Brief History of Automatic Sprinklers

- Discuss the origins of NFPA 13
- Recall how sprinklers operate
- Identify the different ways of calculating sprinkler systems

Major Conflagrations

- 1866 Portland, ME
- 1871 Chicago, IL
- 1872 Boston, MD
- 1904 Baltimore, MD
- 1906 San Francisco, CA

Major Conflagrations

- 1866 Portland, ME
- 1871 Chicago, IL
- 1872 Boston, MD
- 1904 Baltimore, MD
- 1906 San Francisco, CA

Perforated Pipes

- Pre 1800s- explosives
- 1806-Perforated pipe
  - First system Drury Lane, UK
- Most system manual
- Automatic cam by ropes
- Used in industrial applications
  - Experimentation on spacing and size of opening.

Early Sprinklers

- 1860- first fusible links by Wood and Harrison
- 1875- Parmelee
  - Cap held in place by solder
  - Perforated, later slotted, distributor
- Grinnell
  - 0.5'' orifice
  - Solder not in contact with water
  - Fixed deflector

NFPA

- 1896 National Fire Protection Association founded
- Rules and Regulations of the National Board of Fire Underwriters for Sprinkler Equipment, Automatic and Open System

Advantages of Automatic Sprinklers

- Limit fire growth
  - Reduce property loss
  - Lift Safety advantages
- Insurance benefits
- Less restrictive code requirements
- Can be required

Sprinkler Operation

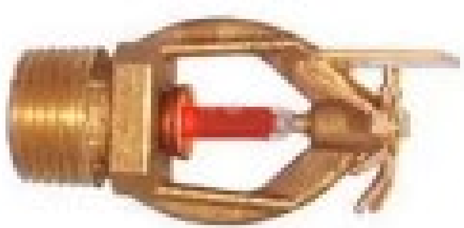
- Glass bulb, fusible link, chemical pellet, bimetallic dis, duraspeed cap
  - Designed to operate at specified temperatures
- Orifice
- Deflector
- Local application

Sprinkler Orientation

- Upright

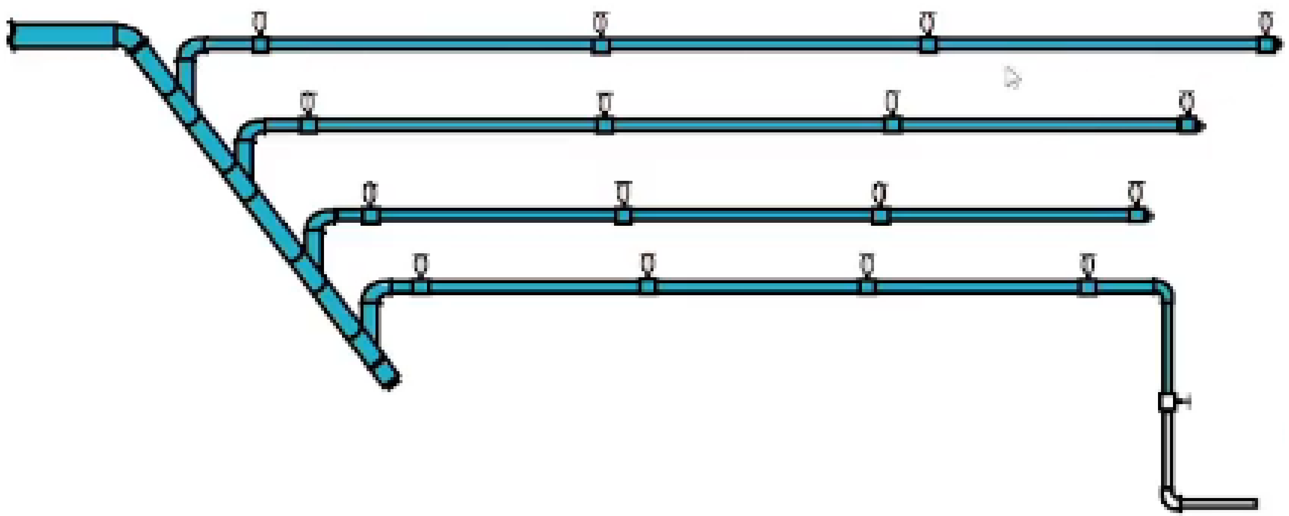
- Pendent

- Sidewall



Sprinkler Spacing

- Spacing along branch lines
- Spacing between branch line
- Dependent on occupancy and system demand



System Types

- Wet Pipe
- Dry Pipe
- Deluge
- Pre-Action

System Calculations

- Pipe Schedule
- Hydraulic Calculations
  - Losses

Basic System Components

- Sprinklers
- Fittings
- Pipes
- Valves

Basics of NFPA 13

- Discuss the structure of NFPA 13

The NFPA Manual of Style

- The first chapter will contain administrative information
- The second chapter will contain referenced publication
- The third chapter will contain definitions
- Appendix A gives explanatory material

Also

- Highlights indicates a change in the standard since the last edition
- An asterisk * in front of a selection indicates additional information in Annex A
- A bullet indicates something was deleted
- First numeral of a section number indicates the chapter

Chapter 1

- 1.1 Scope
  - Design and installation
  - Single fire originating within the building
- 1.2 Purpose
  - “Reasonable” degree of protection
- 1.5 and .17
  - Can use alternatives
    - AHJ must agree

Chapter 2

- Contains a list of publications referenced by NFPA 13
  - Helps to limit the scope of the publication
- These referenced standards are considerated a part of NFPA 13
  - The requirements in them are requirements of NFPA 13

Chapter 3

- This chapter contains important definitions that are used in the industry and will be used throughout this course
  - Learn the NFPA definitions (you need them for all codes)
  - Other learn as they are used
    - Never assume standard dictionary definition

Chapter 4

- General Requirements(Not Many)
  - 4.1 Level of Protection
    - Sprinklers in all areas
  - 4.2 Owner must provide
    - Use of building
    - Preliminary plan
    - Any special knowledge of water supply

Chapter 4

- Miscellaneous storage
- Classification of occupancies that are not warehouses (light, ordinary and extra hazard)
  - Light, Ordinary (Group 1&2), Extra (Group 1&2)
- System protection areas
- Water supply information
- And more general requirements

Chapter 5

- Water supply
  - Capacity
  - Size
  - Water treatment
  - Arrangement

Chapter 6

- Underground piping requirements

Chapter 7

- System Components and Hardware
  - Sprinklers
  - Piping and Fittings
  - Valves
  - Fire Department Connections

Chapter 8

- System Types and Requirements
  - Requirements for specific system type
    - Wet systems
    - Dry systems
    - Pre-action systems

Chapter 9-15 Sprinkler Requirements

- Chapter 9 sprinkler location requirements
- Chapter 10-15 Sprinkler type specific requirements
  - Sprinkler position, location and spacing
  - Obstructions to sprinklers
  - Installation of system components
  - Special situations
  - Omissions

Other Chapters

- Chapter 16: Installation of piping, valves, and appurtenances
- Chapter 17 & 18: Hanging, bracing, and restraint of system piping
- Chapter 19: Design Approaches
- Chapter 20-25: Storage design requirements
- Chapter 26: Special occupancies

Chapter 27:Plans and Calculations

- Rules for what must be shown on drawings and designs
- Rules for Hydraulic Calculations

Requirements for All plans

- See Chapter 27 (Section 27.1.3)
  - Initial list contains 47 items
  - Note that every item does not apply to every plan

Plan Reviewing

- Plan reviewers should not have to be detectives
- Plan reviewers should feel free to reject any plans no substantially complying with Chapter 27

Other Chapters

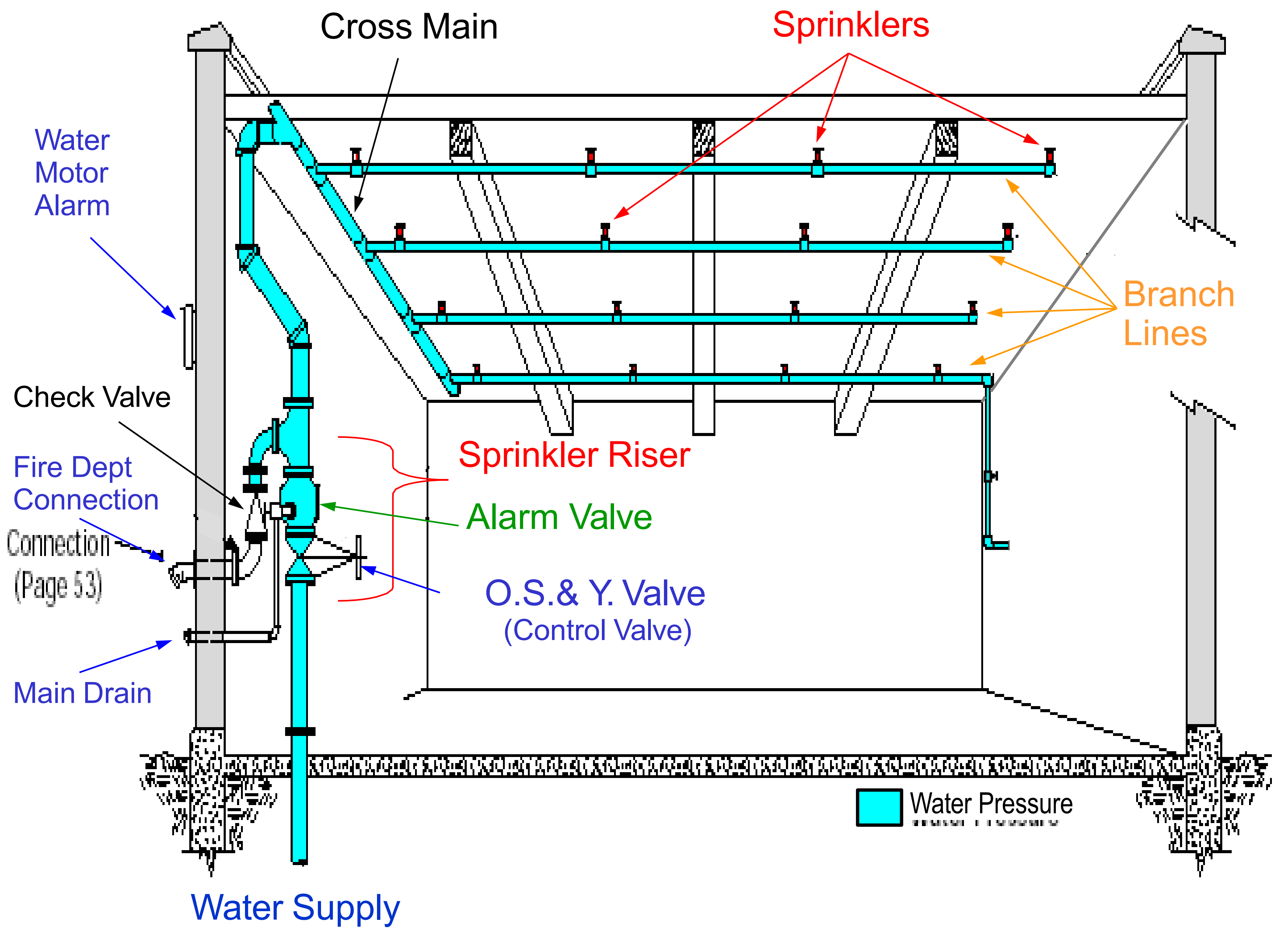
- Chapter 28: Systems acceptance
- Chapter 29: Existing systems modifications
- Chapter 30: Marine Systems
- Chapter 31: ITM-See NFPA 25

System Components and Requirements

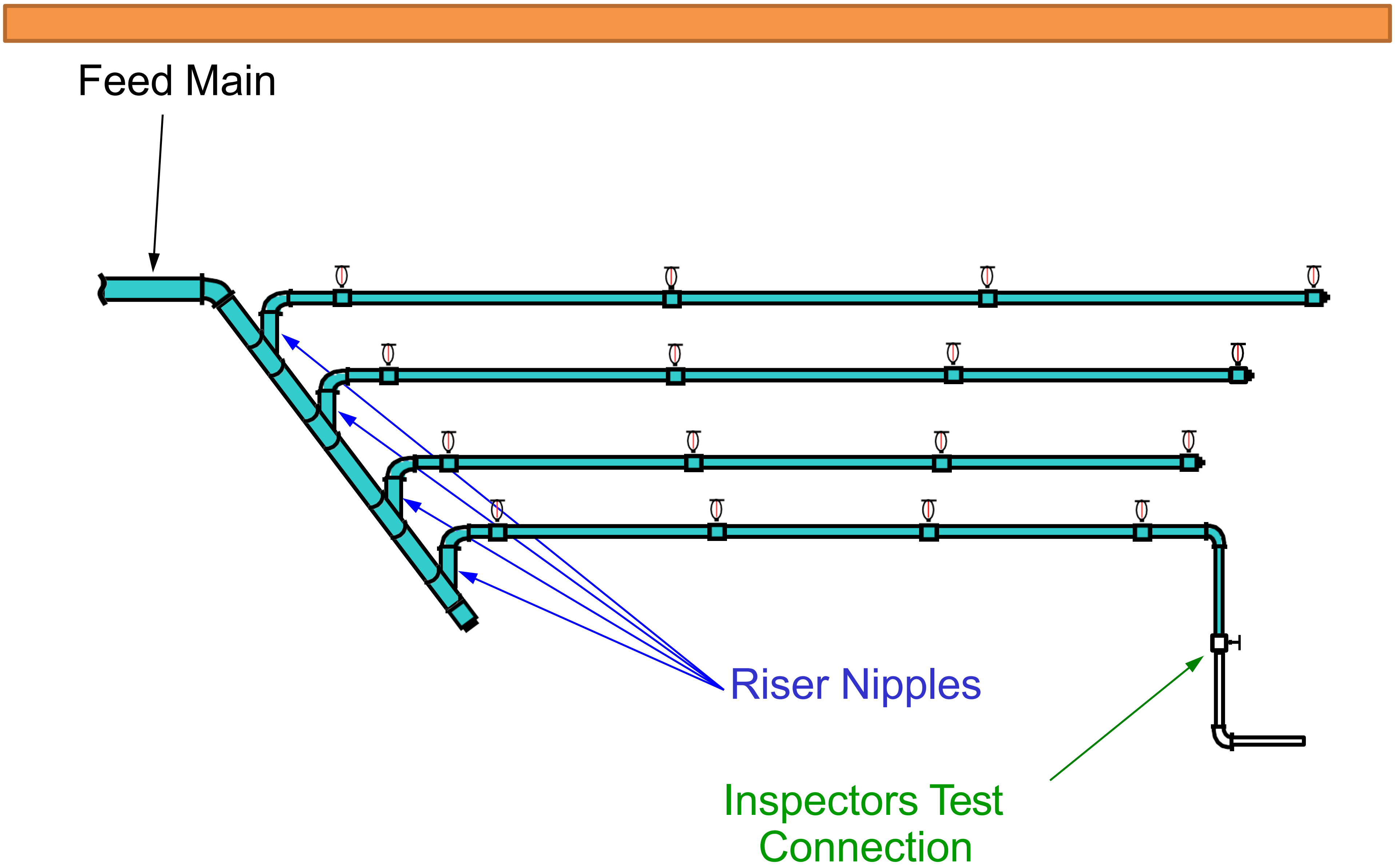
- NFPA 13 Chapters 7 and 8
- Identify the components and requiremntes used on automatic sprinkler systems

Listing

- What does listed means?
- Required for system performance=listed
- Not required for performance =does not have to be listed



Cross Main
Sprinklers
Water Motor Alarm
Branch Lines
Check Valve
Sprinkler Riser
Fire Dept Connection
Connection (Page 53)
Alarm Valve
O.S.& Y. Valve
(Control Valve)
Main Drain
Water Pressure
Water Supply


Feed Main
Riser Nipples
Inspectors Test
Connection

Sprinklers:Temperature Rating

- Maximum expected temperature below rating
- Ratings do not overlap
- Color coded

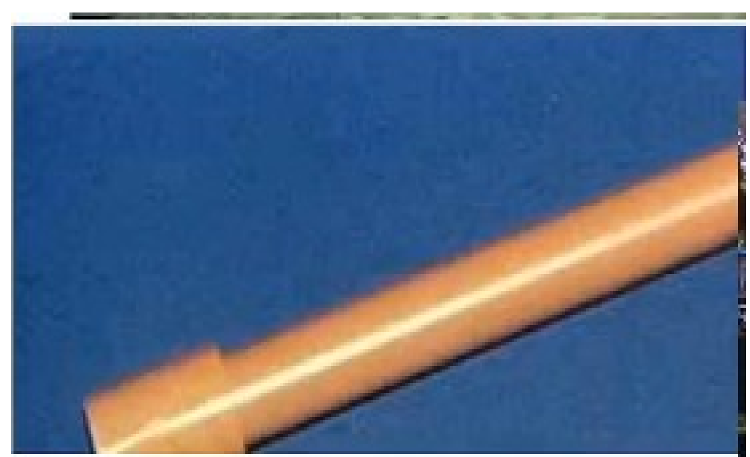
Ceiling Temp.	Temp. Rating	Temp. Class	Color Code	Bulb Color
100 F	135-170	Ordinary	None/ Black	Orange/ Red
150	175-225	Intermediate	White	Yellow/Grn
225	250-300	High	Blue	Blue
300	325-375	Extra High	Red	Purple
375	400-475	Very Extra High	Green	Black
475	500-575	Ultra High	Orange	Black
625	650	Ultra High	Orange	Black

Types of Above Ground Piping

- Black Steel

  - Schedule 40
  - Schedule 10
- Many other thin wall schedules
  Galvanized Steel

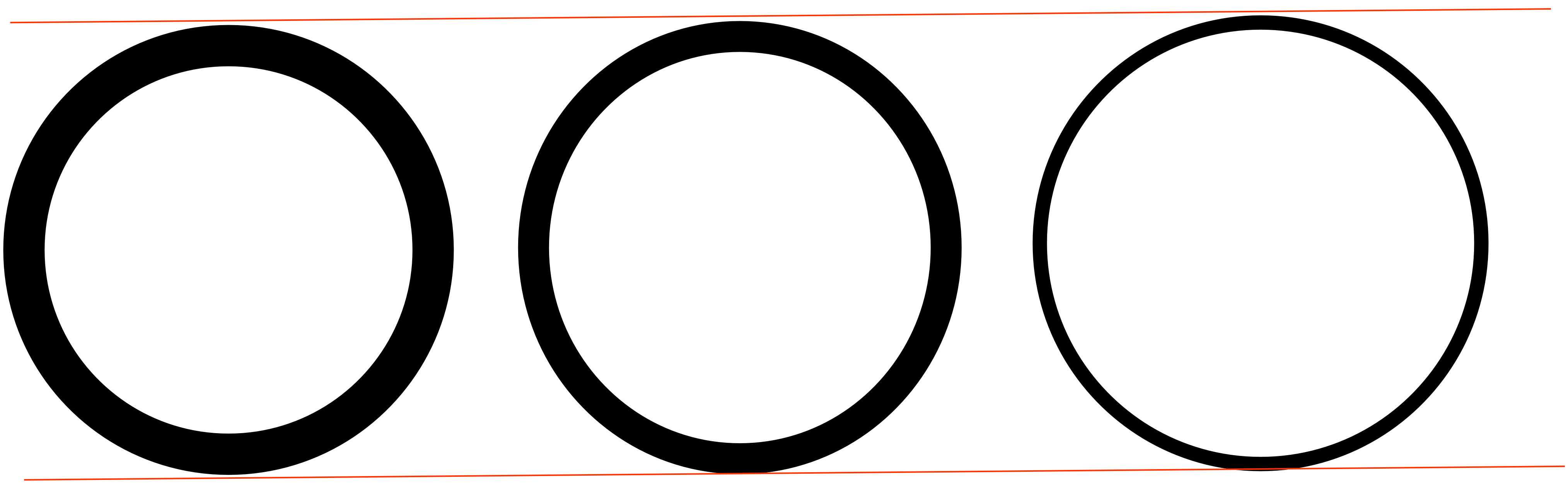
- Copper Tubing
- Plastic piping



- CPVC
  - Polybutylene

Pipe Schedules

Pipe Wall Thickness



Schedule 40 Schedule 30 Schedule 10

Not to Scale

Standard Pipe Sizes

ASTM A 795 - 04

SCHEDULE 10 GRADE A										
		Outside Dia. of Black / Galvanized Tube						Weight of Tube		
SIZE		Minimum		Maximum		Wall thickness		Plain Ends		Pieces
INCH	NB (mm)	Inches	mm	Inches	mm	Inches	mm	lb./Ft.	Kg./Mtr.	per bundle
3/4"	20	1.020	25.90	1.070	27.10	0.083	2.11	0.860	1.280	120
1"	25	1.283	32.60	1.330	33.80	0.109	2.77	1.410	2.090	84
1 1/4"	32	1.630	41.40	1.680	42.60	0.109	2.77	1.810	2.690	61
1 1/2"	40	1.870	47.50	1.920	48.70	0.109	2.77	2.090	3.110	42
2"	50	2.350	59.70	2.400	60.90	0.109	2.77	2.640	3.930	37
2 1/2"	65	2.850	72.30	2.900	73.70	0.120	3.05	3.530	5.260	29
3"	80	3.465	88.00	3.530	89.80	0.120	3.05	4.340	6.460	19
31/2"	90	3.960	100.60	4.040	102.60	0.120	3.05	4.980	7.410	19
4"	100	4.450	113.20	4.540	115.40	0.120	3.05	5.620	8.370	14
5"	125	5.510	139.90	5.620	142.70	0.134	3.40	7.780	11.580	7
6"	150	6.560	166.60	6.690	169.98	0.134	3.40	9.300	13.850	7

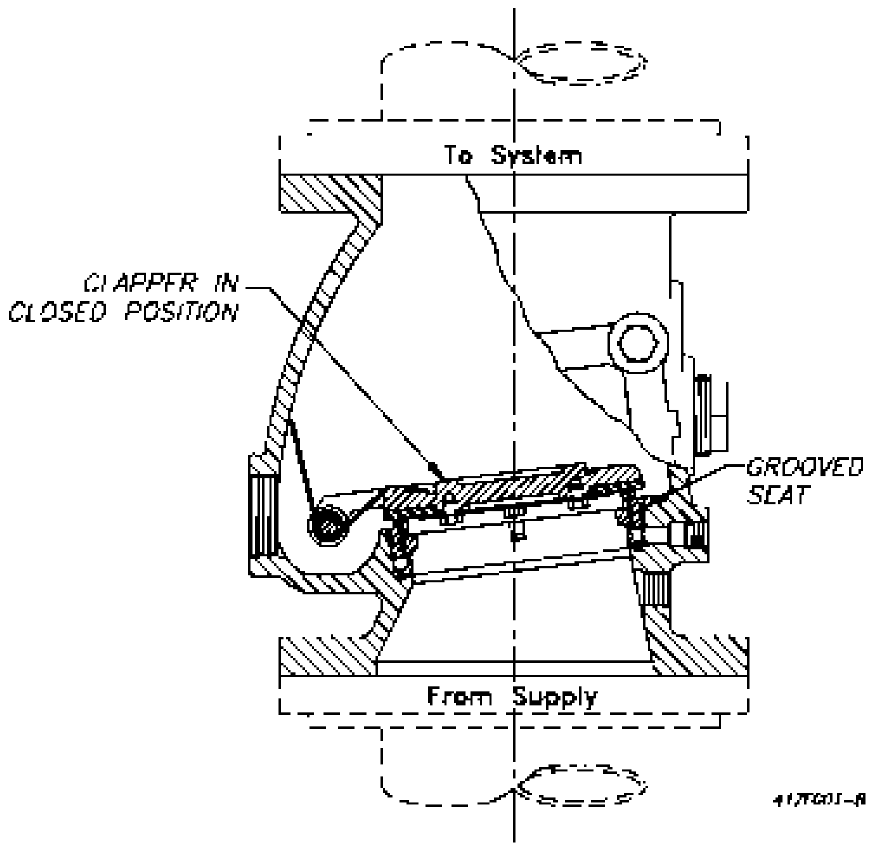
Fittings

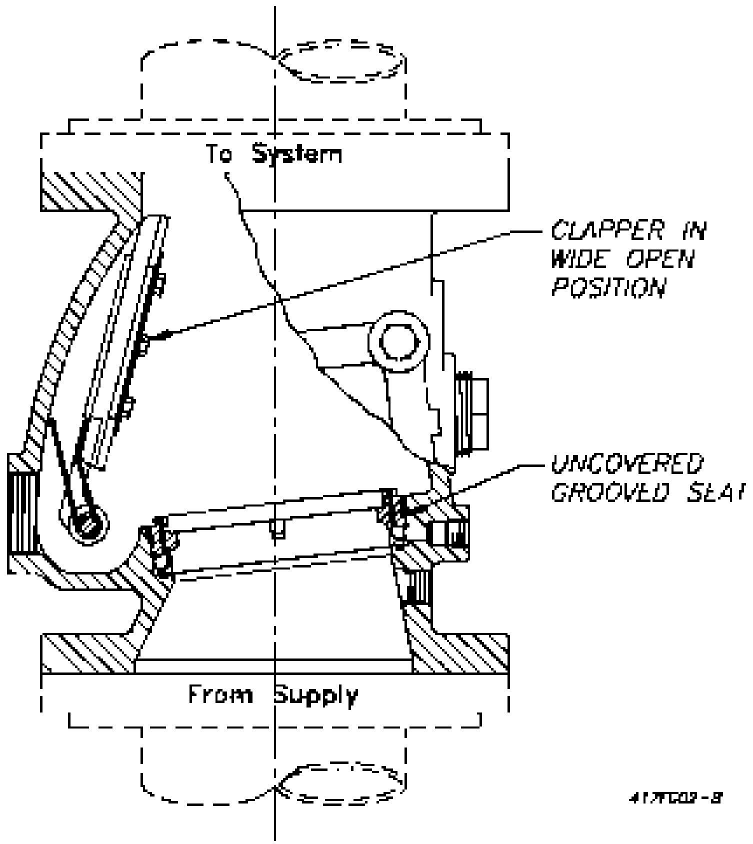
- Performance dictated by ASME standards
  - 300 psi limit
  - Higher than piping

Different Types of Valves

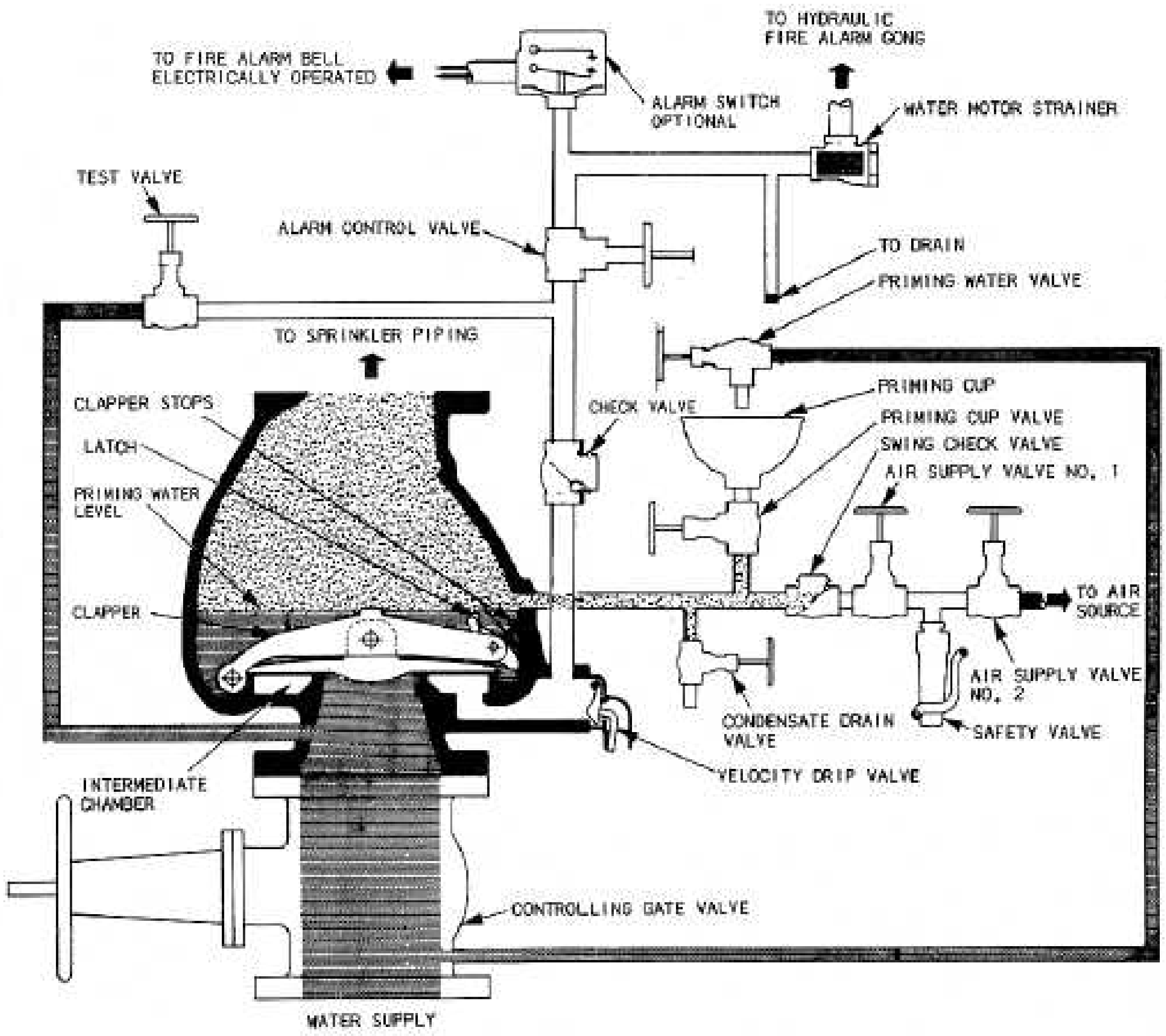
- Alarm Check Valve
- Dry Pipe Valve
- Deluge Value
- Check Valve
- Swing type
- Wafer type
- Control Valve cannot go from fully open to fully close in less than 5 seconds
- Backflow Preventerts
- Double Check
  Reduce Pressure

ALARM CHECK VALVE

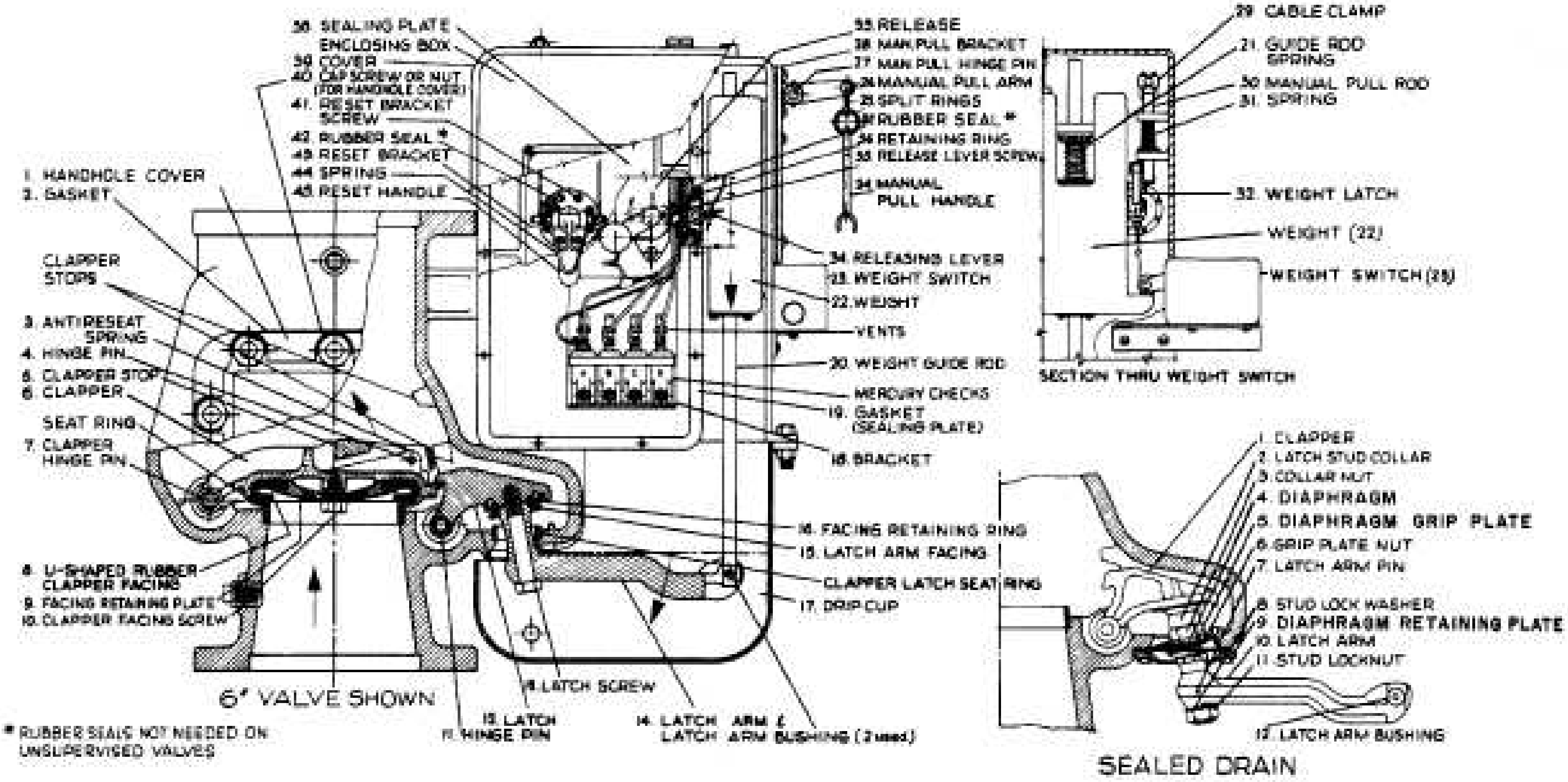




Dry Pipe VALVE



Deluge VALVE



Swing Check Valve

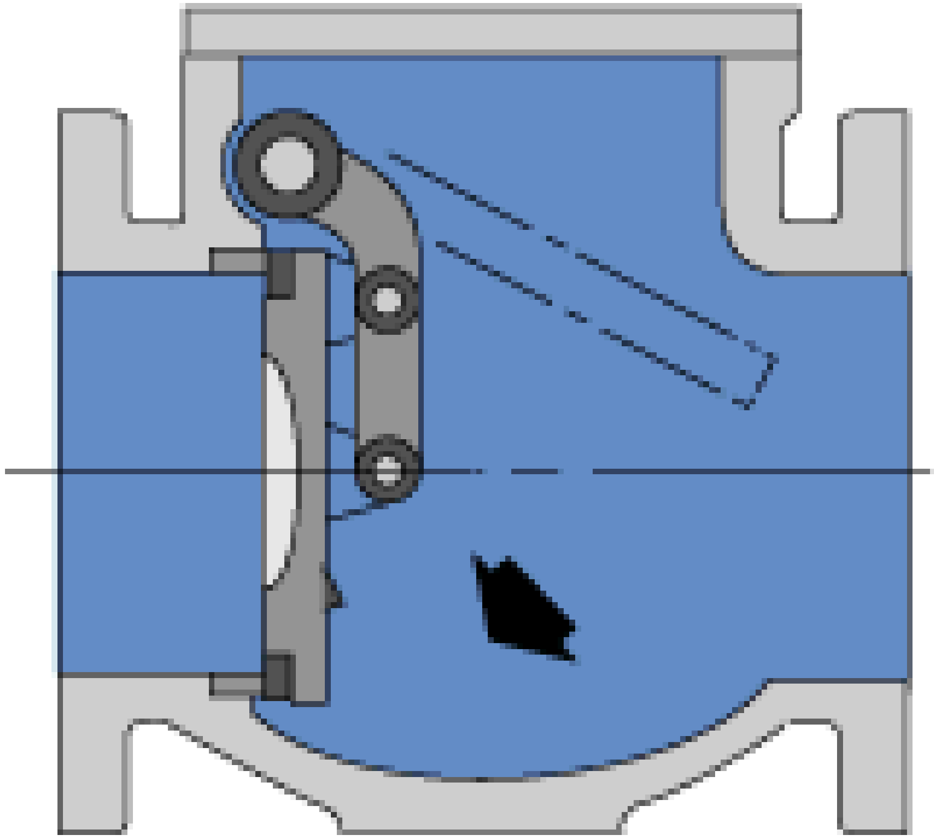
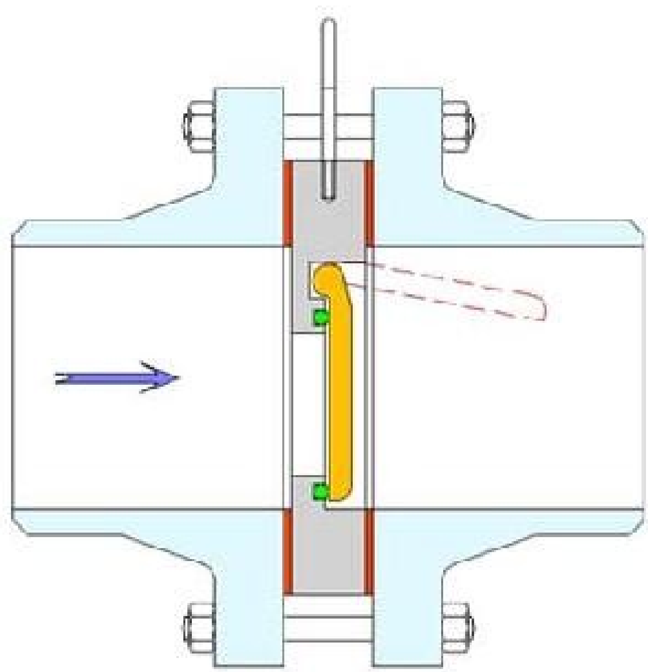


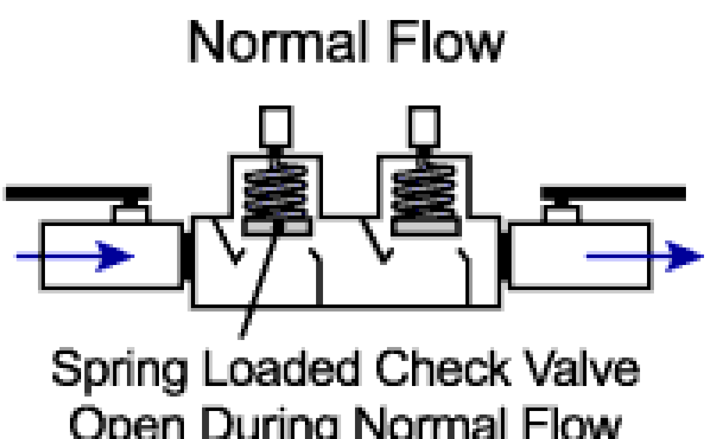
Figure 1

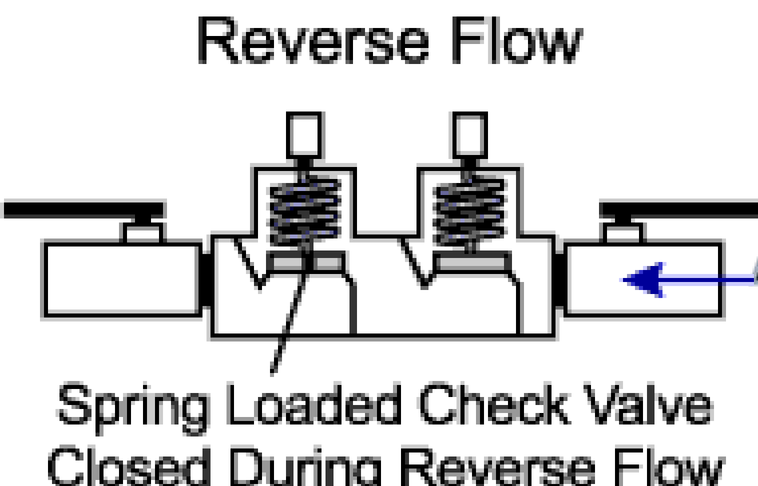
Wafer Check Valve



Wafer Type Check Valve
Flangeless, Sandwich Type

BACKFLOW PREVENTERS

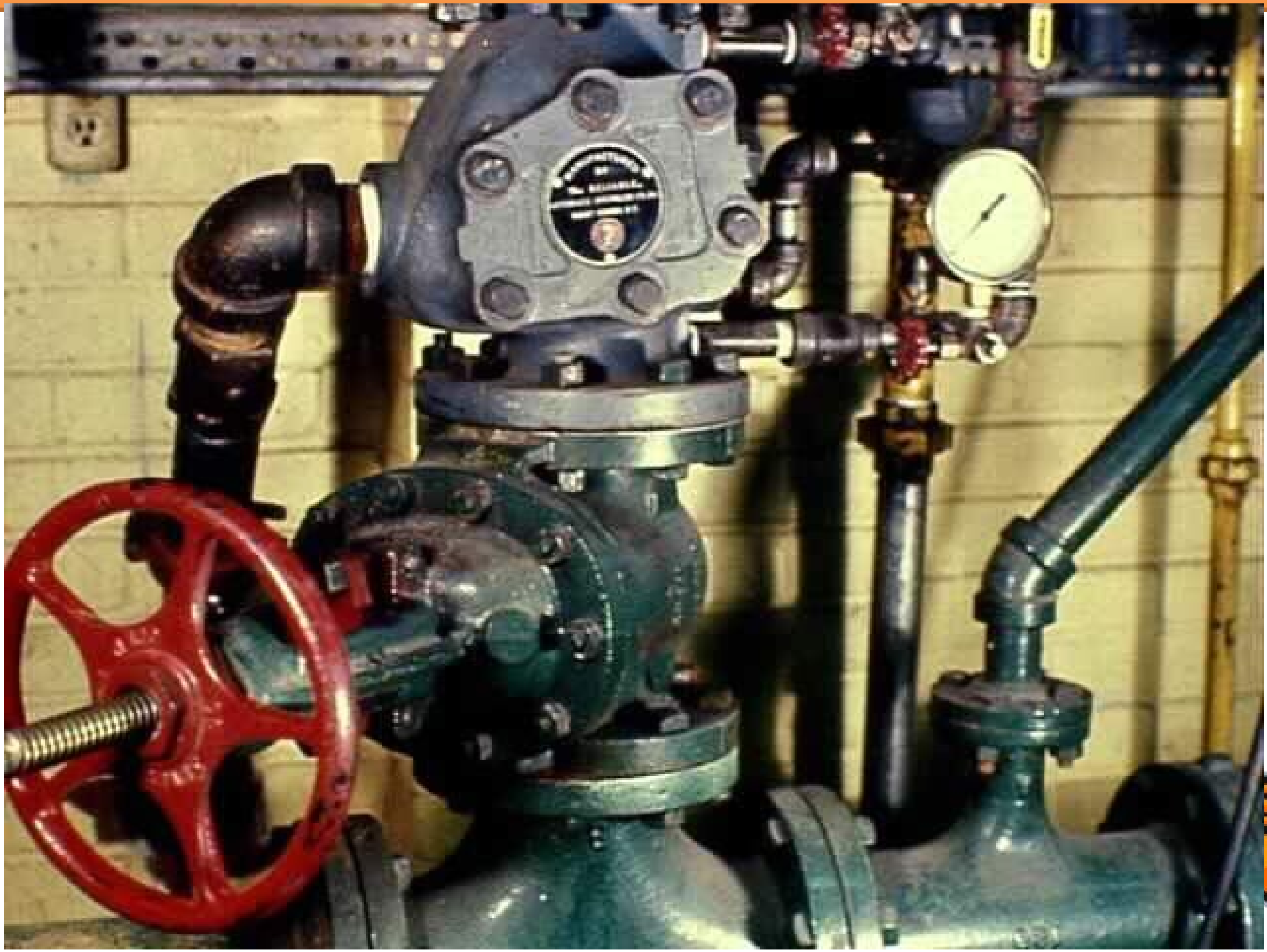




Indicating Control Valves

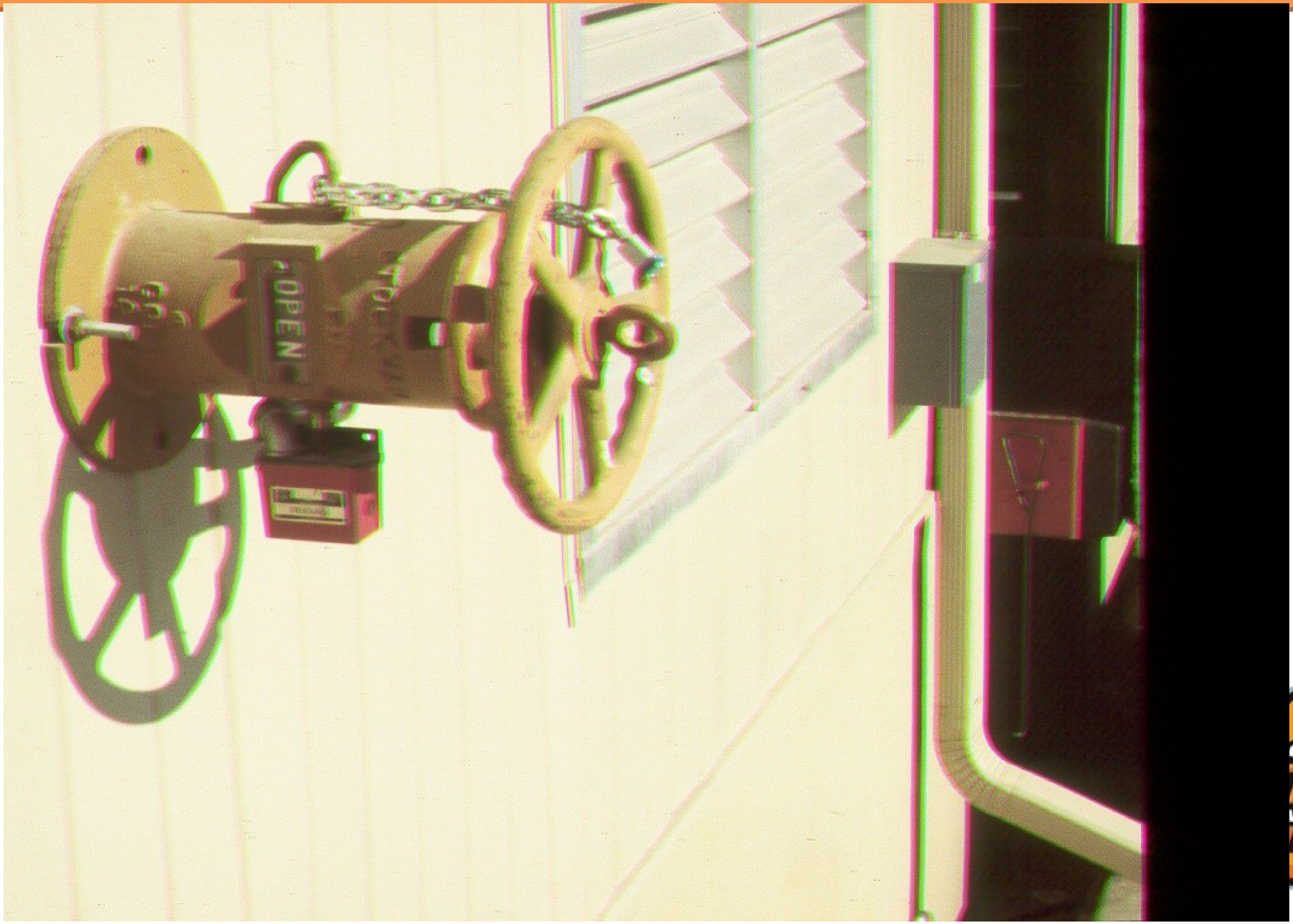
- Must be listed
- Must be supervized open
- Four most commom types
  - OS&Y
  - Post Indicator (PIV)
  - Wall post indicator
  - Butterfly

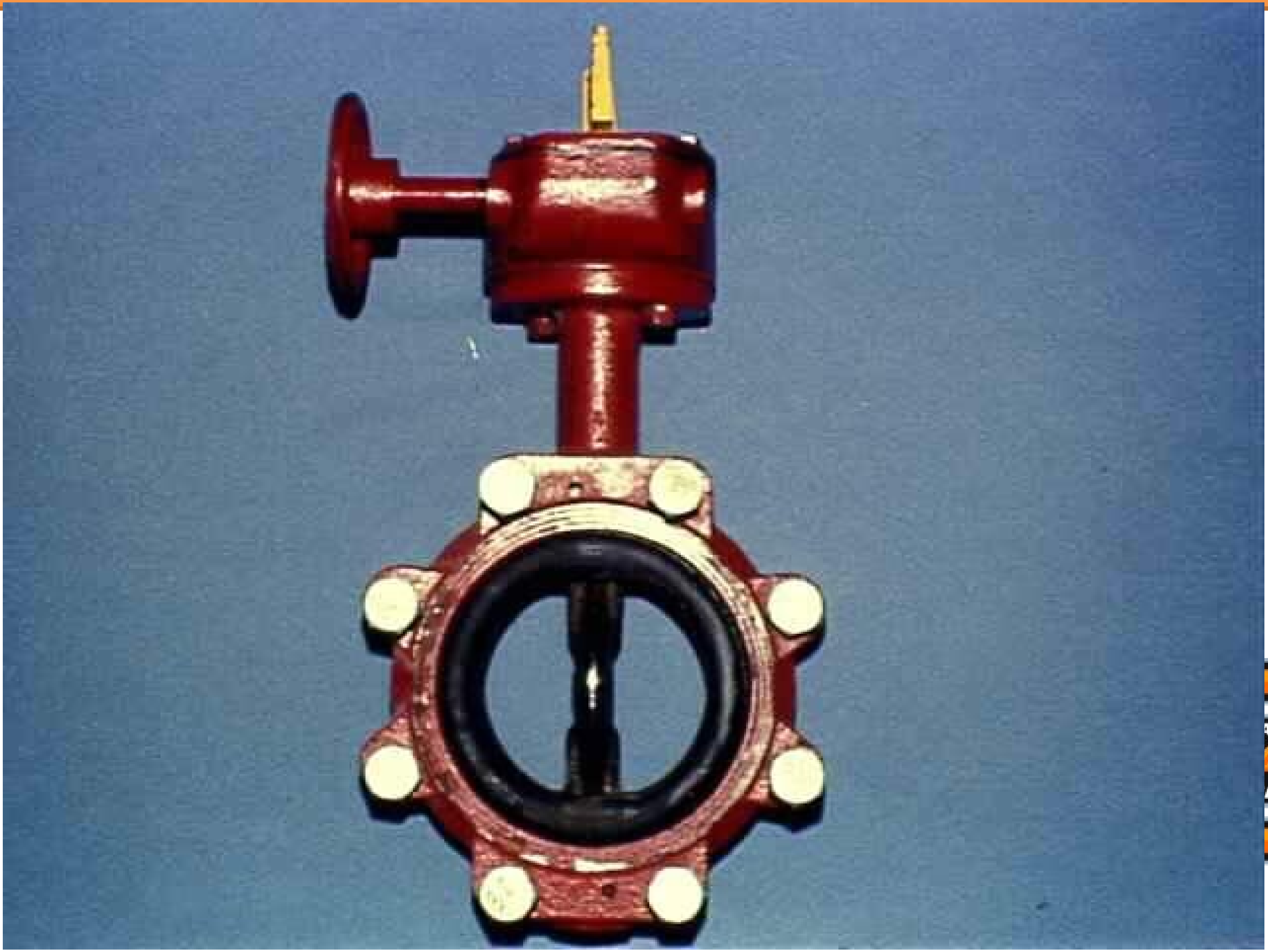
OS&Y Control Valve



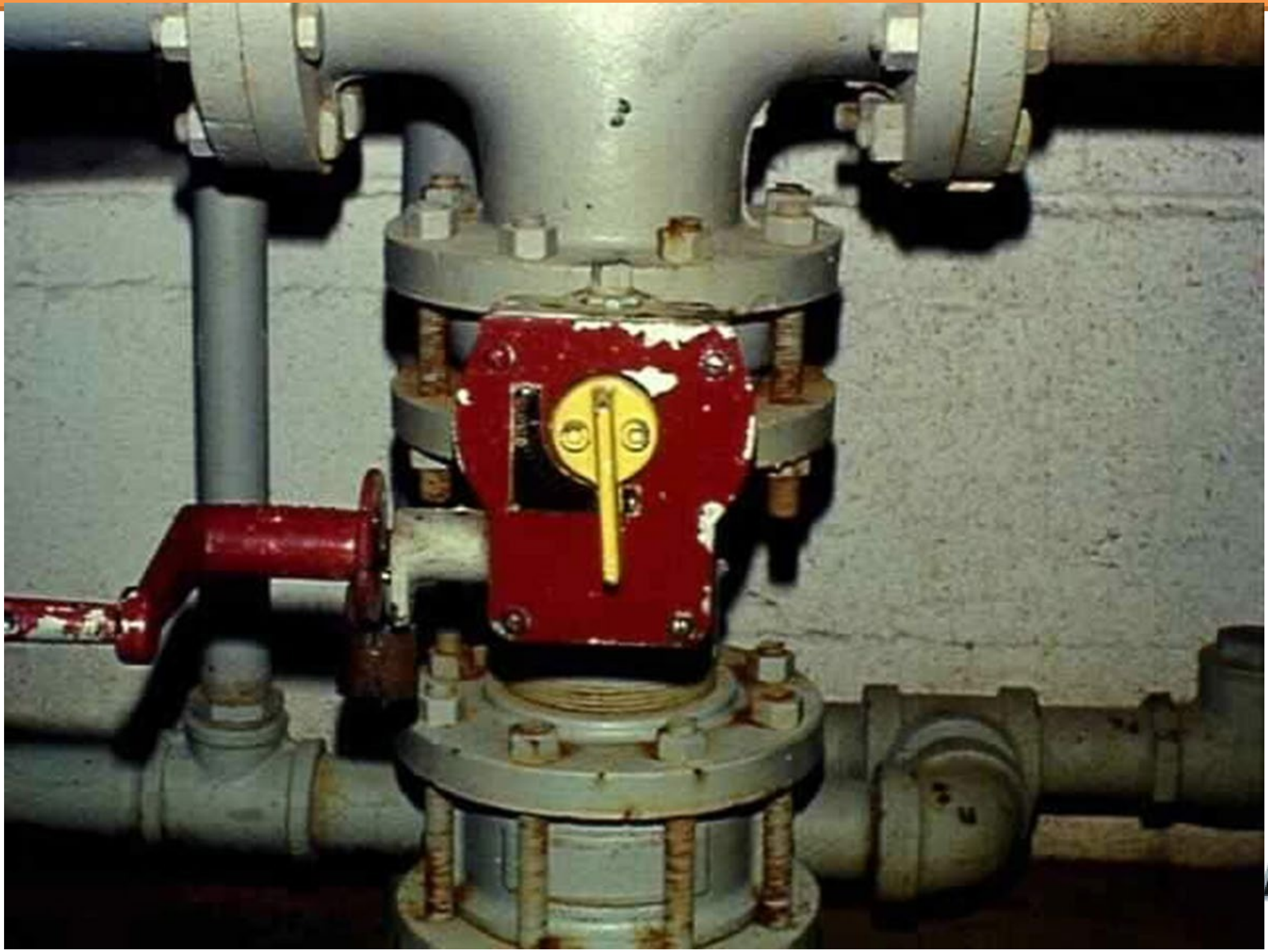
Post Indicator Valve

Wall-Mounted PIV





Butterfly Valve



Butterfly PIV

Fire Department Connection

- Two 2.5 in connection
- 2.5-7.5 NH(National Hose NH=NST) standard thread
  - AHJ can require different

Water Flow Alarm and Detection

- Alarm
  - Must be listed
- Any flow greater than from 1 of the smallest sprinklers
  - 5 minute delay allowed
- Must remain active for duration of flow

- Detection
- Must be listed
- Wet pipe and dry pipe only to water flow
- Paddle type only in wet pipe
- Preaction and Deluge to initiation and water flow

Alarm

- Listed
  - Mechanical
  - Horn
  - Siren
  - Electric
  - Gong Bell
- Speaker
  - Horn
  - Siren
- Piping similar to sprinklers

Gauges

- Wet pipe
  - On each other Above and below the check valve
- Preaction and deluge Above and below valve
  - On air supply

- Dry pipe
  - Water side and air side of dry pipe valve
  - Air pump
  - Air reciver
  - Each independent pipe Accelerators

Wet Pipe System

- Relief valve 0.5 in
  - Operate 175psi or 10 psi above maximum
  - Integrity of piping
- Very few system requirement

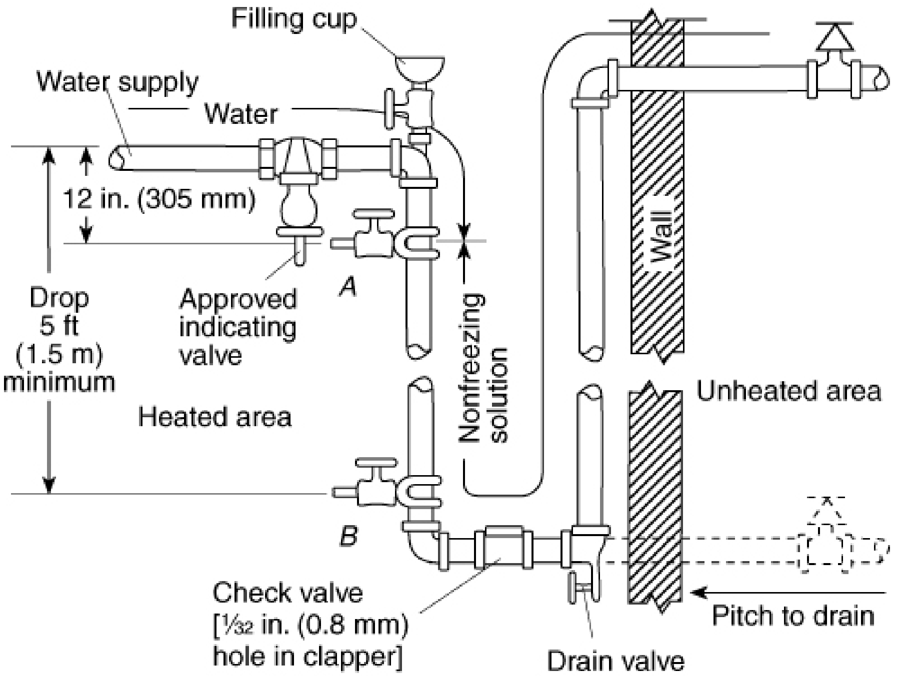
Dry Pipe System

- Sprinklers
- Limitations on head that can be used
  - Size of system
  - Smaller systems
- Water must discharge within 60s (15s in dwelling)
  - More Sprinklers assumed to open
- Quick opening devices
- Valve must be protected from freezing Air pressure
  - 20psi above trip
  - Relief valve

Preaction and Deluge Systems

- Releasing
  - Release system must serve all areas Heat detectors at a temperature below
- sprinklers
- Valve room must be heated
  Preaction
  - Non, single, or double interlock
  - Size limitations
- System requirements similar to dry pipe Deluge
  - Hydraulically calculated

Antifreeze Systems



Notes:

1. Check valves are permitted to be omitted where sprinklers are below the level of valve *A*.
2. The 1⁄32 in. (0.8 mm) hole in the check valve clapper is needed to allow for expansion of the solution during a temperature rise, thus preventing damage to sprinklers.

Water Temperature

- Sprinkler in closed-loop system
  - Must not get above 120F
  - High temperature sprinklers above 100F
  - Must not get below 40F
- Different requirements in refrigerated areas depending on above or below 32F
- Piping pitch

Occupancy and Commodity Classification

- NFPA 13 Chapter 4.3 and Chapter 20.3-20.5
- Select the correct occupancy or commodity classification

Occupancy and Commodity Classification

- Does not provide any specifications for the automatic sprinkler system
- Arguably the most important chapter

Importance

- Defining the occupancy or hazard must be the first step in system design or plan review
  - System design must match occupancy for high probability of system success
  - A wrong occupancy classification or change in occupancy may prove to be the cause of system failure

Occupancies

- For occupancies that are NOT considered storage or miscellaneous storage, five occupancy classes are identified
  - Light Hazard
  - Ordinary Hazard, Group1 and Group 2
    - Used to be Ordinary Group 3
  - Extra Hazard, Group 1and Group 2
- All state for occupancies or portions of
- These occupancies are for NFPA 13
  - Different definitions of occupancies in other standards

Definitions

- Light Hazard
  - Quantity and/or combustibility low
  - Fires with low heat release rates
- Ordinary Group 2
  - Combustibility is low
  - Quantity moderate
    - Stockpiles < 8ft
  - Fires with moderate heat release rates

Definitions Cont.

- Ordinary Group 2
  - Quantity and combustibility moderate to high
  - Fires with moderate heat release rates
    - Stockpiles <12ft
  - Fires with high heat release rates
    - Stockpiles <8ft
- Extra Hazard Group 1
  - Quantity and combustibility very high
  - Fires with high heat release rate
    - Dust, lint, etc, cause rapidly developing fires
    - Little or no combustible or flammable liquids

Definitions Cont.

- Extra Hazard Group 2
  - Moderate to substantial amouns of flammable or comsbutible liquids
  - Shielding of combustibles is extensive

Using Definitions

- Definitions have basically no practical value
- Lists of exmaples in Annex A for guidance

Annex A

- Annex A is not a part of the Standard
- All the lists are incomplete
- Every office building is not the same, every store is not the same, ect
- Use of judgement will still be required in some cases

Light Hazard

- Churches
- Clubs
- Eaves and overhangs, if of combustible construction with no combustibles beneath
- Educational
- Holisticals
- Institutional
- Libraries, except large stack rooms
- Museums
- Nursing or convalescent homes
- Offices, including data processing
- Residential
- Restaurant seating areas
- Theaters and auditorims
- Unused attics

Ordinary Hazard Group 1

- Automobile parking and showrooms
- Bakeries
- Beverage manufacturing
- Canneries
- Dairy products manufacturing and processing
- Electronic plants
- Glass and glass products manufacturing
- Laundries
- Restaurant service areas

Ordinary Hazard Group 2

- Cereal mills
- Chemical plant——ordinary
- Confectionery products
- Distilleries
- Dry cleaners
- Feed mills
- Horse stables
- Leather goods manufacturing
- Libraries——Large stack room areas
- Machine shops
- Metal working
- Mercantile
- Paper and pulp mills
- Paper process plants
- Piers and wharves
- Post offices
- Printing and publishing
- Repair application area
- Stages
- Textile manufacturing
- Tire manufacturing
- Tobacco products manufacturing
- Wood machining
- Wood product assembly

Extra Hazard Group 1

- Aircfact hangar (expect as governed by NFPA 409), Standard on Aircfact Hangars
- Combustible hydraulic fluid use areas
- Die casting
- Metal extruding
- Plywood and particle board manufacturing
- Printing using inks having flash points below 100F
- Rubber reclaiming, compounding, drying, milling, vulcanizing
- Saw mills
- Textile picking, opening, blending, garneting, or carding, combining of cotton, synthetics, wool shoddy, or burlap
- Upholstering with plastic foams

Extra Hazard Group 2

- Asphalt saturating
- Flammable liquid spraying
- Flow coating
- Manufactured home or modular building assemblies (where finished enclosure is present and has combustible interiors)
- Open oil quenching
- Plastics processing
- Solvent cleaning
- Varnish and paint dipping

Miscellaneous Storage

- 10% of building area or 4000ft^2
- Max 1000ft^2 per pile or area
- Separation to other piles or areas by 25ft
- Miscellaneous tire storage
  - 2000 ft^2 max
  - 25 ft max or storage on tread

Low Piled Storage

- Class I-IV commodities that do not meet the definition of miscellaneous storage 12ft or less in storage height
- Group A plastics 5 ft or less

Storage

- Chapter 20
- Storage heights > 12ft =no occupancy classification
- Simply warehouses
  - Commodities stored must be classified

Classifications

- Commodities
  - Class I
  - Class II
  - Class III
  - Class IV
- Plastics
  - Group A plastic
  - Group B plastic
  - Group C plastic
- Roll paper storage
  - Heavy weight
  - Medium weight
  - Light Weight
  - Tissue

Sprinkler Spacing Requirements

- NFPA 13 Chapter 9-15
- Determine placement requirements of sprinklers

Organization

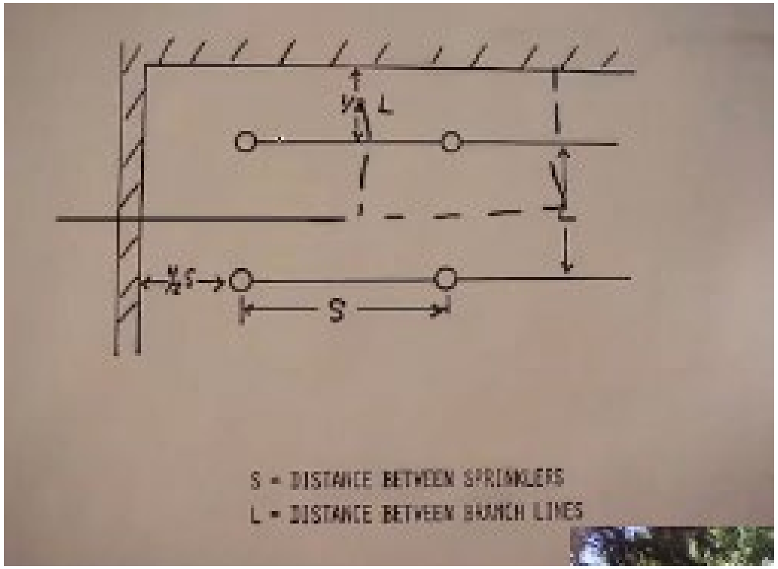
- Section 9.5 gives overview
- Chapter 10-15 give more restrictions for specific circumstances
  - Lecture focuses on 9.5 and Chapter 10
  - Other usually same concepts, different numbers
- Chapter 15 deals with special sprinklers

Protection Area

- Half the distance to sprinklers on either side
- Half the distance to branch lines on either side

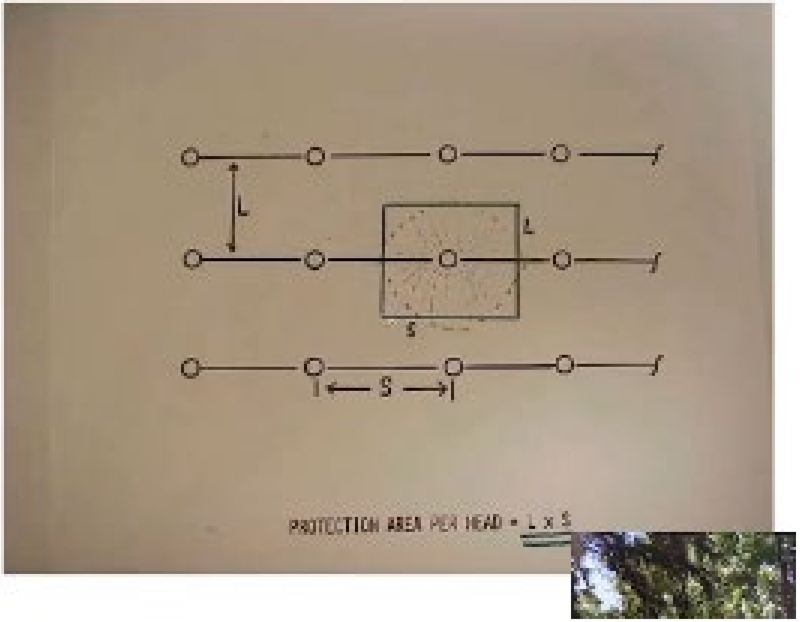
$$A_s = S \times L$$

- Protection Area
- Each rectangle then makes grid



Protection Area

- As cannot be > 400ft^2
- Spray pattern is circular
- Will go well beyond the box



Example

- A sprinkler is located:
  - 10ft from sprinklers in both directions on branch line
  - 12ft from adjacent branch line
  - 4ft from wall
- A_s=10ft*12ft=120ft^2
- If 8ft from wall: A_s=10ft*16ft=160ft^2
  - Why is it not 140ft^2

Upright and Pendent Sprinklers Spacing

- Maximum spacing:
  - 15ft for Light and Ordinary Hazard Occupancies
  - 12ft for Extra Hazard and some warehouses

Upright and Pendent Sprinklers Protection Areas

- Light hazard: 120-225ft^2
  - Determined by pipe sizing approach and construction
- Ordinary hazard: 130ft^2
  - All system
- Extra hazard:90-130 ft^2
  - Determined by pipe sizing approach and required water delivery rate
- High piled storage: 100-130ft^2
  - Determined by required water delivery rate

Protection Areas

- Need to consider both spacing and area rules
  - System acceptable on only one rule not acceptable
  - System can be within spacing, but not area
  - System can be within area, but not spacing

Example

- Design
  - Ordinary hazard occupancy
  - S=15ft, L=15ft
- Spacing rules are met
- Area:
  - 15ft^2 815ft^2 =225ft^2
    - Can only be 130ft^2
    - Would need to be 15ft by 8'-8''

Example

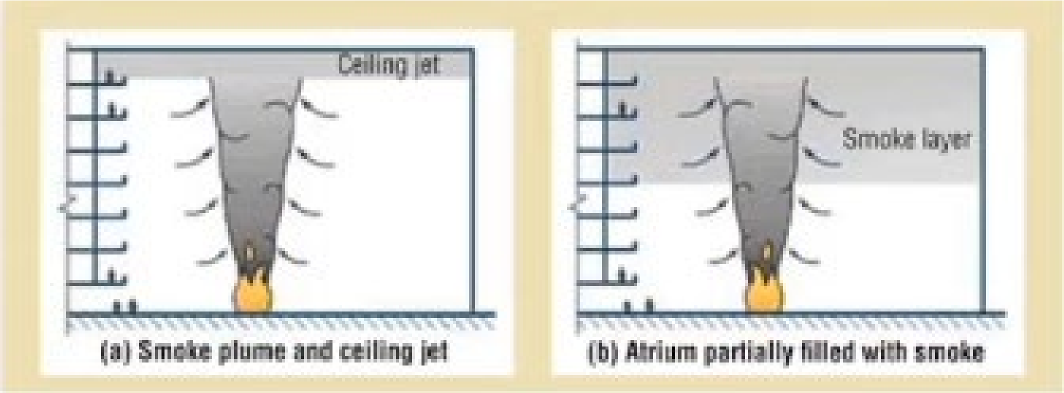
- Design
  - Ordinary hazard occupancy
  - S=15ft, L=5ft
- Spacing rules are met
- Area:
  - 15ft^2 815ft^2 =100ft^2<130ft^2
  - S would need to be 15ft

Additional Rules

- Distance to walls
  - Cannot be more than half the allowable S or L from wall
  - Must be at least 4 in from wall
- Must be 6ft between sprinklers
  - Prevents colling and sprinkler skipping
  - Exceptions if obstructions between

Generalized Smoke Behavior

- Heated air rises from fire
- Air entrained in
- Smoke hits ceiling
  - Spreads radially
- Smoke hits walls
  - Banks down



Sprinkler Orientation

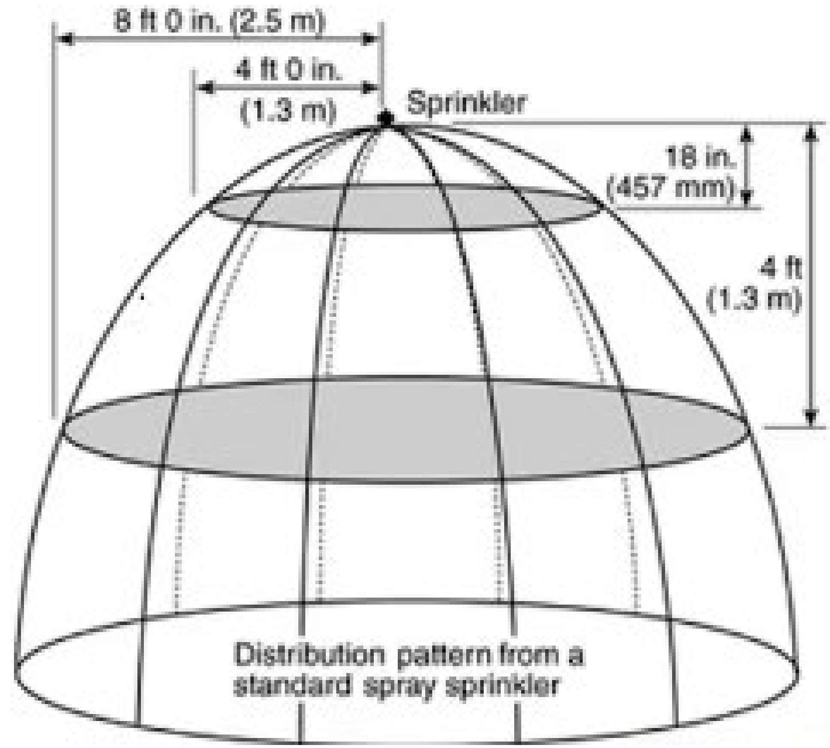
- Good
  - Deflector parallel to the ceiling
- Bad
  - Deflector not parallel to the ceiling

Deflector Position

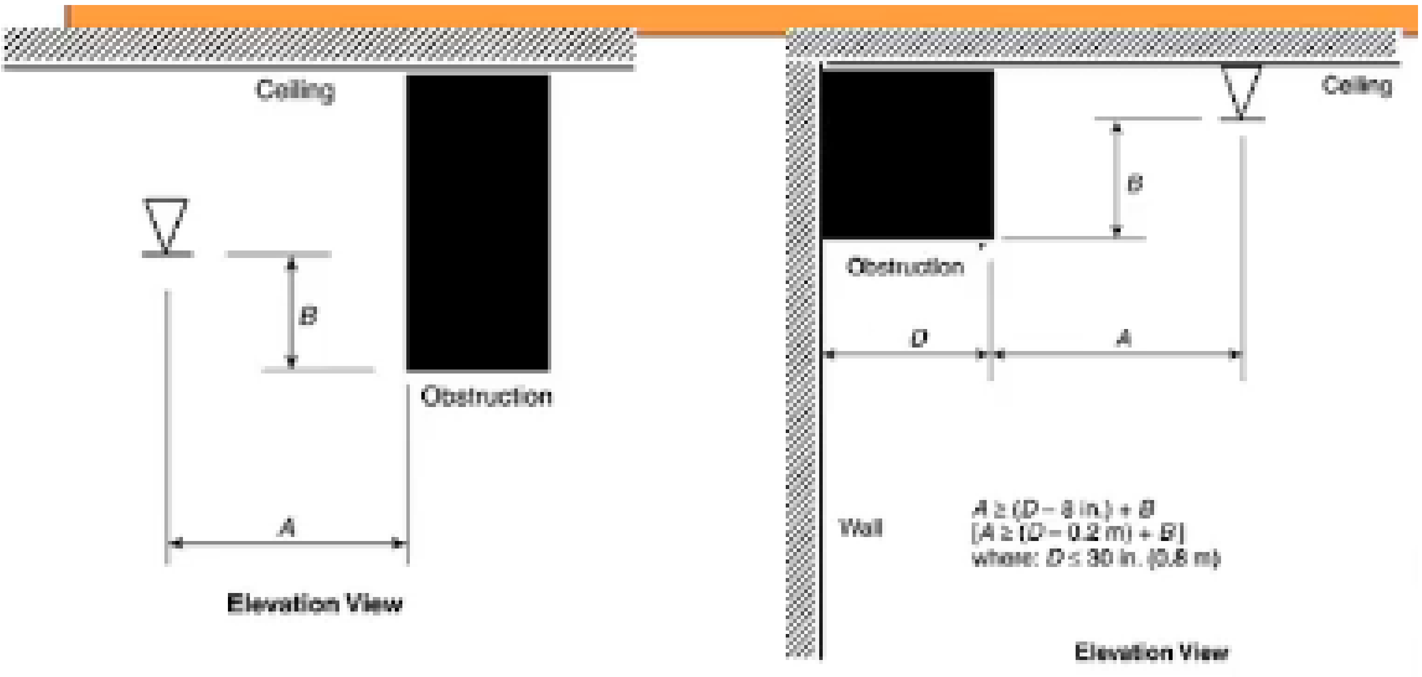
- Unobstructed ceiling
  - 1 to 12in
  - Different rules if ceiling changes plane
- Obstructed ceiling
  - 1 to 6in below obstruction
  - < 22 in below ceiling
  - Installed in each bay

Obstructions

- Pattern development
  - Water breaks into different droplet sizes
    - Starts spreading out
  - Obstructions within 18in
    - Large shadow
  - Relocate horizontally
- Reaching hazard
  - Obstructions up to 4ft
  - Relocate vertically
- Top of storage
  - 18in



Ceiling Obstructions

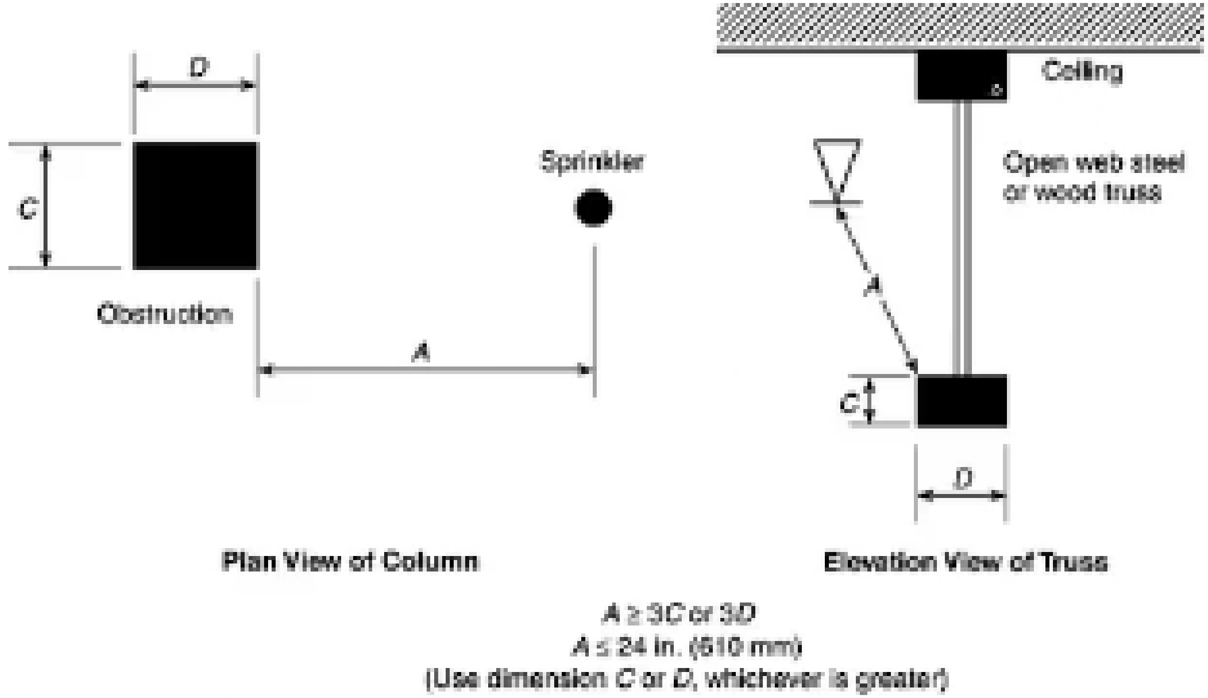


- Spray hitting obstruction =water not reaching intended area
- Example
    - Sprinkler must be within 30'' of duct
    - Duct is 18 in deep
    - How far from the ceiling must the deflector be places

Example

- Can be up to 7.5 in from bottom of duct
- Distance to ceiling=18 -7.5in =10.5in

Position to Obstruction



- Must be 3 obstruction widths away, max requirement 24 in
- Figure 10.2.7.2.1.3(b)
  - Ensures water gets to protection area
  - Exceptions allowed
- Example:
  - Obstruction 10in deep
  - How far away must sprinkler be?

Example

- Distance =3*10in =30in
  - 30in >24in, so is only required to be 24in away

Floor Obstructions

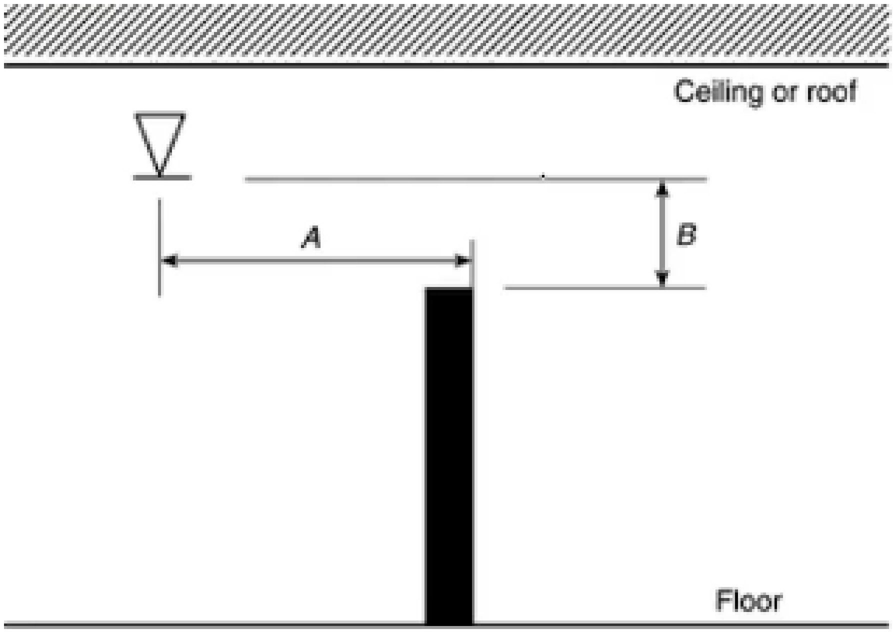


Table 10.2.7.2.2 Suspended or Floor-Mounted Obstructions in Light Hazard Occupancies Only (SSU/SSP)

Horizontal Distance *(A)*	Minimum Vertical Distance Below Deflector (in.) *(B)*
6 in. or less	3
More than 6 in. to 9 in.	4
More than 9 in. to 12 in.	6
More than 12 in. to 15 in.	8
More than 15 in. to 18 in.	9½
More than 18 in. to 24 in.	12½
More than 24 in. to 30 in.	15½
More than 30 in.	

- Do not want obstruction acting as wall
- Example
  - Obstruction 10 in away and 14in below the ceiling
  - How far below the ceiling can the deflector be?

Obstructions from Pipe

- Large pipe (>2in) could disrupt pattern
  - Similar issue to upright sprinklers arms
  - Use pendent sprinklers to avoid issue

Sidewall Sprinklers

- Requirements similar to upright and pendent sprinklers
  - L is half the room length
  - Small spacing (10 to 14 ft)
  - Smaller protection area(80 to 196ft^2)
  - 4 to 6 below ceiling
  - More than 4ft from light fixtures
  - See Section 10.3 for more

Extended Coverage Upright and Pendent Sprinklers

- Requirements similar to upright and pendent sprinklers
  - Larger spacing(12 to 20ft)
  - Larger protection area (144 to 400 ft^2)
  - Minimum 8ft between sprinklers
  - More than 4ft from light fixtures
  - See Chapter 11 for more

Extended Coverage Sidewall Sprinklers

- Requirements similar to standard sidewall sprinklers
  - Larger spacing(up to 28ft)
  - Larger protection area (up to 400 ft^2)
  - See Chapter 11 for more

Residential Sprinklers

- Requirements similar to upright and pendent sprinklers
  - Restricted on slope of ceiling based on listing
  - Must be 8ft between sprinklers plan view
  - Distance between sprinklers measured along slope
  - Deflector 1 to 4 in below ceiling
  - 4 times obstruction width away, maximum 36 in required
  - See Chapter 12 for more

CMSA (Large Drop) Sprinklers

- Requirements similar to upright and pendent sprinklers
  - Protection area from 80ft^2 to 130 ft^2
  - Spacing from 8ft minimum to 10 to 12ft maximum
  - Deflector 6 to 8 below unobstructed ceiling
  - Special conditions for obstruction parallel to branch line
  - 36in above storage
  - See Chapter 13 for more

Early Suppression Fast-Response(ESFR) Sprinklers

- Requirements similar to upright and pendent sprinklers
  - Protection area from 64ft^2 to 100 ft^2
  - Spacing from 8ft minimum to 10 to 12ft maximum
  - Adjustments to area and spacing allowed base on obstructions
  - Deflector distance below ceiling depends on K-Value
  - See Chapter 14 for more

In-Rack Sprinklers

- System Area not to exceed 40000ft^2
- Ordinary temperature, standard or quick response
- Water shields above
  - Why?
- Can be within 6ft

Sprinklers in Shafts and Stairs

- One sprinkler at top of shaft
- Combustible surface in shaft
  - One sprinkler every other floor
- Beneath combustible stairways
- Beneath first landing in noncombustible stairways
- Beneath stairways where storage is present

Sprinklers in Vertical Openings and Elevator Hoistways

- Placed 6 to 12 in of vertical openings
  - 6ft apart
- <2ft from bottom of elevator hoistway
- At top of hoistway or in elevator machine room

Pipe Schedule Design

- NFPA 13 Chapter 19.3.2
- NFPA 13 Chapter 27.5
- Specify pipe schedule systems

Pipe Schedule Method

`

- Oldest design method
- Pipe is sized based on number of sprinklers
- Easy to design and calculate
- More conservative pipe selection
- Open floors =one design area

System Components

- For most applications, K-factor must be 5.6
- Pipe must be steel or copper
- Everything must match time-tested installation

Pipe Schedule Method

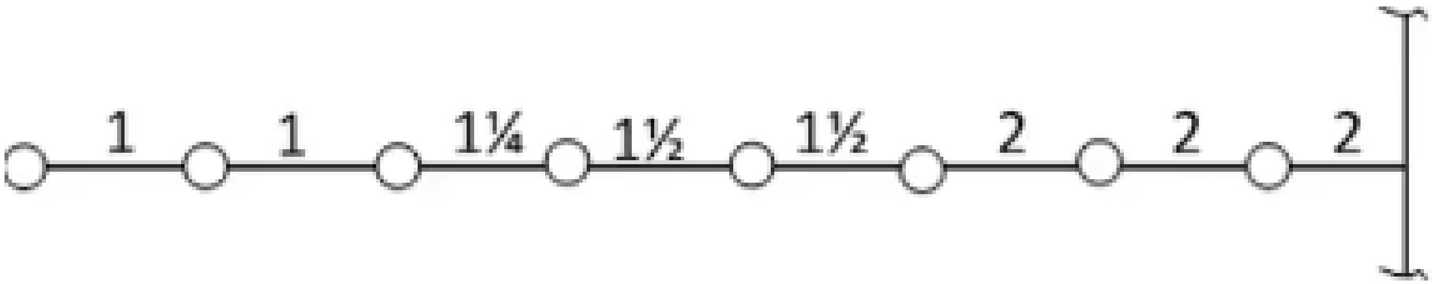
- Start at most remote location (end of branch line)
- Smallest pipe size allowed to next sprinkler
- When "x" sprinklers are allowed on a given size pipe, **include the ones that are further downstream**
- After finishing branch line, continue to cross main

Light Hazard Branch Lines

- 1 to 8 sprinklers on branch line
  - 1 in pipe for first 2 sprinklers
  - 1.25 in pipe from second to third sprinklers
  - 1.5in pipe for next two sections
  - 2 in for sections back to cross main

Example

- There are 8 sprinklers on a branch line. What are the required pipe size



Light Hazard Pipe Schedules

Table 27.5.2.2.1 Light Hazard Pipe Schedules

Steel		Copper	
1 in.	2 sprinklers	1 in.	2 sprinklers
1¼ in.	3 sprinklers	1¼ in.	3 sprinklers
1½ in.	5 sprinklers	1½ in.	5 sprinklers
2 in.	10 sprinklers	2 in.	12 sprinklers
2½ in.	30 sprinklers	2½ in.	40 sprinklers
3 in.	60 sprinklers	3 in.	65 sprinklers
3½ in.	100 sprinklers	3½ in.	115 sprinklers

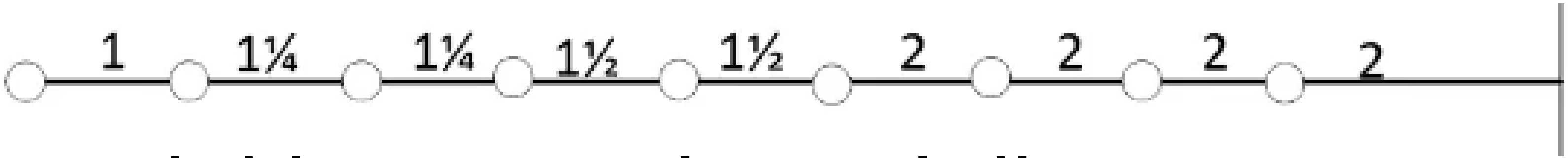
- For 4 in and above without partitions, same as ordinary hazard

Example

- What size cross main would be required to supply two 8-sprinkler branch lines?
- 8*2=16-> 2.5in pipe
- Once serving four 8-sprinkler branch lines, pipe size goes to 3 in

Other Branch Line Configurations

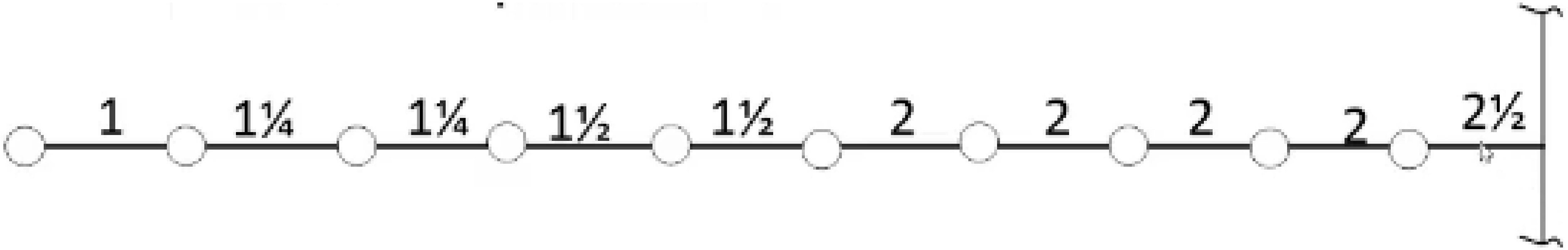
- 9 sprinklers on a branch line
  - The second 1 in section is increased to 1.25 in



- 10 sprinklers on a branch line
  - The second 1 in section is increased to 1.25 in
  - The last section of pipe is increased from 2 to 2.5 in pipe

Example

- What are the required pipe sizes for a branch line with 10 sprinklers



- What size should the cross main be?

Other Sprinkler Arrangements

- Previous information for sprinklers on one level
- Other arrangements possible

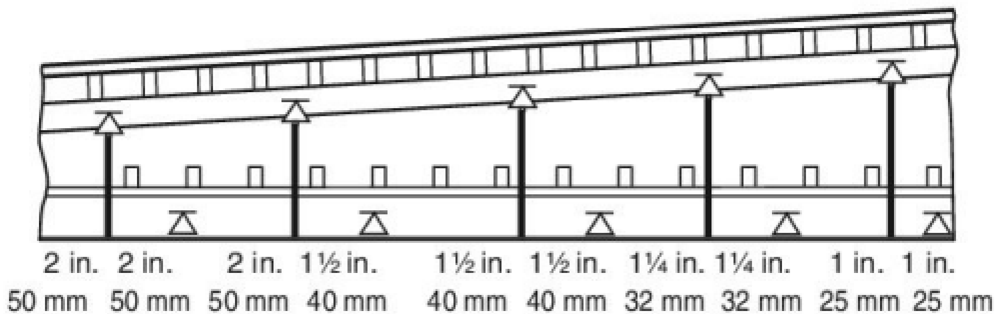


FIGURE 28.5.2.3(a) Arrangement of Branch Lines Supplying Sprinklers Above and Below Ceiling.

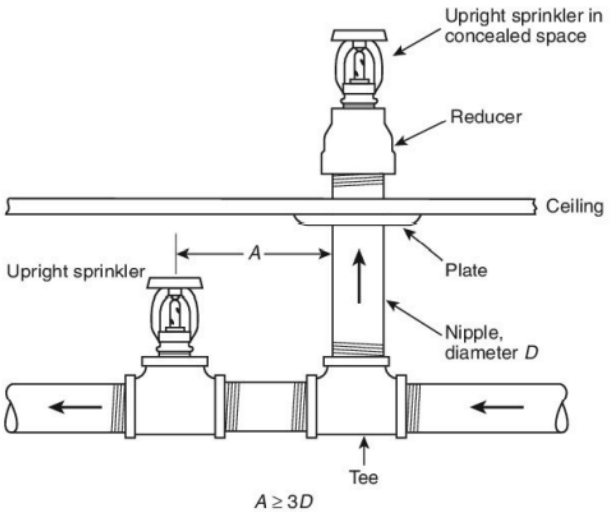


FIGURE 28.5.2.3(b) Sprinkler on Riser Nipple from Branch Line in Lower Fire Area.

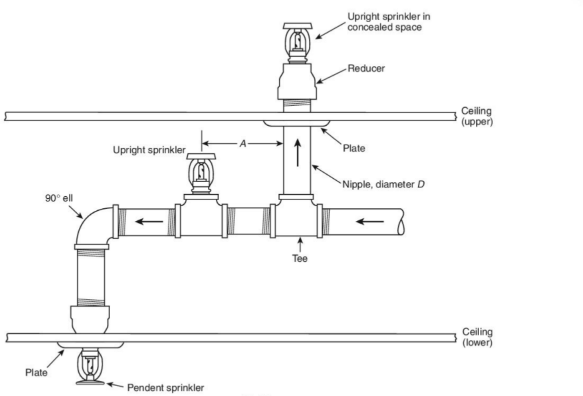


FIGURE 28.5.2.3(c) Arrangement of Branch Lines Supplying Sprinklers Above, Between, and Below Ceilings.

Sprinklers above and below a ceiling

- Table 28.5.2.4 Number of Sprinkler Above and Below a Ceiling

Table 28.5.2.4 Number of Sprinklers Above and Below Ceiling

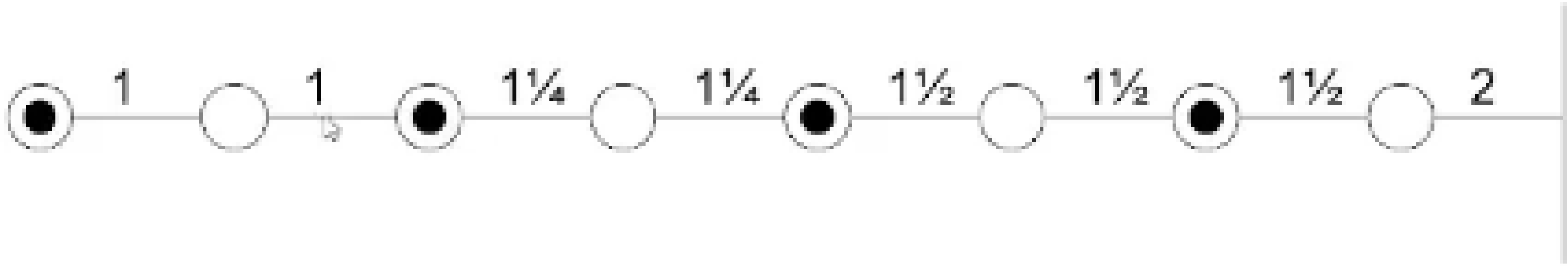
Steel		Copper	
1 in. (25 mm)	2 sprinklers	1 in. (25 mm)	2 sprinklers
1¼ in. (32 mm)	4 sprinklers	1¼ in. (32 mm)	4 sprinklers
1½ in. (40 mm)	7 sprinklers	1½ in. (40 mm)	7 sprinklers
2 in. (50 mm)	15 sprinklers	2 in. (50 mm)	18 sprinklers
2½ in. (65 mm)	50 sprinklers	2½ in. (65 mm)	65 sprinklers

Above and Below Ceiling Sprinklers

- Can have up to 8 above and 8 below
  - Increase in number
  - Use greatest number on any two levels
- **Beyond limits in previous table, use 3 in and then table for single level**

Example

- What are the pipe sizes for 8 sprinklers with 4 above and below ?



Ordinary Hazard Branch Line

- 1 to 8 sprinklers on branch line:
  - 1 in pipe for first 2 sprinklers
  - 1.25 in pipe from second to third sprinklers
  - 1.5 in pipe for next two sections
  - 2 in for sections back to cross main
- Note: on branch lines (including 9 and 10 sprinkler branch lines), the pipe size is **independent** of pipe materials and light or ordinary hazard

Ordinary Hazard Pipe Schedule

Table 28.5.3.4 Ordinary Hazard Pipe Schedule

Table 28.5.3.4 Ordinary Hazard Pipe Schedule

Steel		Copper	
1 in. (25 mm)	2 sprinklers	1 in. (25 mm)	2 sprinklers
1¼ in. (32 mm)	3 sprinklers	1¼ in. (32 mm)	3 sprinklers
1½ in. (40 mm)	5 sprinklers	1½ in. (40 mm)	5 sprinklers
2 in. (50 mm)	10 sprinklers	2 in. (50 mm)	12 sprinklers
2½ in. (65 mm)	20 sprinklers	2½ in. (65 mm)	25 sprinklers
3 in. (80 mm)	40 sprinklers	3 in. (80 mm)	45 sprinklers
3½ in. (90 mm)	65 sprinklers	3½ in. (90 mm)	75 sprinklers
4 in. (100 mm)	100 sprinklers	4 in. (100 mm)	115 sprinklers
5 in. (125 mm)	160 sprinklers	5 in. (125 mm)	180 sprinklers
6 in. (150 mm)	275 sprinklers	6 in. (150 mm)	300 sprinklers
8 in. (200 mm)	See Section 4.4.	8 in. (200 mm)	See Section 4.4.

Ordinary Hazard Branch Lines

- When spacing between heads or between branch lines **>12ft**

Table 28.5.3.5 Number of Sprinklers — Greater Than 12 ft (3.7 m) Separations

Steel		Copper	
2½ in. (65 mm)	15 sprinklers	2½ in. (65 mm)	20 sprinklers
3 in. (80 mm)	30 sprinklers	3 in. (80 mm)	35 sprinklers
3½ in. (90 mm)	60 sprinklers	3½ in. (90 mm)	65 sprinklers

Note: For other pipe and tube sizes, see Table 28.5.3.4.

Extra Hazard Occupancies

- Pipe Schedule not allowed any more
  - Previous requirements

Table A.22.5.4 Extra Hazard Pipe Schedule

Steel		Copper	
1 in.	1 sprinkler	1 in.	1 sprinkler
1¼ in.	2 sprinklers	1¼ in.	2 sprinklers
1½ in.	5 sprinklers	1½ in.	5 sprinklers
2 in.	8 sprinklers	2 in.	8 sprinklers
2½ in.	15 sprinklers	2½ in.	20 sprinklers
3 in.	27 sprinklers	3 in.	30 sprinklers
3½ in.	40 sprinklers	3½ in.	45 sprinklers
4 in.	55 sprinklers	4 in.	65 sprinklers
5 in.	90 sprinklers	5 in.	100 sprinklers
6 in.	150 sprinklers	6 in.	170 sprinklers

For SI units, 1 in. = 25.4 mm.

Systems

- Focus has been on branch lines
- Value apply to entire piping system

Water Supply

- Table 19.3.2.1
- Light hazard
  - Minimum 15 psi at highest elevation
    - 50 psi if system > 5000ft^2
  - 500 to 750 gpm (base of riser)
  - Flow 30 to 60 min
- Ordinary hazard
  - Minimum 20 psi at highest elevation
    - 50 psi if system > 5000ft^2
  - 850 to 1500 gpm (base of riser)
  - Flow 60 to 90 min

Table 19.3.2.1 Water Supply Requirements for Pipe Schedule Sprinkler Systems

Occupancy Classification	Minimum Residual Pressure Required		Acceptable Flow at Base of Riser (Including Hose Stream Allowance)		Duration (minutes)
	psi	bar	gpm	L/min	
Light hazard	15	1	500–750	1900–2850	30–60
Ordinary hazard	20	1.4	850–1500	3200–5700	60–90

General Design Requirements

- NFPA 13 Chapter 17 and 18
- Identify requirements for sprinkler system components
- Select appropriate hanging and bracing designs for sprinkler system

Basic Requirements

- Sprinklers installed throughout
- Position sprinklers to provide enough water quickly
- Sprinklers close to ceiling unless tested
- Areas left unprotected in NFPA 13

Accessibility Requirements

- Valves and gauges must be accessible
  - System will need testing and maintenance
  - Example: Indicating valve on ceiling

Control Valve

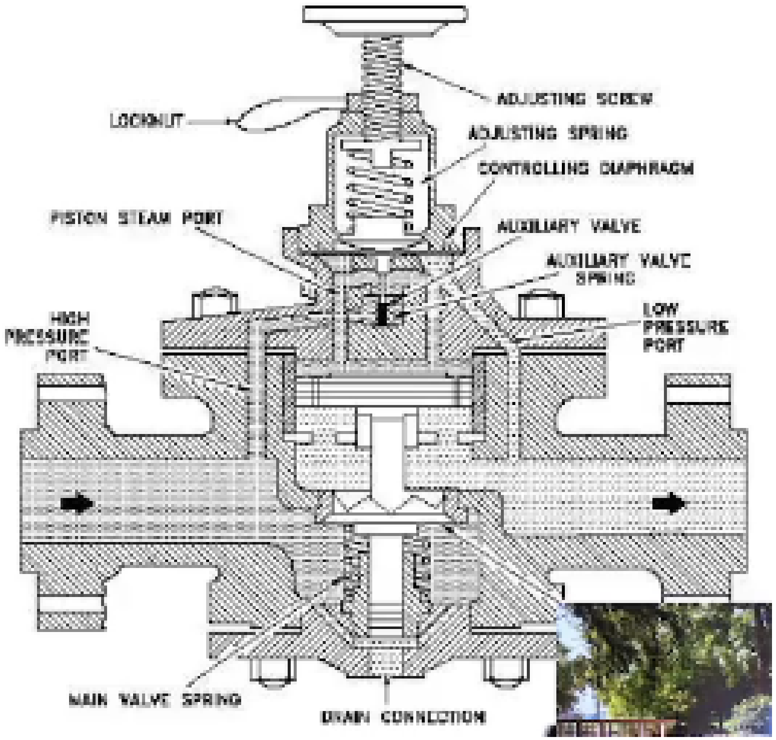
- At least one for each water resource
- Must be supervised
  - Valve in wrong position=system failure
  - Signal to central station
  - Local alarm (constantly attended)
  - Locked
  - Fenced in with weekly inspection

Post-Indicator Valves

- Top of post 32 to 40 in above ground
- Can be in pit
  - When might this be needed?
  - AHJ must give permission

Pressure-Reducing Valves

- Typically, pressure limit of 175 psi
  - Reducing valve should work at 165 psi or less
- Pressure gauges at inlet and outlet side
- Listed indicating valve on inlet side
- 0.5 in relief valve on discharge side
- Means for flow tests downstream



System Drainage

- Wet pipe system can have level pipes
- Dry pipe and pre-action systems piping pitched
- Main drain allows system to be properly drained
  - Size depends on riser size
- Auxiliary drains where sections isolated or freezing
- Cannot discharge directly to sewer

System Attachments

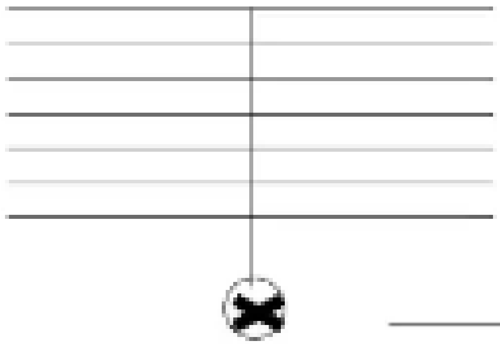
- >20 sprinklers=waterflow alarm
- Alarm bypass test connection on supply side
- Fire department connection on system side
- Alarm test connection or trip test connection on all but deluge systems

Protection Area

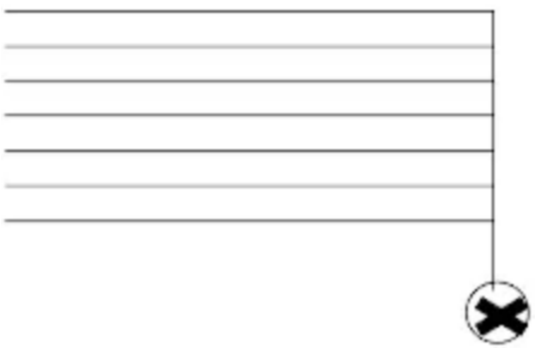
- Light:52000ft^2
- Oridinary:52000ft^2
- Extra Hazard:25000ft^2 or 40000ft^2
- Storage: 40000ft^2
- Mezzanines not included

Piping Layout

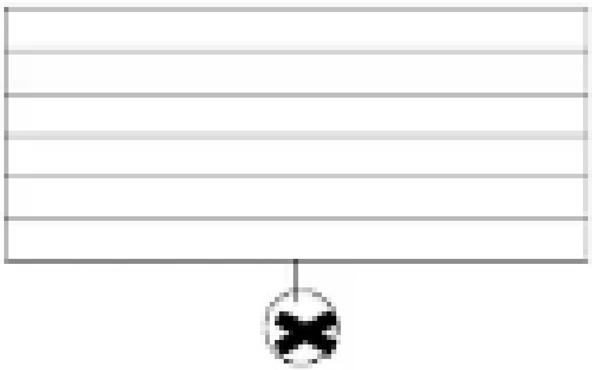
- Center feed



- Side feed



- Gridded



Multiple Buildings

- With connections, can be 1 zone
- Without connection, must be multiple zones

Sprinklers

- Upright sprinklers and pendent sprinklers in all occupancy classifications
  - Sidewall and extended coverage sprinklers limited
- Upright sprinkler with arms parallel to branch line
  - Why?
  - Shadow, shielding from the pipes
- No requirements given for pendent sprinklers
  - Why?

General Design Requirements

- NFPA 13 Chapter 17 and 18
- Identify requirements for sprinkler system components
- Select appropriate hanging and bracing designs for sprinkler system

Sprinkler Temperature

- Ordinary or intermediate temperature sprinklers standard
  - Why?
- Intermediates when
  - Expected temperature
  - Near heat source
  - Direct sun
- Other only when conditions extreme
- Change sprinklers of occupancy change requires

Sprinkler Types

- Residential sprinklers
  - Only in residences and connected areas
  - Must be fast response sprinklers
  - Wet system
- Early suppression fast response
  - Wet system
  - Ceiling slope limitations
  - Draft curtain
  - Generally ordinary temperature

Light Hazard Occupancies

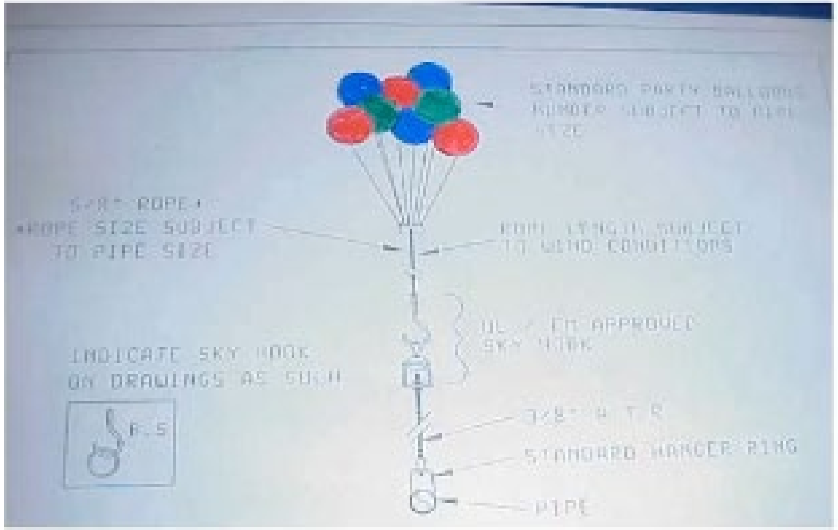
- Quick Response sprinklers in light hazard occupancies
  - Why
- Can use <K-5.6 at 7 psi

In Rack Storage

- Valves to separate system from ceiling system

Hangers

- Must be attached to something
  - Cannot be air



Hangers

- Must support 5x weight of water filled pipe +250lb
  - Why+250lb?
  - **A safety factor to ensure safety in case someone put something else there**
- Must be ferrous
  - Can you use steel
  - **Yes**

Trapeze Hangers

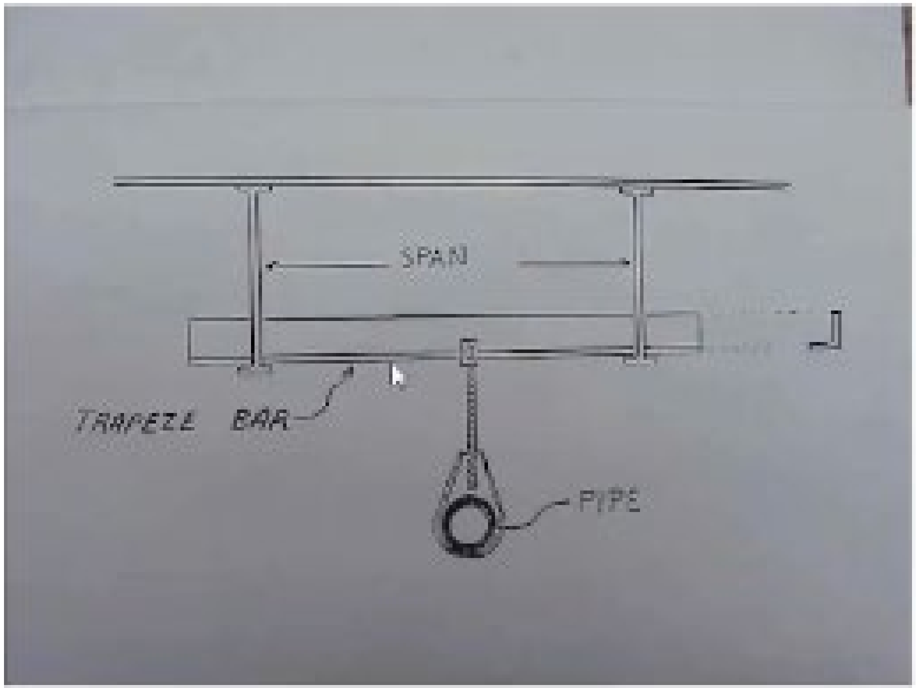
- Usually made of angle iron, but can be made of Schedule 10 or Schedule 40 pipe
- Must know types and diameter of pipe to be supported and the span of the trapeze bar
- Size of trapeze bars are determined through use of Table 17.3.1 (a) and (b)

Table 17.3.1(a) Section Modulus Required for Trapeze Members (in.^{3})

	Nominal Diameter of Pipe Being Supported – Schedule 10 Steel											
Span (ft)	1	1.25	1.5	2	2.5	3	3.5	4	5	6	8	10
1.5	0.08	0.08	0.09	0.09	0.10	0.11	0.12	0.13	0.15	0.18	0.26	0.34
2.0	0.11	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.20	0.24	0.34	0.45
2.5	0.14	0.14	0.15	0.16	0.18	0.21	0.23	0.25	0.30	0.36	0.50	0.69
3.0	0.16	0.17	0.18	0.19	0.20	0.22	0.24	0.26	0.31	0.36	0.51	0.67
3.5	0.19	0.20	0.21	0.22	0.24	0.26	0.28	0.30	0.36	0.42	0.60	0.78
4.0	0.22	0.22	0.24	0.25	0.27	0.30	0.32	0.34	0.41	0.48	0.68	0.89
4.5	0.24	0.25	0.27	0.28	0.30	0.33	0.36	0.38	0.46	0.54	0.77	1.01
5.0	0.27	0.28	0.30	0.31	0.34	0.37	0.40	0.43	0.51	0.60	0.85	1.12
5.5	0.30	0.31	0.33	0.34	0.37	0.41	0.44	0.47	0.56	0.66	0.94	1.23
6.0	0.33	0.34	0.35	0.38	0.41	0.44	0.48	0.51	0.61	0.71	1.02	1.34
6.5	0.35	0.36	0.38	0.41	0.44	0.48	0.52	0.56	0.66	0.77	1.11	1.45
7.0	0.38	0.39	0.41	0.44	0.47	0.52	0.56	0.60	0.71	0.83	1.19	1.56
7.5	0.41	0.42	0.44	0.47	0.51	0.55	0.60	0.64	0.76	0.89	1.28	1.68
8.0	0.43	0.45	0.47	0.50	0.54	0.59	0.63	0.68	0.82	0.95	1.36	1.79
8.5	0.46	0.48	0.50	0.53	0.58	0.63	0.67	0.73	0.87	1.01	1.45	1.90
9.0	0.49	0.50	0.53	0.56	0.61	0.66	0.71	0.77	0.92	1.07	1.53	2.01
9.5	0.52	0.53	0.56	0.60	0.64	0.70	0.75	0.81	0.97	1.13	1.62	2.12
10.0	0.54	0.56	0.59	0.63	0.68	0.74	0.79	0.85	1.02	1.19	1.70	2.23
10.5	0.57	0.59	0.62	0.66	0.71	0.78	0.83	0.90	1.07	1.25	1.79	2.35
11.0	0.60	0.62	0.65	0.69	0.74	0.81	0.87	0.94	1.12	1.31	1.87	2.46
11.5	0.63	0.64	0.68	0.72	0.78	0.85	0.91	0.98	1.17	1.37	1.96	2.57
12.0	0.65	0.67	0.71	0.75	0.81	0.89	0.95	1.02	1.22	1.43	2.04	2.68
12.5	0.68	0.70	0.74	0.78	0.85	0.92	0.99	1.07	1.27	1.49	2.13	2.79
13.0	0.71	0.73	0.77	0.81	0.88	0.96	1.03	1.11	1.33	1.55	2.21	2.90
13.5	0.73	0.76	0.80	0.85	0.91	1.00	1.07	1.15	1.38	1.61	2.30	3.02
14.0	0.76	0.78	0.83	0.88	0.95	1.03	1.11	1.20	1.43	1.67	2.38	3.13
14.5	0.79	0.81	0.86	0.91	0.98	1.07	1.15	1.24	1.48	1.73	2.47	3.24
15.0	0.82	0.84	0.89	0.94	1.02	1.11	1.19	1.28	1.53	1.79	2.56	3.35
15.5	0.84	0.87	0.92	0.97	1.05	1.14	1.23	1.32	1.58	1.85	2.64	3.46
16.0	0.87	0.90	0.95	1.00	1.08	1.18	1.27	1.37	1.63	1.91	2.73	3.58
	Nominal Diameter of Pipe Being Supported – Schedule 40 Steel											
Span (ft)	1	1.25	1.5	2	2.5	3	3.5	4	5	6	8	10
1.5	0.08	0.09	0.09	0.1	0.11	0.12	0.14	0.15	0.18	0.22	0.30	0.41
2.0	0.11	0.11	0.12	0.13	0.15	0.16	0.18	0.20	0.24	0.29	0.40	0.55
2.5	0.14	0.14	0.15	0.16	0.17	0.18	0.20	0.21	0.25	0.30	0.43	0.56
3.0	0.16	0.17	0.18	0.20	0.22	0.25	0.27	0.30	0.36	0.43	0.60	0.82
3.5	0.19	0.20	0.21	0.23	0.26	0.29	0.32	0.35	0.42	0.51	0.70	0.96
4.0	0.22	0.23	0.24	0.26	0.29	0.33	0.36	0.40	0.48	0.58	0.80	1.10
4.5	0.25	0.26	0.27	0.29	0.33	0.37	0.41	0.45	0.54	0.65	0.90	1.23
5.0	0.27	0.29	0.30	0.33	0.37	0.41	0.45	0.49	0.60	0.72	1.00	1.37
5.5	0.30	0.31	0.33	0.36	0.40	0.45	0.50	0.54	0.66	0.79	1.10	1.51
6.0	0.33	0.34	0.36	0.39	0.44	0.49	0.54	0.59	0.72	0.87	1.20	1.64
6.5	0.36	0.37	0.40	0.42	0.48	0.54	0.59	0.64	0.78	0.94	1.31	1.78
7.0	0.38	0.40	0.43	0.46	0.52	0.58	0.63	0.69	0.84	1.01	1.41	1.92
7.5	0.41	0.43	0.46	0.49	0.55	0.62	0.68	0.74	0.90	1.08	1.51	2.06
8.0	0.44	0.46	0.49	0.52	0.59	0.66	0.72	0.79	0.96	1.16	1.61	2.19
8.5	0.47	0.48	0.52	0.56	0.63	0.70	0.77	0.84	1.02	1.23	1.71	2.33
9.0	0.49	0.51	0.55	0.59	0.66	0.74	0.81	0.89	1.08	1.30	1.81	2.47
9.5	0.52	0.54	0.58	0.62	0.70	0.78	0.86	0.94	1.14	1.37	1.91	2.60
10.0	0.55	0.57	0.61	0.65	0.74	0.82	0.90	0.99	1.20	1.45	2.01	2.74
10.5	0.58	0.60	0.64	0.69	0.77	0.86	0.95	1.04	1.26	1.52	2.11	2.88
11.0	0.60	0.63	0.67	0.72	0.81	0.91	0.99	1.09	1.32	1.59	2.21	3.01
11.5	0.63	0.66	0.70	0.75	0.85	0.95	1.04	1.14	1.38	1.66	2.31	3.15
12.0	0.66	0.68	0.73	0.78	0.88	0.99	1.08	1.19	1.44	1.73	2.41	3.29
12.5	0.69	0.71	0.76	0.82	0.92	1.03	1.13	1.24	1.5	1.81	2.51	3.43
13.0	0.71	0.74	0.79	0.85	0.96	1.07	1.17	1.29	1.56	1.88	2.61	3.56
13.5	0.74	0.77	0.82	0.88	0.99	1.11	1.22	1.34	1.62	1.95	2.71	3.70
14.0	0.77	0.80	0.85	0.91	1.03	1.15	1.26	1.39	1.68	2.02	2.81	3.84
14.5	0.80	0.83	0.88	0.95	1.07	1.19	1.31	1.43	1.74	2.1	2.91	3.97
15.0	0.82	0.86	0.91	0.98	1.10	1.24	1.35	1.48	1.8	2.17	3.01	4.11
15.5	0.85	0.88	0.94	1.01	1.14	1.28	1.4	1.53	1.86	2.24	3.11	4.25
16.0	0.88	0.91	0.97	1.05	1.18	1.32	1.44	1.58	1.92	2.31	3.21	4.39

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Note: The table is based on a maximum bending stress of 15 ksi (103.4 MPa) and a midspan concentrated load from 15 ft (4.6 m) of water-filled pipe, plus 250 lb (114 kg).

Example



- If the span is 5 ft and 8-in, 2” Sche.10 pipe is to be supported
  - The Section Modulus is 0.38 from Table (a).
  - If angle iron is used it must be 2.5*2.5*0.25in
  - Or, 2 in Schedule 10 or 2-in Schedule 40 pipe could be used

Other Hangers

- Hanger rods
  - U-Hooks
  - Eye rods
  - Minimum sizes
- Fastened to concrete or steel
  - Minimum sizes and installation techniques
- Fastened to wood
  - Dependent on wood and type of fastener

Location of Hangers

- Must be at least one hanger per section of pipe
- Maximum spacing depends on pipe size and material
  - Examples:
    - 1i in steel pipe->12ft
    - 1 in CPVC pipe ->6ft
    - 2 in steel pipe->15ft
- Sprinklers <6ft apart =hangers <12ft apart
- Cannot be within 3 in of upright sprinkler

Location of Riser Clamps

- Riser clamps < 24 in from centerline

Seismic Protection

- Seismic zones are determined by the building codes
- Seismic rules generally apply to cross mains feed mains and risers, but not to branch line
  - Cannot obstruct sprinklers

OKLAHOMA STATE UNIVERSITY

Seismic Considerations

- Flexible couplings required for piping 2.5 in and larger
- Clearance required around piping where it penetrates walls and floors

Introduction to Hydraulic Calculations

- Selection the correct inputs for hydraulic calculations

Reasons for Hydraulic Calculations(Rationale)

- Calculated systems are the same as other systems with the important exceptions that there is no regulation of pipe sizing
  - 1 minimum
- To save money by proving that smaller pipe will do the job
  - Cuts material costs
  - Cuts labor costs

Reasons for Hydraulic Calculations(Applications)

- To provide adequate protection in situations where a pipe schedule system will not do the job
  - High-piled storage
  - Rack storage
  - Rubber tires
  - Extra Hazard Occupancies

Other Components

`

- With the exception of pip sizing, most other system components must meet same requirements as pipe schedule systems

Design Density

- Density
  - The required minimum sprinkler discharge measured in gallons per minute per square foot of floor area(gpm/ft^2)
- Examples:
  - 25 gpm/100ft^2=0.25gpm/ft^2
  - 30gpm/130ft^2=0.231 gpm/ft^2

Area of Sprinkler Operations

- Design Area
  - The most hydraulically demanding area of the building in which all of the heads are assumed to be operating
  - Based upon our knowledge that in the typical fire, only a few sprinklers operate
  - Important considerations
    - Size
    - Shape
    - Location

Calculation Steps: Step 1

- Classify the occupancy
  - Hydraulically calculated systems are more specific than pipe schedule systems
    - Only two pipe schedule exits
    - There are five density curves, one of each of the five occupancy classifications: Figure 19.3.3.1.1
    - Numerous other requirements for special hazards are given elsewhere in NFPA 13 and other standards
      - For example, there are additional density graphs for high piled and rack storage in Chapter 21 of NFPA 13

Calculation Steps: Step 2

- Size of design area
  - This will sometimes be dictated by the AHJ
  - If not dictated, designer is free to choose any size area that is on the density graph
    - Smallest areas are most economical
    - Largest areas provide best fire protection
  - Room design method
  - Special sprinklers (large drop, ESFR) have special design areas
  - NFPA 13R and 13D have special rules

Calculation Steps: Step 2

- Adjustments made for
  - Dry and pre-action systems
  - Steepy pitched roofs
  - Quick response sprinklers

Calculation Steps: Step 3

- Establish required density
  - Dictated by a standard, code or authority having jurisdiction for protection of a specific occupancy
  - Once occupancy class and size of design area have been established, required density is read from the appropriate graph
  - Required density is read at intersectrion of occupancy curve and design area line
  - Each vertical line represents an increment of 0,01 gpm/ft^2
  - Densities should be established to the thousandths (.000) place

Calculation Steps: Step 3

- Examples:
  - Ordinary Hazard Group 2, 1500 ft^2
  - Light Hazard , 2000 ft^2
  - Ordinary Hazard Group 1, 2000ft^2
  - Extra Hazard Group 2, 4000ft^2
  - Extra Hazard Group 1, 4600 ft^2

Consistency Check

`

- Total flow>= density * design area
- Examples:
  - Ordinary Hazard Group 2, 1500ft^2
  - Light Hazard, 2000ft^2

Calculation Steps: Step 4

- Establish number of sprinklers operating

$$N = \frac{A_d}{A_S}$$

  - Where
    - N=Number of sprinklers operating
    - A_d=Size of design area
    - A_s=Actual protection area per sprinkler from plan
  - N must be rounded up to next whole sprinkler

Calculation Steps: Step 4

- Examples
  - Light Hazard occupancy, design area =1500ft^2, each sprinkler protect 168ft^2
  - Extra Hazard Group 1 occupancy, design area=5200 ft^2, each sprinkler protects 80ft^2
  - Design area of 1500ft^2, each sprinkler protecting 156ft^2
  - Design area of 2900ft^2, each sprinkler protecting 130ft^2

Calculation Steps: Step 5

- Determine shape and location of design area
  - Must be rectangular with the dimension parallel to the branch lines, W, at least

$$W \geq 1.2 \times (Design\ Area)^{0.5}$$

  - Must be located at the most demanding part of the system

Introduction to Hydraulic Calculations

`

- Selection the correct inputs for hydraulic calculations

Calculation Steps: Step 6

- Determine the flow from the first sprinklers

$$Q = density \times \ area\ per\ sprinkler$$

  - Example:
    - Light hazard occupancy, design area is 1500 ft^2, each sprinkler protecting 168ft^2

Calculation Steps: Step 7

- Determine pressure need at first sprinkler

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

- Where
  - P=pressure(psi)
  - Q=Flow(gpm)
  - K=sprinkler constant(will be given)
- For standard sprinklers, minimum acceptable pressure is 7.0psi

Calculation Steps: Step 7

- Examples
  - 19.2 gpm required from sprinkler with 0.5 in orifice
  - 25 gpm required from a 17/32 in orifice

Calculation Steps: Step 8

- Determine pressure loss to second sprinkler
  - Must use Hazen-Williams formula
    - Friction loss per foot
  - Use actual inside pipe diameters
  - C-Factor depends on pipe material and system type

Calculation Steps: Step 8

- Determine pressure loss to second sprinkler
  - Must use Hazen-Williams formula
    - Friction loss per foot
  - Use actual inside pipe diameters
  - C-Factor depends on pipe material and system type

Calculation Steps: Step 9

- Calculate flow from second sprinkler

$$q = k \times P^{0.5}$$

Equivalent Length of Fittings

- Values for equivalent lengths of fittings for friction calculations comes from Table 27.2.3.1.1
  - Table values only good for C=120 and Schedule 40 steel
  - Use Table 27.2.3.2.1 if C value is different
  - Use 27.2.3.1.3.1 if different pipe
    - (Actual Diameter/Schedule 40 diameter)^4.87

Equivalent Length of Fittings

- Examples:
  - Schedule 40, C=120, 100ft of 6 in pipe with butterfly valve
  - Schedule 10, C=100, 100ft of 6 in pipe with butterfly valve

Hydraulic Calculations

- Calculate the hydraulic demand on a system

Example

- Bakery (Ordinary I)
- Room 130 ft by 80 ft
  - Design 13ft between branch lines, 10 ft along branch lines
- Figure 11.2.3.1.1
  - 0.15 gpm/ft^2, 1500ft^2
- $N=A_d/A_s=1500/130=11.5\rightarrow 12$
- $W>1.2*A_d^{0.5}=46.5ft\rightarrow 5$ heads

Step 8

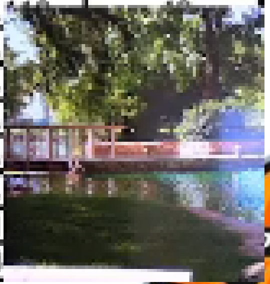
- The eighth step is to calculate the pressure lost to friction between the first and second sprinkler
  - Must use Hazen-Williams Formula
  - Use actual inside pipe diameters
  - C-Factor depends on pipe material and system type

Example

- Calculate the flow from the two heads of a branch line with
  - 1 in schedule 10 pipes

ASTM A 795 - 04

SCHEDULE 10 GRADE A										
		Outside Dia. of Black / Galvanized Tube						Weight of Tube		
SIZE		Minimum		Maximum		Wall thickness		Plain Ends		Pieces
INCH	NB (mm)	Inches	mm	Inches	mm	Inches	mm	lb./Ft.	Kg./Mtr.	per bundle
3/4"	20	1.020	25.90	1.070	27.10	0.083	2.11	0.860	1.280	120
1"	25	1.283	32.60	1.330	33.80	0.109	2.77	1.410	2.090	84
1 1/4"	32	1.630	41.40	1.680	42.60	0.109	2.77	1.810	2.690	61
1 1/2"	40	1.870	47.50	1.920	48.70	0.109	2.77	2.090	[illegible]	[illegible]
2"	50	2.350	59.70	2.400	60.90	0.109	2.77	2.640	[illegible]	[illegible]
2 1/2"	65	2.850	72.30	2.900	73.70	0.120	3.05	3.530	[illegible]	[illegible]
3"	80	3.465	88.00	3.530	89.80	0.120	3.05	4.340	[illegible]	[illegible]
31/2"	90	3.960	100.60	4.040	102.60	0.120	3.05	4.980	[illegible]	[illegible]
4"	100	4.450	113.20	4.540	115.40	0.120	3.05	5.620	[illegible]	[illegible]
5"	125	5.510	139.90	5.620	142.70	0.134	3.40	7.780	[illegible]	[illegible]
6"	150	6.560	166.60	6.690	169.98	0.134	3.40	9.300	[illegible]	[illegible]



Calculation Steps: Step 9

- Calculate flow from second sprinkler

$$q = k \times P^{0.5}$$

Example

- Flow: Q=10ft*13ft*0.15gpm/ft^2=19.5gpm
- Pressure : P=(Q/K)^2=(19.5/5.6)^2=12.13psi
  - 12.13>7

- Pressure loss: $\Delta P = 4.52 * Q^{1.85}/(C^{1.85} * d^{4.87}) * l$
  $= 4.52 * 19.5^{1.85}/(120^{1.85} * 1.097^{4.87}) * (10)$
  = 1.00 psi

- Pressure at head 2: 12.13+1.00 = 13.13 p
- Flow at head 2: $Q = k * P^{0.5} = 5.6 * 13.13^{0.5}$
  = 20.3 gpm

Step 10

- Repeat Step 8 &9 for successive sprinklers until all operating sprinkler on the first branch line are calculated

Example

- Head 3 on the example branch line
- Pressure loss:=3.74psi
- Pressure at head 3:13.13+3.74=16.87psi
- Flow at head 3: 23.0gpm

Example

- Head 4: Assume pipe size 1.25in
- Pressure loss=2.29psi
- Pressure at head 4=19.16psi
- Flow at head 4: 24.5gpm

Example

- To cross main
- 1.25 in tee:
  - Equivalent length: 6ft * (1.442/1.38)^4.87=7.38ft
- Pressure loss=5.24psi
- Pressure at cross main =24.4psi
- Flow at cross amin:87.4gpm

Step 11

- If the design area extends to the opposite side of the cross main, Steps 6 through 10 are repeated for the opposite side.
- If the pressure imbalance is more than 0.5psi, the flow adjustment is:

$$Q_{adj}=Q_L*(P_H/P_L)^{0.5}$$

Where:

Q_{adj}= Adjusted flow into low branch line

Q_L= Calculated flow in low branch line

P_H= Pressure in high branch line

P_L= Pressure in low branch line

Example

- 1 sprinkler on the other side of cross main
- 1.25 in tee equivalent length: 7.38 ft
- Pressure loss=0.33psi
- Pressure at cross main: 12.46psi
- Different at cross main: 12.46+0.5<<24.4
- Q_adj=Q_L*(P_H/P_L)^0.5=27.3gpm

Example

`

- Total flow at first riser nipple
- 87.4+27.3=114.7 gpm

- Add a 11.25in diameter 1 ft riser nipple
- Pressure loss=5.86psi
- Pressure at RN:24.4+5.86=30.26psi

Step 12

- Compute the K-factor for the first riser nipple

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

- Applies to all identical riser nipple

Example

- K=Q/P^(0.5)=20.9
- Applies to first and second riser nipples

Step 13

- Repeat steps 8 and 9 using riser nipples

Example

- From first riser nipple to second
- Pressure loss: 9.09 psi
- Pressure at RN=39.35 psi
- Flow at RN2:131.1gpm

Example

- From second riser nipple to third (1.5 in pipe)
- Pressure loss=17.60 psi
- Pressure at RN 3=56.95 psi

Example

- Need to calculate K
- Flow from each =19.5 gpm, 12.46 psi
- Pressure loss=0.8psi
- Pressure at RN=13.26 psi
- K=39/13.26 ^(0.5)=10.7
- Q=80.7gpm

Step 14

- Compute friction loss to the point of supply with compensation for elevation changes, valves, and fittings and differences in materials of underground piping

Example

- 97.5 ft to end of the building, 2 in piping
  - Elbow
- Elevation of 8 ft
  - Alarm check valve
  - Control valve
- 100 ft underground piping

Example

- Q=326.5gpm, P=56.95psi
- Main:97.5ft
- 2 in elbow:
  - Equivalent length: 3.69 ft
- Riser: 8ft
- 2 in valves (ideally from manufacturer)
  - Equivalent length:
    - $(11ft+1ft+3)*(2.157/2.067)^{(4.87)}=18.46ft$
  - Total length to base of riser
    - =127.65 ft

Example

- Pressure loss to the base of riser-87.00psi
- Underground pipe: 4in Schedule 40, C=140, elbow, tee, gate
  - Equivalent length : 28ft*1.33=37.24ft
- Total length: 100+37.24=137ft
- P=3.36psi

Example

- Pressure loss due to elevation:
  - 9 ft*0.433psi/ft=3.9psi
- Backflow preventer
  - 3.8 (from manufacturer)
- Total pressure at reference point:
  - 56.95+87.00+3.36+3.90+3.8=155.0psi

Hydraulic Calculations

- Calculate the hydraulic demand on a system

Step 15

- Add hose stream requirement (Table 19.3.3.1.2)

Table 19.3.3.1.2 Hose Stream Allowance and Water Supply Duration Requirements for Hydraulically Calculated Systems

Occupancy	Inside Hose		Total Combined Inside and Outside Hose		Duration (minutes)
	gpm	L/min	gpm	L/min	
Light hazard	0, 50, or 100	0, 189, or 379	100	379	30
Ordinary hazard	0, 50, or 100	0, 189, or 379	250	946	60–90
Extra hazard	0, 50, or 100	0, 189, or 379	500	1893	90–120

Example

- Q=326.5 +250=576gpm
  - @ 155psi

Step 16

- Compare calculated demand with water supply available
- Use hydraulic graph paper
- Might apply safety factors
    - Engineering judgment should be used

Example

- City supplies
  - Static:120psi
  - Flow:700 gpm @ 100 psi
  - ~106psi @576 gpm
  - Need a pump to increase pressure by 48 psi
    - Building owner does not want a pump (very strong water supply)

Example

- 554 gpm @ 78.67 psi
  - 576 gpm @ 154 psi
- ~108 psi @ 554 gpm

Example

- Can use Hydraulic Calculation Sheets

HYDRAULIC SPRINKLER CALCULATIONS

SHEET 1 OF 3

STEP NO.	NOZZLE IDENT. AND LOCATION	FLOW IN GPM	PIPE SIZE	PIPE FITTINGS AND DEVICES	EQUIV. PIPE LENGTH	FRICTION LOSS PSI/FOOT	PRESSURE SUMMARY	NORMAL PRESSURE	NOTES K=5.6	REF. STEP
	#1	q Q 19.5	1 1.097		L 10 F T 10	C=120 0.100	Pt 12.1 Pe Pf 1.0	Pt Pv Pn	Q=0.15*130 P=(19.5/5.6)²	
	#2	q 20.3 Q 39.8	1 1.097		L 10 F T 10	0.374	Pt 13.1 Pe Pf 3.7	Pt Pv Pn	q=5.6*(13.1)^0.5	
	#3	q 23.0 Q 62.8	1.25 1.442		L 10 F T 10	0.229	Pt 16.9 Pe Pf 2.3	Pt Pv Pn	q=5.6*(16.9)^0.5	
	#4	q 24.5 Q 87.4	1.25 1.442	(1) Tee	L 5 F 7.38 T 12.38	0.423	Pt 19.2 Pe Pf 5.2	Pt Pv Pn	P=6* (1.44/1.38)^4.87 q=5.6*(19.2)^0.5	
		q Q			L F T		Pt 24.4 Pe Pf	Pt Pv Pn		
	#5	q Q 19.5	1.25 1.442	(1) Tee	L 5 F 7.38 T 12.38	0.027	Pt 12.1 Pe Pf 0.3	Pt Pv Pn	Right Side of Cross Main	
		q Q			L F T		Pt 12.5 Pe Pf	Pt Pv Pn	Q_{adj}=19.5*(24.4/12.5)^0.5 =27.2	
	Riser Nipple	q 87.4+27.2 Q 114.7		(1) Tee	L 1 F 7.38 T 8.38	0.099	Pt 24.4 Pe Pf 5.9	Pt Pv Pn		
		q Q			L F T		Pt 30.9 Pe Pf	Pt Pv Pn	K= 114.7/30.9^0.5 =20.6	

Summary of steps

1. Occupancy
2. Design area
3. Required design density
4. Number of sprinklers in design area
5. Shape of the design area
6. Minimum flow from first sprinkler
7. Minimum pressure for first sprinkler
8. Friction loss between first and second sprinklers
9. Minimum flow from second sprinkler
10. Repeat steps 8 and 9 for branch line

Summary of steps

11. Repeat previous steps for opposite branch line
12. Calculate K factor for riser nipples
13. Repeat steps 8 and 9 for branch lines
14. Add friction loss beyond design area
15. Add hose stream demand
16. Conduct water supply analysis

Warehouses

- NFPA 13 Chapters 20 to 26
- Select the correct commodity classification
- Design system for storage applications

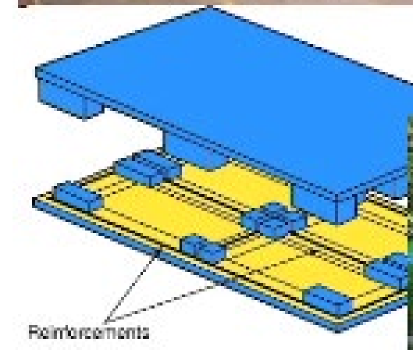
Warehouses

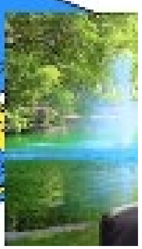
`

- Storage heights > 12 ft =no occupancy classification
- Simply warehouses
  - Commodities stored must be classified

Pallets

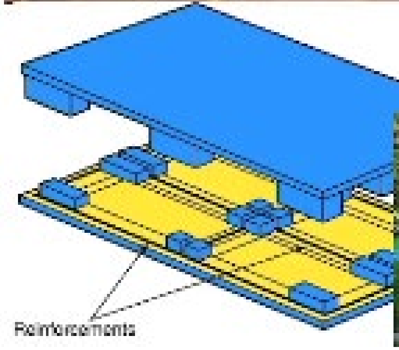
- Wood, metal, or listed
- Unreinforced plastic pallet, Class I-IV =+1 Class
- Reinforced plastic pallet, Class I-IV =+2 Classes
  - If unknown, assume reinforced

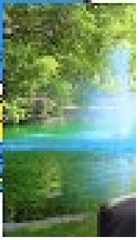




Pallets

- Wood, metal, or listed
- Unreinforced plastic pallet, Class I-IV =+1 Class
- Reinforced plastic pallet, Class I-IV =+2 Classes
  - If unknown, assume reinforced





Classifications

- Commodities
  - Class I
  - Class II
  - Class III
  - Class IV
- Plastics
  - Group A Plastic
  - Group B Plastic
  - Group C Plastic
- Roll paper storage
  - Heavy weight
  - Medium weight
  - Light weight
  - Tissue
- Tires
  - Shapes and size

Definition

- Better than occupancies in descriptions

3.3.35 Commodity. The combination of products, packing material, and container that determines commodity classification.

N **3.3.147 Pallet.**

3.3.147.1* ***Conventional Pallets.*** A material-handling aid designed to support a unit load with openings to provide access for material-handling devices. *(See Figure A.3.3.147.1.)*

3.3.147.2 ***Plastic Pallet.*** A pallet having any portion of its construction consisting of a plastic material.

3.3.147.3* ***Reinforced Plastic Pallet.*** A plastic pallet incorporating a secondary reinforcing material (such as steel or fiberglass) within the pallet.

3.3.147.4 ***Slave Pallet.*** A special pallet captive to a material-handling system. *(See Figure A.3.3.147.1.)*

3.3.147.5 ***Wood Pallet.*** A pallet constructed entirely of wood with metal fasteners.

3.3.182 Roll Paper Storage.

3.3.182.1 ***Banded Roll Paper Storage.*** Rolls provided with a circumferential steel strap [$\frac{3}{8}$ in. (10 mm) or wider] at each end of the roll.

3.3.182.2 ***Horizontal Roll Paper Storage.*** Rolls stored with the cores in the horizontal plane (on-side storage).

3.3.182.3* ***Roll Paper Storage Height.*** The maximum vertical distance above the floor at which roll paper is normally stored.

3.3.182.4 ***Vertical Roll Paper Storage.*** Rolls stored with the cores in the vertical plane (on-end storage).

3.3.182.5* ***Wrapped Roll Paper Storage.*** Rolls provided with a complete heavy kraft covering around both sides and ends.

- Need to refer to Annex A for a long list of examples

Class I Commodity

- Noncombustible
- Storage
  - Directly on wood pallets
  - Single layer corrugated cardboard
  - Shrink-wrapped or paper-rapped

Class II Commodity

- Noncombustible
- Storage
  - Slatted wooden crates
  - Solid wood boxes
  - Multiple-layered corrugated cartons

Class III Commodity

- Wood, paper, natural fibers, or Group C plastic
- Storage
    - No requirements
- Can have <5 % Group A or Group B plastics

Class IV Commodity

`

- Contains
  - Group B plastic
  - Free flowing Group A plastic
  - Weight 5% to 15% Group A plastic
  - Volume 5% to 25% Group A plastic
- Storage
  - No requirements

Mixed Commodities

- Use the most stringent requirement for all
- Unless
  - Limited in size
  - < 10 pallets in less than 40000ft^2
  - Randomly distributed and never adjacent
- Special protection for more hazardous materials

Plastics

- Group A is most hazardous, Group C least
- 5 ft is critical height for plastic storage

Group A Plastics

- Many common materials and storage crates (see Annex A)

Group B and C Plastics

- Group B
  - Cellulosic
  - Chloroprene rubber
  - Fluoroplastics
  - Natural rubber(not expanded)
  - Nylon (nylon 6, nylon6/6)
  - Silicone rubber
- Group C
  - Fluoroplastics
  - Melamine
  - Phenolic
  - PVC
  - PVDC
  - PVDF
  - PVF
  - Urea

No Annex A material for either

Rolled Paper

- Classified by weight per 1000ft^2 for 3 classes
  - Heavyweight:> 20lb
  - Mediumweight:>10lb and <20 lb
  - Lightweight:<10lb
- Tissue
  - Gauzy
  - Transparent
  - Soft, absorbent

Other factors

- Storage arrangement
  - Rack
  - Bin
  - Palletized
  - Pile
  - Stability
- Covering
  - Encapsulation
  - Wrapping

Warehouse

`

- NFPA 13 Chapters 20 to 26
- Select the correct commodity classification
- Design system for storage applications

Type of Sprinkler

- Standard spray
  - Temperature
  - K-factor
  - Design curves
- CMSA
  - K-factor
  - Number of sprinklers
- ESFR
  - K-factor
  - 12 sprinklers

CMSA and ESFR Sprinklers

- Allow in high plied storage and rack storage warehouse
- Limitations
- Strong water supply
- CMSA Sprinklers (Wet or Dry Systems)
  - Chapter 13
- ESFR Sprinklers (Wet Systems Only)
  - Chapter 14
- See relating table in **Chapter 22**

Table 22.2 CMSA Sprinkler Design Criteria for Palletized and Solid-Piled Storage of Class I Through Class IV Commodities (Encapsulated and Nonencapsulated)

Configuration	Commodity Class	Maximum Storage Height		Maximum Ceiling/ Roof Height		K-Factor/ Orientation	Type of System	Number of Design Sprinklers	Minimum Operating Pressure	
		ft	m	ft	m				psi	bar
Palletized	Class I or II	25	7.6	30	9.1	11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	10	0.7
							Dry	25	15	1.0
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				35	11	11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	15	1.0
							Dry	25	15	1.0
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		30	9.1	35	11	19.6 (280) Pendent	Wet	15	25	1.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		35	11	40	12	19.6 (280) Pendent	Wet	15	30	2.1
						25.2 (360) Pendent	Wet	15	23	1.6
	Class III	25	7.6	30	9.1	11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	15	1.0
							Dry	25	15	1.0
						19.6 (280) Pendent	Wet	15	16	1.1
						25.2 (360) Pendent	Wet	15	10	0.7
				35	11	11.2 (160) Upright	Wet	15	25	1.7
							Dry	25	25	1.7
						16.8 (240) Upright	Wet	15	15	1.0
							Dry	25	15	1.0
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		30	9.1	35	11	19.6 (280) Pendent	Wet	15	25	1.7
				40	12	25.2 (360) Pendent	Wet	15	23	1.6
		35	11	40	12	19.6 (280) Pendent	Wet	15	30	2.1
				40	12	25.2 (360) Pendent	Wet	15	23	1.6

(continues)

CMSA Advantages

- Chapter 22
- Water droplets with greater mass
- Better delivery of water into sear of fire
- Wetting combustibles to slow or suppress fire growth
- Might eliminate requirement for in-rack sprinklers

ESFR Advantages

- Chapter 23
- Water droplets delivered sooner
- Wetting combustibles to slow or suppress fire growth
- Might eliminate requirement for in-rack sprinklers

Storage Configurations

- Commodities can be stored in a variety of arrangements
  - In piles
  - On racks
  - Etc.

Multiple Row Drive

- Multiple Row Drive-in rack----two or more pallets deep
  - Fork truck drives into the rack to deposit and withdraw loads in the depth of the rack

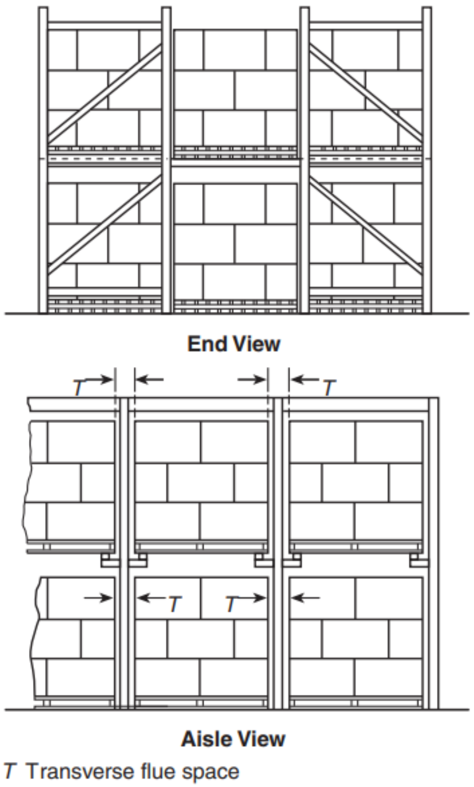
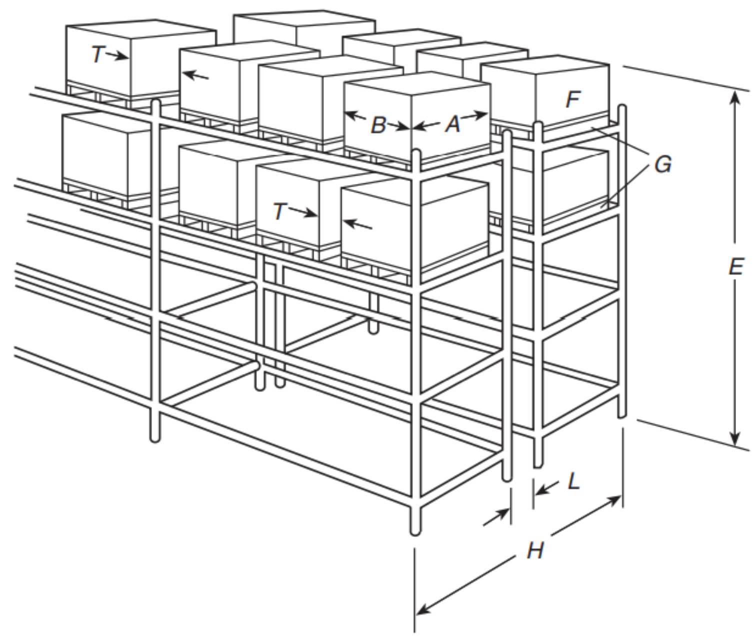


FIGURE A.3.3.171(h) Drive-In Rack — Two or More Pallets Deep (Fork Truck Drives into Rack to Deposit and Withdraw Loads in Depth of Rack).

Double Row without Shelves

- Double-row racks without sloid or slatted shelves

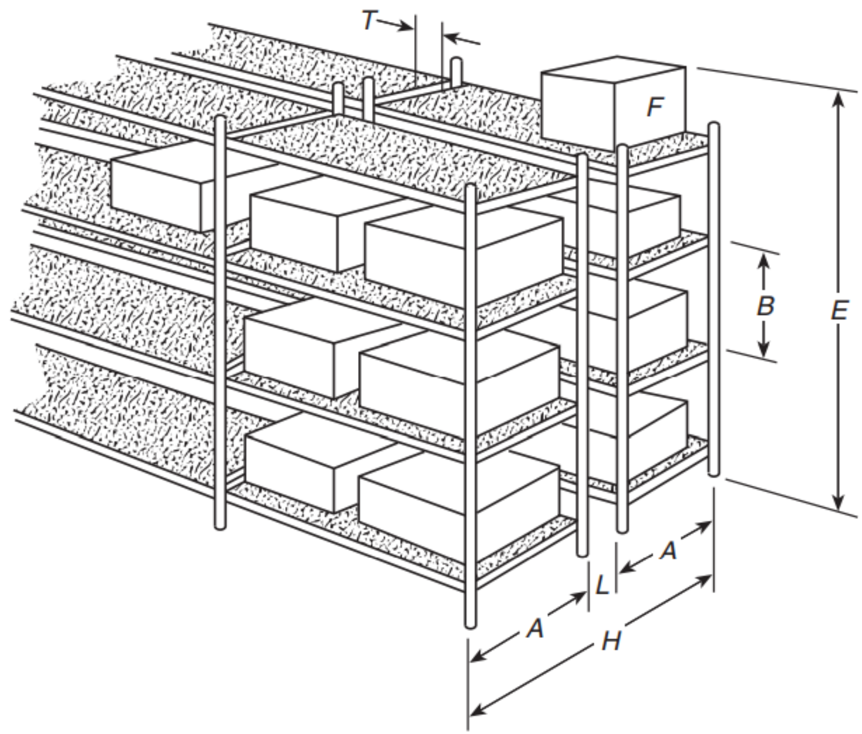


A Load depth
B Load width
E Storage height
F Commodity
G Pallet
H Rack depth
L Longitudinal flue space
T Transverse flue space

FIGURE A.3.3.171(b) Double-Row Racks Without Solid or Slatted Shelves.

Double Row with Shelves

- Double-row racks with solid or slatted shelves

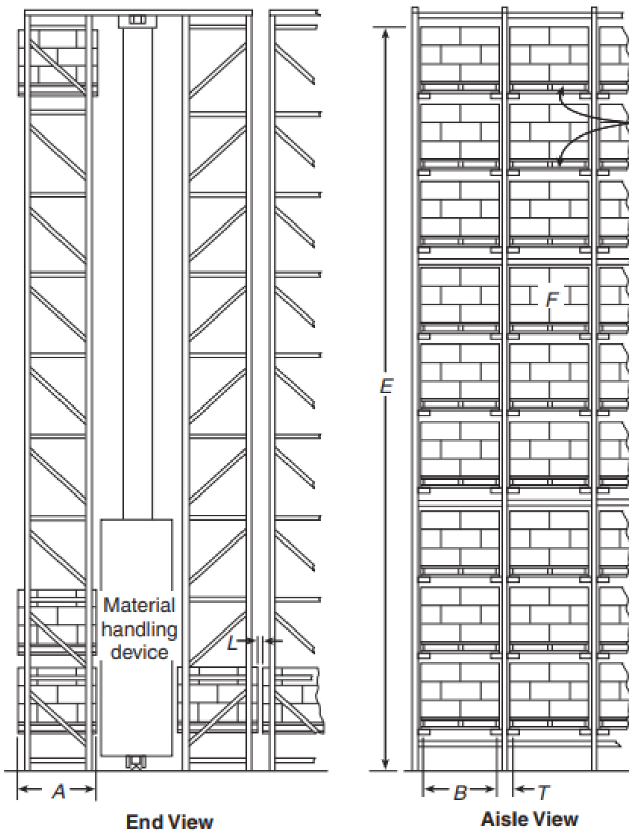


A Shelf depth
B Shelf height
E Storage height
F Commodity
H Rack depth
L Longitudinal flue space
T Transverse flue space

FIGURE A.3.3.171(c) Double-Row Racks with Solid Shelves.

Automatic Storage

- Automatic storage-type rack



A Load depth
B Load width
E Storage height
F Commodity
G Pallet
L Longitudinal flue space
T Transverse flue space

FIGURE A.3.3.171(e) Automatic Storage-Type Rack.

Reach Truck

- Multiple-row rack to be served by a reach truck

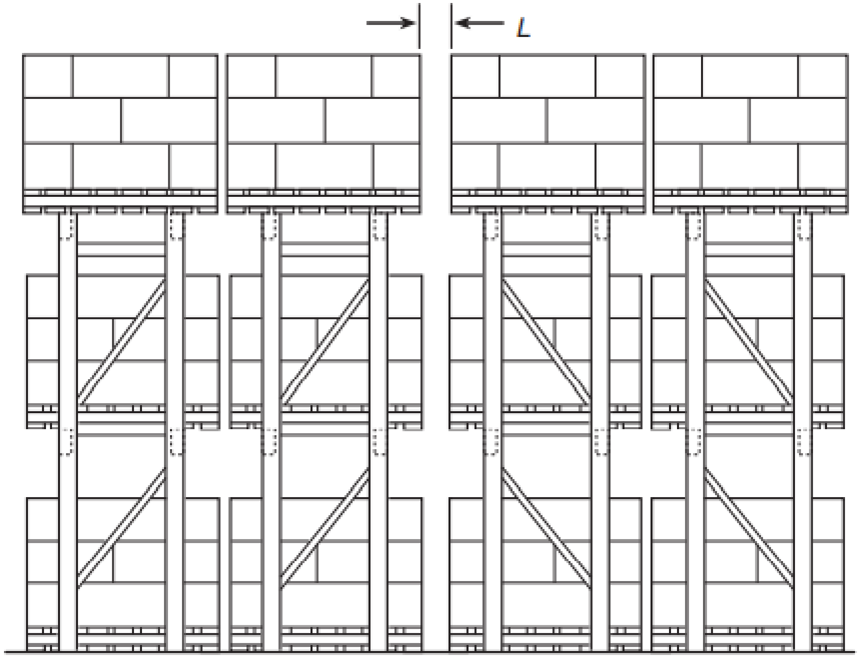


FIGURE A.3.3.171(f) Multiple-Row Rack Served by Reach Truck.

Flow-Through Pallet

`

- Multiple row flow-through pallet rack

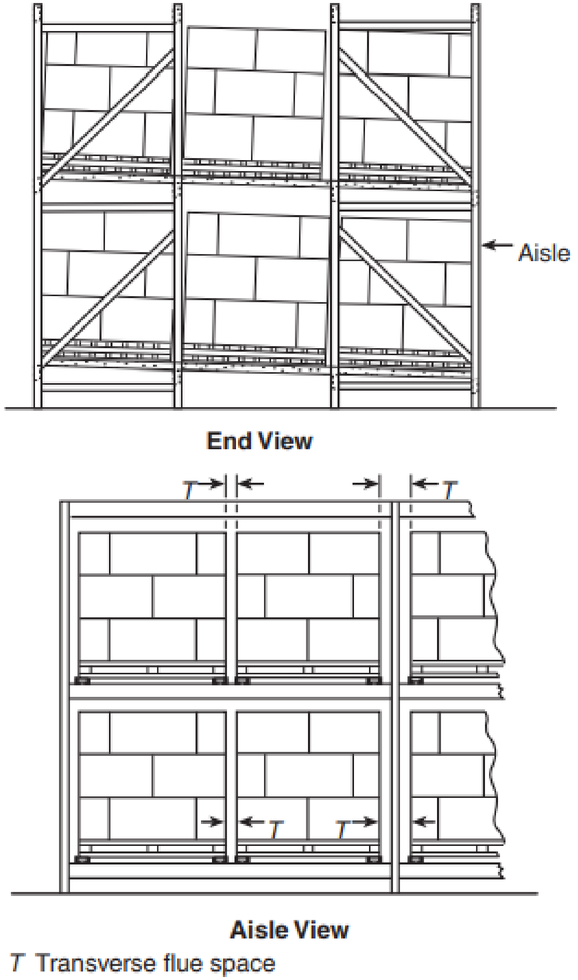


FIGURE A.3.3.171(g) Flow-Through Pallet Rack.

Movable Rack

`

- Multiple Row Movable rack

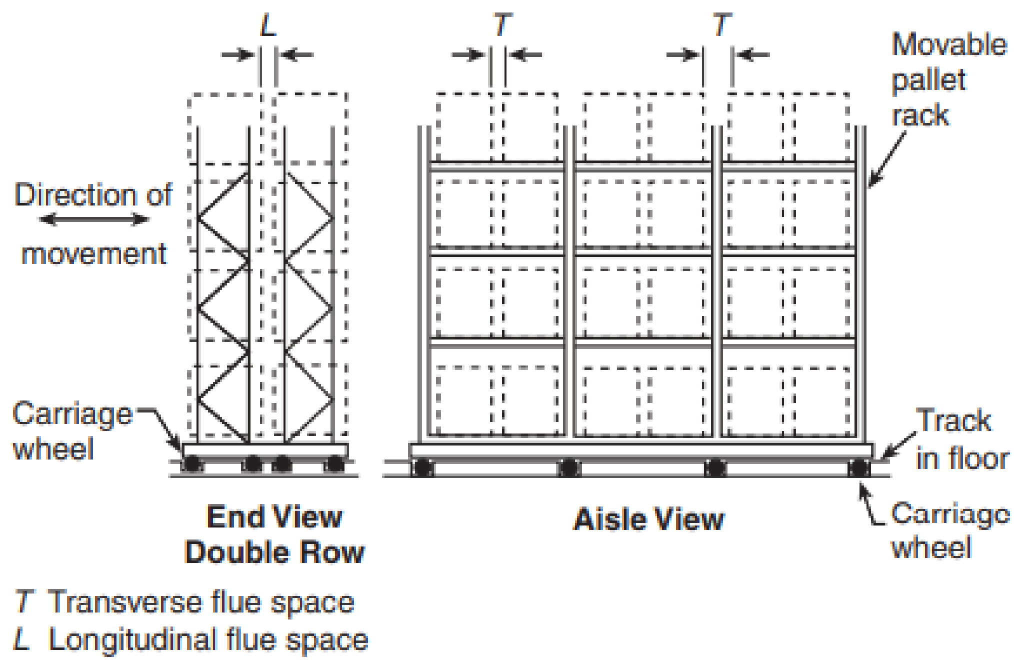


FIGURE A.3.3.171(k) Movable Rack.

Other

- Multiple row flow-through racks
- Portable racks

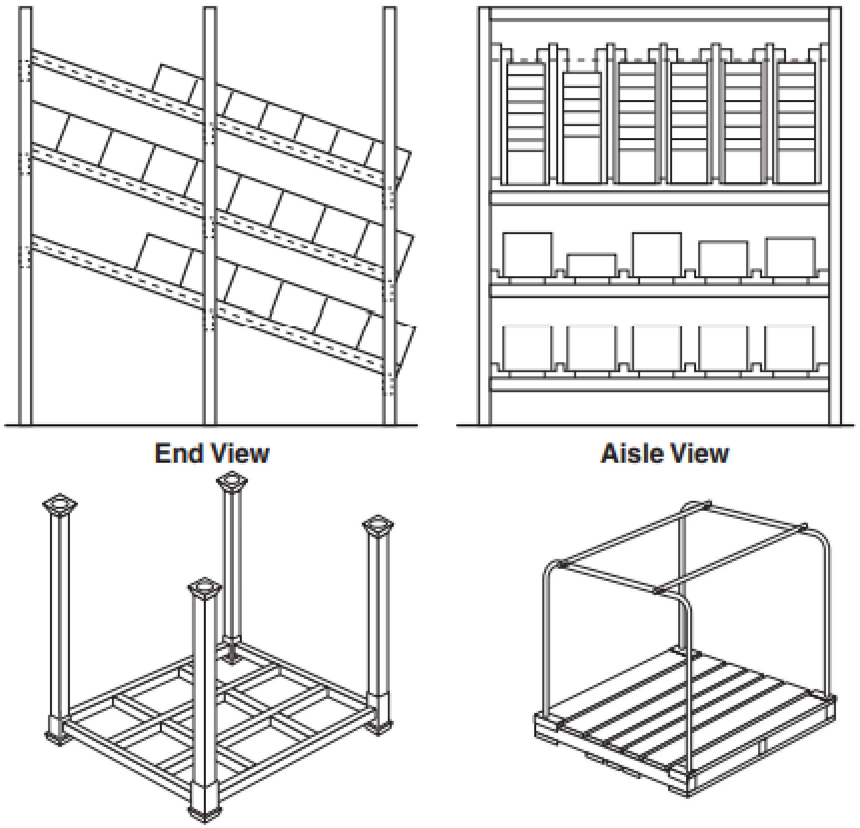


FIGURE A.3.3.171(i) Flow-Through Racks (Top) and Portable Racks (Bottom).

Tires

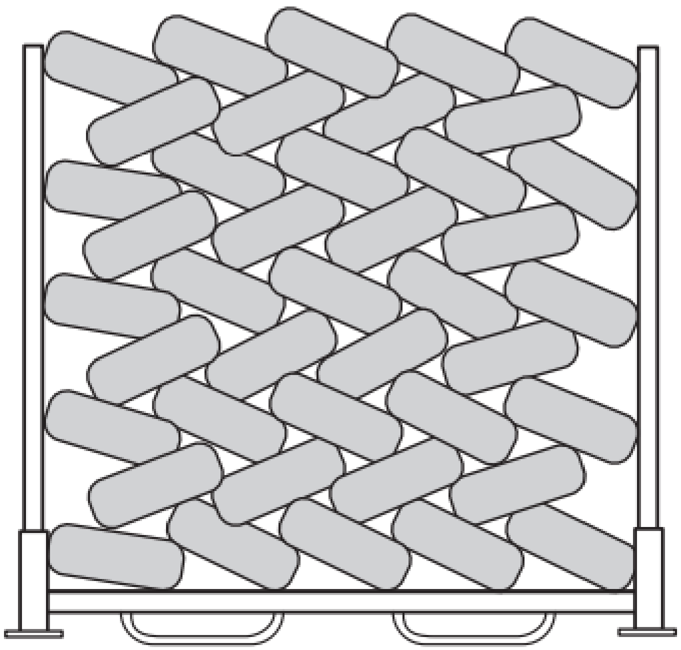


FIGURE A.3.3.185(g) Typical Laced Tire Storage.

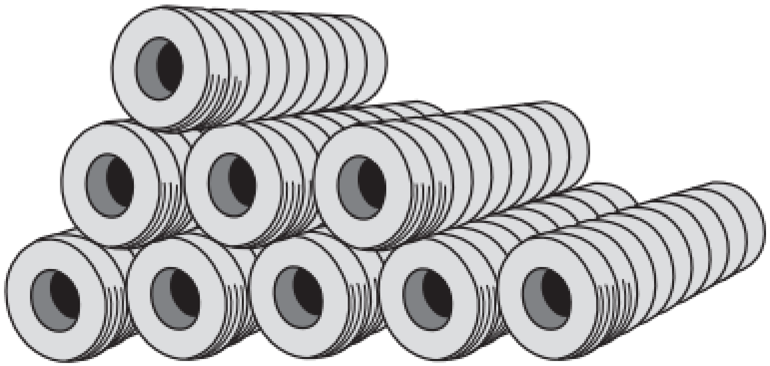


FIGURE A.3.3.185(f) On-Floor Storage; On-Tread, Normally Banded.

Tires

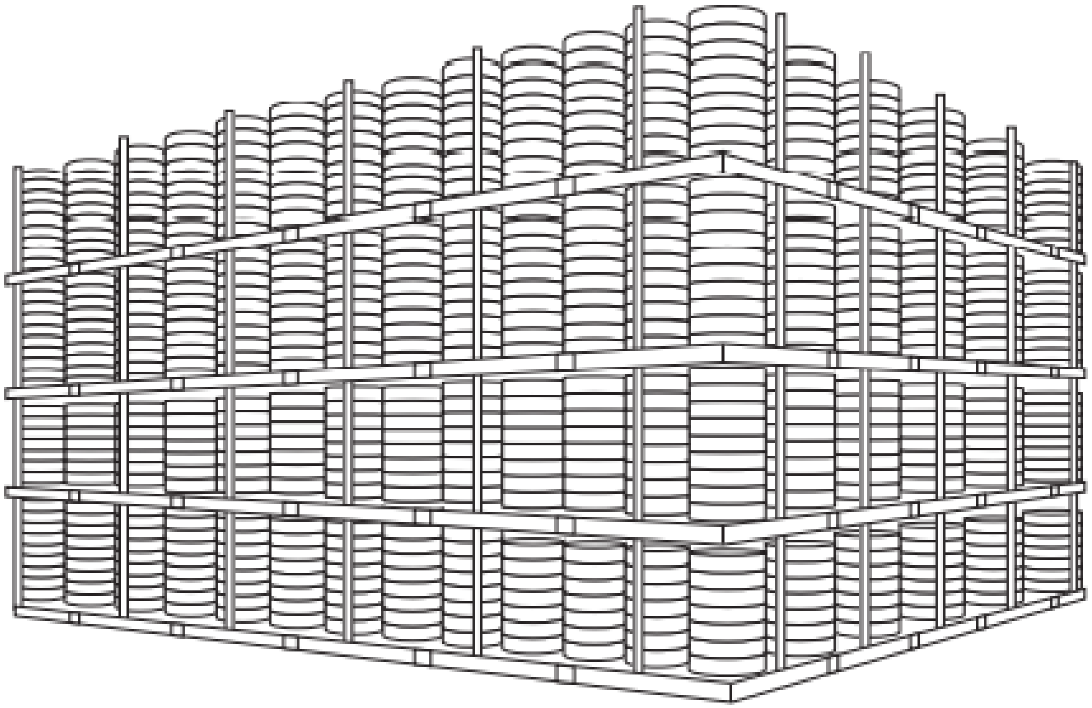
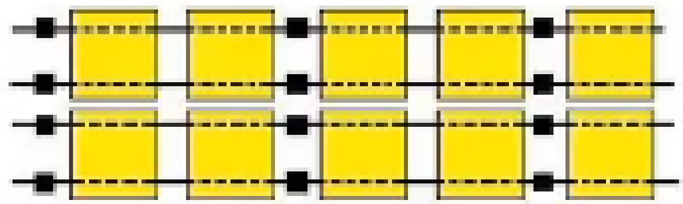
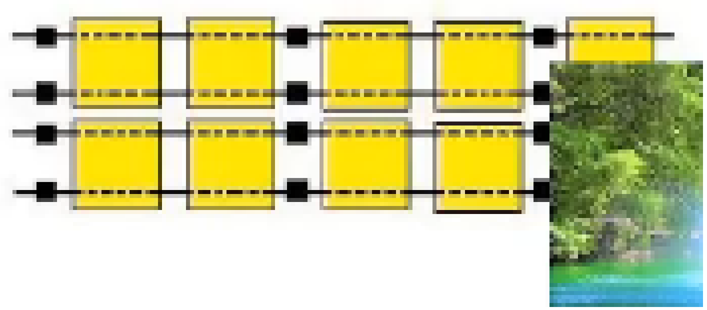


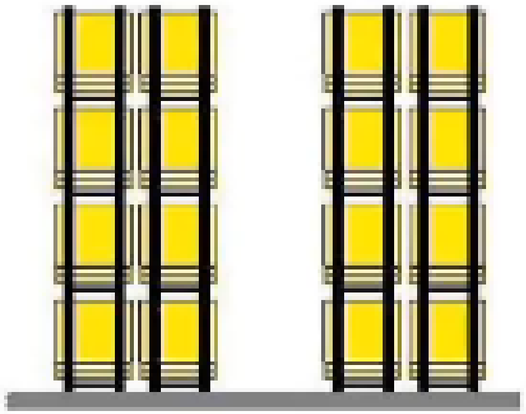
FIGURE A.3.3.185(e) Palletized Portable Tire Rack, On-Side Storage Arrangement (Banded or Unbanded).

Definitions

- Encapsulated
- Longitudinal Flue Space
- Transverse Flue Space
- Aisle Width

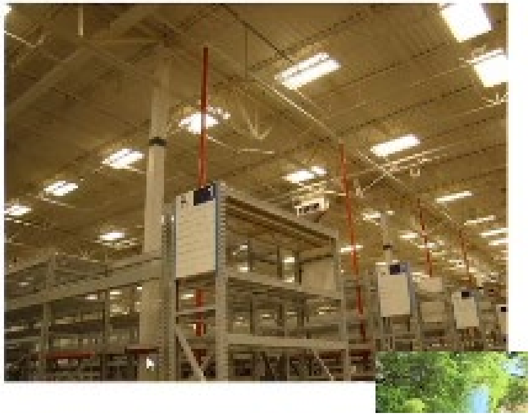






Structural Columns

- Often located within rack and flue spaces
- Results in severe fire exposure
- Sprinklers at ceiling required



In-Rack Sprinklers

- Rules for spacing and location
- Rules for number of in-rack sprinklers to hydraulically calculate
- Discharge pressure of 15 psi

Idle Pallets

- Density and design are requirements for idle pallets given in Section 20.14
- Limit Quantities
  - Height of Piles
  - Number of Stacks in Pile
- Separate
  - By Commodities
  - By Aisles

Example 1 Empty Wood Pallets

- Table 20.14.1.2(a)
- Pallets Stored 10 ft high
- 0.60 gpm/ft^2
- 3500ft^2 or 2000ft^2
  - Depends on k-factor

Table 20.14.1.2(a) Control Mode Density/Area Sprinkler Protection for Indoor Storage of Idle Wood Pallets

Type of Sprinkler	Location of Storage	Nominal K-Factor	Maximum Storage Height		Maximum Ceiling/Roof Height		Sprinkler Density		Areas of Operation	
			ft	m	ft	m	gpm/ft²	mm/min	ft²	m²
Control mode density/area	On floor	8 (115) or larger	Up to 6	Up to 1.8	20	6.1	0.20	8.2	3000*	280*
	On floor	11.2 (160) or larger	Up to 8	Up to 2.4	30	9.1	0.45	18.3	2500	230
	On floor or rack without solid shelves	11.2 (160) or larger	8 to 12	2.4 to 3.7	30	9.1	0.6	24.5	3500	325
			12 to 20	3.7 to 6.1	30	9.1	0.6	24.5	4500	420
	On floor	16.8 (240) or larger	Up to 20	Up to 6.1	30	9.1	0.6	24.5	2000	185

*The area of sprinkler operation should be permitted to be reduced to 2000 ft² (186 m²) when sprinklers having a nominal K-factor of 11.2 or larger are used or if high-temperature-rated sprinklers with a nominal K-factor of 8.0 are used.

Information needed

- Information necessary for establishing design requirements for Commodity Classes I through IV are:
- Commodity Classification
- Storage height
- Temperature rating of sprinklers
- Wet or dry system
  - Shall be wet system
  - Exception allowed for freezers

Chapter 21

- Broad range of commodities
- Tables and graphs for different types of sprinklers
  - Ordinary temperature
  - High temperature

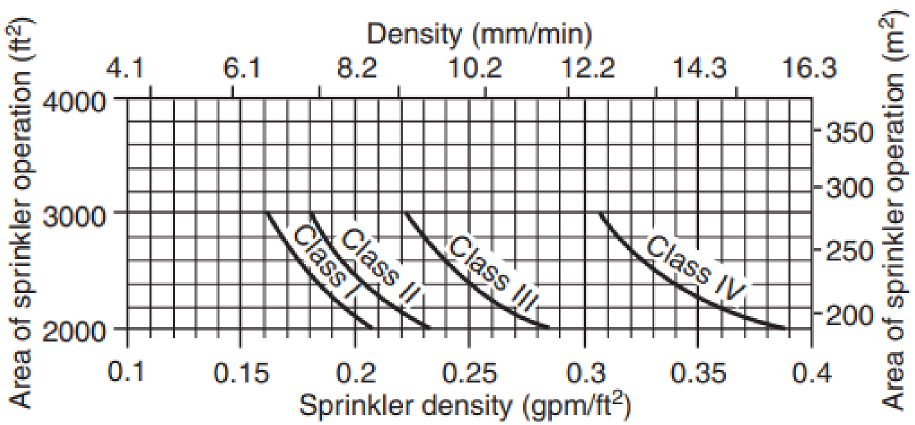


FIGURE 21.2.2.1 Sprinkler System Design Curves for 20 ft (6.1 m) High Storage — Ordinary Temperature–Rated Sprinklers.

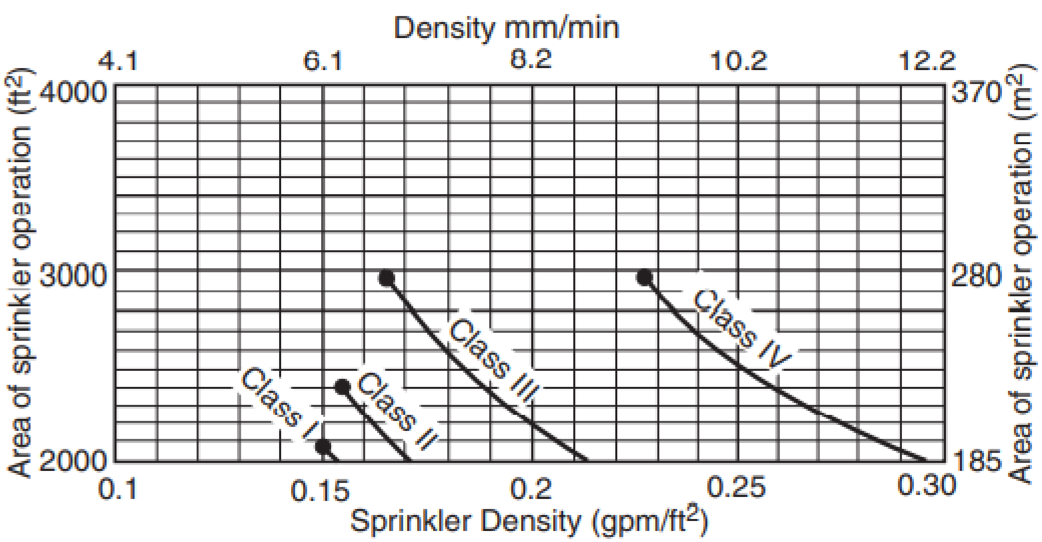


FIGURE 21.2.2.2 Sprinkler System Design Curves for 20 ft (6.1 m) High Storage — High Temperature–Rated Sprinklers.

Adjustment

- Tables based on **20ft** design height
  - Similar approach as fittings
  - Height adjusted using Figure 21.2.2.3
  - 33% reduction for **metal bin boxes and metal closed shelves**
    - Must still meet **minimums**
  - 30% increase for **dry and pre-action**

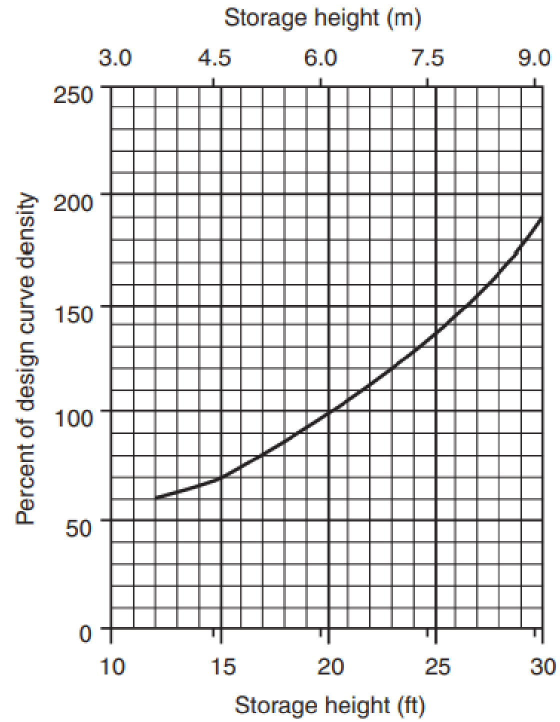


FIGURE 21.2.2.3 Ceiling Sprinkler Density vs. Storage Height.

Minimums

- The design density >= than 0.15 gpm/ft^2
- Design areas >= 2000ft^2 for wet pipe or 2600 ft^2 for dry pipe
- Density for **any** given of operation for a Class III or Class IV commodity >= than the density for the corresponding area of operation for **Ordinary Hazard** Group 2
- Sprinkler K-Factors are selected based upon Required Density
  - Per 21.1.2 through 21.1.6

Example 2 Class III Commodities

`

- Class III 20 ft storage height
- Design Area 3,000 ft^2
- Ordinary Temperature Sprinklers
- 0.233 gpm ft^2
- **Compare with /OrdGrp2@3000**

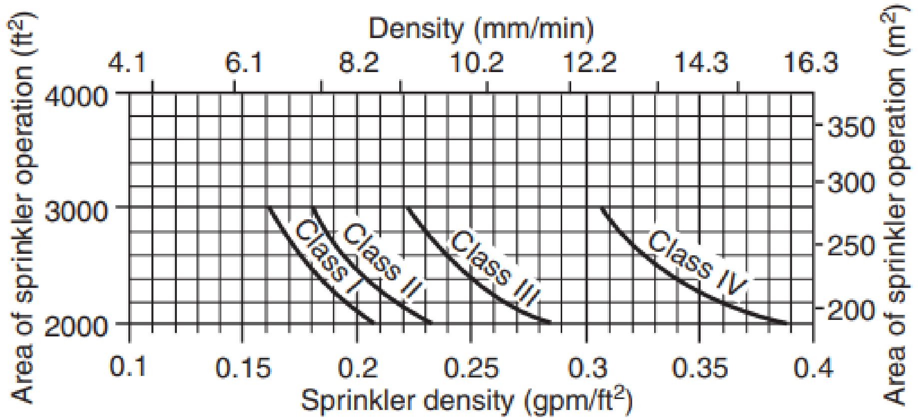


FIGURE 21.2.2.1 Sprinkler System Design Curves for 20 ft (6.1 m) High Storage — Ordinary Temperature–Rated Sprinklers.

Example 3 Class III

- Class III 17ft Storage Height
- Design Area:
  - 3000ft^2
  - Ordinary Temperature
- Figure 21.2.2.1:
  - 0.233 gpm/ft^2
- Figure 21.2.2.4
  - 80% Adjustment
- 0.233*0.8=0.178 gpm/ft^2
- 3000ft^2 Design Area

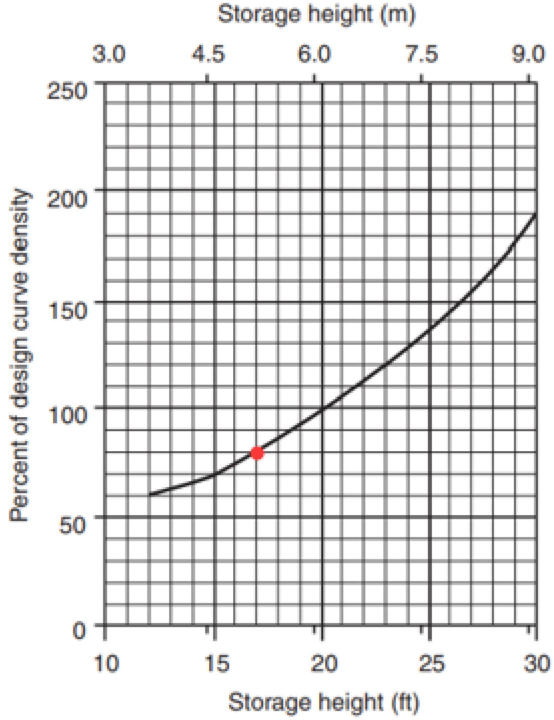


FIGURE 21.2.2.3 Ceiling Sprinkler Density vs. Storage Height.

Example 4

- What Design Area was used for a:
  - Class IV commodity
  - 20ft Storage Height
  - High Temperature Sprinklers
  - Provided with a Density of 0.260 gpm/ft^2
- 2375ft^2

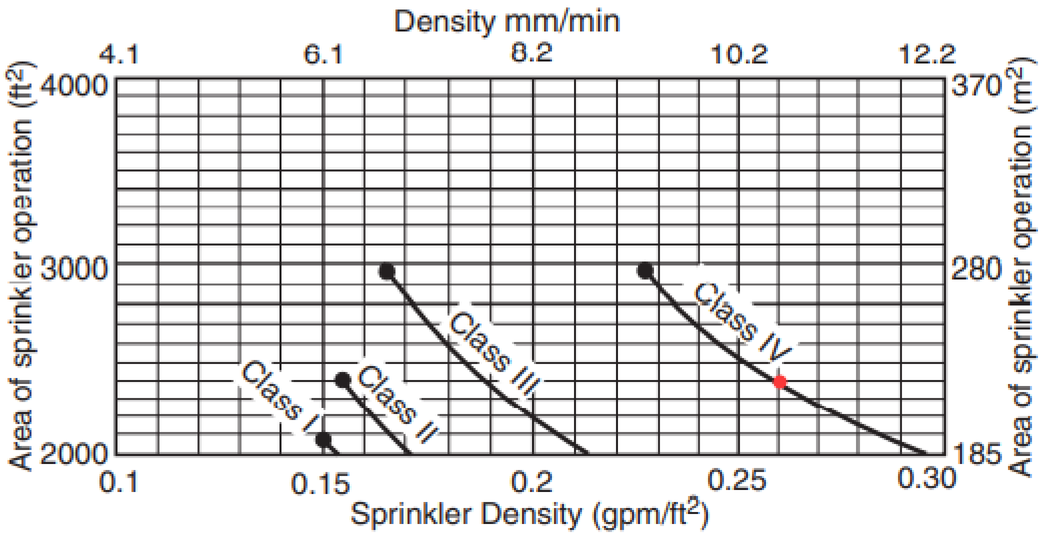


FIGURE 21.2.2.2 Sprinkler System Design Curves for 20 ft (6.1 m) High Storage — High Temperature–Rated Sprinklers.

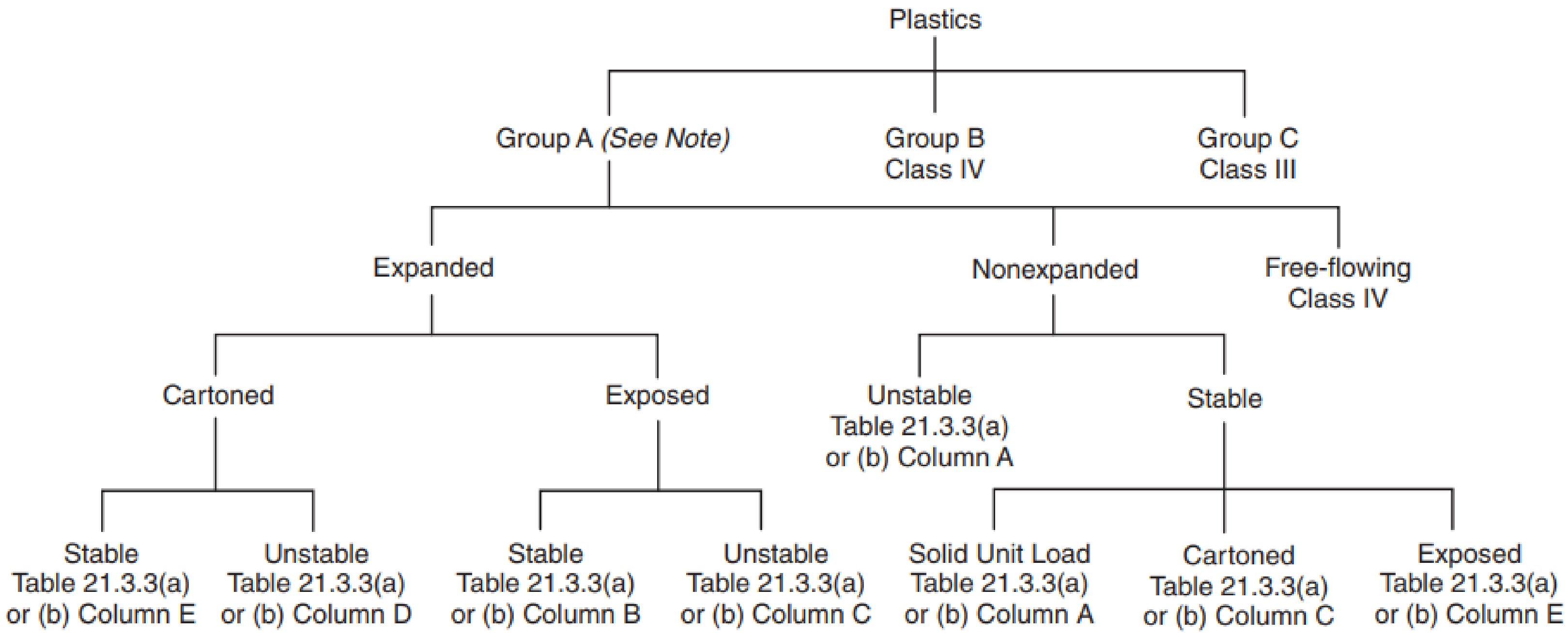
Plastics and Rubber Definitions

- Definitions (NFPA 13 Chapter 3)
  - Expanded Plastics
  - Cartoned
  - Free-Flowing Plastics
  - Exposed
  - Stable / Unstable Piles

Selection of System

- Storage over 5 ft
- Minimum area 2500ft^2
- Hose stream must be provided
- Use decision tree for exact characteristics

Selection of System



Note: Cartons that contain Group A plastic material are permitted to be treated as Class IV commodities under either of the following conditions:

(1) There are multiple layers of corrugation or equivalent outer material that would significantly delay fire involvement of the Group A plastic.

(2) The amount and arrangement of Group A plastic material within a carton with a single layer of corrugation would not be expected to significantly increase the fire hazard.

FIGURE 21.3.1 Decision Tree.

Selection of System

- Density Selected from Table 21.3.3(a)
- Design Area per Section 21.3.3.1
- Interpolation Allowed per 21.3.3.2

Table 21.3.3(a) Design Densities for Palletized, Solid-Piled, Bin Box, or Shelf Storage of Group A Plastic Commodities (U.S. Customary Units)

Maximum Storage Height (ft)	Roof/Ceiling Height (ft)	Density (gpm/ft^2)				
		A	B	C	D	E
>5 to ≤12	Up to 15	0.2	EH2	0.3	EH1	EH2
	>15 to 20	0.3	0.6	0.5	EH2	EH2
	>20 to 32	0.4	0.8	0.6	0.45	0.7
15	Up to 20	0.3	0.6	0.5	0.4	0.45
	>20 to 25	0.4	0.8	0.6	0.45	0.7
	>25 to 35	0.45	0.9	0.7	0.55	0.85
20	Up to 25	0.4	0.8	0.6	0.45	0.7
	>25 to 30	0.45	0.9	0.7	0.55	0.85
	>30 to 35	0.6	1.2	0.85	0.7	1.1
25	Up to 30	0.45	0.9	0.7	0.55	0.85
	>30 to 35	0.6	1.2	0.85	0.7	1.1

Notes:
(1) Minimum clearance between sprinkler deflector and top of storage shall be maintained as required.
(2) Column designations correspond to the configuration of plastics storage as follows:
A: (1) Nonexpanded, unstable
(2) Nonexpanded, stable, solid unit load
B: Expanded, exposed, stable
C: (1) Expanded, exposed, unstable
(2) Nonexpanded, stable, cartoned
D: Expanded, cartoned, unstable
E: (1) Expanded, cartoned, stable
(2) Nonexpanded, stable, exposed
(3) EH1 = Density required by Extra Hazard Group 1 design curve and 19.3.3.1.1
EH2 = Density required by Extra Hazard Group 2 design curve and 19.3.3.1.1
(4) Roof/ceiling height >35 ft is not permitted.

Example 5

- Determine density and design area
  - Expanded polyurethane → A (Table A 20.4(b))
  - Cartoned
  - Stable piles
  - Open array
  - Storage height 20 ft
  - Roof height 25 ft

0.7gpm/ft^2
2000ft^2

Example 6

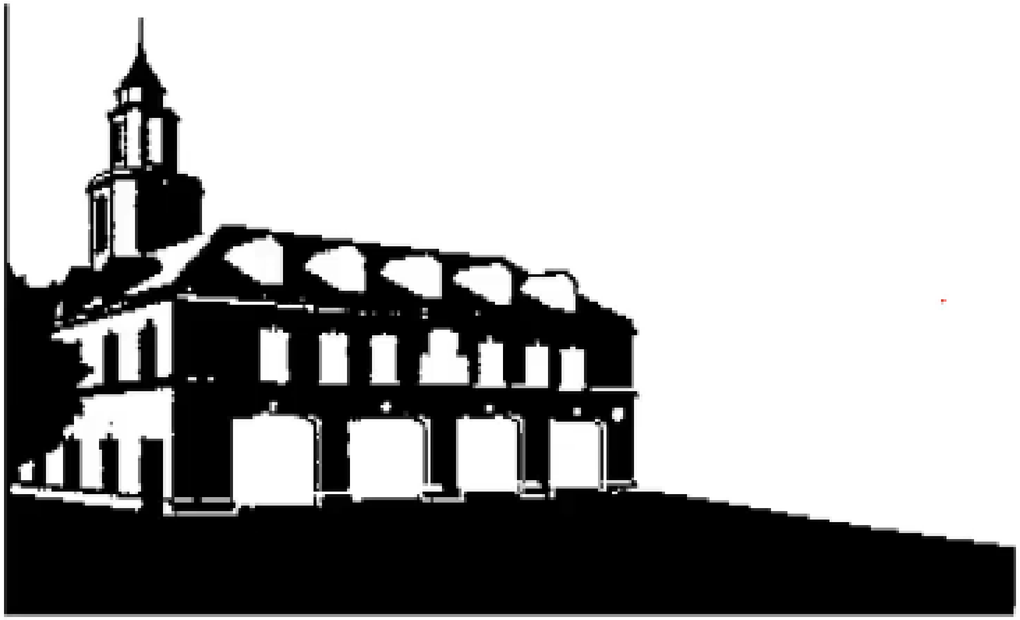
- Determine density and design area
  - Expanded polystyrenene plastic
  - Uncartoned
  - Closed array
  - Stable piles
  - Storage height 17ft
  - Roof height 20ft

0.68gpm/ft^2
2000ft^2

Uncartoned Styrofoam

- Group A, Expanded, Exposed, Stable
- Closed Array, Dry Pipe Sprinkler System
- Storage Height 18 feet, Building Height 35 ft
- 0.9 at 15 ft storage height
- 1.2 at 20 ft storage height
- 1.2-[(1.2-0.9)((20-18)/(20-15))]=1.08
- 2000*1.3=2600ft^2 (Dry System)

Review and Evaluation of Automatic Sprinkler System Plans and Designs



INTRODUCTION, OBJECTIVES & GENERAL CONCEPTS

1. Course Objectives Are to Learn
   1. What makes up a good sprinkler system
   2. How to know a good one when you see one
2. What Constitutes a Good Sprinkler System
   1. A system that can be expected to control fire

INTRODUCTION, OBJECTIVES & GENERAL CONCEPTS

`

1. How Do You Know If It Will Control Fire?
   1. Design and installation in accordance with recognized standards
   2. NFPA 13
      1. The most widely recognized
      2. A “Minimum” standard
      3. NOT the only one
      4. NFPA 20 Fire Pump,
      5. NFPA 13D/R, Residential Sprinklers
      6. FM Data Sheets
      7. IRI and other insurance requirements
      8. NFPA 30
      9. etc

INTRODUCTION, OBJECTIVES & GENERAL CONCEPTS

`

1. How Do You Know If It Will Control Fire?
   1. Design and installation in accordance with recognized standards
   2. NFPA 13
      1. The most widely recognized
      2. A “Minimum” standard
      3. NOT the only one

         NFPA 20 Fire Pump,

         NFPA 13D/R, Residential Sprinklers

         FM Data Sheets

         IRI and other insurance requirements

         NFPA 30

         etc

INTRODUCTION, OBJECTIVES & GENERAL CONCEPTS

1. Noncompliance with recognized standards does not necessarily mean that a system is ***worthless***, but it can be difficult to prove its ***worth*** and ***value***
2. Most authorities having jurisdiction use NFPA standards as the measure of acceptability
3. Therefore, this course will look at design in compliance with NFPA 13

INTRODUCTION, OBJECTIVES & GENERAL CONCEPTS

1. Design Evaluation
   1. Sprinkler system design evaluation can be broken down into four basic parts
      1. Hazard Definition
      2. Evaluation of Water Delivery System **(Piping)**
      3. Water Supply Evaluation **(Hydraulic)**
      4. Evaluation of Structural and Mechanical Integrity
   2. Other areas are important, but these four are most important with respect to fire control

INTRODUCTION, OBJECTIVES & GENERAL CONCEPTS

1. Two sprinkler design techniques can be identified
   1. Pipe Schedule Design
   2. Hydraulically Calculated Design
2. Both types of designs can be evaluated by addressing the four basic parts

PLAN SUBMITTAL REQUIREMENTS OF NFPA 13

1. NFPA 13 contains specific requirements for contractors relative to what they must submit on plans
2. Requirements for all Plans
    1. See Chapter 27, Section 27.1
        1. Every item cannot apply to every plan
        2. Some requirements are insignificant if not ridiculous
        3. The requirements of Chapter 27 are as real as those other any other chapter
    2. Plan reviewers should not have to be detectives
    3. Plan reviewers should feel free to reject any plans not substantially complying with Chapter 27

PLAN SUBMITTAL REQUIREMENTS OF NFPA 13

`

1. Requirements for Hydraulically Designed Systems
    1. See Chapter 27, Section 27.2 and 27.3
    2. Note particularly
        1. Requirement for summary sheet
        2. Requirement for water supply graphs
        3. Requirements for grid diagrams

DEFINING THE OCCUPANCY

`

1. Defining the Occupancy or Hazard must be the first step in System Design or Plan Review
   1. A system design must match occupancy for high probability of system success
   2. Wrong occupancy classification or charge in occupancy may prove to be cause of system failure

TIP

Everything in the design
is dependent upon properly
classifying the hazard.

OKLAHOMA STATE UNIVERSITY

PLAN SUBMITTAL REQUIREMENTS OF NFPA 13

1. NFPA 13 Defines Occupancies and Commodity Classifications in Chapter **4, 20**
   1. Currently five occupancy classes
   2. Class I-IV Commodities
   3. Plastics Groups A, B, C

SPRINKLER SPACING & LOCATION

1. Light Hazard
    1. Non Combustible Construction: 225 sq. ft
    2. Combustible Obstructed 168 sq.ft
    3. Pipe schedule: 200 sq.ft
    4. **Note other exceptions**

SPRINKLER SPACING & LOCATION

Ordinary Hazard

All Type Construction ---130 sq.ft

Extra hazard

Hydraulically designed 100 ft^2

Pipe schedule 90 ft^2

Density more/less than 0.25 gpm/ft^2

SPRINKLER SPACING & LOCATION

`

Note requirements for ESFR and other special sprinklers in sections

11 Extended Coverage(Sidewall)
12 Residential
13 CMSA (Large Drop)
14 ESFR
15 Special Situations
25.3 In-Rack

GENERAL DESIGN CONSIDERATIONS

Following items apply to most systems

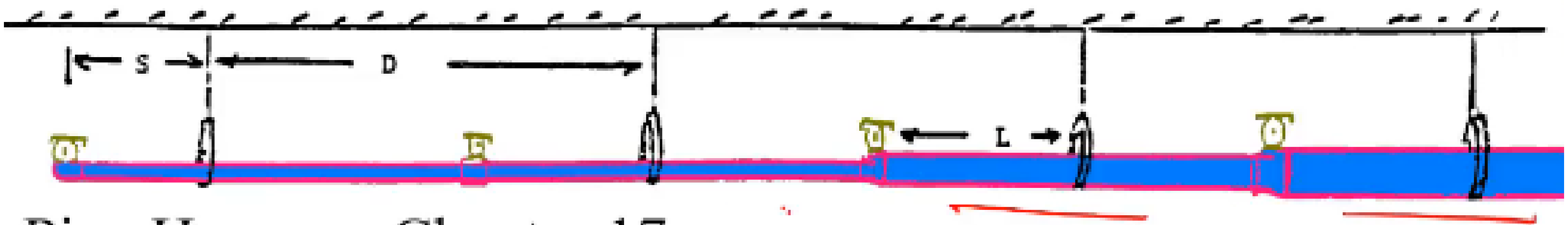
Proper materials for piping and valves

- Note lists in Chapter 7
- UL or FM listing is the key
- Underground pipe addressed in Chapter 6

GENERAL DESIGN CONSIDERATIONS

Proper Types and Placement of Valve
Must be indicating types
Only one generally required
Must be supervised
Individual Floor Control Valves are now required

GENERAL DESIGN CONSIDERATIONS



Pipe Hangers Chapter 17

D = Maximum Distance Between Hangers
S = Maximum Unsupported Length Past Last Hanger
L = Minimum Distance Allowed Between Hanger and Centerline of Upright Sprinkler

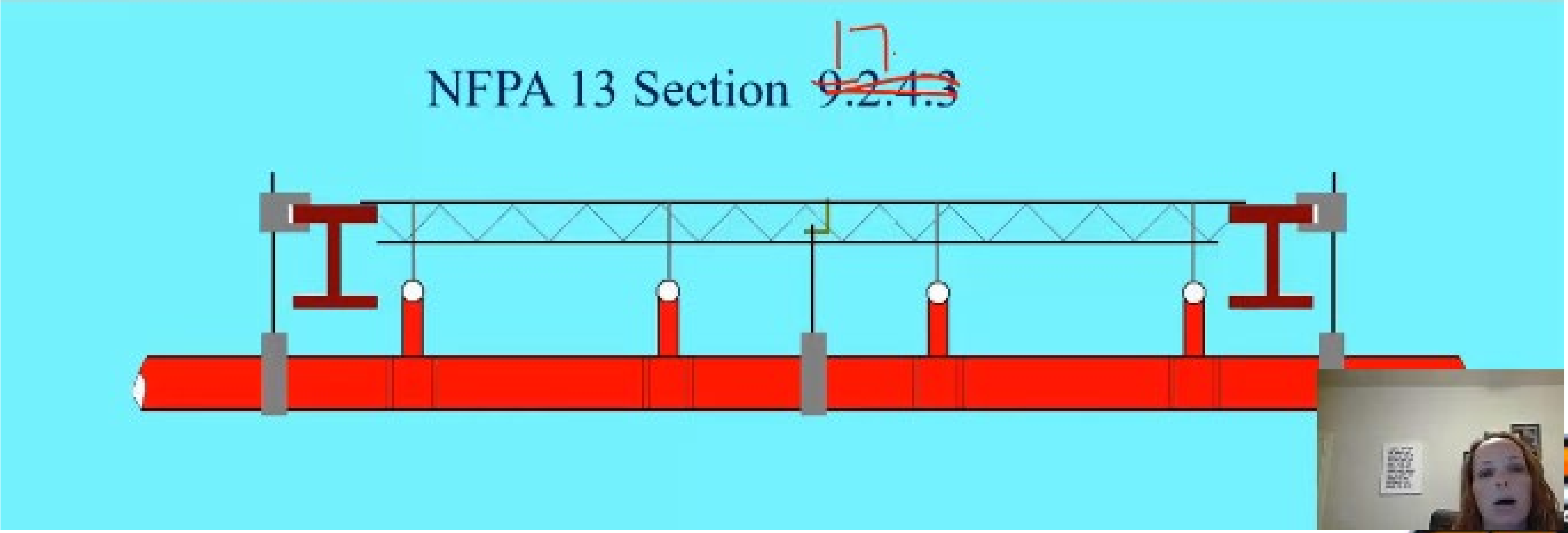
D = 12' for 1" & 1 ¼" Pipe
= 15' for 1 ½" And Larger

S = 36" for 1" Pipe
= 48" for 1 ¼" Pipe
= 60" for 1 ½" And Larger

L = 3" for Upright Sprinklers

GENERAL DESIGN CONSIDERATIONS

ALSO, Branchline: One Hanger for each length of pipe, unless sprinklers less than 6ft apart
Cross Mains and Feed Mains,



GENERAL DESIGN CONSIDERATIONS

`

SEISMIC Protection (18)
Generally required for cross mains, feed mains and risers, not for branch lines
Flexible couplings required as indicated in

Clearance required where pipes penetrate walls, floors, etc.
Note Exceptions

GENERAL DESIGN CONSIDERATIONS

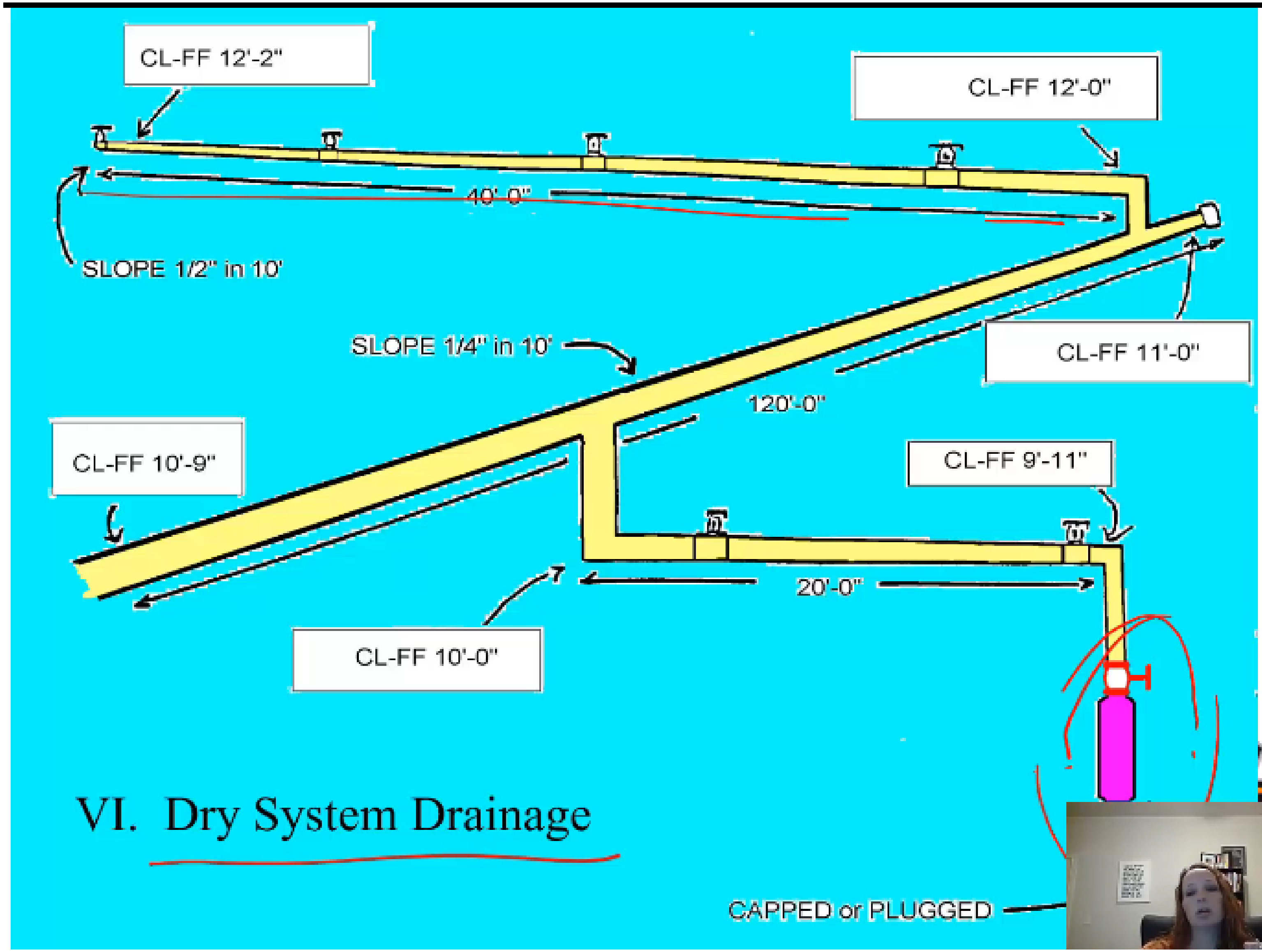
Sway bracing

Longitudinal branching 80 ft on center for cross mains and feed mains

Top of risers, four way sway brace

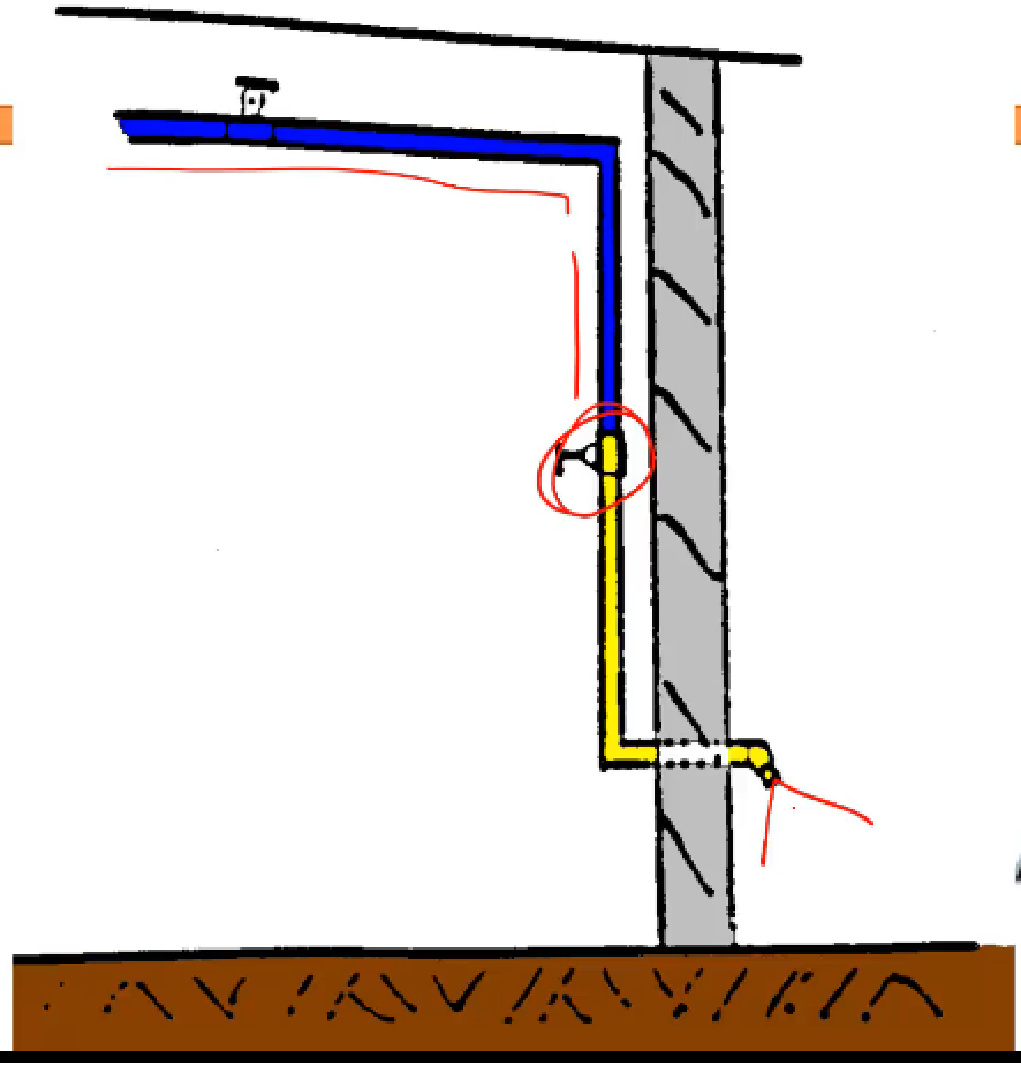
Lateral bracing 40 ft on center for cross mains, feed mains and branch lines

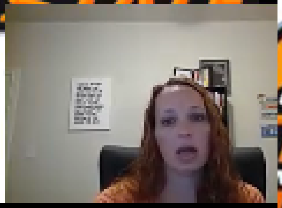
Dimensions of braces in accordance with tables

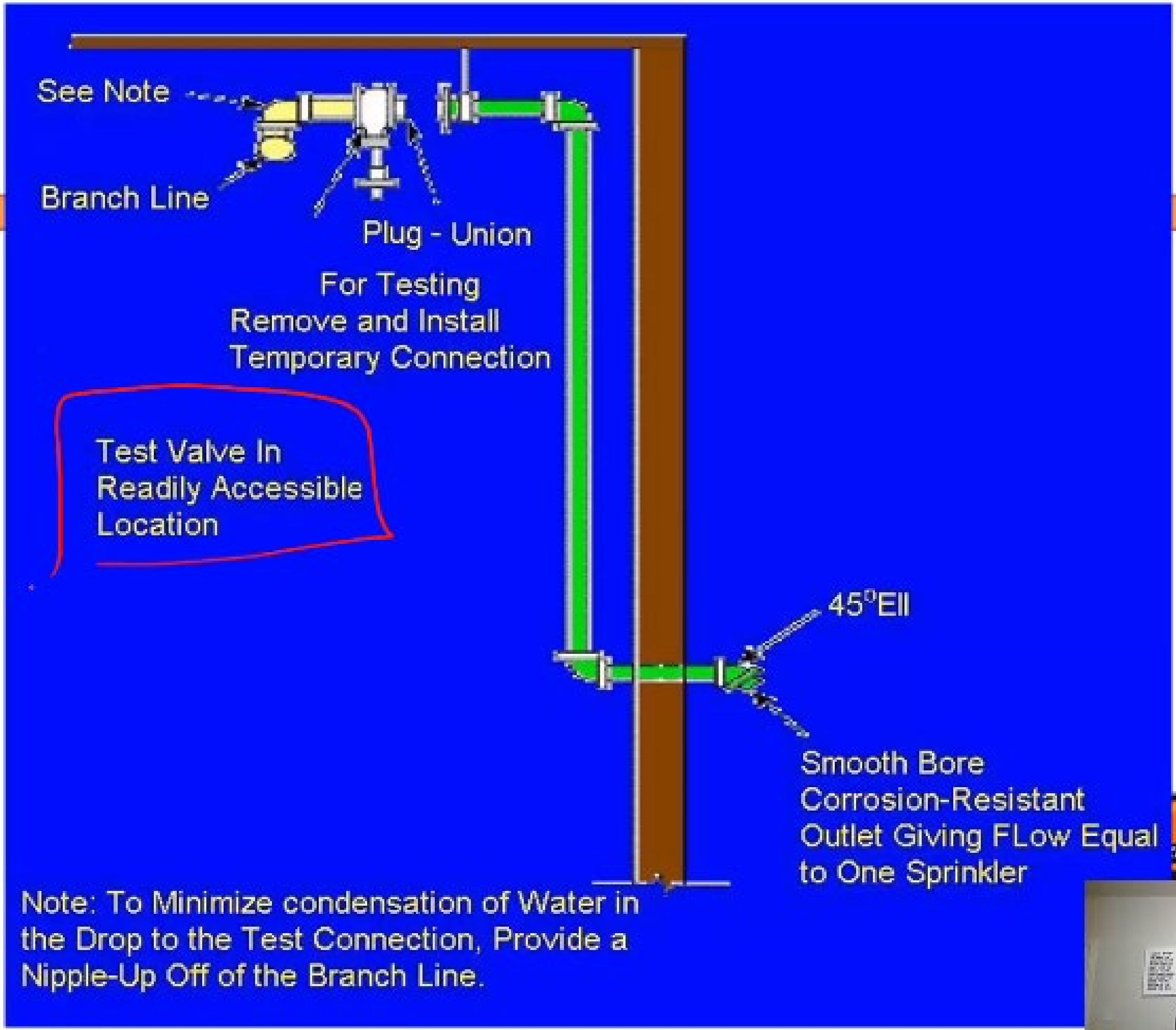


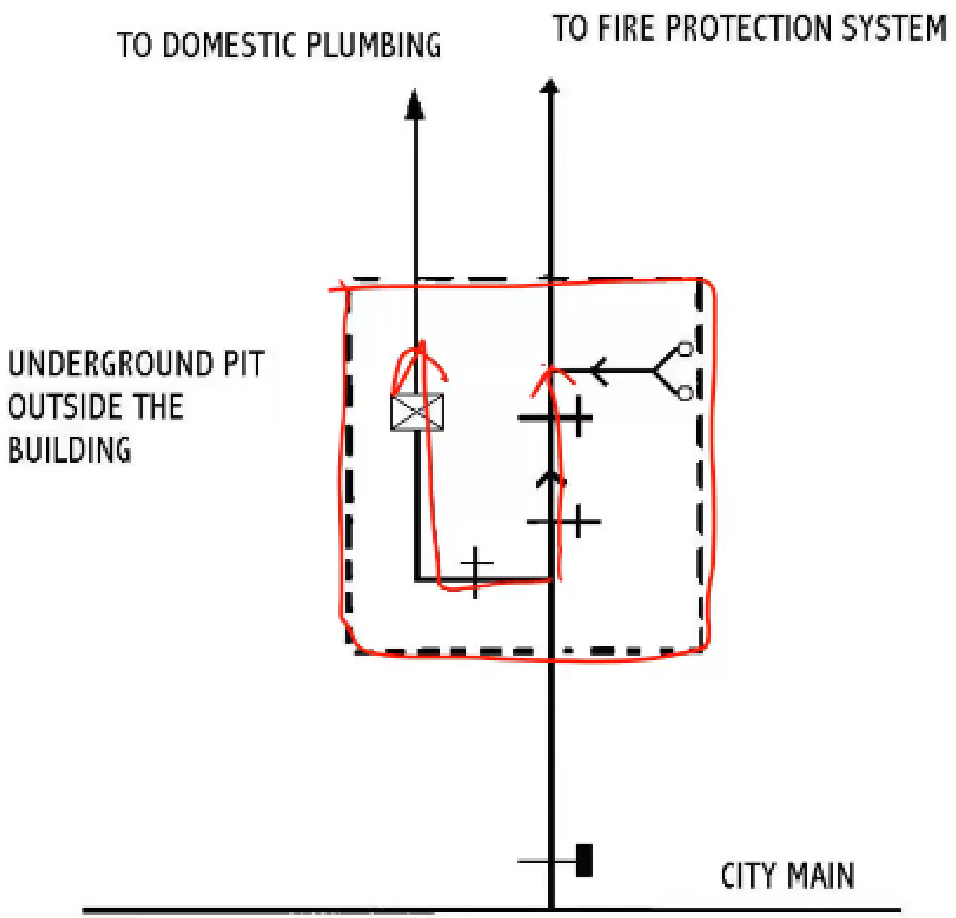
VI. Dry System Drainage

WET SYSTEM INSPECTOR TEST VALVE






See Note
Branch Line
Plug - Union
For Testing
Remove and Install
Temporary Connection
Test Valve In
Readily Accessible
Location
45°Ell
Smooth Bore
Corrosion-Resistant
Outlet Giving FLow Equal
to One Sprinkler
Note: To Minimize condensation of Water in
the Drop to the Test Connection, Provide a
Nipple-Up Off of the Branch Line.

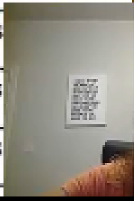

TO DOMESTIC PLUMBING
TO FIRE PROTECTION SYSTEM
UNDERGROUND PIT
OUTSIDE THE
BUILDING
CITY MAIN

PLAN REVIEW CHECKLIST

SAMPLE
PLAN PREVIEW CHECKLIST
for
HYDRAULICALLY DESIGNED SYSTEMS

'ding Name: ______
Building Location: ______
Building Occupancy: ______
Reviewer: ______ Review Date: ______

1.	Occupancy Classification Correct?	Yes ☐ No ☐
2.	Current water supply information provided?	Yes ☐ No ☐
3.	All plan submittal requirements of 22.1.3 provided?	Yes ☐ No ☐
4.	All hydraulic summary sheets, work sheets and forms provided as required in 22.3 ?	Yes ☐ No ☐
5.	Size of design area acceptable?	Yes ☐ No ☐
6.	Density correct for occupancy and design area size?	Yes ☐ No ☐
7.	Design area increased by 30% for dry system?	Yes ☐ No ☐
8.	Calculated GPM demand for sprinklers exceeds quick-calc minimum?	Yes ☐ No ☐
9.	Correct number of heads calculated?	Yes ☐ No ☐
10.	Correct shape of design area?	Yes ☐ No ☐
11.	Correct location of design area?	Yes ☐ No ☐
12.	Correct minimum sprinkler flows?	Yes
13.	Correct minimum sprinkler pressure?	Yes
14.	Do pipe sizes and lengths on plans match calculations?	Yes
15.	Correct C-factors for pipe?	



PLAN REVIEW CHECKLIST

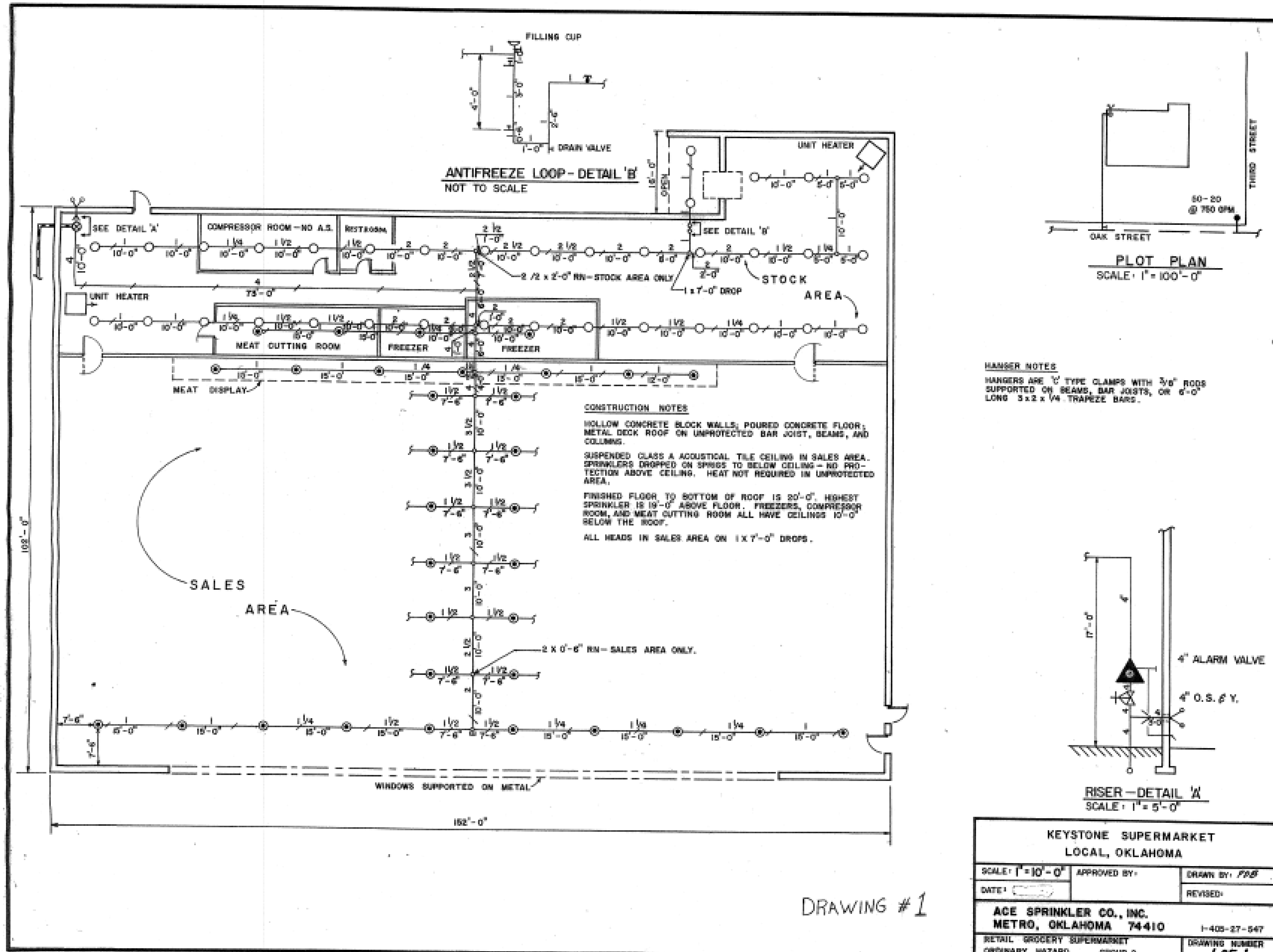
11. Correct location of design area? Yes ☐ No ☐
12. Correct minimum sprinkler flows? Yes ☐ No ☐
13. Correct minimum sprinkler pressure? Yes ☐ No ☐
14. Do pipe sizes and lengths on plans match calculations? Yes ☐ No ☐
15. Correct C-factors for pipe? Yes ☐ No ☐
16. Spot check of friction loss OK? Yes ☐ No ☐
17. Elevation correction OK? Yes ☐ No ☐
18. Correct hose stream addition? Yes ☐ No ☐
19. Is total demand point on or below the supply curve? Yes ☐ No ☐
20. All areas protected? Yes ☐ No ☐
21. Individual sprinkler protection areas acceptable? Yes ☐ No ☐
22. Hanger locations indicated and acceptable? Yes ☐ No ☐
23. Inspector's test location indicated and acceptable? Yes ☐ No ☐

COMMENTS:

Keystone Supermarket

Automatic Sprinkler

Plans



FILLING CUP
DRAIN VALVE
ANTIFREEZE LOOP - DETAIL 'B'
NOT TO SCALE
UNIT HEATER
SEE DETAIL 'A'
COMPRESSOR ROOM - NO A.S.
RESTROOM
SEE DETAIL 'B'
2 1/2 x 2'-0" RN - STOCK AREA ONLY
1 x 7'-0" DROP
STOCK
AREA
UNIT HEATER
MEAT CUTTING ROOM
FREEZER
FREEZER
MEAT DISPLAY
CONSTRUCTION NOTES
HOLLOW CONCRETE BLOCK WALLS; POURED CONCRETE FLOOR; METAL DECK ROOF ON UNPROTECTED BAR JOIST, BEAMS, AND COLUMNS.
SUSPENDED CLASS A ACOUSTICAL TILE CEILING IN SALES AREA. SPRINKLERS DROPPED ON SPRIGS TO BELOW CEILING - NO PROTECTION ABOVE CEILING. HEAT NOT REQUIRED IN UNPROTECTED AREA.
FINISHED FLOOR TO BOTTOM OF ROOF IS 20'-0". HIGHEST SPRINKLER IS 19'-0" ABOVE FLOOR. FREEZERS, COMPRESSOR ROOM, AND MEAT CUTTING ROOM ALL HAVE CEILINGS 10'-0" BELOW THE ROOF.
ALL HEADS IN SALES AREA ON 1 x 7'-0" DROPS.
SALES
AREA
2 x 0'-6" RN - SALES AREA ONLY.
WINDOWS SUPPORTED ON METAL
102'-0"
152'-0"
THIRD STREET
50-20
@ 750 GPM
OAK STREET
PLOT PLAN
SCALE: 1" = 100'-0"
HANGER NOTES
HANGERS ARE 'C' TYPE CLAMPS WITH 3/8" RODS SUPPORTED ON BEAMS, BAR JOISTS, OR 6'-0" LONG 3 x 2 x 1/4 TRAPEZE BARS.
4" ALARM VALVE
4" O.S. & Y.
RISER - DETAIL 'A'
SCALE: 1" = 5'-0"
KEYSTONE SUPERMARKET
LOCAL, OKLAHOMA
SCALE: 1" = 10'-0"
APPROVED BY:
DRAWN BY: FBB
DATE:
REVISED:
ACE SPRINKLER CO., INC.
METRO, OKLAHOMA 74410
1-405-27-547
RETAIL GROCERY SUPERMARKET
ORDINARY HAZARD GROUP 2
DRAWING NUMBER
1 OF 1
DRAWING #1

Riser Location

Need
Pipe
Details,
Size and
Type

Miss ITC(Inspector Test Connection) Location

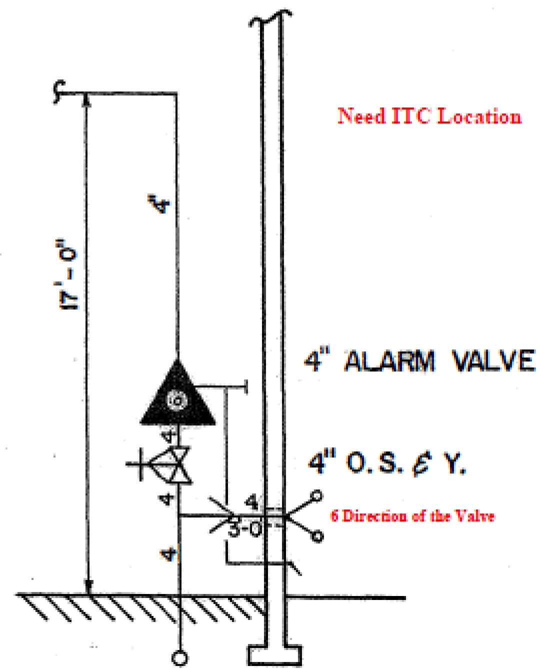
Flow Test Results

PLOT PLAN

SCALE: 1" = 100'-0"

Need Graph Scale Here !!!

Need More Information on
Water Distribution



Need Underground Detail

RISER — DETAIL 'A'

SCALE: 1" = 5'-0"

7 No Address

KEYSTONE SUPERMARKET
LOCAL, OKLAHOMA

SCALE: 1" = 10'-0" | APPROVED BY: | DRAWN BY: PDB

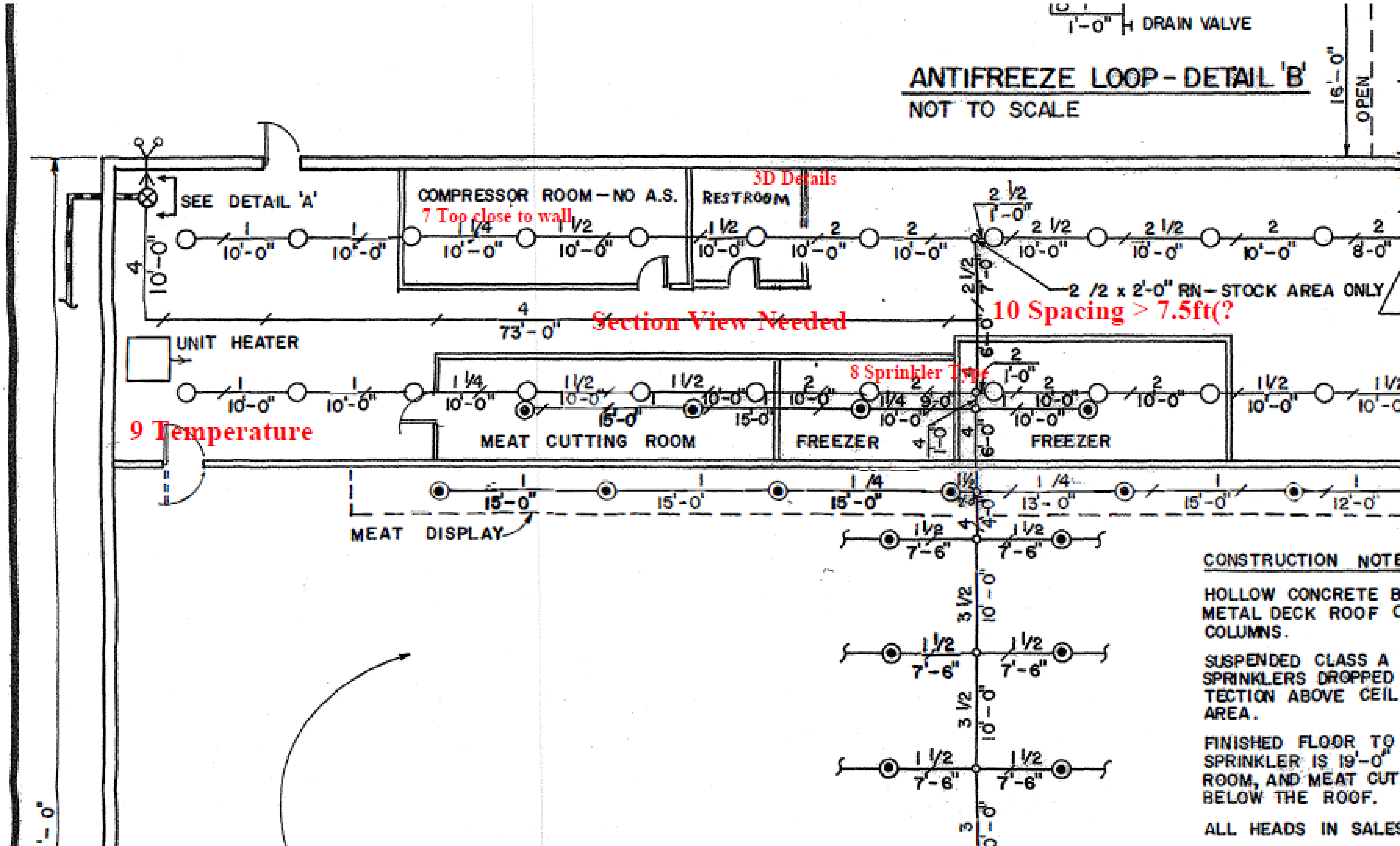
DATE:

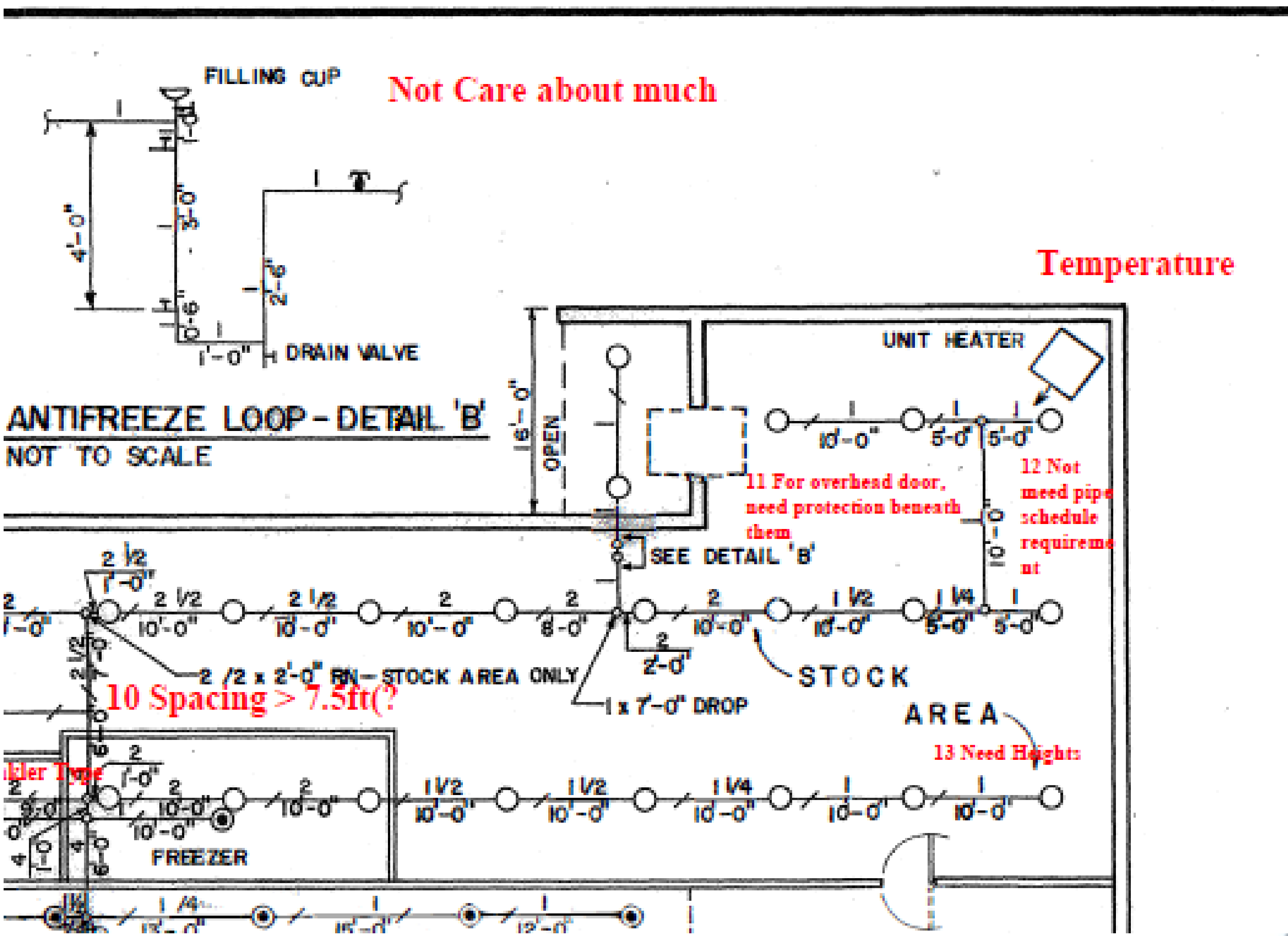
REVISED:

ACE SPRINKLER CO., INC.
METRO, OKLAHOMA 74410
1-405-27-547

RETAIL GROCERY SUPERMARKET
ORDINARY HAZARD GROUP 2

DRAWING NUMBER
1 OF 1


ANTIFREEZE LOOP - DETAIL 'B'
NOT TO SCALE
DRAIN VALVE
OPEN
SEE DETAIL 'A'
COMPRESSOR ROOM — NO A.S.
RESTROOM
3D Details
7 Too close to wall
2 1/2 x 2'-0" RN— STOCK AREA ONLY
Section View Needed
10 Spacing > 7.5ft(?
UNIT HEATER
8 Sprinkler Type
9 Temperature
MEAT CUTTING ROOM
FREEZER
FREEZER
MEAT DISPLAY
73'- 0"
CONSTRUCTION NOTES
HOLLOW CONCRETE BL
METAL DECK ROOF ON
COLUMNS.
SUSPENDED CLASS A A
SPRINKLERS DROPPED
TECTION ABOVE CEILIN
AREA.
FINISHED FLOOR TO
SPRINKLER IS 19'-0" A
ROOM, AND MEAT CUTT
BELOW THE ROOF.
ALL HEADS IN SALES



FILLING CUP
Not Care about much
DRAIN VALVE
ANTIFREEZE LOOP - DETAIL 'B'
NOT TO SCALE
Temperature
UNIT HEATER
OPEN
11 For overhead door, need protection beneath them
12 Not meed pipe schedule requirement
SEE DETAIL 'B'
2 1/2 x 2'-0" RN - STOCK AREA ONLY
10 Spacing > 7.5ft(?
1 x 7'-0" DROP
STOCK
AREA
13 Need Heights
FREEZER

CONSTRUCTION NOTES

HOLLOW CONCRETE BLOCK WALLS; POURED CONCRETE FLOOR; METAL DECK ROOF ON UNPROTECTED BAR JOIST, BEAMS, AND COLUMNS.

SUSPENDED CLASS A ACOUSTICAL TILE CEILING IN SALES AREA. SPRINKLERS DROPPED ON SPRIGS TO BELOW CEILING – NO PROTECTION ABOVE CEILING. HEAT NOT REQUIRED IN UNPROTECTED AREA.

14 Need Expected Temperature

FINISHED FLOOR TO BOTTOM OF ROOF IS 20'-0". HIGHEST SPRINKLER IS 19'-0" ABOVE FLOOR. FREEZERS, COMPRESSOR ROOM, AND MEAT CUTTING ROOM ALL HAVE CEILINGS 10'-0" BELOW THE ROOF.

ALL HEADS IN SALES AREA ON 1 X 7'-0" DROPS.

End-Head Analysis

- Determine if existing systems are sufficient when there is a change in occupancy classification

Usage

- System being changed
  - Is the current design adequate
- Interpolation or extrapolation based on
  - System demand
  - Water supply information

Information Required

- Sprinkler system demand
- Size of the design area
- Protection area per sprinkler and density
- Sprinkler K-factor
- Height of the highest sprinkler

Step 1(Demand Curve)

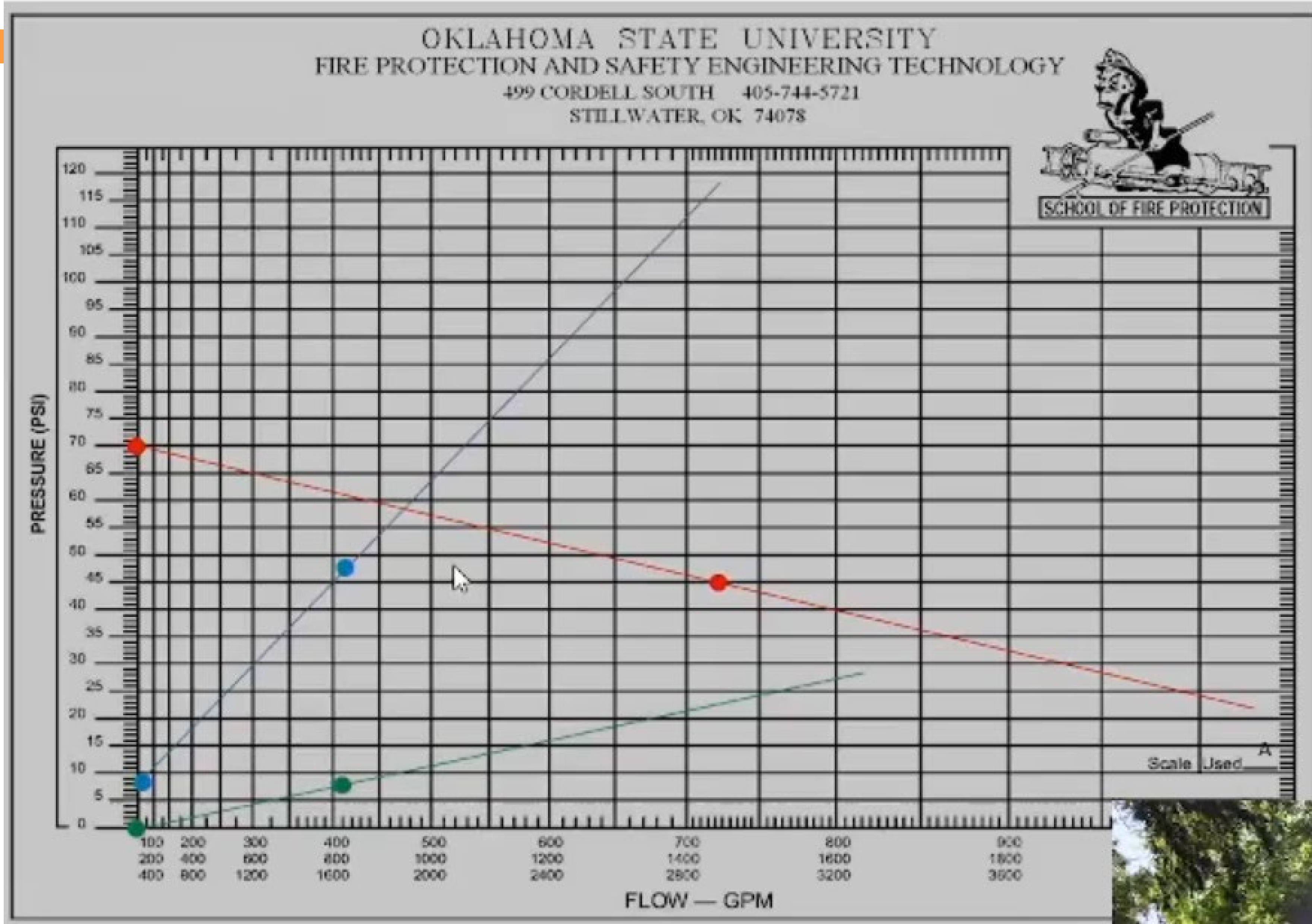
- Plot the system demand curve
  - Demand point
  - At 0 gpm the pressure required to overcome elevation up to the highest sprinkler
- Example
  - System for 410 gpm @ 48 psi
  - 18ft elevation of highest sprinkler
  - Blue curve

Step 2(End Head pressure curve)

- Plot the end head pressure curve
  - **Drop vertical line straight down from demand point**
  - Calculate the required end head pressure from
    - $P=(q/k)^2$
  - Plot this pressure on the vertical line
  - Plot a point at (0,0)
  - Connect these points with a straight line
- Example:
  - System designed for:
    - 0.12gpm/ft^2, 120ft^2 per head, k=5.4(7.1psi)
    - Green curve

Step 3(Water Supply Curve)

- Can now calculate any demand curve
- Plot the water supply curve
- Example
  - Static pressure 70 psi
  - Flow test 720gpm @ 45 psi
  - Red curve



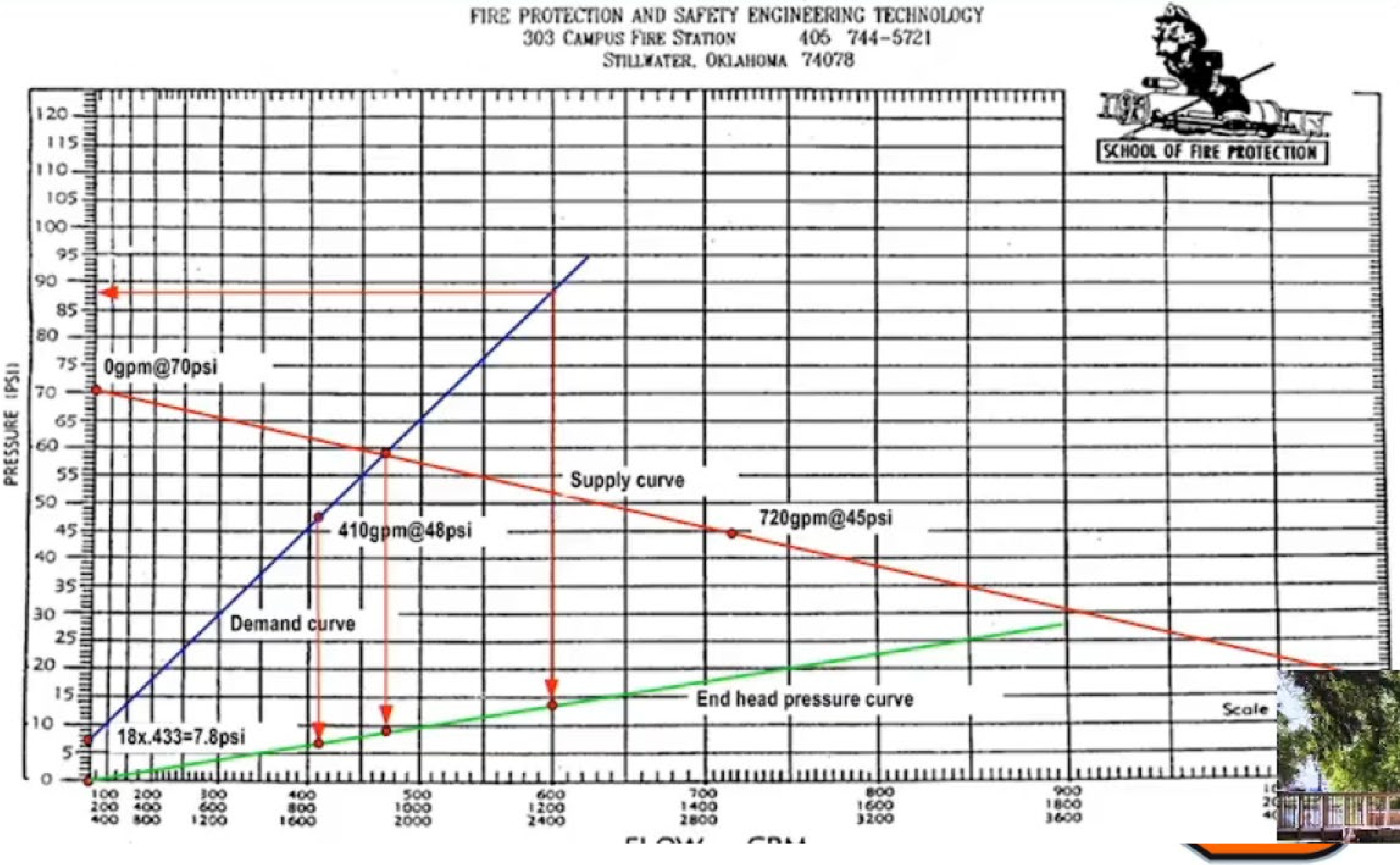
OKLAHOMA STATE UNIVERSITY
FIRE PROTECTION AND SAFETY ENGINEERING TECHNOLOGY
499 CORDELL SOUTH 405-744-5721
STILLWATER, OK 74078
SCHOOL OF FIRE PROTECTION
PRESSURE (PSI)
FLOW — GPM
Scale Used A

Example

Why 9 psi here

- What density will the system actually deliver?
  - Q=5.4*9^0.5=16.2gpm
  - Density=16.2 gpm/120ft^2=0.135 gpm/ft^2
- What will the new system demand be if the occupancy changes to Ordinary Group 2(System design area 3000ft^2)
  - Q=0.17gpm/ft^2*120ft^2=20.4gpm
  - P=(20.4/5.4)^2=14.3psi
  - From graph: 600 gpm @ 88 psi

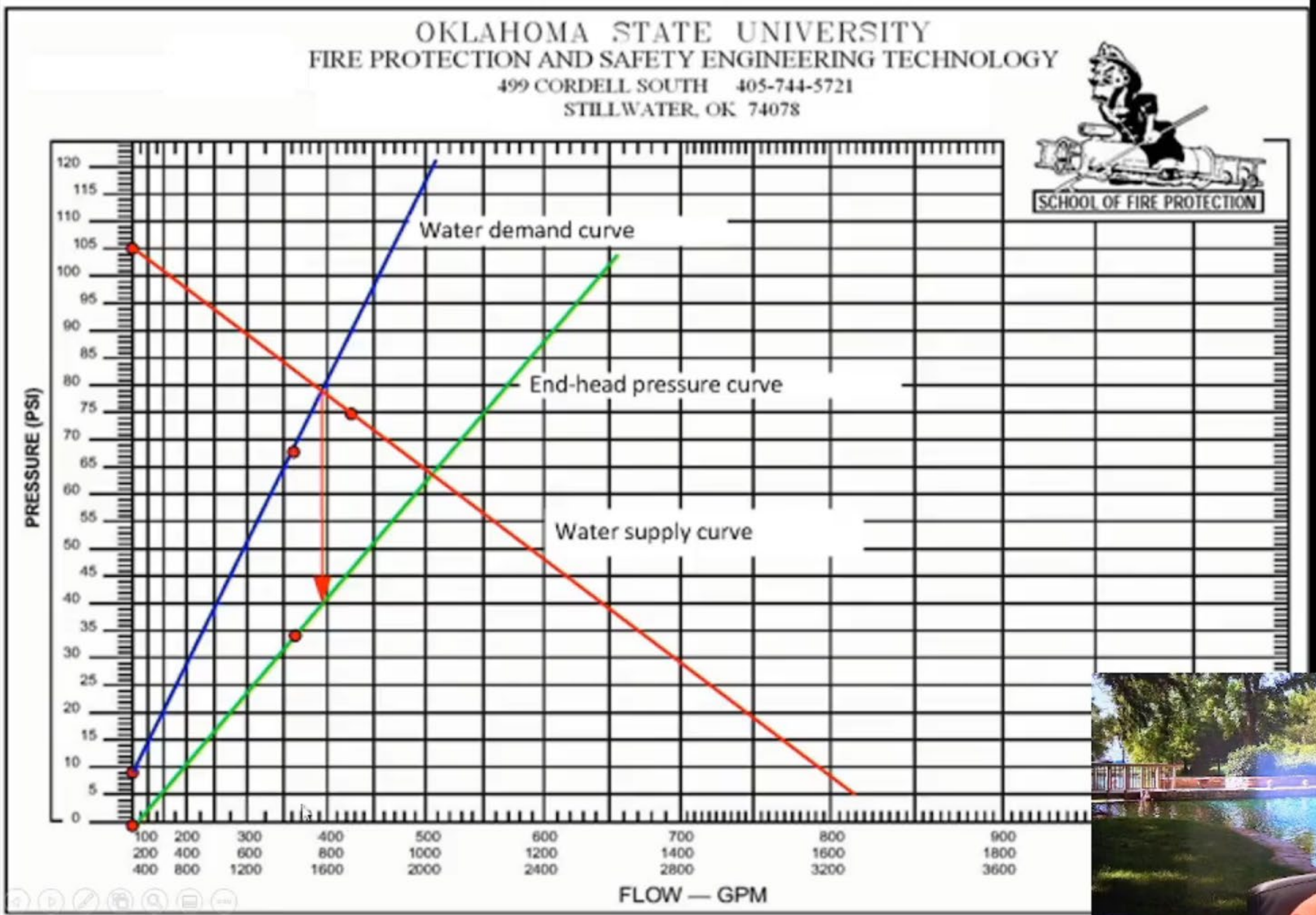
Example


FIRE PROTECTION AND SAFETY ENGINEERING TECHNOLOGY
303 CAMPUS FIRE STATION 405 744-5721
STILLWATER, OKLAHOMA 74078
SCHOOL OF FIRE PROTECTION
PRESSURE (PSI)
0gpm@70psi
Supply curve
720gpm@45psi
410gpm@48psi
Demand curve
End head pressure curve
18x.433=7.8psi
Scale

Example

- System originally
  - 39 sprinklers
  - 22ft high
  - 0.33gpm/ft^2
  - 3900ft^2
  - 68psi
  - K=5.65
- New sprinklers
  - 1450 gpm
- Water supply
  - Static 105psi
  - Residual 1700gpm @ 75psi
- Dry system
  - Extra hazard group 2

Example



OKLAHOMA STATE UNIVERSITY
FIRE PROTECTION AND SAFETY ENGINEERING TECHNOLOGY
499 CORDELL SOUTH 405-744-5721
STILLWATER, OK 74078
SCHOOL OF FIRE PROTECTION
Water demand curve
End-head pressure curve
Water supply curve
PRESSURE (PSI)
FLOW — GPM

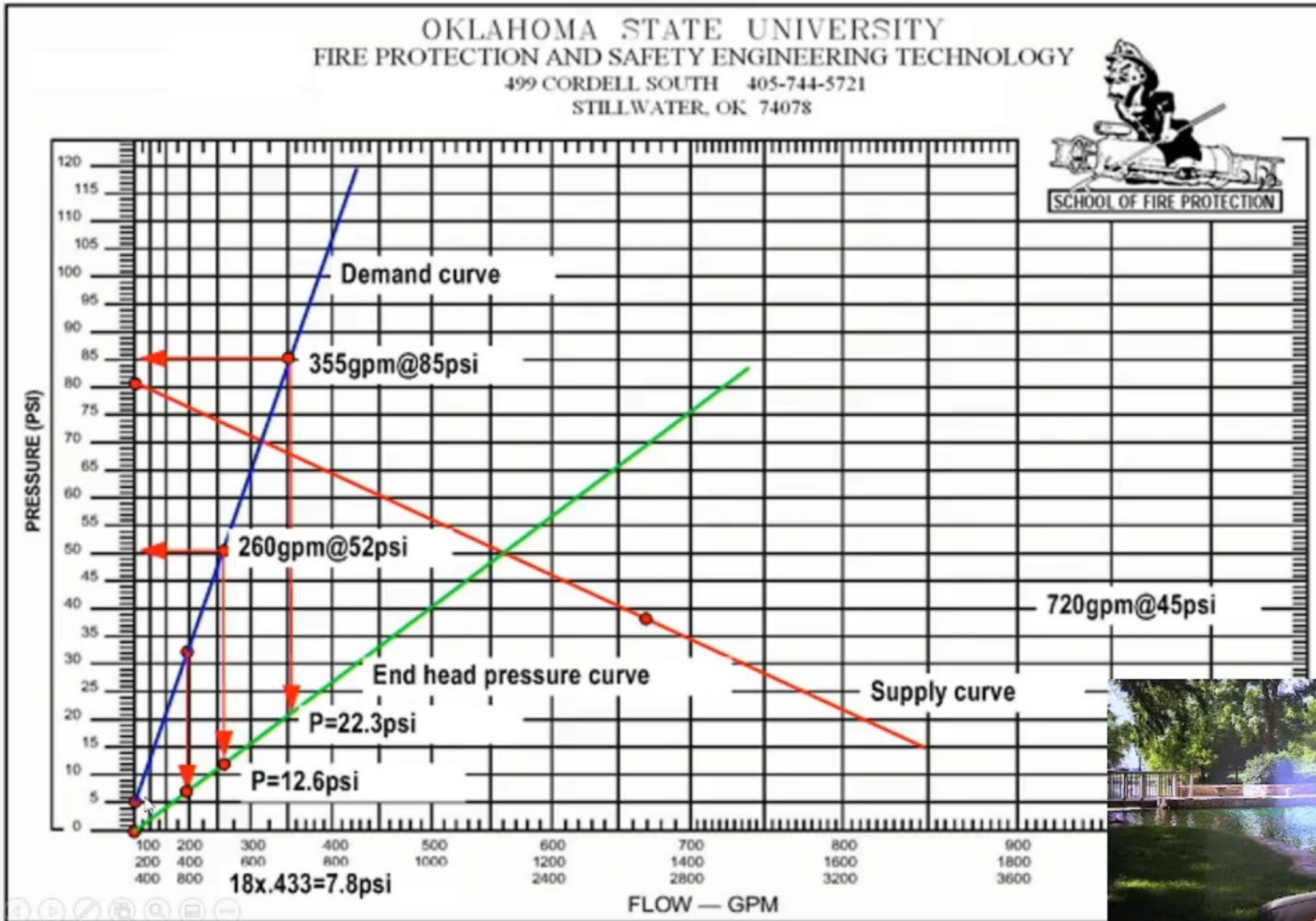
Example

- Actual p=40psi
- Q=5.65*40^0.5=35.7gpm
- Density=35.7 gpm/100ft^2=0.357gpm/ft^2
- Required density:0.38 gpm/ft^2
- Will need fire pump

Example 3

- System originally
  - Sprinkler protects 130ft^2
  - 12ft high
  - 0.10 gpm/ft^2
  - 196 gpm
  - 32psi
  - 1500ft^2
  - K=5.5
- Water supply
  - Static 81 psi
  - Residual 670 gpm @ 39 psi
- Wet system
  - Ordinary 1 or Ordinary 2

Example 3


OKLAHOMA STATE UNIVERSITY
FIRE PROTECTION AND SAFETY ENGINEERING TECHNOLOGY
499 CORDELL SOUTH 405-744-5721
STILLWATER, OK 74078
SCHOOL OF FIRE PROTECTION
PRESSURE (PSI)
Demand curve
355gpm@85psi
260gpm@52psi
720gpm@45psi
End head pressure curve
Supply curve
P=22.3psi
P=12.6psi
18x.433=7.8psi
FLOW — GPM

Building Code Applications

- Determine when a sprinkler system is required

International Building Code (IBC)

- Structure is different:
  - Chapter 1 : Scope and Administration
  - Chapter 2 : Definitions
  - Chapter 3 : Occupancy Classifications
  - Chapter 4 : Special Occupancy Requirements
  - Chapter 5 : Building Height and Areas
  - Chapter 6 : Types of Construction
  - Chapter 7 : Fire and Smoke Protection Features
  - Chapter 8 : Interior Finishes
  - Chapter 9 : Fire Protection Systems
  - Chapter 10 : Means of Egress
  - Chapter 34 : Existing Buildings

Chapter 9

`

- Addresses all fire protection systems
  - Automatic Sprinkler Systems
  - Automatic Fire Extinguishing Systems
  - Standard pipe Systems
  - Extinguishers, Fire Alarm and Detection, Smoke Control, Fire Command Centers, Fire Department Connections, Fire Pumps, Emergency Responder Safety Features, and Radio Coverage

Section 903

- Section 903: Automatic Sprinkler Systems
  - Dictates WHEN a sprinkler system is required
    - Occupancy classification
    - Floor area
    - Occupant load
    - Exit discharge locations
  - Indicates which NFPA standards are applicable
  - Supervision requirements

Section 904

- Section 904: Alternative Automatic Fire Extinguishing Systems
  - Where approved as an alternative to meeting Section 903
  - Which NFPA standards are applicable

Section 905

- Section 905: Standpipe System
  - When they are required
  - Where they are required

Residential Sprinklers

`

- Determine when residential sprinklers are required
- Apply rules for residential sprinkler systems to designs
  - Residential —— to make people safe

Residential Sprinklers

- NFPA 13 R
  - Low-rise residential
  - 1989
- Less risk, more losses
- More flexibility in components

System Type

- Inside dwelling unit
  - Must only be used on wet pipe systems
  - Quick-response only if <5 sprinklers in compartment
- Outside dwelling unit
  - Areas
    - Lobbies, foyers, corridors, halls, lounges, places with similar fire loads
    - Quick response sprinklers
    - Minimum 0.1 gpm/ft^2

System Type

- Inside dwelling unit
  - Must **only** be used on **wet** pipe systems
  - Quick-response only if <5 sprinklers in compartment
- Outside dwelling unit
  - Areas
    - Lobbies, foyers, corridors, halls, lounges, places with similar fire loads
    - Quick response sprinklers
    - Minimum 0.1 gpm/ft^2

Discharge Criteria

- Inside dwelling unit
  - Minimum density 0.05 gpm/ft^2
  - All sprinklers in design area, maximum 4
  - Quick response by NFPA 13
- Outside dwelling unit
  - Quick response by NFPA 13
  - Can reduce design area under very specific conditions
- Hydraulic calculations
- 30 min supply

Temperature Ratings

`

- Typically ordinary or intermediate temperature
- Under skylight=intermediate temperature
- Unventilated=intermediate temperature

Table 6.2.3.3.3 Minimum Distances for Ordinary and Intermediate Temperature Residential Sprinklers

Heat Source	From Edge of Source to Ordinary Temperature Sprinkler		From Edge of Source to Intermediate Temperature Sprinkler	
	in.	mm	in.	mm
Side of open or recessed fireplace	36	900	12	300
Front of recessed fireplace	60	1500	36	900
Coal- or wood- burning stove	42	1050	12	300
Kitchen range	18	450	9	225
Wall oven	18	450	9	225
Hot air flues	18	450	9	225
Uninsulated heat ducts	18	450	9	225
Uninsulated hot water pipes	12	300	6	150
Side of ceiling- or wall-mounted hot air diffusers	24	600	12	300
Front of wall-mounted hot air diffusers	36	900	18	450
Hot water heater or furnace	6	150	3	75
Light fixture:				
0 W–250 W	6	150	3	75
250 W–499 W	12	300	6	150

OKLAHOMA STATE UNIVERSITY

Positioning

- Upright and Pendent
  - Deflectors 1 in to 4 in from ceiling
  - Minimum 4 in from wall
- Sidewall
  - Deflectors 4 in to 6 in from ceiling
  - Within 6 in of wall

Location

`

- Closets < 400ft^2 need single sprinkler
- Shadow areas < 15ft^2/sprinkler allowed
- Pendent sprinklers 3 ft from obstructions
- Sidewall sprinklers 5 ft from obstructions
- Not required in:
  - Bathrooms < 55ft^2
  - Closets < 24ft^2
  - Porches, etc.
  - Attics, etc.

System Components

- Can have dual-purpose main
  - Single control valve
  - Sprinkler only control valve
- Must have at least 1 in main drain
- Test connection at least 1 in or smallest pipe size
- Fire department connection minimum 1.5 in
- Local waterflow alarm on all systems

Plans 8.1.7

- Working plans need to be submitted (25 items)
  - Name of owner and occupant
  - Location, including street address
  - Point of compass
  - Ceiling construction
  - Full height cross-section
  - Location of fire walls
  - Location of partitions
  - Occupancy of each area of room
  - Sprinkler details
- Kind and location of alarm bells
- Type of pipe and fittings
- Type of protection for nonmetallic pipe
- Nominal pipe size with lengths shown to scale
- Location and size of riser nipples
- Name and address of the contractor
- Etc.

Maintenance

- Spare sprinklers
  - System < 300 heads, 6
  - System < 1001 heads, 12
  - System > 1000 heads, 24
- Testing in accordance with NFPA 25
- Installing contractor must supply
  - Instruction from manufacturer
  - NFPA 25

Dwelling Sprinklers

- NFPA 13D
  - One and two family dwellings
  - 1975
- Less risk, more losses
- More flexibility in components

Piping and Water Supply

`

- Piping
  - Specified types of material
  - 1'' steel;.0.75 other**(plastic in common)** minimum
  - Withstand pressure of 130 psi or 175 psi
  - Pressure reducer if pressure > 80psi
  - Underground piping according to plumbing code
  - Minimum 0.5 in drain
  - Test connection same size as smallest sprinkler orifice
- Water supply
  - Water supply must last 10 min
  - Can have multiple purpose system
  - Single control valve

Systems

- Wet
  - Dry only in unheated areas
- Same temperature, positioning, shadow area requirements as 13R
- Local waterflow alarms

Systems Calculations

- Hydraulic calculations
  - Minimum 0.05gpm/ft^2
  - All sprinklers in compartment maximum 2
- Prescriptive method

10.4.9.1 Available Pressure Equation. The pressure available to offset friction loss in the interior piping system (P_t) shall be determined in accordance with the following formula:

[10.4.9.1]

$$P_t = P_{sup} - PL_{svc} - PL_m - PL_d - PL_e - P_{sp}$$

where:

P_t = pressure used in applying Table 10.4.9.2(a) through Table 10.4.9.2(h)
P_{sup} = pressure available from the water supply source
PL_{svc} = pressure loss in the water service pipe
PL_m = pressure loss in the water meter
PL_d = pressure loss from devices other than the water meter
PL_e = pressure loss associated with changes in elevation
P_{sp} = maximum pressure required by a sprinkler

Prescriptive Method Procedure

- Step1: Obtain supply information
- Step2: Determine friction loss in service pipe(table)
- Step3: Obtain pressure loss from meter(table)
- Step4: Determine pressure loss from devices(manufacturer)

Table 10.4.9.2(a) Water Service Pressure Loss (PLsvc)

Flow Rate* (gpm)	¾ in. Water Service Pressure Loss (psi)				1 in. Water Service Pressure Loss (psi)				1¼ in. Water Service Pressure Loss (psi)			
	40 ft or less	41 ft to 75 ft	76 ft to 100 ft	101 ft to 150 ft	40 ft or less	41 ft to 75 ft	76 ft to 100 ft	101 ft to 150 ft	40 ft or less	41 ft to 75 ft	76 ft to 100 ft	101 ft to 150 ft
8	5.1	8.7	11.8	17.4	1.5	2.5	3.4	5.1	0.6	1.0	1.3	1.9
10	7.7	13.1	17.8	26.3	2.3	3.8	5.2	7.7	0.8	1.4	2.0	2.9
12	10.8	18.4	24.9	NP	3.2	5.4	7.3	10.7	1.2	2.0	2.7	4.0
14	14.4	24.5	NP	NP	4.2	7.1	9.6	14.3	1.6	2.7	3.6	5.4
16	18.4	NP	NP	NP	5.4	9.1	12.4	18.3	2.0	3.4	4.7	6.9
18	22.9	NP	NP	NP	6.7	11.4	15.4	22.7	2.5	4.3	5.8	8.6
20	27.8	NP	NP	NP	8.1	13.8	18.7	27.6	3.1	5.2	7.0	10.4
22	NP	NP	NP	NP	9.7	16.5	22.3	NP	3.7	6.2	8.4	12.4
24	NP	NP	NP	NP	11.4	19.3	26.2	NP	4.3	7.3	9.9	14.6
26	NP	NP	NP	NP	13.2	22.4	NP	NP	5.0	8.5	11.4	16.9
28	NP	NP	NP	NP	15.1	25.7	NP	NP	5.7	9.7	13.1	19.4
30	NP	NP	NP	NP	17.2	NP	NP	NP	6.5	11.0	14.9	22.0
32	NP	NP	NP	NP	19.4	NP	NP	NP	7.3	12.4	16.8	24.8
34	NP	NP	NP	NP	21.7	NP	NP	NP	8.2	13.9	18.8	NP
36	NP	NP	NP	NP	24.1	NP	NP	NP	9.1	15.4	20.9	NP

NP: Not permitted. Pressure loss exceeds reasonable limits.
Notes:
(1) Values are applicable for underground piping materials permitted by the local plumbing code and are based on an SDR of 11 and a Hazen-Williams *C* factor of 150.
(2) Values include the following length allowances for fittings: 25 percent length increase for actual lengths up to 100 ft (30.5 m) and 15 percent length increase for actual lengths over 100 ft (30.5 m).
*Flow rate from Sections 10.1 and 10.2. Add 5 gpm (18.9 lpm) to the flow rate required by 10.4.9.2, Step 4, where the water service pipe supplies more than one dwelling.

Table 10.4.4(a) Pressure Losses in psi in Water Meters

Meter Size (in.)	Flow (gpm) (L/min)					
	18 or less (68)	23 (87)	26 (98)	31 (117)	39 (148)	52 (197)
⅝(15 mm)	9 (0.67 bar)	14 (0.97 bar)	18 (1.2 bar)	26 (1.8 bar)	38 (2.6 bar)	*
¾(20 mm)	7 (0.48 bar)	11 (0.76 bar)	14 (1.5 bar)	22 (1.5 bar)	35 (2.4 bar)	*
1 (25 mm)	2 (0.14 bar)	3 (0.21 bar)	3 (0.21 bar)	4 (0.28 bar)	6 (0.41 bar)	10 (0.69 bar)
1½(40 mm)	1 (0.07 bar)	1 (0.07 bar)	2 (0.14 bar)	2 (0.14 bar)	4 (0.28 bar)	7 (0.48 bar)
2 (50 mm)	1 (0.07 bar)	1 (0.07 bar)	1 (0.07 bar)	1 (0.07 bar)	2 (0.14 bar)	3 (0.21 bar)

For SI units, 1 gpm = 3.785 L/min; 1 in. = 25 mm; 1 psi = 0.07 bar.
*Above maximum rated flow of commonly available meters.

Prescriptive Method Procedure

- Step5: Calculate pressure loss from elevation
- Step6: Determine the maximum pressure required by a sprinkler (from manufacturer)
- Step7: Use equation
- Step8: Determine maximum pipe length (table)

Table 10.4.9.2(d) Allowable Pipe Length for 1 in. Type M Copper Water Tubing

Sprinkler Flow Rate* (gpm)	Water Distribution Size (in.)	Available Pressure, P_t (psi)									
		15	20	25	30	35	40	45	50	55	60
		Allowable Length of Pipe from Service Valve to Farthest Sprinkler (ft)									
8	1	806	1075	1343	1612	1881	2149	2418	2687	2955	3224
9	1	648	864	1080	1296	1512	1728	1945	2161	2377	2593
10	1	533	711	889	1067	1245	1422	1600	1778	1956	2134
11	1	447	596	745	894	1043	1192	1341	1491	1640	1789
12	1	381	508	634	761	888	1015	1142	1269	1396	1523
13	1	328	438	547	657	766	875	985	1094	1204	1313
14	1	286	382	477	572	668	763	859	954	1049	1145
15	1	252	336	420	504	588	672	756	840	924	1008
16	1	224	298	373	447	522	596	671	745	820	894
17	1	200	266	333	400	466	533	600	666	733	799
18	1	180	240	300	360	420	479	539	599	659	719
19	1	163	217	271	325	380	434	488	542	597	651
20	1	148	197	247	296	345	395	444	493	543	592
21	1	135	180	225	270	315	360	406	451	496	541
22	1	124	165	207	248	289	331	372	413	455	496
23	1	114	152	190	228	267	305	343	381	419	457
24	1	106	141	176	211	246	282	317	352	387	422
25	1	98	131	163	196	228	261	294	326	359	392
26	1	91	121	152	182	212	243	273	304	334	364
27	1	85	113	142	170	198	226	255	283	311	340
28	1	79	106	132	159	185	212	238	265	291	318
29	1	74	99	124	149	174	198	223	248	273	298
30	1	70	93	116	140	163	186	210	233	256	280
31	1	66	88	110	132	153	175	197	219	241	263
32	1	62	83	103	124	145	165	186	207	227	248
33	1	59	78	98	117	137	156	176	195	215	234
34	1	55	74	92	111	129	148	166	185	203	222
35	1	53	70	88	105	123	140	158	175	193	210
36	1	50	66	83	100	116	133	150	166	183	199
37	1	47	63	79	95	111	126	142	158	174	190
38	1	45	60	75	90	105	120	135	150	165	181
39	1	43	57	72	86	100	115	129	143	158	172
40	1	41	55	68	82	96	109	123	137	150	164

*Flow rate from Sections 10.1 and 10.2.

Maintenance

- Installer provides owner instructions
- “Periodic” inspections
  - Not requirement to follow other standards
- Antifreeze sampled **yearly**
- **No** required spare sprinklers

Standpipe and Hose System

- Determine requirements for standpipe systems

History

- 1915
  - NFPA 14 adopted
  - Provided for workers' use as well as fire departments' use
  - 2.5 in and 1.5 in connections
  - 75 psi at highest outlet
- 1917
  - Class I, II, and III defined
- 1952
  - 4 basic types of standpipe system defined

General

- A vertical or horizontal water main
  - Extends from the basement to the roof and/or throughout entire floor
  - Used exclusively for fire fighting purposes
- Three (four) types:
  - Class I: 2.5 valves and hose connections
  - Class II: 1.5 valves and hose lines
  - Class III: Combination of both I and II
  - “Combined” systems (with sprinklers)

Purpose

- Means for the manual application of water
  - Large, one-story buildings
  - High-rise buildings
  - Horizontal reduce manual effort and time

Class I Standpipe System

- Used by trained fire fighting personnel
- Can supply effective fire streams
- Required when:
  - Full-scale fire fighting
  - More than 3 stories above or below grade
  - Shopping malls without access

Class II Standpipe System

- Used by untrained building occupants
- Not relied upon by fire department
- Required when:
  - First-aid fire fighting
  - Large unsprinklered buildings
  - Special hazard areas, such as exhibit halls and stages

Class III Standpipe System

- Combine features of Class I and Class II
  - Simultaneous use of Class I and Class II
- Fire department can rely on
- Building occupants can rely on

Water Supply for Standpipe Systems

- Class I and Class III:
  - One riser
    - 500 gpm for 30 minutes
    - 100 psi at most hydraulically remote outlet
  - More than one riser
    - 250 gpm each additional riser
    - Maximum of 1250 gpm (1000 if sprinklered)
  - Class II:
    - 100 gpm for 30 min
    - 65 psi at most hydraulically remote outlet

Water Supply for Standpipe Systems

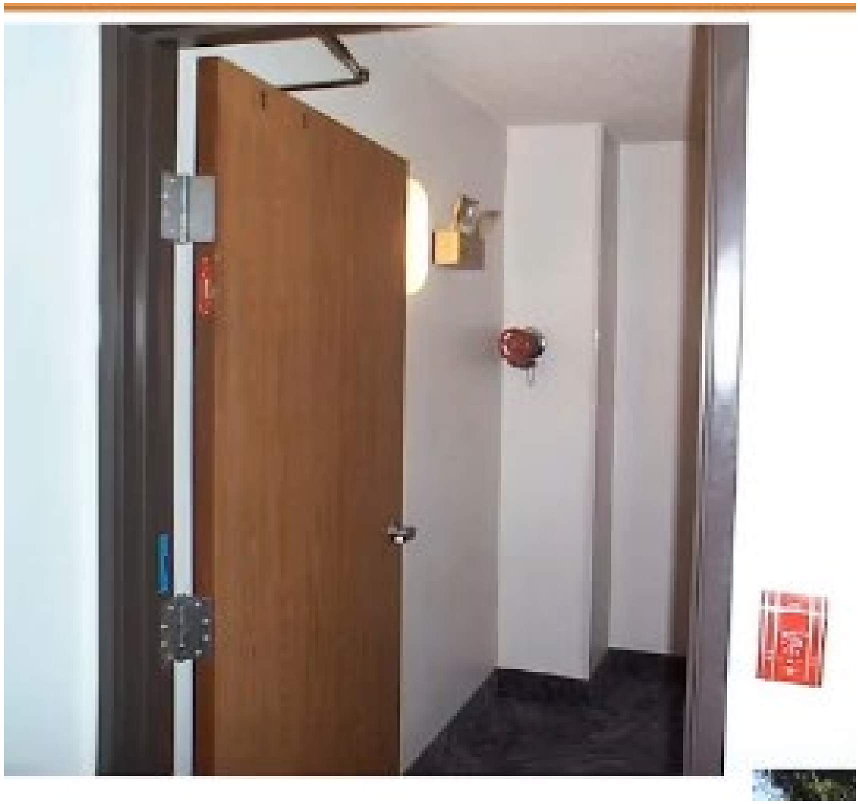
- Acceptable types of water supplies:
  - Public water systems
  - Automatic fire pumps
  - Pressure tanks
  - Gravity tanks
  - Manual fire pumps
- Factors in determining amount
  - Number of streams
  - Probable duration of use
- 30 min duration

Combined Systems

- Sprinklers and standpipe on same system
  - Use NFPA 13 & 14 for design
  - NFPA 14 governs water supply requirements (the sprinkler demand is not added to the standpipe demand)

Standpipe Locations

- 3 to 5 ft above the floor
- In stairwells
  - Hotels
  - Multistory buildings
  - Hospitals
- At entrances
  - Malls
  - Anchor stores
  - Large warehouses
- High hazard locations
  - Grain elevators



Design Requirements

- Minimum pipe diameters
  - Class I & III: 4in
  - Combined system: 6 in
    - Hydraulically design for less
  - Location of hose connections
    - Class I:
      - Main floor landing on each floor in each required exit stair. (Previous editions required intermediate landing location between floors)
    - Class II:
      - Within 130ft of a connection everywhere

Exit Location Methods

- Class I and Class III systems
  - Connections located based on a building's exits

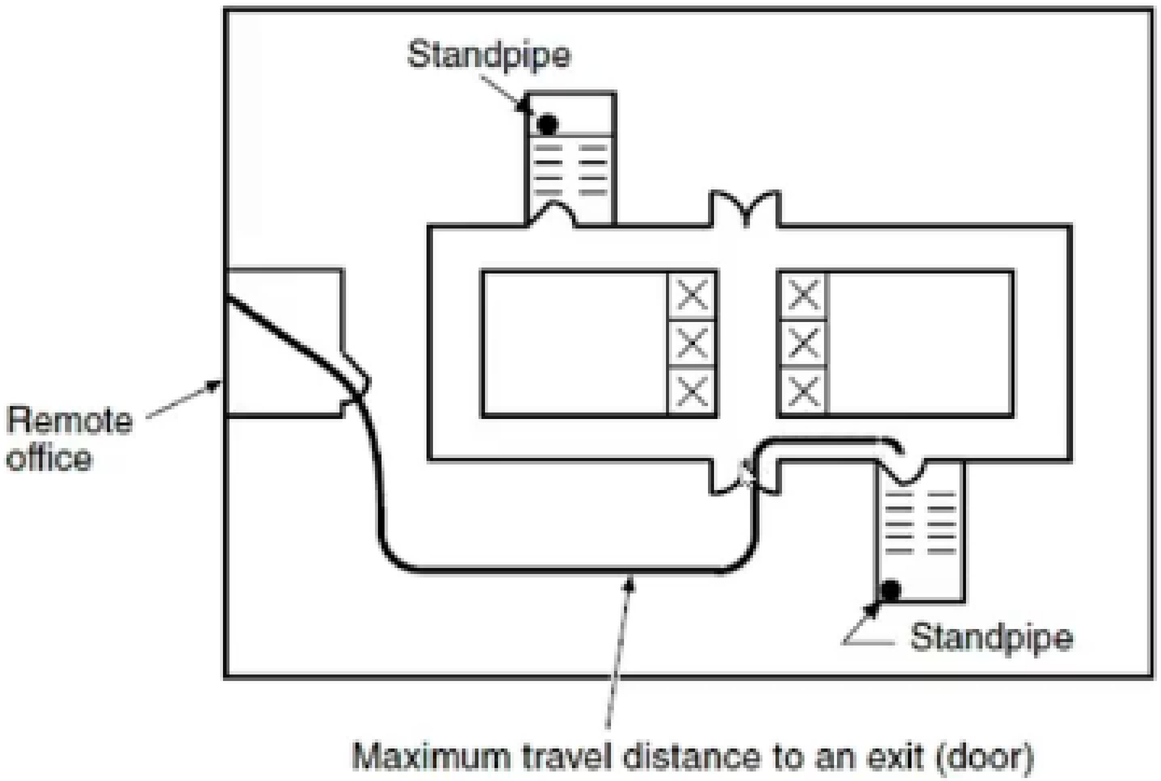


FIGURE 10.18.2 *Exit Location Method for Locating Hose Connections*

Actual Length Method

- Maximum distance of 130 ft
- 100 ft of hose
- 30ft of spray

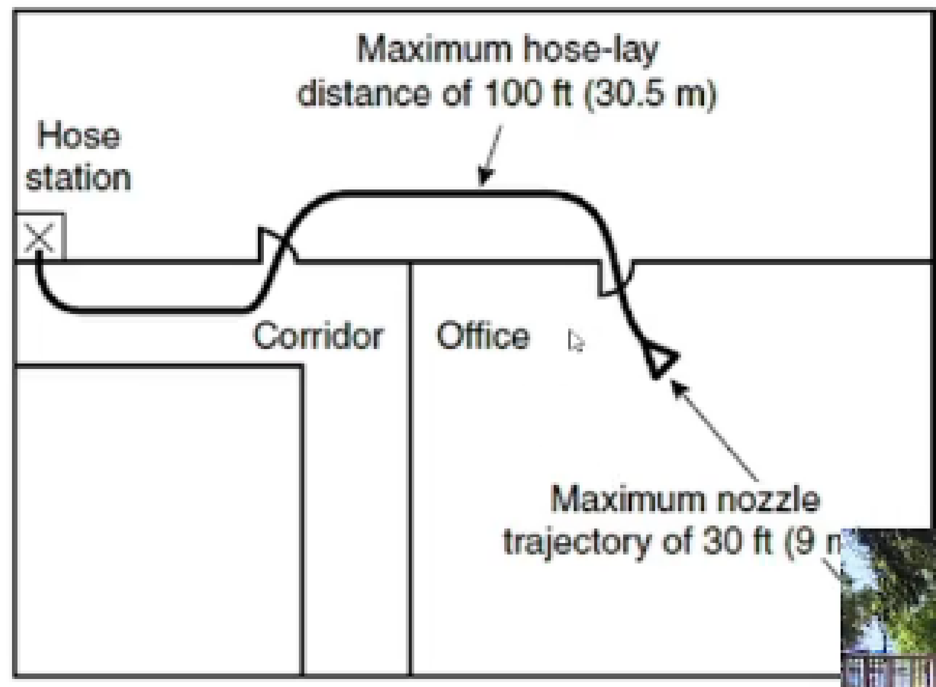
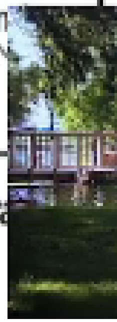


FIGURE 10.18.1 *Actual Length Method for Loc*
Connections



Pressure Requirements

- Maximum pressure in system 350 psi
- Pressure reducing devices required to limit
  - Residual pressure on 1.5 in connections to 100 psi
  - Static and residual pressures on 2.5 in connections to 175 psi
  - Static and residual pressures to 100 psi on 1.5 in connections where static pressure exceeds 175 psi
- Drain riser
  - 0.75 in to 2 in depending on riser size

Types of Standpipe Systems

- Automatic-wet
- Manual-wet
  - Minimal water connection
  - Needs fire department pumpers
- Automatic-dry
- Semiautomatic-dry
  - Deluge valve
- Manual-dry
  - Needs fire department pumper

Causes of System Failures

- From actual inspections:
  - Standpipe never actually completed
  - Leaking valves (dry pipe systems)
  - Faulty pipes
  - Improper threads
  - Fire department connection filled with garbage
  - Valves shut off

Initial Testing

`

- Plans review
- Initial inspection
  - Hydrostatic test
  - Flow tests
  - Listing of all devices by testing laboratory
  - Hose stations and connections
  - Signage on cabinets/closets and FDC

Required Testing

Δ Table 6.1.1.2 Summary of Standpipe and Hose Systems Inspection, Testing, and Maintenance

Item	Frequency	Reference
Inspection		
Cabinet	Annually	6.2.8
Control valves		Chapter 13
Gauges		Chapter 13
Hose	Annually	6.2.5
Hose connection	Annually	6.2.3
Hose nozzle	Annually and after each use	6.2.6
Hose storage device	Annually	6.2.7
Hydraulic design information sign	Annually	6.2.2
Hose valves		Chapter 13
Piping	Annually	6.2.4
Pressure-regulating devices		Chapter 13
Supervisory devices (except valve supervisory devices)		Chapter 13
Valve supervisory devices		Chapter 13
Test		
Control valves		Chapter 13
System valves		Chapter 13
Flow test	5 years	6.3.1
Hose		NFPA 1962
Hose connection pressure regulating devices		Chapter 13
Hose valves		Chapter 13
Hydrostatic test	5 years	6.3.2
Main drain test		Chapter 13
Pressure control valve		Chapter 13
Pressure-reducing valve		Chapter 13
Supervisory signal devices (except valve supervisory switches)		Chapter 13
Valve status test		Chapter 13
Valve supervisory devices		Chapter 13
Waterflow alarm devices		Chapter 13
Maintenance		
Hose valves		Chapter 13
Pressure gauges		Chapter 13
Valves (all types)	Annually/as needed	Chapter 13

Δ Table 13.1.1.2 Summary of Valves, Valve Components, and Trim Inspection, Testing, and Maintenance

Item	Frequency	Reference
Inspection		
Alarm Valves		
Exterior	Quarterly	13.4.1.1
Interior	5 years	13.4.1.2
Strainers, filters, orifices	5 years	13.4.1.2
Backflow Prevention Assemblies		
Reduced pressure	Weekly	13.7.1
Reduced-pressure detectors	Weekly	13.7.1
Interior	5 years	13.7.1.3
Check Valves		
Interior	5 years	13.4.2.1
Control Valves		
All valves except locked or supervised	Weekly	13.3.2.1
Locked or supervised	Monthly	13.3.2.1.1
Electrically supervised	Quarterly	13.3.2.1.2
Dry Pipe Valves/ Quick-Opening Devices		
Enclosure (during cold weather)		Chapter 4
Exterior	Monthly	13.4.5.1.2
Interior	Annually	13.4.5.1.3
Strainers, filters, orifices	5 years	13.4.5.1.4
Low temperature alarm	Annually	Chapter 4
Deluge Valves		
Enclosure (during cold weather)	Daily/weekly	Chapter 4
Exterior	Monthly	13.4.4.1.1
Interior	Annually/5 years	13.4.4.1.2
Strainers, filters, orifices	5 years	13.4.4.1.3
Fire Department Connections	Quarterly	13.8.1
Gauges	Monthly/quarterly	13.2.5
Hose Valves	Quarterly	13.6.1
Preaction Valves		
Enclosure (during cold weather)		Chapter 4
Exterior	Monthly	13.4.3.1.1
Interior	Annually/5 years	13.4.3.1.2
Strainers, filters, orifices	5 years	13.4.3.1.3
Pressure-Regulating and Relief Valves		
Master pressure-regulating	Weekly	13.5.4.1
Sprinkler system pressure-reducing	Quarterly	13.5.1.1
Hose connection pressure-regulating	Annually	13.5.2.1
Hose rack pressure-regulating	Annually	13.5.3.1
Fire pump circulation relief	With no flow test	13.5.6.1
Fire pump main pressure-relief	With fire pump test	13.5.6.2.1
Valve Supervisory Signal Initiating Device	Quarterly	13.3.2.1.3
Supervisory Signal Devices (except valve supervisory switches)	Quarterly	13.2.6.1
Testing		
Backflow Prevention Assemblies	Annually	13.7.2
Control Valves		
Operation and position	Annually	13.3.3.1
Valve status test	After the control valve closed and reopened	13.3.3.4
Supervisory	Semiannually	13.3.3.5
Deluge Valves		
Trip test	Annually/3 years	13.4.4.2.3

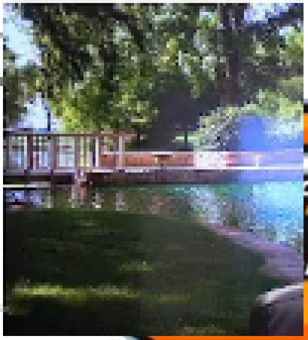
(continues)

UNIVERSITY

Inspections

Table 6.1.2 Standpipe and Hose Systems

Component/Checkpoint	Corrective Action
Hose Connections	
Cap missing	Replace
Fire hose connection damaged	Repair
Valve handles missing	Replace
Cap gaskets missing or deteriorated	Replace
Valve leaking	Close or repair
Visible obstructions	Remove
Restricting device missing	Replace
Manual, semiautomatic, or dry standpipe — valve does not operate smoothly	Lubricate or repair
Piping	
Damaged piping	Repair
Control valves damaged	Repair or replace
Missing or damaged pipe support device	Repair or replace
Damaged supervisory devices	Repair or replace
Hose	
Inspect	Remove and inspect the hose, including gaskets, and rerack or rereel at intervals in accordance with NFPA 1962, *Standard for the Inspection, Care, and Use of Fire Hose, Couplings, and Nozzles and the Service Testing of Fire Hose*
Mildew, cuts, abrasions, and deterioration evident	Replace with listed lined, jacketed hose
Coupling damaged	Replace or repair
Gaskets missing or deteriorated	Replace
Incompatible threads on coupling	Replace or provide thread adapter
Hose not connected to hose rack nipple or valve	Connect
Hose test outdated	Retest or replace in accordance with NFPA 1962
Hose Nozzle	
Hose nozzle missing	Replace with listed nozzle
Gasket missing or deteriorated	Replace
Obstructions	Remove
Nozzle does not operate smoothly	Repair or replace
Hose Storage Device	
Difficult to operate	Repair or replace
Damaged	Repair or replace
Obstruction	Remove
Hose improperly racked or rolled	Remove
Nozzle clip in place and nozzle correctly contained?	Replace if necessary
If enclosed in cabinet, will hose rack swing out at least 90 degrees?	Repair or remove any obstructions
Cabinet	
Check overall condition for corroded or damaged parts	Repair or replace parts; replac
Difficult to open	Repair
Cabinet door will not open fully	Repair or move obstructions
Door glazing cracked or broken	Replace
If cabinet is break-glass type, is lock functioning properly?	Repair or replace
Glass break device missing or not attached	Replace or attach
Not properly identified as containing fire equipment	Provide identification
Visible obstructions	Remove
All valves, hose, nozzles, fire extinguisher, etc., easily accessible	Remove any material not rela



Δ **Table 6.5.1 Summary of Component Action Requirements**

Component	Adjust	Repair	Replace	Required Action
Water Delivery Components				
Backflow prevention device	X	X	X	See Chapter 13
Control valves	X	X	X	See Chapter 13
Fire department connections	X	X	X	See Chapter 13
Fire hose			X	No action required
Fire hose		X		Perform hydrostatic test in accordance with NFPA 1962
Hose valve	X	X	X	See Chapter 13
Hose valve pressure-regulating devices	X	X	X	See Chapter 13
Piping	X	X	X	Hydrostatic test in conformance with NFPA 14
System pressure-regulating devices	X	X	X	See Chapter 13
Alarm and Supervisory Components				
Pressure switch–type waterflow	X	X	X	Operational test using inspector's test connection
Valve supervisory device	X	X	X	Operational test for receipt of alarms and verification of conformance with NFPA 14 and/or *NFPA 72*
Vane-type waterflow	X	X	X	Operational test using inspector's test connection
Water motor gong	X	X	X	Operational test using inspector's test connection
Status-Indicating Components				
Gauges	X		X	Verify at 0 psi (0 bar) and system working pressure
System Housing and Protection Components				
Cabinet	X	X	X	Verify conformance with NFPA 14
Hose storage rack	X	X	X	Verify conformance with NFPA 14
Testing and Maintenance Components				
Auxiliary drains	X	X	X	Inspect for leaks at system working pressure
Drain riser	X	X	X	Inspect for leaks while flowing from connection above the repair
Main drain	X	X	X	Inspect for leaks and residual pressure during main drain test
Structural Components				
Hanger/seismic bracing	X	X	X	Verify conformance with NFPA 14
Pipe stands	X	X	X	Verify conformance with NFPA 14
Informational Components				
Hydraulic design information sign	X	X	X	Verify conformance with NFPA 14
Identification signs	X	X	X	Verify conformance with NFPA 14

Fire Department Connections

- Located within 100 ft of hydrant
  - <18 in above sidewalk
- Class I and Class III
  - At least one FDC
  - Zoned buildings: at least one FDC per zone
- Maximum height:
  - 450 feet (two-stage pumper)
- Connections:
  - Female or Storz
  - Standard caps
- Signage

Course Review

Final Exam

`

- 100 points, 25% of final grade, comprehensive
- 1 full hydraulic calculation
- 1 end head analysis
- 1 pipe schedule method design
- 12 additional questions
  - Warehouses
  - NFPA and IBC code look up
  - Information from lectures
    - Residential systems, standpipe systems, ethics plan review

Final Exam

- Open notes
- NFPA 13
- IBC packet (Chapter 9)
- Approved calculator
- Straight edge
- NO PHONE

Final Exam

You NEED !

- Hydraulic calculation paper
- Water supply graph
- 1 blank sheet to draw your design area

Light Hazard Pipe Schedules

Table 27.5.2.2.1 Light Hazard Pipe Schedules

Steel		Copper in.	Copper mm	
1 in. (25 mm)	2 sprinklers	1 in.	25 mm	2 sprinklers
1¼ in. (32 mm)	3 sprinklers	1¼ in.	32 mm	3 sprinklers
1½ in. (40 mm)	5 sprinklers	1½ in.	40 mm	5 sprinklers
2 in. (50 mm)	10 sprinklers	2 in.	50 mm	12 sprinklers
2½ in. (65 mm)	30 sprinklers	2½ in.	65 mm	40 sprinklers
3 in. (80 mm)	60 sprinklers	3 in.	80 mm	65 sprinklers
3½ in. (90 mm)	100 sprinklers	3½ in.	90 mm	115 sprinklers
4 in. (100 mm)	See Section 4.5	4 in.	100 mm	See Section 4.5

- For 4 in and above without partitions, same as ordinary hazard

Sprinklers above and below a ceiling

Table 27.5.2.4 Number of Sprinklers Above and Below Ceiling

Steel		Copper	
1 in. (25 mm)	2 sprinklers	1 in. (25 mm)	2 sprinklers
1¼ in. (32 mm)	4 sprinklers	1¼ in. (32 mm)	4 sprinklers
1½ in. (40 mm)	7 sprinklers	1½ in. (40 mm)	7 sprinklers
2 in. (50 mm)	15 sprinklers	2 in. (50 mm)	18 sprinklers
2½ in. (65 mm)	50 sprinklers	2½ in. (65 mm)	65 sprinklers

Ordinary hazard pipe schedule

Table 27.5.3.4 Ordinary Hazard Pipe Schedule

Steel		Copper	
1 in. (25 mm)	2 sprinklers	1 in. (25 mm)	2 sprinklers
1¼ in. (32 mm)	3 sprinklers	1¼ in. (32 mm)	3 sprinklers
1½ in. (40 mm)	5 sprinklers	1½ in. (40 mm)	5 sprinklers
2 in. (50 mm)	10 sprinklers	2 in. (50 mm)	12 sprinklers
2½ in. (65 mm)	20 sprinklers	2½ in. (65 mm)	25 sprinklers
3 in. (80 mm)	40 sprinklers	3 in. (80 mm)	45 sprinklers
3½ in. (90 mm)	65 sprinklers	3½ in. (90 mm)	75 sprinklers
4 in. (100 mm)	100 sprinklers	4 in. (100 mm)	115 sprinklers
5 in. (125 mm)	160 sprinklers	5 in. (125 mm)	180 sprinklers
6 in. (150 mm)	275 sprinklers	6 in. (150 mm)	300 sprinklers
8 in. (200 mm)	See Section 4.5	8 in. (200 mm)	See Section 4.5

Ordinary hazard branch lines

- When spacing between heads or between branch lines > 12 ft:

Table 27.5.3.5 Number of Sprinklers — Greater Than 12 ft (3.7 m) Separations

Steel		Copper	
2½ in. (65 mm)	15 sprinklers	2½ in. (65 mm)	20 sprinklers
3 in. (80 mm)	30 sprinklers	3 in. (80 mm)	35 sprinklers
3½ in. (90 mm)	60 sprinklers	3½ in. (90 mm)	65 sprinklers

Note: For other pipe and tube sizes, see Table 27.5.3.4.

Summary of steps

1. Occupancy
2. Design area
3. Required design density
4. Number of sprinklers in design area
5. Shape of the design area

Summary of steps

1. Occupancy
2. Design area
3. Required design density
4. Number of sprinklers in design area
5. Shape of the design area
6. Minimum flow from the first sprinkler
7. Minimum pressure for first sprinkler (>7psi)
8. Friction loss between first and second sprinklers
9. Minimum flow from second sprinkler
10. Repeat steps 8 and 9 for branch lines
11. Repeat previous steps for opposite branch line
12. Calculate K factor for riser nipple
13. Repeat steps 8 and 9 for branch lines
14. Addition friction loss beyond design area
15. Add hose stream demand
16. Conduct water supply analysis

End Head Analysis Step 1

- Plot the system demand curve
  - Demand point
  - At 0 gpm the pressure required to overcome elevation up to the highest sprinkler
- Example
  - System designed for 410 gpm at 48 psi
  - 18 ft elevation of highest sprinkler
  - Blue curve

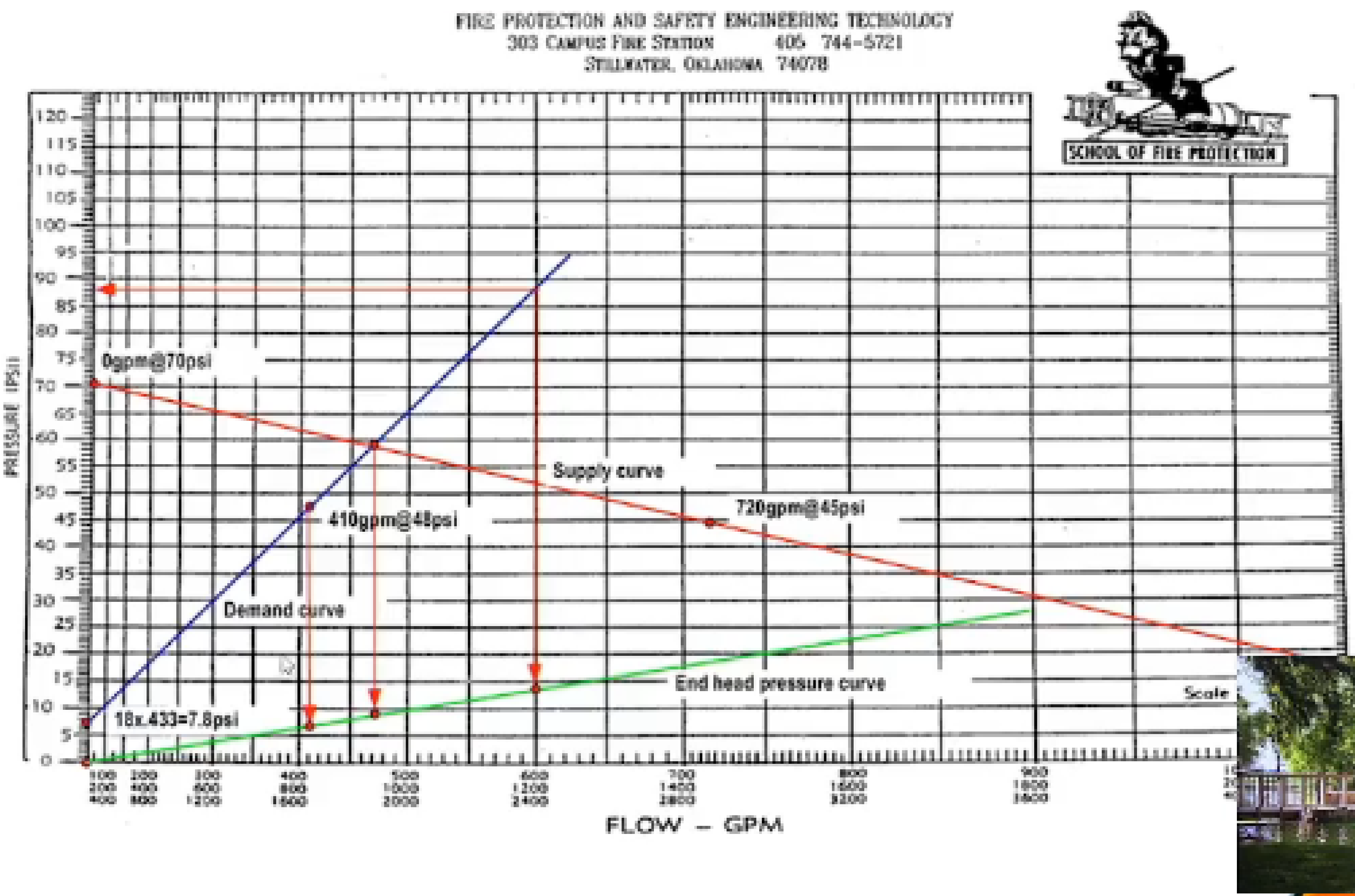
End Head Analysis Step 2

- Plot the end head pressure curve
  - Drop vertical line straight down from demand point
  - Calculate the required end head pressure from:
    - P=(q/k)^2
  - Plot this pressure on the vertical line
  - Plot a point at (0,0)
  - Connect these points with a straight line
- Example:
  - System designed for:
    - 0.12gom/ft^2, 120 ft^2 per head, k=5.4(7.1psi)
  - Green curve

End Head Analysis Step 3

- Can now calculate any demand curve
- Plot the water supply curve
- Example
  - Static pressure 70 psi
  - Flow test 720 gpm at 45 psi
  - Red curve

Example



FIRE PROTECTION AND SAFETY ENGINEERING TECHNOLOGY
303 CAMPUS FIRE STATION 405 744-5721
STILLWATER, OKLAHOMA 74078
SCHOOL OF FIRE PROTECTION
PRESSURE (PSI)
0gpm@70psi
Supply curve
720gpm@45psi
410gpm@48psi
Demand curve
End head pressure curve
18x.433=7.8psi
Scale
FLOW — GPM

Engineering Ethics

"Among the universal ethical values are honesty, integrity', promise-keeping, fidelity. fairness, respect for others, responsible citizenship, pursuit of excellence and acceptability."

-Michael Josephson

Engineering Ethics

- **Black and White Areas –Easy**
  - Right vs. Wrong
- **Gray Areas – Tougher**
  - Right vs. Right
  - Lesser of the Evils/Dilemma
- **Other Factors**
  - Time/Money
  - Family
  - Career
  - Reputation

Engineering Ethics

- Professional Maturity
- Learning to Be Comfortable with Ambiguity
- More than One Answer to the Same Question
- Sometimes One Answer is Not Entirely Correct

SFPE
Engineering A Fire Safe World

Engineering Ethics

- Emotional Intelligence
  - Self-awareness (e.g., handling stress)
  - Self-regulation (e.g., the words you use)
  - Empathy (e.g., feeling other's pain)
  - Social Skills (verbal, non-verbal skills)

Engineering Ethics

- **“Novice”** ——complies with strict rules based on context free features of the task environment
- **“Advanced Beginner”** ——Recognizes the situational aspects of the task environment and follows maxims to adjust his or her actions accordingly

Engineering Ethics

- **“Competent Performer”** —— Does not try to account for all discrete elements of the task environment; instead, he or she selects a plan, goal or perspective to establish which elements are relevant and which may be safely ignored.
- **“Proficient Performer”** ——No longer reflects on the task environment as a detached observer; without having to evaluate multiple options, he or she simply sees that needs to be done and then chooses how to go about doing it

Engineering Ethics

- **“Expert”** —— Intuitively perceives both that need to be done and how to do it, making extremely subtle and refined discriminations in a variety of task environments that are sufficiently similar to those previously encountered.

Engineering Ethics

- Data
- Information
- Facts
- Knowledge
- Expertise
- Wisdom

Engineering Ethics

- **Utilitarianism**—What is ethical is that which produces the greatest good for the greatest number
- **Duty Ethics**—What is ethical is to perform duties regardless of whether they lead to "good" outcomes
- **Right Ethics**—Mirror of Duty Ethics; People have rights that cannot be violated
- **Virtue Ethics**—Actions reflecting good character traits are good, vices are bad, outcome of action is not relevant

Engineering Ethics

- **Why Study Engineering Ethics?**
  - To Understand the Standards Governing
  - What is Acceptable Behavior in the Practices of Engineering
- **Why Practice Engineering Ethically?**
  - Personal Injury/Property Damage
  - Disciplinary Action
  - Impact on Reputation, Employer, Clients, Profession
  - Possible Loss of Job, Business, etc

Engineering Ethics

Hierarchy of Ethical Obligation

- <u>Primary: </u>Ethical Obligations to the Public
- <u>Secondary: </u>Ethical Obligations to Employer or Client
- <u>Tertiary: </u>Ethical Obligations to Other Professionals and Other Parties

Engineering Ethics

Three Basic Ethical Obligations (1)Public, (2) Employer/Client, and (3)Other Professionals

- Never Mutually Exclusive-Reciprocal
- Not A “Zero Sum Game”
- All Need to Be Considered At all time
- Should Be Complementary to be Integrated With One Another To The Fullest Extent Possible
- Ethical Integration=Professional Integrity

Engineering Ethics

Seven Principle Impacting Each Obligation

1. Protecting The Public Health, Safety and Welfare
2. Demonstrating Professional Competence
3. Maintaining Objectivity /Truthfulness
4. Addressing Conflict of Interest
5. Receiving Confidentiality
6. Receiving and Providing Valuable Consideration
7. Emerging Areas/Emerging Challenges

Engineering Ethics

1. Protecting the public health, safety and welfare
    - Conformance with applicable standard
    - Approval/signing and sealing of engineering drawings
    - Responsible charge/responsible control
    - Judgment overruled
    - Awareness of safety violations
    - Awareness of illegal practice

Engineering Ethics

2. Demonstrating Professional Competence
    - Education, experience, qualifications
    - Acceptance of assignment
    - Signing and sealing of work
    - Coordination of work
    - Scope of practice

Engineering Ethics

3. Maintaining objectivity/truthfulness/non-deception
   - Inclusion of All relevant information
   - Issuance of public statements
   - Disclosure to interested parties
   - Expression of technical opinions
   - Reviewing work of another
   - Sales and market practices

Engineering Ethics

4. Addressing conflicts of interest
   - Faithful agent and trustee
   - Avoid vs. disclosure
   - "Appearances"
   - Acceptance of compensation from more than one party
   - Serving on public bodies
   - Accepting contracts from government bodies
   - Part-time engineering work
   - Contingent fee arrangements
   - Representing Adversary Interest
   - Consent

Engineering Ethics

5. Preserving Confidentiality

- Business or Technical Affairs of Employers/Clients
- Proprietary Information/Files
- Arranging for new employment or business opportunities
- Consent

Engineering Ethics

6. Receiving and Providing Gifts and Other Valuable Consideration

- Accepting Consideration from suppliers for specifying product
- Accepting commissions/allowances directly from contactors
- Political contributions
- Bribery

Engineering Ethics

7. Emerging Areas/Emerging Challenges

- Technology
  - Use of Internet and Electronic Practice
- Sustainable Design/Development
  - Environmental Considerations
- Alternative Project Delivery
  - Integrated Project Delivery
  - Building Information Modeling
  - Design/Build

Engineering Ethics

A Word About Fraud

Fraud is…

- A deceitful practice
- Results in an injury
- It is always intentional
- It always includes a lie

Engineering Ethics

Fraud and Other Financial Risks

According to National Inspector General Organizations, there are three elements often present:

- "Opportunity" -accessibility
- "Motive" -Easy Money
- "Justification" - "I am entitled"

=MISCONDUCT