

# Fire Sprinkler Systems

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Why would I want to pay for a fire protection system in my building when I have smoke detectors?

# For people and facilities

A fire protection system does more than protect the building. It is also a key component in the life safety strategy against fires. It both notifies the occupants of a fire and it suppresses the fire. For instance, if the building is a low-rise office or school building, fire sprinklers are proven to be greater value than smoke detectors. Consequently, having sprinklers in these buildings will allow the designer longer travel distances to exits whereas having smoke detectors in these buildings affords the designer no such benefits.

# Importance of Fire Sprinklers

- Automatic sprinklers are widely recognized as the number one tool of fire protection
- In over one hundred years of use, there has never been a multiple fatality of building occupants from fire in a building with a properly designed, installed, and maintained sprinkler system
- Sprinklers respond to a fire while it is still small, preventing the fire from developing into a major threat



# How reliable are sprinklers?

- Records of fires in buildings with supervised automatic fire sprinkler systems have indicated successful extinguishment or control in more than 99% of fire incidents. No other fire protection system or feature has a comparable record of reliability.
- Most fires are contained by one or two sprinklers.

# What about water damage?

- Because sprinklers attack the fire while it is still small, the total amount of water needed for fire suppression is small (often less than 50 gallons per minute)
- Without sprinkler protection, a fire is permitted to grow and the fire department will typically apply hundreds of gallons of water per minute during their operations
- For this reason, total amounts of water used in sprinklered buildings approximate one-tenth the amounts used for fires in nonsprinklered buildings

# What about water damage?

- The likelihood of a sprinkler discharging water in the absence of a fire is very small
- Each model of sprinkler is subjected to rigorous laboratory tests to guarantee long-term integrity, and every single sprinkler is hydrostatically tested at twice the maximum system water pressure prior to leaving the factory
- Sprinkler guards should be used in environments where sprinklers could be damaged

# Aren't Sprinkler Systems Expensive?

- No, in fact sprinklers can often reduce the total cost of construction
- Typically, sprinkler systems can be installed for about 1% of building cost, or less than \$2 per square foot
- If the decision to install sprinklers is made early enough in the planning process, sprinklers can actually reduce total construction costs through the use of code incentives or “trade-ups”

# Aren't Sprinkler Systems Expensive?

- In recognition of the superior fire protection afforded by sprinklers, codes permit reductions in fire resistance ratings, longer exit travel distances, and a wider range of interior finish materials in sprinklered buildings
- Insurance rates are substantially less for sprinklered facilities
- These incentives make it possible to build a safer building for less money

The best fire protection system is...

...the one that works when it's  
needed.

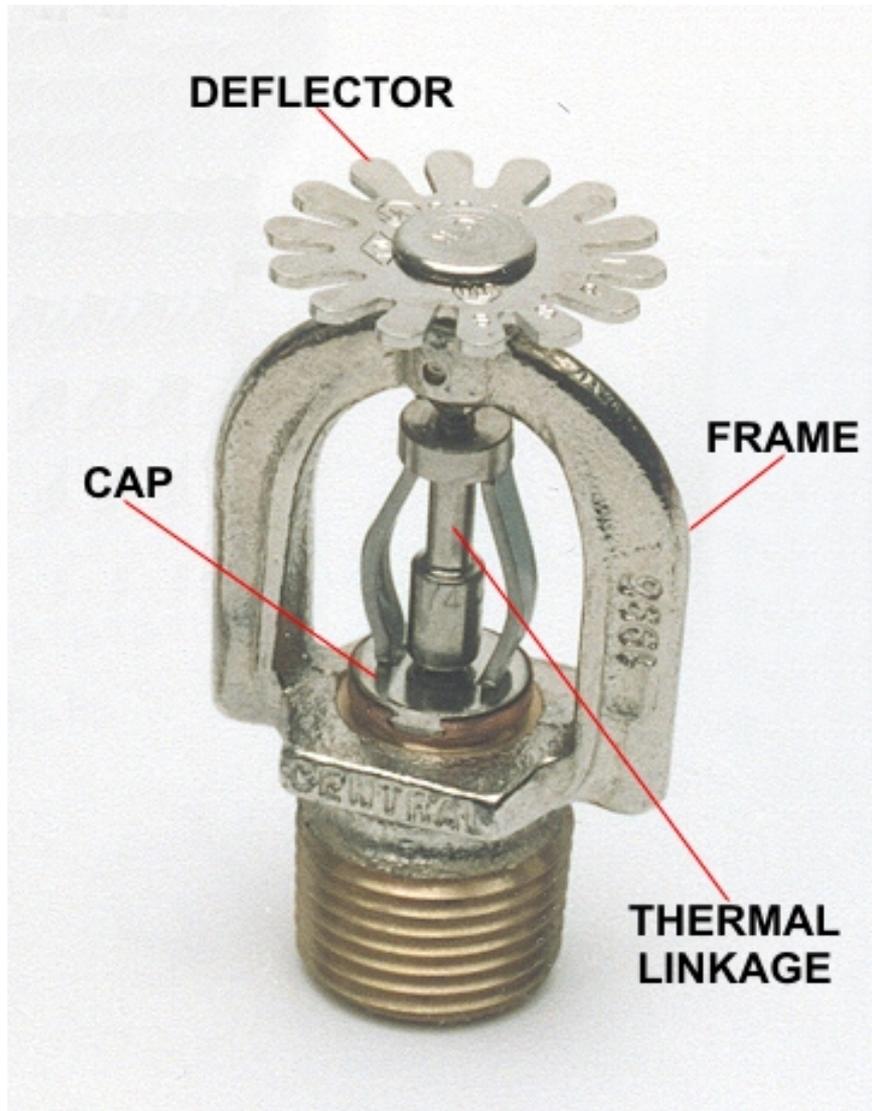
# Reliability

- Chose the appropriate system for the application.
- The right system is typically the most cost effective one from a risk management perspective.
- Design the simplest system that can be used.
- Proper inspection, maintenance, and testing is a must.

# Sprinkler System Components

- Basic components:
  - Sprinklers
  - System piping
  - A dependable water source
  - Most systems also require an alarm and system control valves

# Sprinkler Head Components



- The typical sprinkler consists of a frame, thermal operated linkage, cap, orifice, and deflector
- Styles of each component may vary but the basic principles of each remain the same

# Sprinkler Head Components

- Frame
  - The frame provides the main structural component which holds the sprinkler together.
  - The water supply pipe connects to the sprinkler at the base of the frame
  - The frame holds the thermal linkage and cap in place, and supports the deflector during discharge

# Sprinkler Head Components

- Thermal linkage
  - The thermal linkage is the component which controls water release
  - Under normal conditions the linkage holds the cap in place and prevents water flow
  - Common linkage styles include soldered metal levers, frangible glass bulbs, and solder pellets

# Sprinkler Head Components

- Cap
  - The cap provides the water tight seal which is located over the sprinkler orifice.
  - This component is held in place by the thermal linkage
  - Operation of the linkage causes the cap to fall from position and permit water flow

# Sprinkler Head Components

- Orifice
  - A machined opening at the base of the sprinkler frame
  - It is from this opening which extinguishing water flows
- Deflector
  - The deflector is mounted on the frame opposite the orifice
  - The purpose of this component is to break up the water stream discharging from the orifice into a more efficient extinguishing pattern
  - Deflector styles determine how the sprinkler is mounted

# Types of Sprinkler Heads

- Common sprinkler mounting styles include

Upright



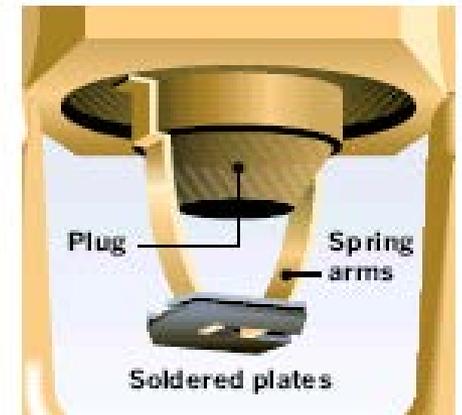
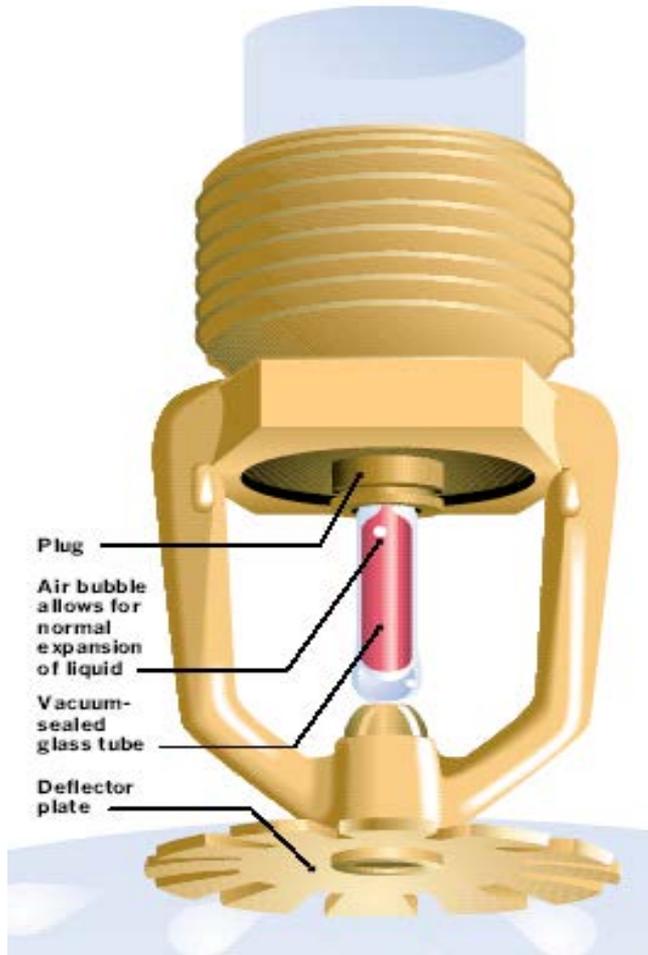
Sidewall

Pendent



# How does a fire sprinkler work?

The typical sprinkler head consists of a plug held in place by a trigger mechanism. The most common type of trigger is a glass bulb filled with a liquid that expands when heated.



A less commonly used type of trigger consists of two metal plates held together by a solder link. When the solder melts, two spring arms pull the plates apart, releasing the plug.

# How does a fire sprinkler work?



The liquid in the glass bulb is designed to expand and break the tube at a certain temperature. The most common are designed to break at 155 degrees.

# How does a fire sprinkler work?

The plug is forced out by the pressurized water behind it and deflected away. The water sprays over the deflector plate which is designed to distribute it in an even pattern directly over the source of the fire. Contrary to what is sometimes shown on television shows, all sprinklers in the building do not operate simultaneously.



# Sprinkler System Components

- Other major components include
  - Control valves : A sprinkler system must be capable of shut down after the fire has been controlled, and for periodic maintenance and modification. Control valves provide this function.
  - Alarms : Alarms alert building occupants and emergency forces when a sprinkler water flow occurs. Alarms are also provided to alert building management when a sprinkler valve is closed

# Sprinkler System Components

- Drain and test connections : Most sprinkler systems have provisions to drain pipes during system maintenance. Test connections are usually provided to simulate the flow of a sprinkler flow, thereby verifying the working condition of alarms
- Fire hose connections: Fire fighters will often supplement sprinkler systems with hoses. Firefighting tasks are enhanced by installing hose connections to sprinkler system piping.

# Sprinkler System Components

- Backflow preventer: The normal backflow requirement for an automatic fire sprinkler system is a double check valve assembly. A backflow preventer prevents the backflow of polluted water into the potable water supply. A reduced pressure type backflow preventer is required if the piping does or can contain hazardous substances.



# Types of sprinkler systems

- Wet
- Dry
- Deluge
- Pre-action
- Water Mist

# Wet Pipe Sprinkler Systems

- A wet pipe sprinkler system uses automatic sprinklers attached to a piping system filled with water and connected to a water supply so that water discharges immediately from sprinklers opened by heat from a fire
- Most common type of system
- Used for buildings where there is no risk of freezing
- Quick to react because water under pressure is always in the pipework
- Wet pipe systems required for multi-story or high-rise building and for life safety, such as those installed in shopping centers

# Dry Pipe Sprinkler System

- A dry pipe sprinkler system is one in which pipes are filled with pressurized air, rather than water
- This air holds a remote valve, known as a dry pipe valve, in a closed position
- The dry-pipe valve prevents water from entering the pipe until a fire causes one or more sprinkler to operate. Once this happens, the air escapes and the dry pipe valve releases.
- Water then enters the pipe, flowing through open sprinklers onto the fire.
- Used where there is a risk of frost damage
- **WARNING:** Frequent operation of compressor means trouble! Get help immediately!

# Deluge Sprinkler Systems

- The arrangement of deluge system piping is similar to a wet or dry pipe system with two major differences:
  - Standard sprinklers are used but they are all open. The activating elements (fusible link or glass bulb) have been removed so that when the control valve is opened, water will flow from all of the sprinklers and deluge the area with water
  - The deluge valve is normally closed. The valve is opened by the activation of a separate fire detection system

# Deluge Sprinkler Systems

- The detection system is installed in the same area as the sprinklers
- Deluge systems are used in places that are considered high hazard areas such as power plants, aircraft hangars, and chemical storage or processing facilities.
- Deluge systems are needed where high velocity suppression is necessary to prevent fire spread.

# Pre-action Sprinkler Systems

- The pre-action sprinkler system is similar to the deluge sprinkler system except that the sprinklers are not open; they are closed sprinklers with fusible links or glass bulbs
- For a single interlocked system, the pre-action valve is normally closed and operated by a separate fire detection system. Activation of a fire detector will open the pre-action valve, allowing water to enter the system piping.

# Pre-action Sprinkler Systems

- Water will not flow from the sprinklers until heat from the fire activates the operating element in individual sprinklers
- Used where it is not acceptable to have the pipes full of water until there is a fire (e.g. computer suites)
- Double interlock only for areas subject to freezing!

# Water Mist Systems

- Water mist systems include many of the same elements found in automatic sprinkler systems, but the application of water is different
- These systems use very fine water spray (mist) that absorbs heat, displaces oxygen, or blocks radiant heat to control, suppress, or extinguish fires
- Water mist systems are typically used for small confined areas, such as inside equipment enclosures or cabinets

# Other related systems...

- Standpipe system
- Clean Agent system

# Standpipe System

- Standpipes are an arrangement of piping, valves, hose connections and allied equipment installed in a building or structure with the hose connections located in such a manner that the water can be discharged through attached hoses and nozzles

# Standpipe Systems

- Standpipe systems provide fire hose connections within a building or industrial complex
- Hose connections are fed by a supply pipe (often referred to as a riser) and are located throughout the facility, usually on each floor

# Standpipe Systems

- Four methods in which water is supplied to standpipes:
  - Wet standpipe in which water is supplied directly from a water main (or through a fire pump if higher pressures are needed). Water supply valve is always open and the system is always under water pressure
  - Dry manual standpipe in which there is no permanent water supply. Water must be supplied by the fire department

# Standpipe Systems

- Four methods (cont.)
  - Dry standpipe in which a connection to a water main is provided by a manual control valve which is kept closed. The standpipe system remains dry until needed
  - Dry automatic standpipe in which the valve controlling water to the system is automatic, as with a dry pipe valve. Water is admitted to the system when a hose valve is opened and air pressure in the system is released

# Clean Agent System

- Commonly comprised of inert gases or safer HCFCs
- Can dilute the amount of oxygen to prevent combustion or can cool reactants on the molecular level below the heat of combustion.

# Clean Agent Systems

- Clean, nonconductive, noncorrosive – good for important electronics
- Environmentally friendlier than Halon
- React quickly – triggered by smoke and/or heat detectors
- High first cost – costly to recharge
- One shot to extinguish fire - best if coupled with sprinklers

# Design of Sprinkler Systems

- Sprinkler system piping is installed in accordance with one of two methods:
  - Pipe schedule system
  - Hydraulically designed system
- Pipe schedule systems are not allowed for new installations
- The first step is to determine the classification of hazard

# A Design Application

- Large drop sprinklers attack the fire plume that develops in atriums due to the delay in sprinkler operation from the height issue
- Ordinary Group II Hazard Classification (.20 gpm/ft<sup>2</sup> over 1500 ft<sup>2</sup>) provides an adequate amount of water to suppress typical atrium fuel loadings

# Occupancy Classifications

- The occupancy or use of the building will predominantly determine the type of system required:
  - Light Hazard
  - Ordinary Hazard
    - Group 1
    - Group 2
  - Extra Hazard
    - Group 1
    - Group 2

# Pipe – Schedule System

- The number of sprinklers fed by a given pipe size is determined by schedules given in sprinkler installation rules
- Installation rules vary with the occupancy of the area to be protected

# Hydraulically Designed System

- Most sprinklers require 7 psi (minimum) to operate
- Quick analysis:
  - Determine worst hazard (ex: Small office building is Light Hazard throughout)
  - Select design density and corresponding area of sprinkler operation (our ex: .10 gpm/ft<sup>2</sup>/1500 ft<sup>2</sup>)
  - Determine inside water demand ( $.1 \times 1500 \times 1.25 = 187.5$  gpm)

# Hydraulically Designed System

- Quick analysis (cont.):
  - Add pipe, fittings, devices, backflow preventer, and elevator losses

$$\begin{array}{cccc} & \nearrow & \uparrow & \nwarrow & \nearrow \\ & \text{(pipe)} & \text{(ftgs)} & \text{(BFP)} & \text{(elev.)} \\ 5 + 5 + 4 + (0.433 \times 15') & \approx & 21 \text{ psi} \end{array}$$

- $21 + 7 \text{ psi} = 28 @ 187.5 \text{ gpm}$
- Add 100 gpm for hoses
- $28 @ 287.5 \text{ gpm}$  at city

# Hydraulically Designed System

- Note: Building square footage has little effect on the need for a fire pump. However, the hazard classification and building height do have a significant effect on whether a fire pump is needed.

# Do I really need a fire pump?

- Installing a fire pump is often the default rather than something that must prove it's needed
- Many are not comfortable deciding if a fire protection system can do without one.
- Fire pumps are great when needed but not desired if not needed.
  - Cost
  - Reliability

# How do I know if a pump is needed?

- Look at highest fire hazard classifications
- Look at available flow and pressure from utility
- Look at building elevations
- Perform basic hydraulic calculations
- Can standpipe design be manual wet?

# Basic Fire Pump Calculations

- Hydrant Flow Test Results
  - 55psi gauge pressure at hydrant #1 while no flow from hydrants
  - 50psi gauge pressure at hydrant #1 While 1050 *GPM* at Hydrant #2
- Building Elevation
  - 40ft from gauge on hydrant #1 to highest sprinkler in building
  - $40ft * .4333 \frac{psi}{ft} = 17.3psi$

# Basic Fire Pump Calculations

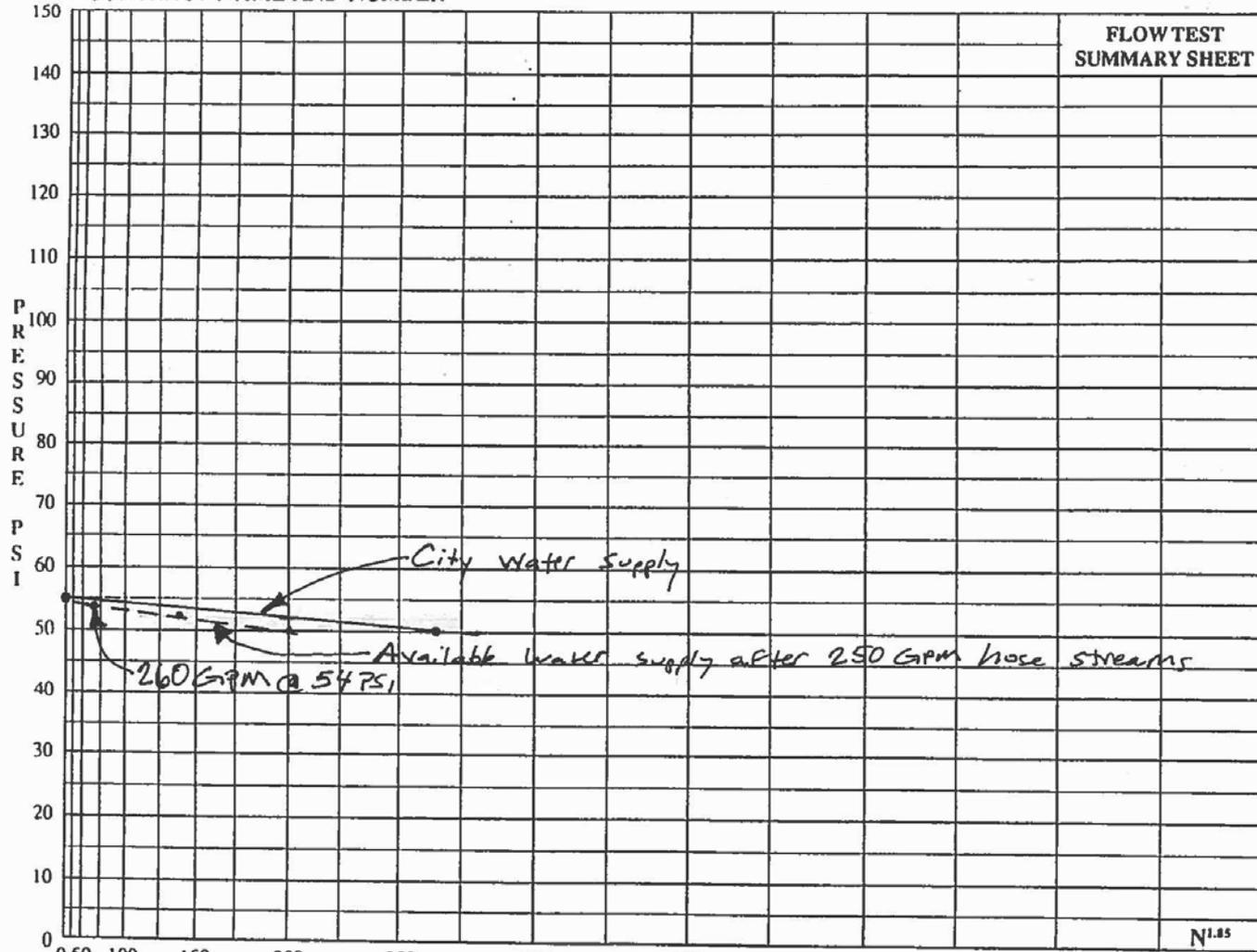
- Backflow Preventer (BFP) Type
  - Double detector check backflow assembly (no antifreeze)
  - Backflow Preventer Pressure drop: 4.0psi
- Hazard Classification and Required Flow Rate
  - Ordinary Hazard Group 1 (with manual wet standpipe system)
  - Flow Rate:  $.15 \frac{GPM}{SQ.FT.} * 1500 SQ.FT. * 1.15 = 260 GPM$ 
    - ↑  
Density Diversity

# Basic Fire Pump Calculations

- Service Size and Pressure Drop
  - Service size: 6” pipe and 320 ft equivalent distance
  - Pressure Drop:  $.002 \frac{psi}{ft} * 320 ft = .6 psi$
- Interior Pipe and Fitting Lost
  - 15 *psi* (must be at least 8 *psi*)
- Available Pressure at Main
  - 54 *psi* (from  $N^{1.85}$  graph on next slide)

CONTRACT NAME AND NUMBER

FLOW TEST  
SUMMARY SHEET



Page 30

0	50	100	150	200	250	300	350	400	450	500	Scale A
100	200	300	400	500	600	700	800	900	1000	1000	Scale B
200	400	600	800	1000	1200	1400	1600	1800	2000	2000	Scale C
400	800	1200	1600	2000	2400	2800	3200	3600	4000	4000	Scale D

Flow - GPM (Circle scale used.)

Form H - 2

# Basic Fire Pump Calculations

54

-0.6

-4.0 (BFP)

-17.3

-15

-7.0

10.1psi cushion

# Fire Pump Selection

- Consider resulting city water pressure when pump is flowing 150% of its rating (city water pressure must not drop below 20 psi)
- Consider resulting system water pressure when at pump churn (standard fittings and components are only rated for 175 psi)
- Jockey (maintenance) pump should be selected to maintain system pressure above fire pump starting pressure

# Water Supply Requirements

- Every automatic sprinkler system shall have at least one automatic water supply
- Water supply treatment
  - Water supplies and environmental conditions will be evaluated for the existence of microbes and conditions that contribute to microbiologically influenced corrosion (MIC)

# Installation of Sprinkler Systems

- Basic requirements include
  - Position, location, spacing, and use of sprinklers
    - Determination of the protection area of coverage
    - Maximum/Minimum distance between sprinklers
    - Maximum/Minimum distance of sprinkler from walls
  - System protection area limitations
  - Application of sprinkler types
- Requirements may vary depending on type of system used
- For any system, pre-lubed grooved couplings are recommended

# Wet Pipe Sprinkler System Requirements

- Must be reliably heated. Overhangs and chases on exterior walls cannot be trusted
- Normal black steel piping is fine for wet systems
- CPVC can be used in many applications

# Dry Pipe Sprinkler System Requirements

- Gridded dry pipe system are not allowed
- Air pressure should be maintained on dry pipe systems throughout the year
- The compressed air supply should be from a source available at all times – Initial charge with Nitrogen
- Galvanized black steel pipe
- Dry systems should be drained completely to minimize corrosion – No roll groove ends
- Use accelerators only when absolutely necessary

# Inspection, Testing, & Maintenance of Sprinkler Systems

- Maintaining adequate fire protection systems is as critical as the original decision to install these systems
- Because fire suppression, detection, and alarm systems are generally not used on a routine basis, their state of readiness is not immediately apparent
- The periodic inspection, testing, and maintenance of fire detection and suppression systems are essential to ensure successful performance when these systems are needed

# Inspection

- Visual examination of the sprinkler system to verify that it appears to be in operating condition and free of physical damage
- Visual examination of storage and general environment surrounding sprinkler system

# Inspection

- Sprinklers
  - Inspected from floor level annually
  - Should not show signs of leakage
  - Should be free of corrosion, foreign materials, paint, and physical damage
  - Should be installed in the proper orientation

# Inspection

- Pipe and Fittings
  - Should be in good condition
  - Free of mechanical damage, leakage, corrosion, and misalignment
  - Piping should not be subjected to external loads by materials either resting on the pipe or hung from the pipe

# Inspection

- Hangers and Seismic Bracing
  - Should not be damaged or loose
- Gauges
  - Wet pipe systems : Should be inspected monthly to ensure that they are in good condition and that normal water supply pressure is being maintained
  - Dry, pre-action, and deluge systems : Should be inspected weekly to ensure that normal air and water pressures are being maintained

# Testing

- Sprinklers
  - Sample sprinklers submitted to a recognized testing laboratory acceptable to the authority having jurisdiction for field service testing
  - Test procedures repeated at 10-year intervals
  - If one sprinkler within a representative sample fails to meet the test requirement, all sprinklers represented by that sample shall be replaced
- Drains
  - Put ITC (Inspector's Test Connection) for wet systems at the riser. Reduces corrosion in piping, lessens chances of obstructions to sprinklers and it makes testing easier
  - System main drain must discharge to a place that can accept full flow under pressure and gravity drain completely

# Testing

- Pumps, alarms, and valves also need to be tested and exercised on schedule for reliability and longevity. Keep records on all tests
- NFPA 25 provides descriptions of these tests and recommended forms

# Maintenance

Fire protection systems require little maintenance when properly cared for.

- Sprinklers
  - Replacement sprinklers shall have the proper characteristics for the application intended. They should be the same type as the adjacent existing sprinklers.
  - A supply of spare sprinklers (never fewer than 6) shall be maintained on the premises so that any sprinklers that have operated or been damaged in any way can be promptly replaced
- Dry pipe systems shall be kept dry at all times.

# Prevention and Control of Internal Corrosion in Sprinkler Systems

- Over the past years an increasing number of leaks and other corrosion related problems have been associated with microbial or bacterial activity in fire protection piping

# Prevention and Control of Internal Corrosion in Sprinkler Systems

- What is Microbiologically Influenced Corrosion (MIC)?
  - MIC is one of the many forms of corrosion that can affect sprinkler systems
  - MIC is not a new corrosion mechanism; however, its association to fire protection piping is relatively new

# Prevention and Control of Internal Corrosion in Sprinkler Systems

- How does MIC affect sprinkler systems?
  - Because of its nature and the complexity of fire protection piping, MIC is not easily controlled in fire protection systems
  - MIC can affect any piping within the sprinkler system, however, branchlines and risers seem to be more seriously affected

# Prevention and Control of Internal Corrosion in Sprinkler Systems

- How does MIC affect sprinkler systems?
  - MIC generally results in the growth of biofilms and nodules within the piping
  - Nodules and biofilm may result in increased friction loss, and affect the ability of the pipe to carry the necessary flow
  - MIC may also affect sprinklers and valves, and block water motor gongs, and alarm lines and other components of a fire protection system

# Prevention and Control of Internal Corrosion in Sprinkler Systems

- How to protect sprinkler systems from MIC
  - Existing sprinkler systems:
    - Investigate for possible corrosion problems and obstructed waterways, pinhole leaks, or other signs of corrosion in pipes, valves or sprinkler heads
    - Flush sprinkler systems where investigation reveals obstructions of the waterway
    - Replace any section of piping that contains obstructions that cannot become removed by flushing procedures\*
    - Reinvestigate systems for waterway obstruction annually.

# Prevention and Control of Internal Corrosion in Sprinkler Systems

- How to protect sprinkler systems from MIC
  - New Sprinkler Systems:
    - Use new, clean, coated pipe for all new sprinkler system installations and retrofits
    - Do not use chlorine for disinfecting purposes
    - Do not leave open pipe exposed where it could accumulate dust, dirt, water and other residue prior to installation

# Prevention and Control of Internal Corrosion in Sprinkler Systems

- How to protect sprinkler systems from MIC
  - New wet-pipe sprinkler systems:
    - Avoid repeated cycles of system shutdowns where the system is drained and recharged
    - Avoid air gaps (pockets) within the system, which can expose piping to dry/wet conditions. Air gaps can be avoided by providing means for air release at the highest point of each branchline

# Prevention and Control of Internal Corrosion in Sprinkler Systems

- How to protect sprinkler systems from MIC
  - New dry pipe and pre-action systems:
    - Avoid the use of roll grooved joints. Roll grooved joints in a dry sprinkler system promote water accumulation that can result in preferred corrosion sites
    - Install pipe with proper pitch to promote drainage of all testing water and water vapor condensate within piping
    - Keep low point drains clean and drain condensate as needed to prevent water accumulation

# Prevention and Control of Internal Corrosion in Sprinkler Systems



Corrosion at roll groove in a wet pipe system

Heavy tubercle formation in a 8 in. sprinkler pipe



# Earthquake Protection

- Uncontrolled differential movement can cause damage when fire protection systems are not provided in a systematic manner with the necessary features that incorporate sway bracing, flexibility, clearances, and anchorage where needed
- The most common type of damage is water damage due to water leakage from broken overhead sprinkler piping or sprinklers, primarily due to lack of sway bracing where needed

# Earthquake Protection

- How to adequately protect sprinkler systems from earthquake damage
  - Brace piping or equipment to minimize uncontrolled differential movement between piping or equipment and the structure to which it is attached
  - Provide flexibility on piping systems and on other equipment where differential movement between portions of those piping systems or equipment is expected

# Earthquake Protection

- How to adequately protect sprinkler systems from earthquake damage
  - Provide clearance between piping or equipment and structural members, walls, floors, or other objects so that potential damage from impact is minimized
  - Provide anchorage to minimize potential sliding and/or overturning

# Earthquake Protection

- How to adequately protect sprinkler systems from earthquake damage
  - Use appropriate types of pipe hangers and sway bracing, properly locate them, and properly attach them to the structure to minimize the potential for pullout
  - Use appropriate types of piping and pipe joining methods to minimize potential pipe breaks

What to do with a broken fire line  
under floor?

1. Replaced RPZ with DDC BFP
2. Fed 4" HDPE thru 6" DI pipe



1st Floor  
RISER

MEZZANINE  
RISER

2nd Floor  
RISER

Pressure Gauge

Pressure Gauge

Pressure Gauge

Control Valve

**FEBCO**

Factory Mutual System

TESTED BY UNDERWRITERS LABORATORIES INC. © AS TO FRICTION LOSS AND BODY STRENGTH ONLY 897 U

Approved

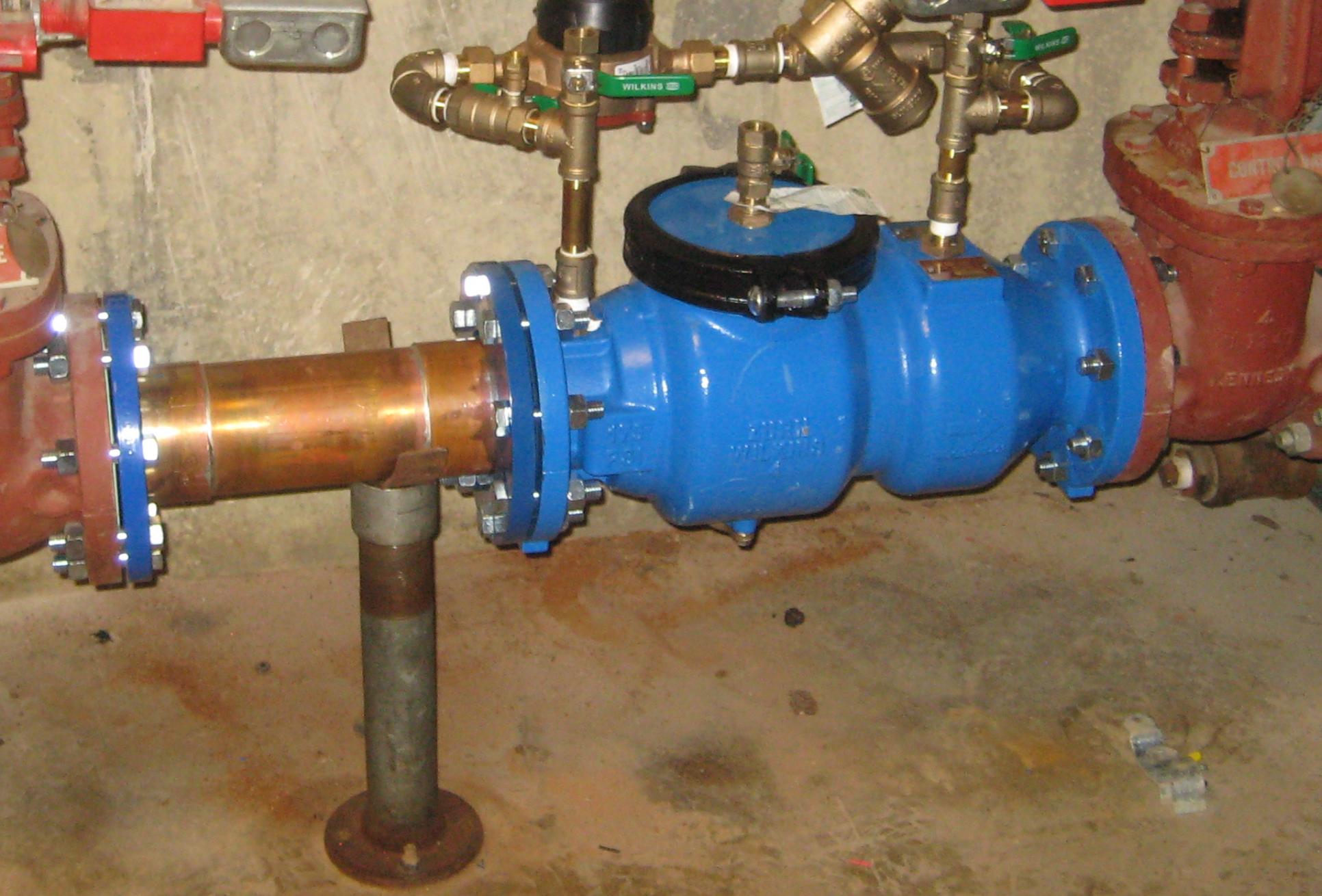
**REDUCED PRESSURE BACKFLOW PREVENTER**

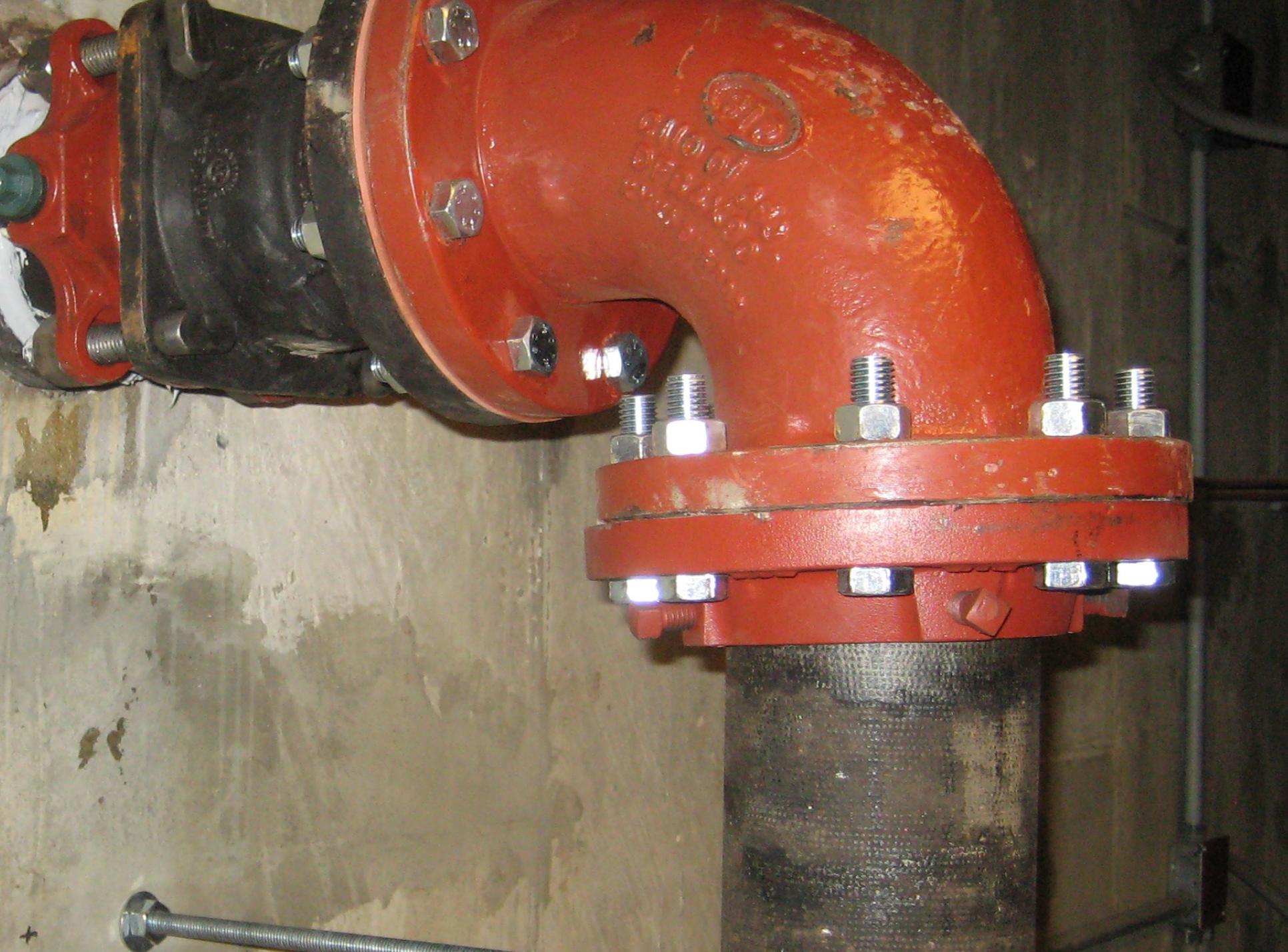
MODEL 825 SIZE 1 1/2" 175 PSI

SERIAL [REDACTED] 140 °F

FRESNO CA.







100000  
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# References

- Factory Mutual Global Property Loss Prevention Data Books
- National Fire Protection Association  
National Fire Codes Pamphlets 13, 14 and 25