umbrella should clear the beam.

Obstruction Rules

The Beam Rule :

Table 8.6.5.1.2 Positioning of Sprinklers to Avoid Obstructions to Discharge [Standard Spray Upright/Standard Spray Pendent (SSU/SSP)]

Distance from Sprinklers to Side of Obstruction (*A*)	Maximum Allowable Distance of Deflector Above Bottom of Obstruction (*B*) (in.)
Less than 1 ft	0
1 ft to less than 1 ft 6 in.	2½
1 ft 6 in. to less than 2 ft	3½
2 ft to less than 2 ft 6 in.	5½
2 ft 6 in. to less than 3 ft	7½
3 ft to less than 3 ft 6 in.	9½
3 ft 6 in. to less than 4 ft	12
4 ft to less than 4 ft 6 in.	14
4 ft 6 in. to less than 5 ft	16½
5 ft to less than 5 ft 6 in.	18
5 ft 6 in. to less than 6 ft	20
6 ft to less than 6 ft 6 in.	24



The distances specified in Table 8.6.5.1.2 outline the discharge pattern of the sprinkler and define how far away from a building element a sprinkler must be positioned to allow the sprinkler discharge to extend underneath the building element rather than to hit it.

These distances are based on the discharge patterns of typical standard spray upright and pendent sprinklers at pressures from 15 psi to 100 psi (1 bar to 7 bar).

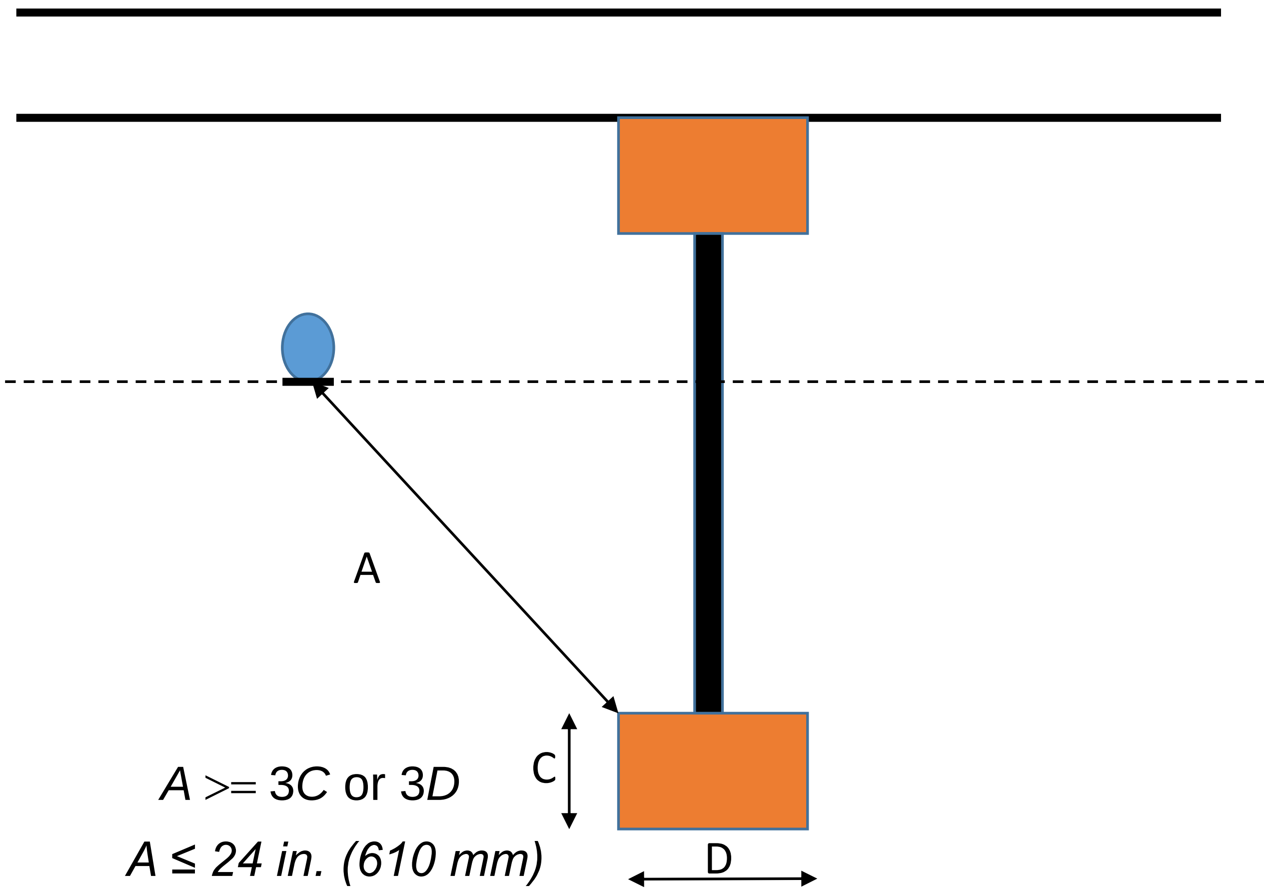
Obstruction Rules

The Three Time Rule :

It states that unless specific requirements are met *"sprinklers shall be positioned away from obstructions a minimum distance of three times the maximum dimensions of the obstruction"*, up to a maximum of 24 inches (0.6096 m) though the *"maximum clear distance does not apply to obstructions in the vertical orientation*

This rule have been written to apply to obstructions where the sprinkler can be expected to get water to both sides of the obstruction without allowing a significant dry shadow on the other side of the obstruction

This works for small non-continuous obstructions and for continuous obstructions where the sprinkler can throw water over and under the obstruction, such as the bottom chord of an open truss or joist. For solid continuous obstructions, such as a beam, the Three Times Rule is ineffective since the sprinkler cannot throw water over and under the obstruction



(Use dimension C or D, whichever is greater)

Obstruction Rules

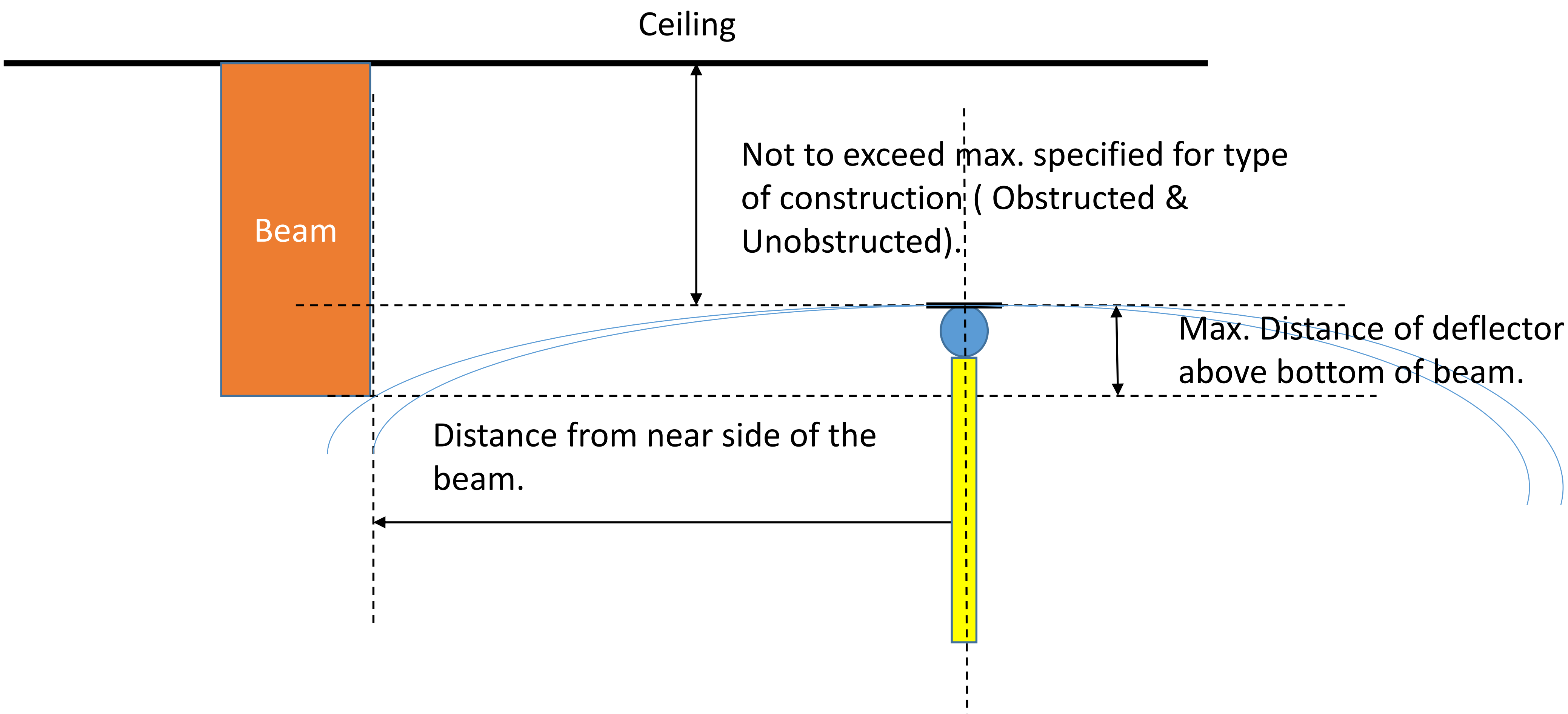
The Four-Foot and Wide Obstruction Rule

The *"Four Times Rule"* is really just an extension of the *"three times rule"* however it covers extended coverage sprinklers and the maximum clearance is 36 inches (0.9144 m).

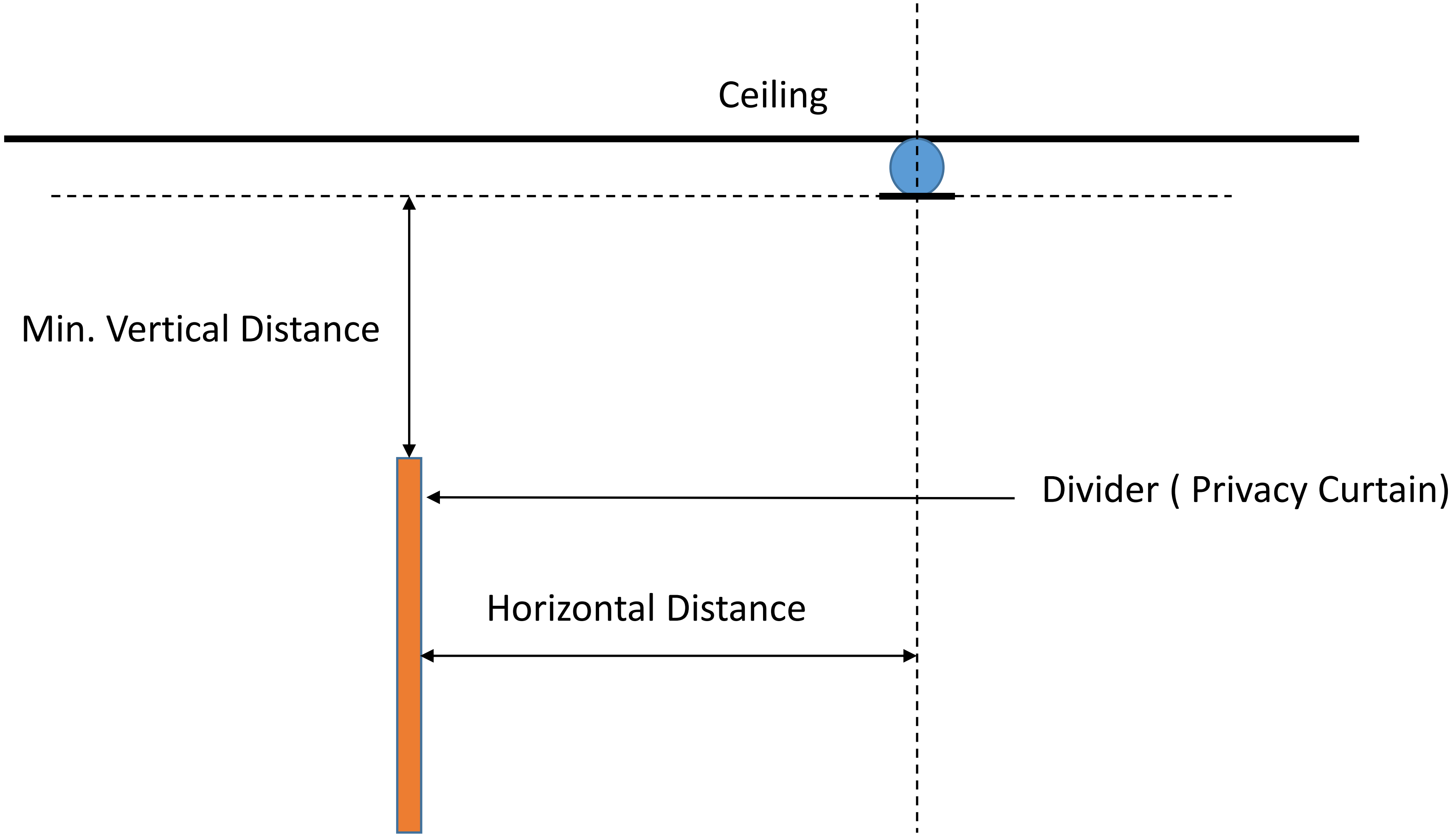
For obstructions wider than 4 feet (1.2192 m), sprinkler protection is required below the obstruction with deflectors to be located less than 12 inches (0.3048 m) from the bottom of the obstruction.

For obstructions less than 4 feet (1.2192 m) in width sprinklers may not be required underneath the obstruction

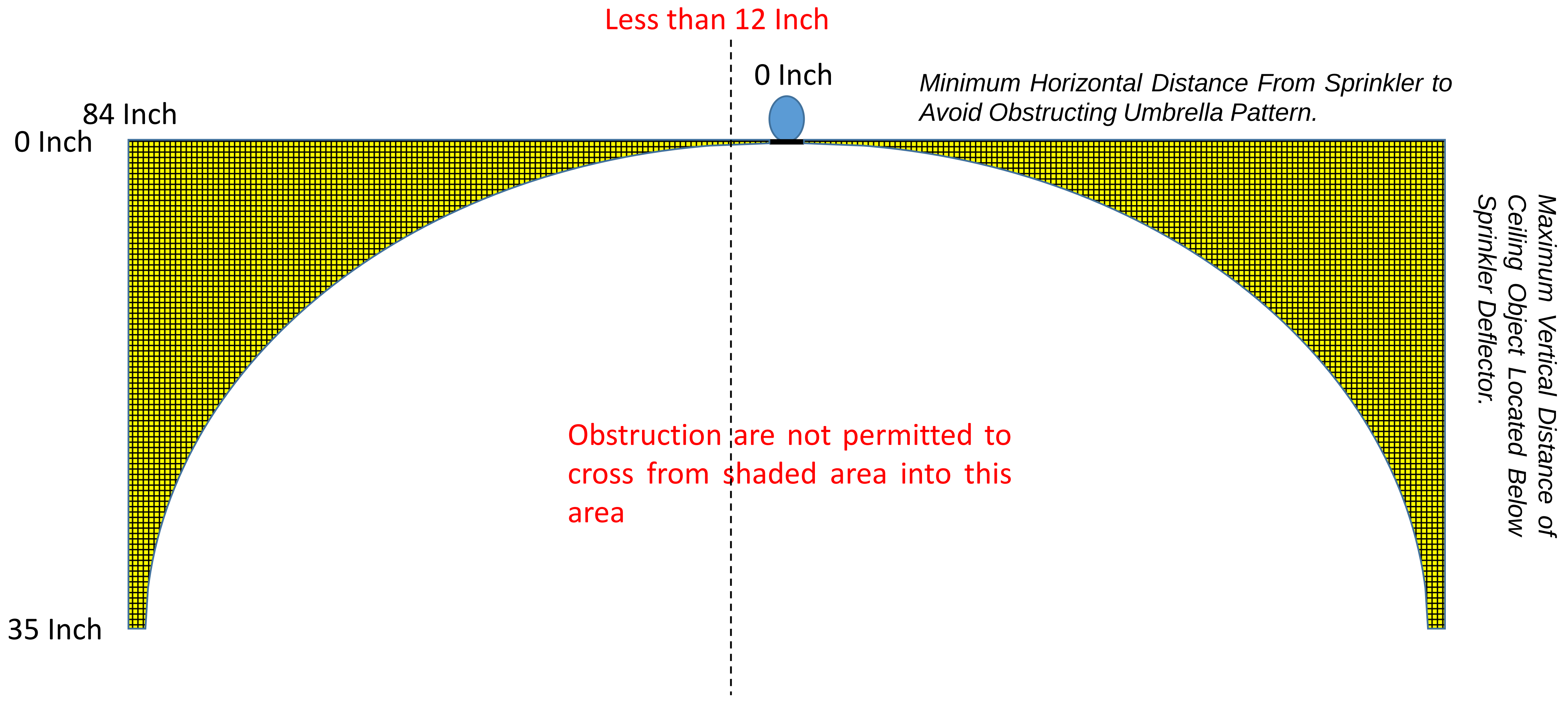
8.6.5 – Obstruction to Sprinkler Discharge



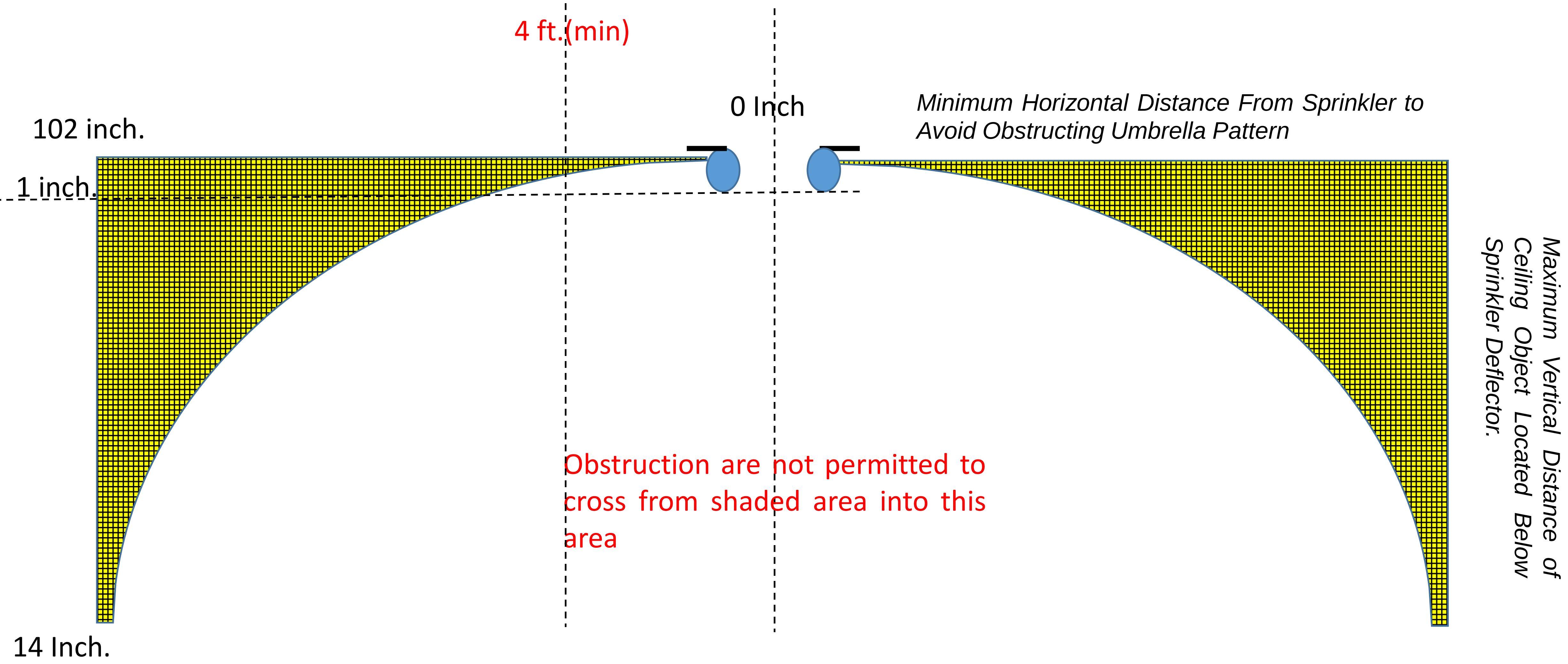
8.6.5 – Obstruction to Sprinkler Discharge



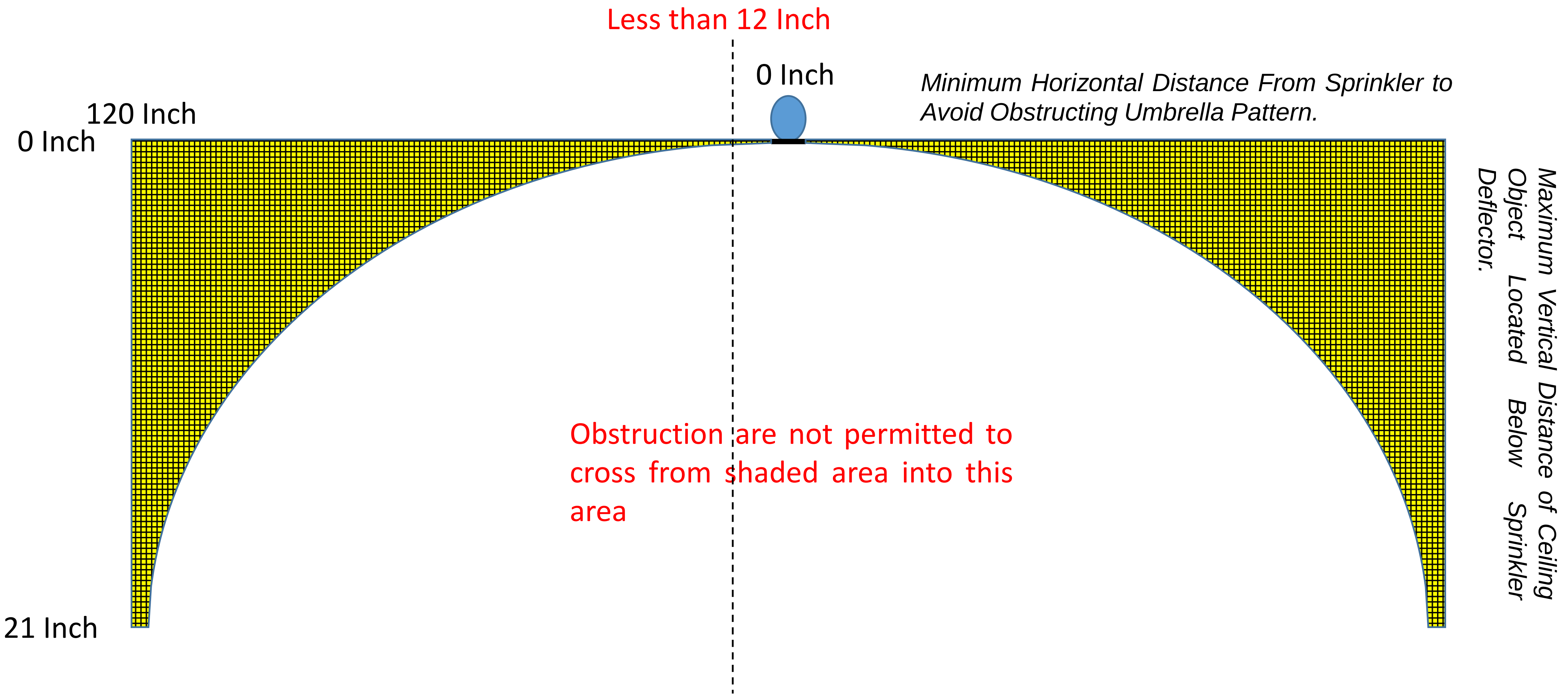
8.6.5- SSP and SSU – Non Storage



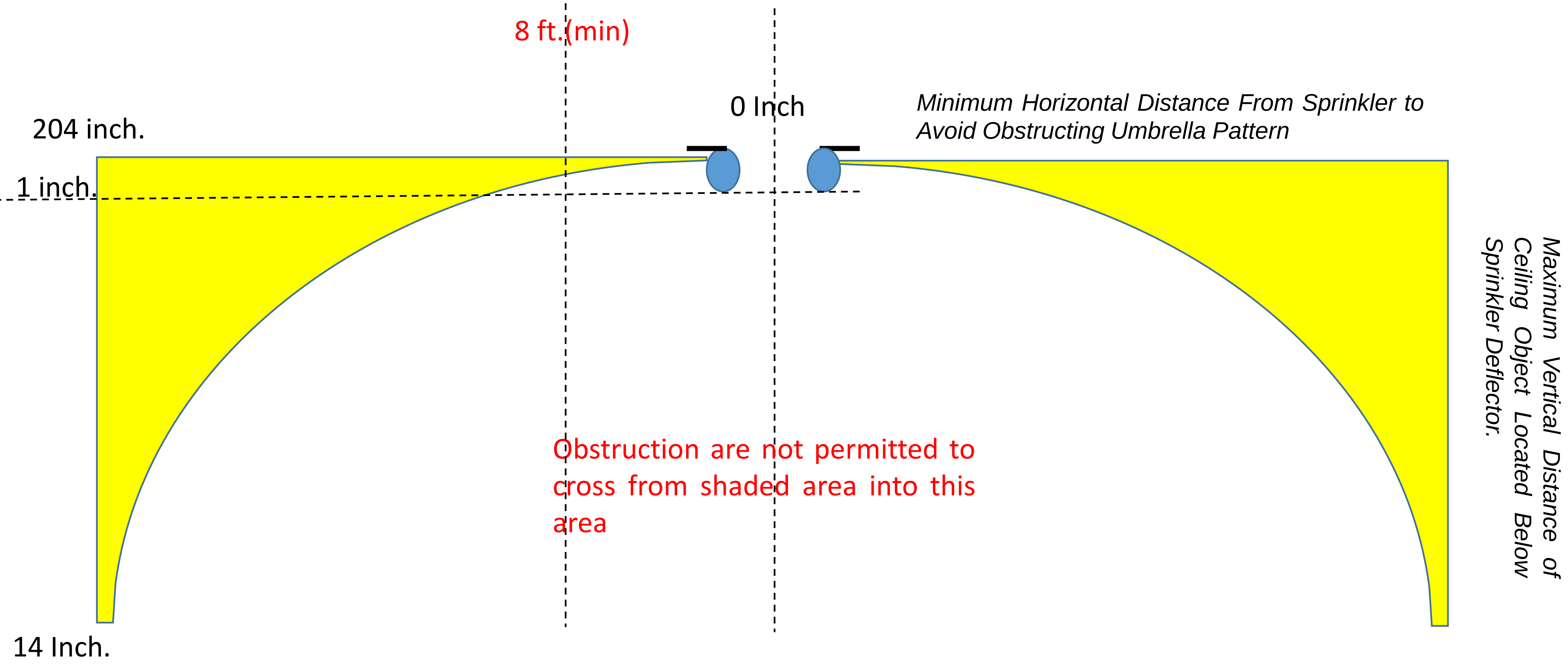
8.7.5 - Standard Coverage Sidewall – Non Storage



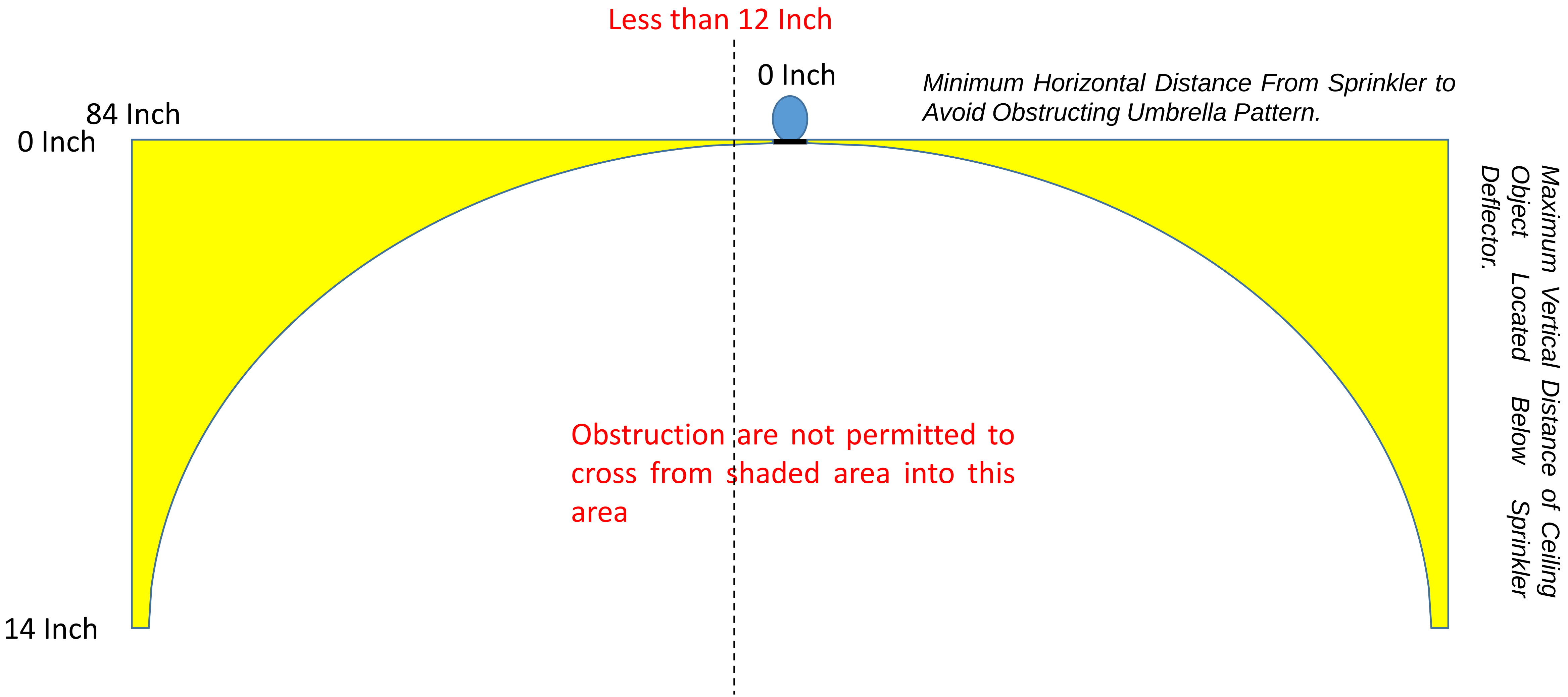
8.8.5- SSP and SSU EC – Non Storage



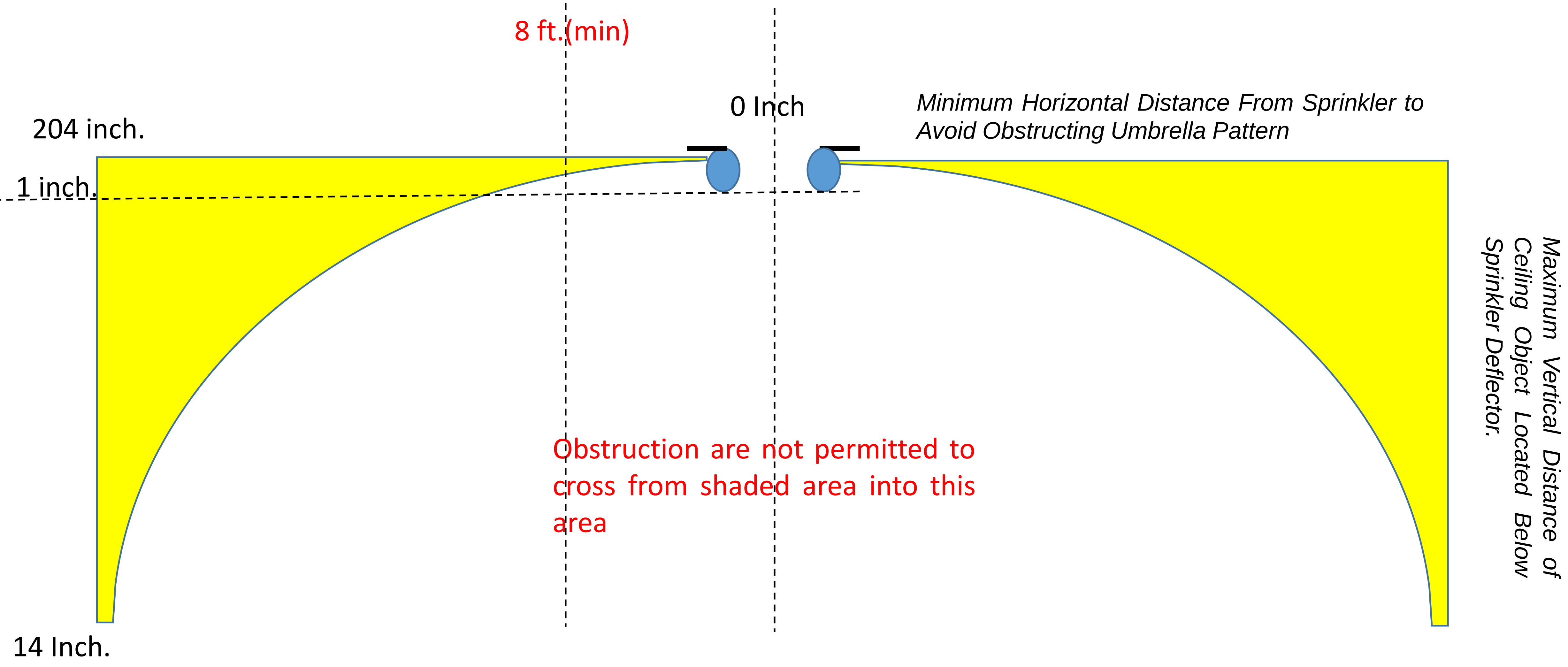
8.9.5 - Extended Coverage Sidewall – Non Storage



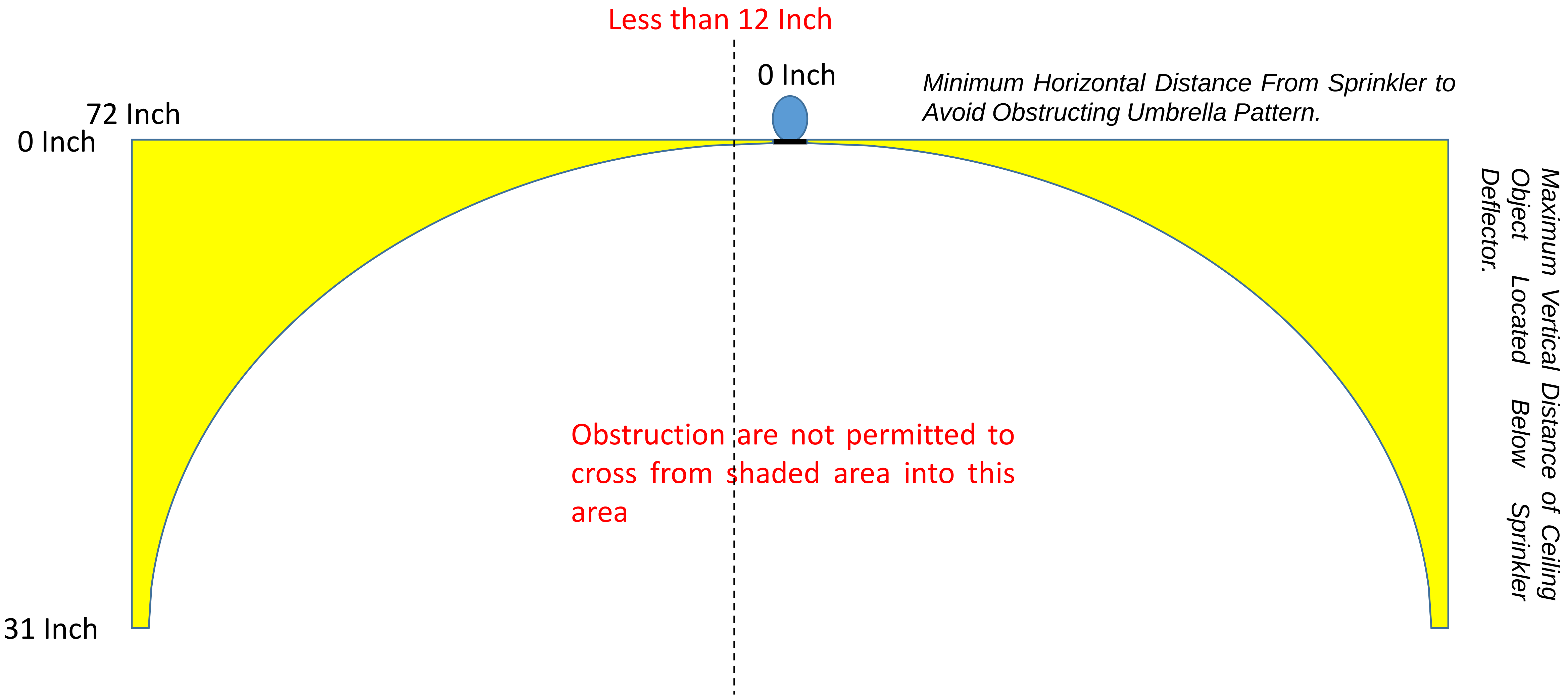
8.10.6- Residential Pendant and upright– Non Storage



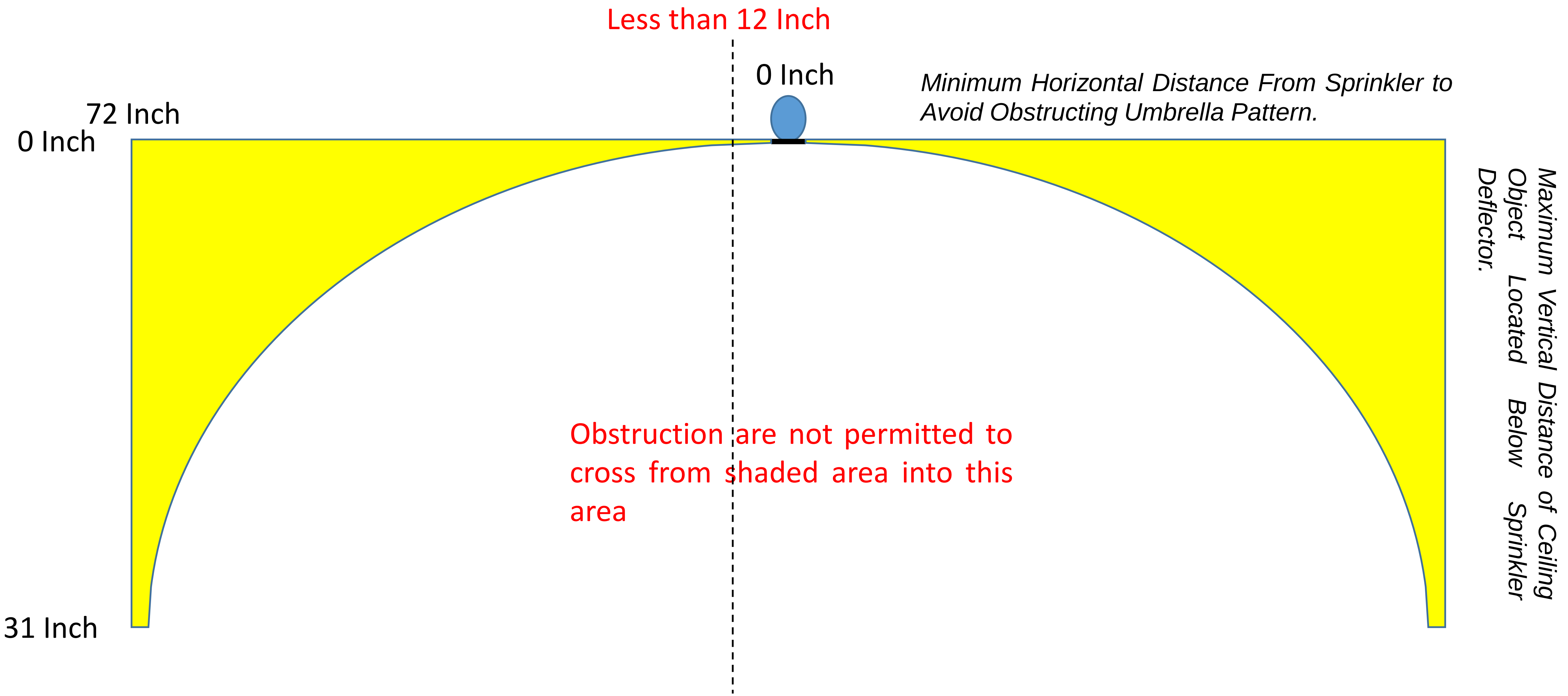
8.10.7 – Residential Sidewall – Non Storage



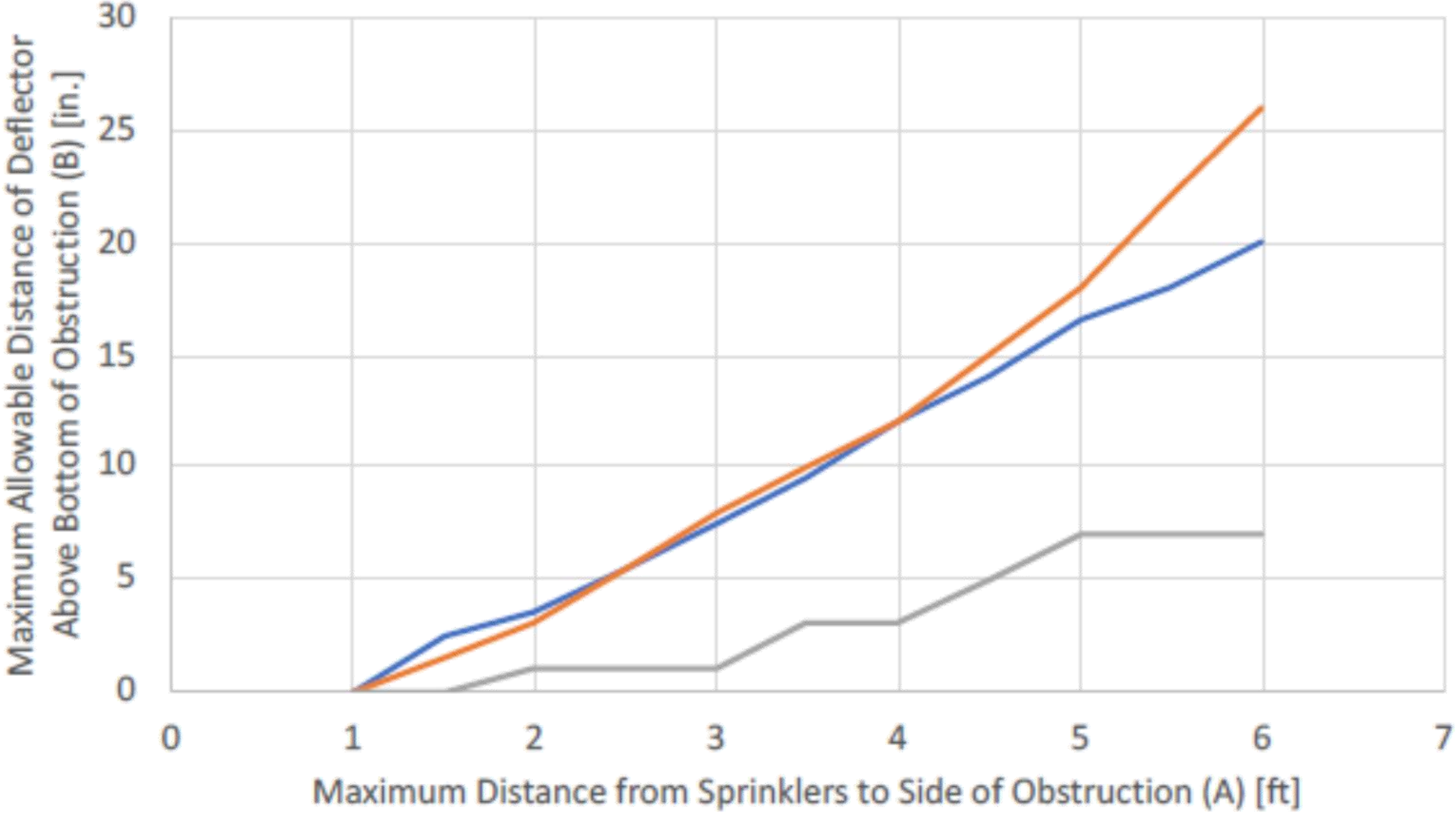
8.11.5- CMSA Sprinklers



8.12.5- ESFR Sprinklers



COMPARISON



30
25
20
15
10
5
0
0
1
2
3
4
5
6
7
Maximum Allowable Distance of Deflector Above Bottom of Obstruction (B) [in.]
Maximum Distance from Sprinklers to Side of Obstruction (A) [ft]

Thank You