History of Sprinkler Systems
&
NFPA 25

Presented by:
Steven Schneider-CFPS

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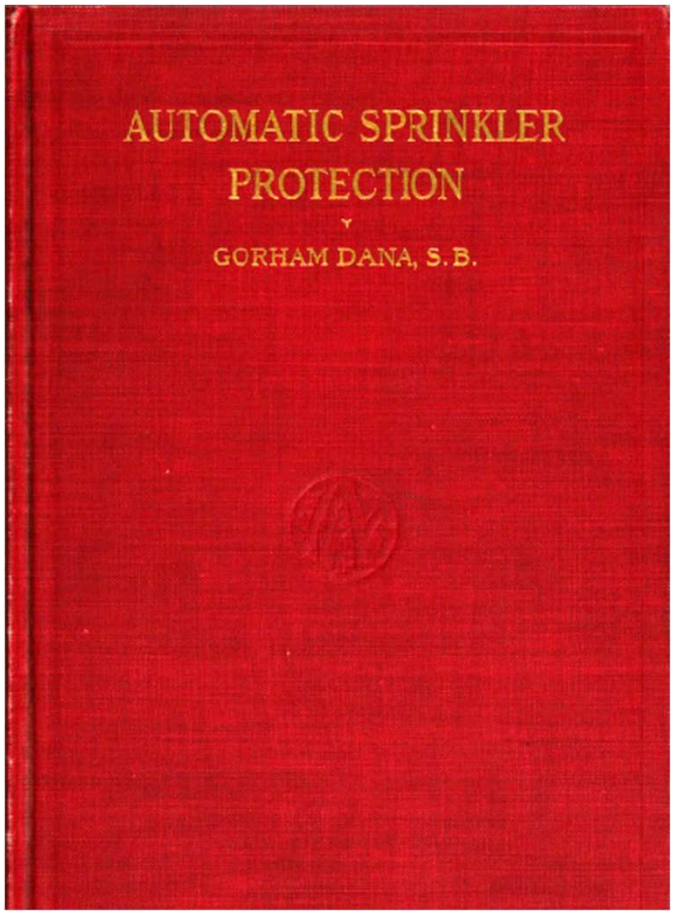
History

Reference Text

- Gorham Dana's, *Automatic Sprinkler Protection*
- Second Edition, published 1919
- Manager, The Underwriters Bureau of New England, Boston, Massachusetts



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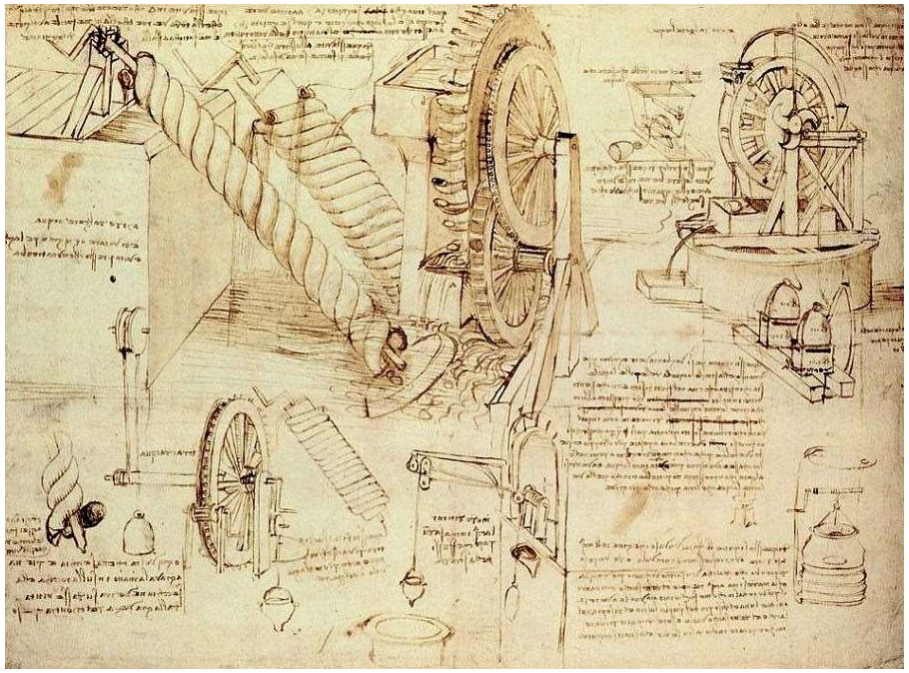
History

15th Century

- Leonardo da Vinci
- One of the first know sprinkler systems
- Designs conveyer belt system for kitchen, higher temperature oven and sprinkler system
- Small fire activates system, flooding kitchen



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History

1723

- Ambrose Godfrey
- German born apothecary and phosphorous manufacturer
- First automated sprinkler system
- Cask of water, containing a pewter chamber of gunpowder
- Fire would ignite fuses connected to chamber of gunpowder, exploding the cask of water

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History

1806

- John Carey files patent for perforated pipe system in England
- First automatic system where water flowed through pipes
- Rows of perforated sprinkler pipes, with 1/3” width holes spaced 3’ to 10’ apart, connected to an elevated water tank
- Main supply valve would be closed and connected to a system of cords and weights
- Fire would burn through cord, causing counter-weight to operate valve
- Was considered revolutionary, because firefighters at that time, could not enter a building

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History

1812

- Sir William Congreve
- Installs system in London's Theatre Royal using rose sprinklers with cords to outdoor control valve at watertight reservoir
- Contained connection and valve outside for fire department to connect to and supply water independently of reservoir
- Also included an alarm attachment operated by a dropping weight

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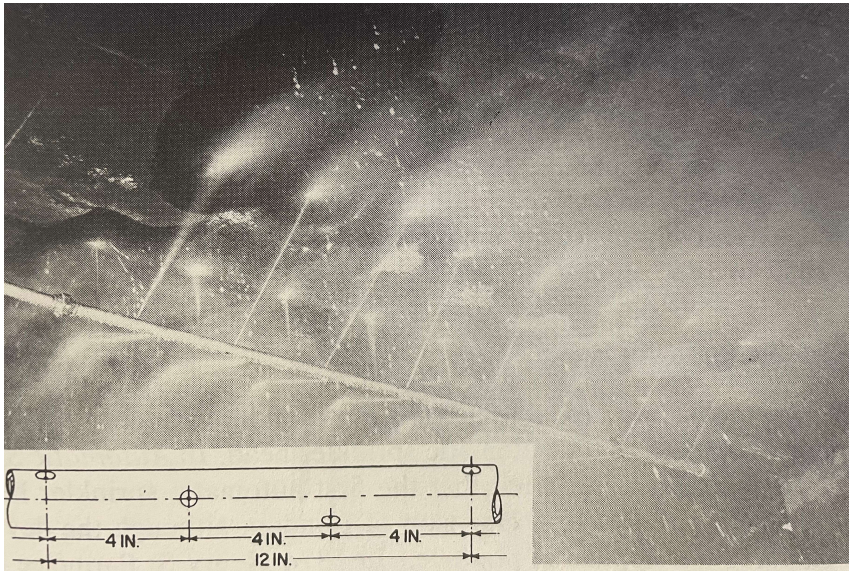
History

1850

- Mid-nineteenth century, manually operated, perforated pipe systems being installed in America
  - Typically 1/10” holes, 9” apart on alternating sides of pipe, slightly above the horizontal center
  - Initially installed to protect roofs of textile mills and consequentially the floor area



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History

1850

- Providence Steam and Gas Company founded, which later became the Grinnell Company
  - Installs perforated pipe systems in New England mills

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History

Perforated Pipe Systems

- Issues were even distribution of the water and the pipes would rust, blocking the holes
- To prevent rusting, pipe was coated with tar and pitch
  - Heat from the fire melted the tar, allowing water to flow through the perforations
  - If fire started too far from pipe, tar would not melt quickly
  - Water flowing through pipe to open perforations further down pipe, would cool upstream tar, preventing it from melting
- Water damage due to water flowing from all holes on all pipes

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History

1860

- Inventors began focusing on designs that could turn themselves on; automatic systems
- Barnabas Wood of Nashville, Tennessee patents the first automatic sprinkler head in the United States?
  - Uses eutectic fusible solder link
  - Operates at 165^{o}F

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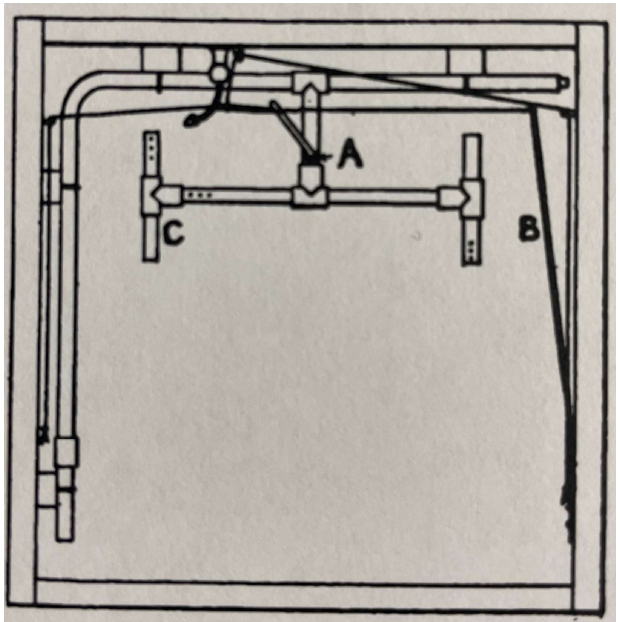
History

1872

- Philip W Pratt patented the first automatic system
- Two revolving perforated arms connected to a valve under water pressure
- When fuse melted, the weighted cord pulled valve open, water flowing out of the perforations caused the assembly to rotate



PRATT SPRINKLER SYSTEM.
A, valve. B, cord. C, distributor.

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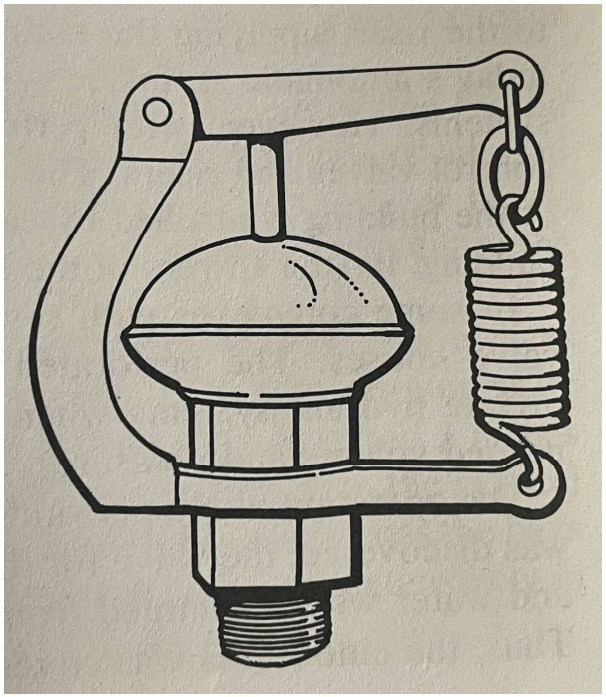
History

1874

- Henry Parmelee patents first practical automatic sprinkler head
- Perforated head containing a valve, which is held closed against water pressure by a heavy spring
- Spring is held in place by metal eye manufactured from low-fusing material



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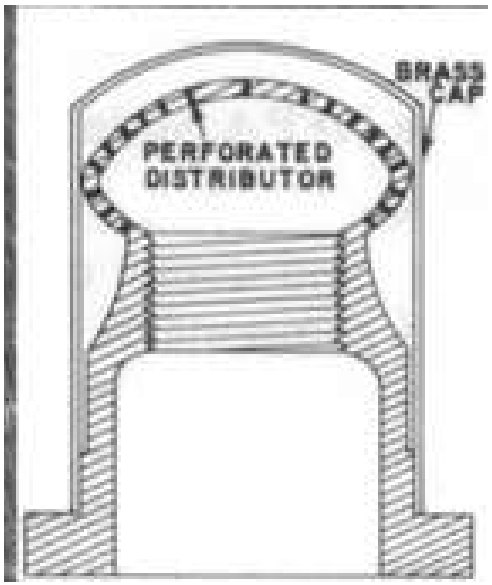
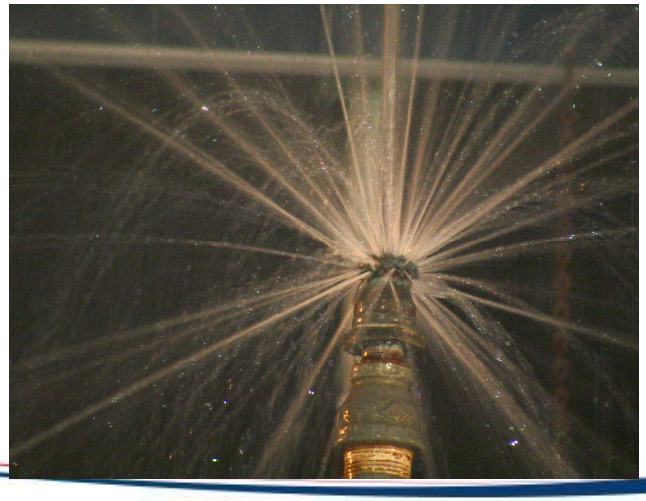
History



1875

- Parmelee patents sprinkler design where cap is held in place by solder, covering a perforated distributor
- Simple design, but water against back of cap acted as a heat sink, delaying activation
- First automatic sprinkler head extensively installed



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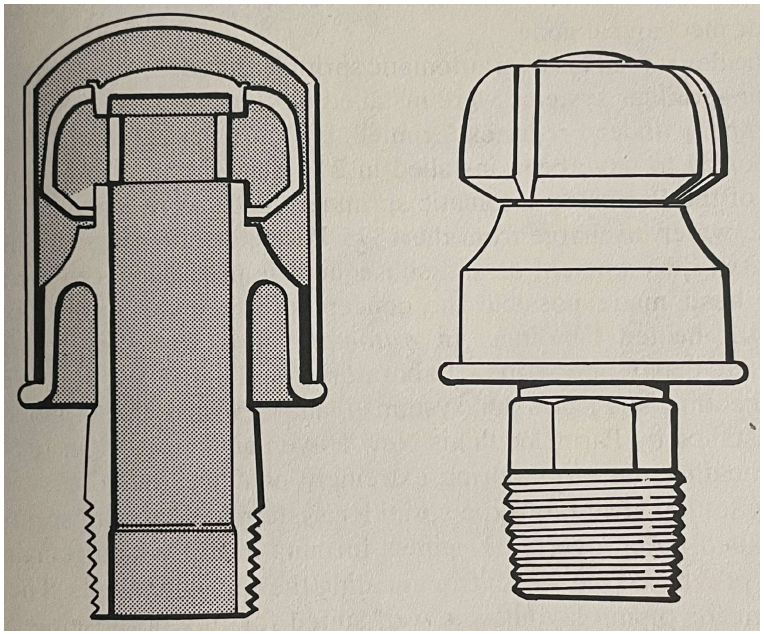
History

1878

- Parmelee further improves sprinkler when perforated head is replaced with rotating, slotted turbine
- Once cap was forced off at approximately 160^{o}F, water flow through turbine spun head, providing better water distribution
- Less likely to clog versus perforated distributor



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History

Parmelee Systems

- Installed with a single riser to feed all floors with riser being large enough to supply the greatest number of sprinklers on any one floor
  - This replaced a separate riser for every floor, which was the case for perforated pipe systems.
  - Assumption was that fire would be confined to one floor, due to quicker response of sprinkler heads directly over fire
- Essentially the same thought process of designing modern systems

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History

Parmelee Systems

- System also contained an alarm style valve that operated a steam whistle or bell when water flowed
  - Consisted of a check valve with a lever attached to the hinged end of the clapper
  - Lever extended through a stuffing box with wire connected to whistle or mechanical gong
  - Waterflow lifts clapper, moving lever down, pulling wire activating alarm

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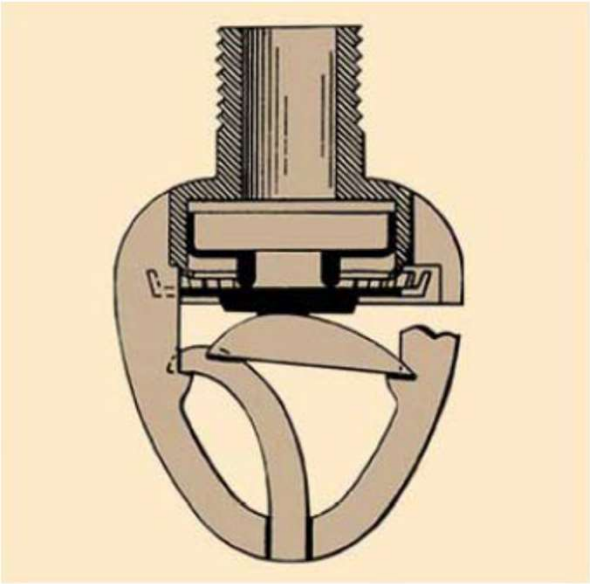
History

1881

- Frederick Grinnell patents first “sensitive” automatic sprinkler head
- Design incorporates some of today’s sprinkler features
  - Less mass, making it more responsive
  - Single ½” orifice, less likely to clog, as 1/10th holes in perforated distributor style
  - Tooth-edged deflector



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History

1879

- First patent for a dry pipe valve
  - Mechanical type and were susceptible to corrosion and required tedious adjustment
  - Most were replaced by the mid-1920s

1884

- Factory Mutual begins testing of sprinklers
  - 18 different types were available
- First recorded sprinkler report published

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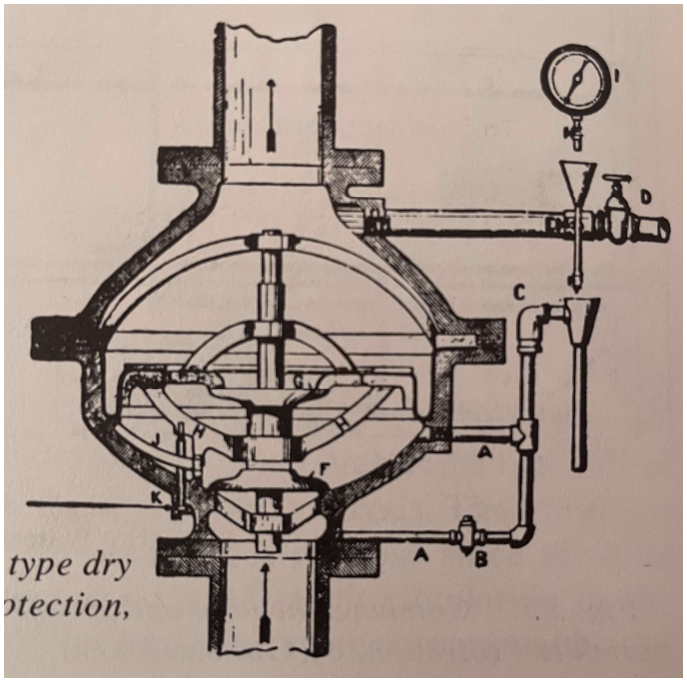
History

1885

- Grinnell patents a “bellows” style differential dry valve
  - Replaces mechanical dry valves
  - Most generally used dry valve prior to 1900



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History

1887

- Factory Mutual adopts sprinkler installation rules

1888

- Providence Steam & Gas develop the “English” style alarm valve
  - First widely used alarm valve

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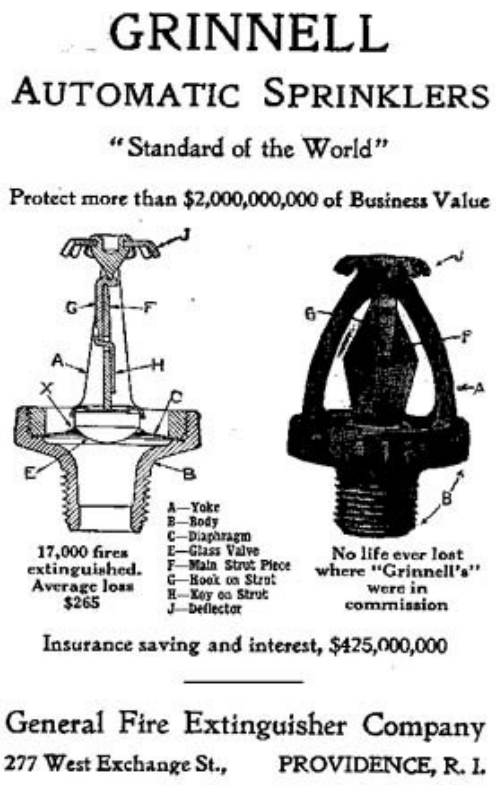
History

1891

- Grinnell Model A
  - Glass disc
  - Became the industry standard
  - Manufactured until 1935



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History

1896

- The National Fire Protection Association (NFPA) is formed in Boston
  - Initial meeting held in 1895 by Frederick Grinnell and representatives of five insurance companies
  - Founding was in response to complaints of improper system installations
- First standard for installation of automatic sprinkler systems written by the Committee on Automatic Sprinklers (NFPA 13)
  - *Rules and Regulations of the National Fire Board of Fire Underwriters for Sprinkler Equipments, Automatic and Open Systems*
- Installation of sprinklers became somewhat uniform in the United States and Canada.

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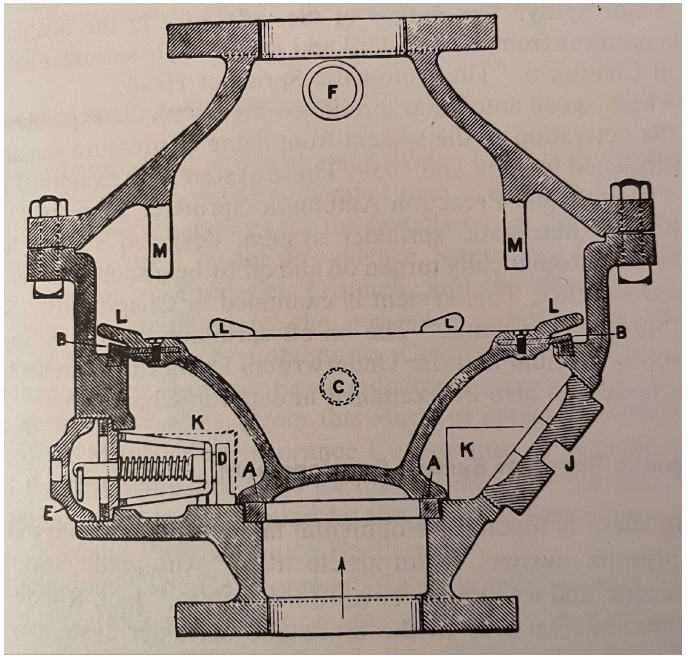
History

1900

- Grinnell differential dry pipe valve No. 12 is released
  - Predecessor to the modern clapper style differential valve
    - Latches in open position



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History

1905

- ¾”-1”-1¼” pipe schedule for three sprinklers adopted (NFPA 13)

1906

- George Hibbard of Chicago creates a sprinkler head with two levers and a two-piece fusible link
- Becomes the standard for future sprinklers

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History

1909

- Sprinklers installed for the first time in a school, in Buffalo, New York

1914

- Sprinklers installed for the first time on seagoing vessels

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History

1917

- Underwriter's Laboratories (UL) approves combination sprinkler/heating system
  - Parmelee's 1874 system was also used for heating during extreme cold weather
  - Sprinkler heads installed on U shaped pipes to trap water and prevent steam in system from heating sprinkler head
- 1900s systems involved circulating hot water in lieu of steam
  - Larger branch lines of 1½" or 2" connected to auxiliary risers
  - Last system installed in 1940

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History

1919

- UL publishes *Standard for Automatic Sprinklers*
- NFPA study shows majority of sprinkler failures are due to valves closed
  - Leads to valve supervision requirements

1920

- First Quartzoid sprinkler head released
  - Originally known as the Grinnell Silica Bulb Sprinkler

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History

1930

- Light and Extra Hazard classifications designated in standard for first time

1931

- Grinnell Duraspeed sprinkler released
  - Manufactured till early 1990's
  - Much quicker response with heat collector, versus solid link
- Research testing confirms that quartzoid bulb sprinklers more heat sensitive than solder links

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History

1933

- NFPA issues the first pamphlet/guide for fire departments regarding the use of sprinkler systems; *Use of Automatic Sprinklers By Fire Departments*
  - Evolves into NFPA 13E in 1966, *Recommended Practices for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems*
- Deluge and preaction initially developed in early 1900s, but a preaction valve with supervisory air capability first released in 1933

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History

1935

- Pioneering installation of water spray system for transformer protection installed at Consolidated Edison, New York, Hells Gate Station

1939

- First edition of *Care and Maintenance of Sprinkler Systems* published
  - Evolves into NFPA 25, *Standard for Inspection, Testing and Maintenance of Water Based Fire Protection Systems*

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History

1940

- ¾” branch line no longer permitted

1952

- Foam-water system introduced

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History

1955

- NFPA 13
  - Makes new distribution patterns “standard”. Must meet a performance criteria
    - Replaces older distribution patterns; conventional pattern heads
  - Increases maximum sprinkler spacing for Ordinary Hazard from 100 sq. ft. to 130 sq. ft.
  - 8” pipe allowed and increases maximum allowable number of sprinklers using large pipe, pipe schedule systems.

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History

1958

- Grinnell releases “Primac”, high speed deluge system
  - Uses small explosive charge to open deluge valve to preprimed piping network

1962

- NFPA releases first edition of Standard 16, *Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*

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History

1963

- Factory Insurance Association issues report on the protection of high piled storage
  - Report states extinguishment cannot be achieved for storage in excess of 20 ‘ high
  - Becomes Industrial Risk Insurers

1971

- First concealed sprinkler head released by Star, the Model G Unspoiler

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History

1973

- First on-off sprinklers released
  - Grinnell AquaMatic
  - Star Quick-E
- NFPA 13 allows hydraulically calculated systems
- NFPA 13 appoints a subcommittee to develop a residential standard
- Central Sprinkler Corporation pioneers the miniaturization of sprinklers

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History

1974

- First edition of NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes* adopted

1980

- First listed residential sprinkler
  - Grinnell Model FR-1
- MGM Grand fire in Las Vegas kills 85 guests and workers
  - Leads to one of the nation's first fire sprinkler system retrofit ordinances in high rise buildings

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History

1983

- First horizontal sidewall (HSW) sprinkler heads for residential use
- First institutional sprinkler head
  - Star PH-34
- Factory Mutual begins research on what would become the Early Suppression Fast Response (ESFR) sprinkler head
- NFPA 13 divides Extra Hazard occupancies into two separate classes

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History

1984

- The first BF Goodrich, *BlazeMaster®* systems installed

1987

- Factory Mutual issues its first guidelines for ESFR sprinklers for the protection of rack storage
- BOCA adopts codes calling for fire sprinklers in multi-family structures

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History

1988

- First FM approved ESFR sprinkler released
- Following the Safeway Warehouse and Interstate Bank fires, California enacts retrofit ordinances for high rise structures

1991

- Following One Meridian Plaza fire, Philadelphia enacts high rise retrofit ordnance

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History

1992

- First edition of NFPA 25 published, *Standard for Inspection, Testing and Maintenance of Water Based Fire Protection Systems*
  - Combination of NFPA 13A, *Recommended Practice for Inspection, Testing and Maintenance of Sprinkler Systems* NFPA 14A, *Recommended Practice for Inspection, Testing and Maintenance of Standpipe and Hose Systems*
- First Extra Large Orifice (ELO) sprinkler introduced

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History

1993

- First “residential shut off valve” introduced; diverts all the residential water supply to the fire protection system in the event of sprinkler activation

2002

- First Extended Coverage sprinkler head for storage occupancies introduced

Maintaining
Inspecting
General Considerations

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Maintaining

Old Style Sprinklers Versus Standard Sprinklers

- Old style manufactured prior to 1953 (conventional)
  - Discharges approximately 40% of water upwards towards ceiling
- If a representative sample of heads pass testing, the remaining do not have to be replaced
- If replacing, replace with standard sprinkler upright (SSU)
  - Unless a combustible ceiling surface is above heads
  - Standard sprinklers, SSU, SSP and sidewall, discharge horizontally, not upwards

Maintaining

Thermal Sensitivity

- Measure of thermal sensitivity is known as Response Time Index (RTI)
  - 50 or less: fast response
  - 80 to 100: standard response
  - In between 50 and 80, not recognized in the United States
- Sprinkler head is placed in a heated oven and measured for time to activate
  - UL and FM don’t use same oven or testing criteria, but results are close

Maintaining

Thermal Sensitivity

- Fast response
  - Refers only to element, not entire sprinkler, typically 26 RTI
    - ESFR
- Quick response
  - Entire assembly tested, typically 25 RTI
  - Specific testing; room size, placement, higher horizontal water discharge
    - Residential heads

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Maintaining

Inspection of sprinklers

- Visual inspection from floor
- Must be replaced
  - Paint, caulk, spackle, loaded
  - Corrosion
- Do sprinklers have bags or protective caps

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Maintaining

Recalled sprinkler heads

- Tyco “voluntary recall” of Central Omega heads
  - Voluntary, due to Tyco agreeing to program before being required by the Consumer Product Safety Commission
  - Heads are required to be replaced, its not voluntary whether it is done or not
- 2020 edition of NFPA 25
  - If identified as recalled, must be replaced, has been moved from the Annex, back into the body of the standard

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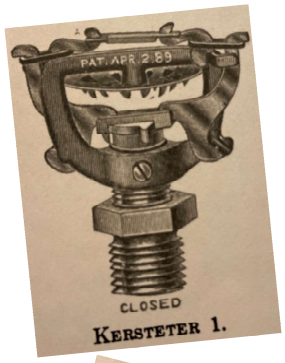
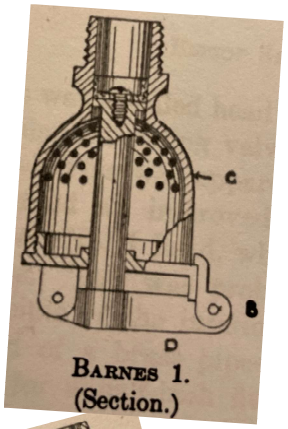
Maintaining

Testing

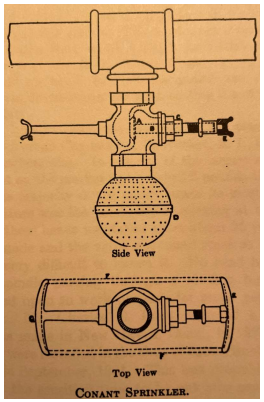
- Sprinklers manufactured 1920 or earlier, must be replaced
  - Solder used at the time did not respond predictably
  - Head designs were overly complex
- Some sprinkler styles and brands from that era have a 100% failure rate



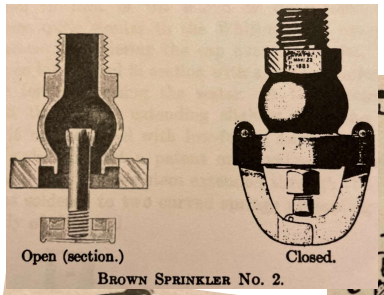
KERSTETER 1.



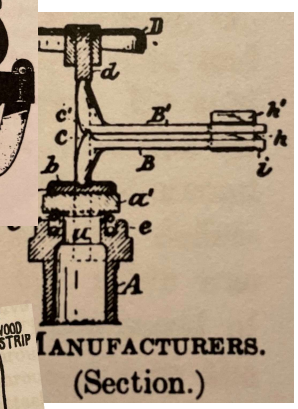
BARNES 1.
(Section.)



CONANT SPRINKLER.



BROWN SPRINKLER No. 2.



MANUFACTURERS.
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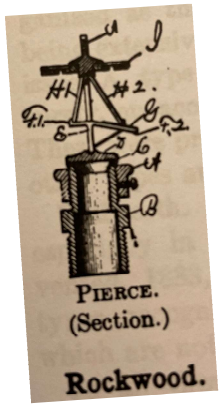
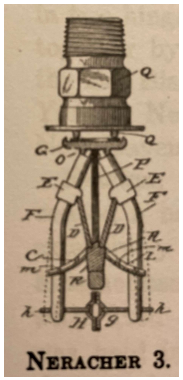
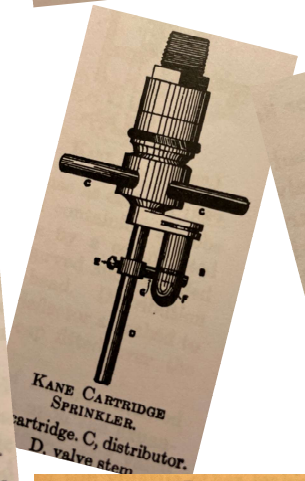


PIERCE.
(Section.)
Rockwood.


NERACHER 3.


KANE CARTRIDGE SPRINKLER.
artridge. C, distributor.
D, valve stem.

BARNES 1.
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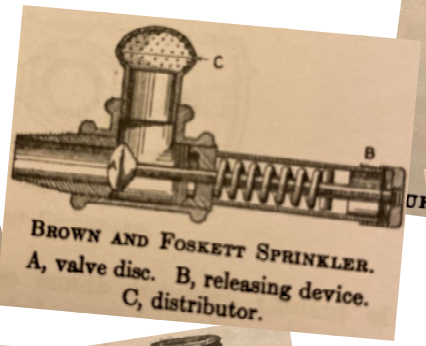
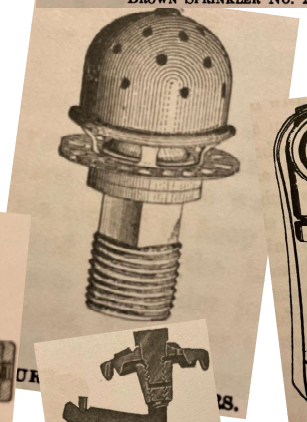
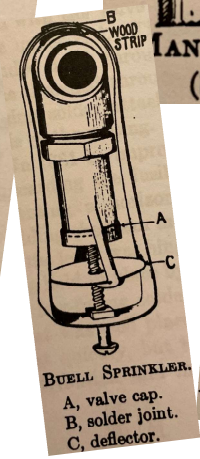
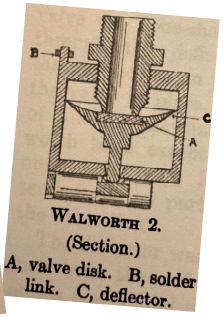


BROWN AND FOSKETT SPRINKLER.
A, valve disc. B, releasing device.
C, distributor.

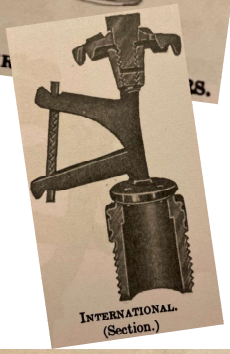




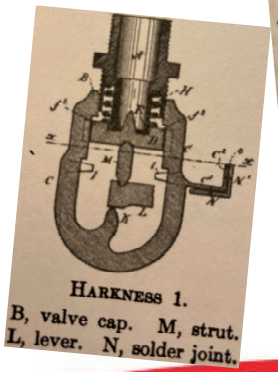
BUELL SPRINKLER.
A, valve cap.
B, solder joint.
C, deflector.

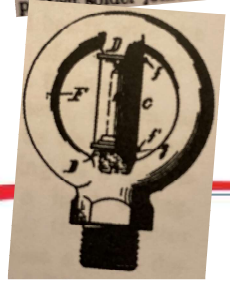


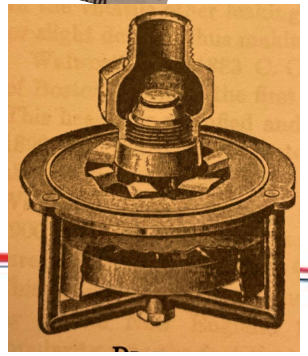
WALWORTH 2.
(Section.)
A, valve disk. B, solder link. C, deflector.

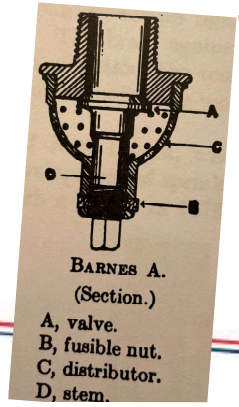

INTERNATIONAL.
(Section.)


STAR SPRINKLER.
h, valve cap. j, k, levers.
n, solder joint. r, disc to
solder joint.

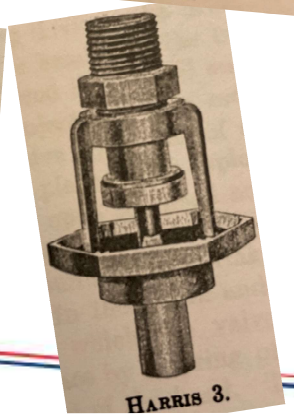

HARKNESS 1.
B, valve cap. M, strut.
L, lever. N, solder joint.

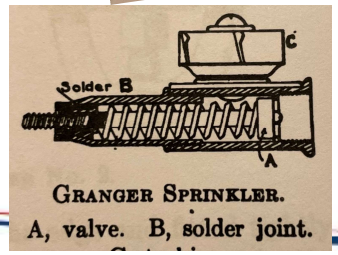




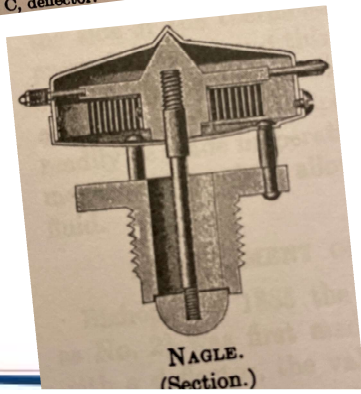


BARNES A.
(Section.)
A, valve.
B, fusible nut.
C, distributor.
D, stem.


HARRIS 3.



GRANGER SPRINKLER.
A, valve. B, solder joint.


NAGLE.
(Section.)

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Maintaining

Testing

- Sprinkler heads 50 years old
  - 10 year intervals following
- Sprinkler heads 75 years old
  - 5 year intervals following

Sprinklers tested do not have to meet the exact RTI performance as when they were new

Maintaining

Testing

- Dry sprinklers
  - 2020 edition of NFPA 25, testing extended from every 10 years to 15 years
    - Still states 10 years there after
- Fast response sprinklers
  - 2023 edition of NFPA 25, testing will be extended from 20 years to 25 years
- Harsh environments
  - Testing every 5 years, unless sprinkler is a listed, corrosion resistant finish, which now allows 10 year cycles

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Maintaining

Testing

- Solder type extra high (325^{o}F) or greater heads exposed to semicontinuous or continuous maximum allowable ambient temperatures tested every 5 years
- Numerous changes to NFPA 25 in 2020, 2023 and 2026 for global compatibility

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Maintaining

Pipe Schedule Systems

- Systems installed prior to the late 1970's
- Insurance companies may require hydraulic calculations of the system to confirm level of protection
  - Require additional hydraulic demand
  - Must deliver current density and water supply demand
- Pipe schedule was a conservative protection scheme, many systems are found to be acceptable with no changes required

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Maintaining

Hydraulic Calculations

- AHJ needs to have basic understanding of how to read calculations
- NFPA does not specify the format used, creates confusion
  - Contractor inadvertently or intentionally enters incorrect data
- Confirm hydraulic name plates on risers match printed calculations

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Maintaining

Changes in Occupancy, Use, Process, or Materials

- The property owner or designated representative shall not make changes in the occupancy, the use or process, or the materials used or stored in the building without evaluation of the fire protection system(s) for its capability to protect the new occupancy, use, or materials.
- Has building use changed since system originally installed?

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Maintaining

¾” Pipe

- If system is being modified; replace ¾” branch line ends with 1”?
- Not specifically required by NFPA, but ¾” may not be able to supply adequate flow to sprinkler head at end of branch line

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Maintaining

Pipe Inspections

- Older systems had higher quality piping, greater wall thickness
  - Corrode slower, more material for corrosion to penetrate
- Sedimentation concerns are not solely based on the age of the system

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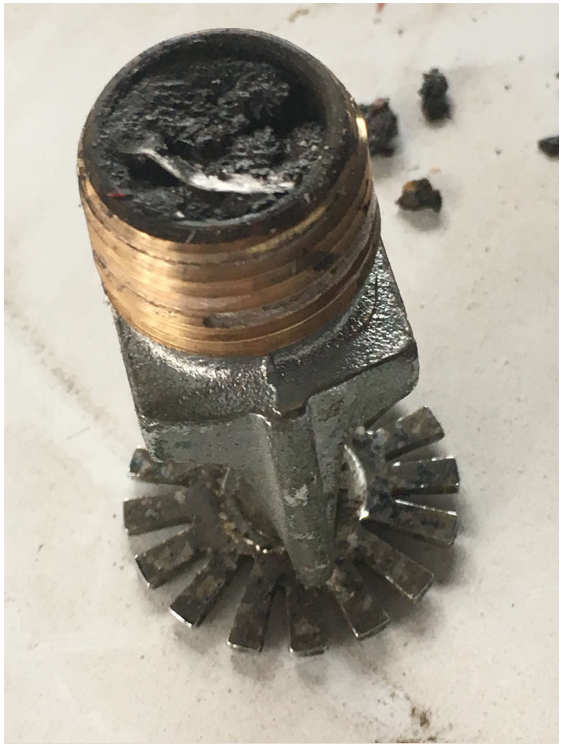
Maintaining

Pipe Inspections

- Newer systems seem to encounter more corrosion leaks and sedimentation accumulation
- During renovations, a pipe system assessment would be appropriate
  - If concerns are discovered, a thorough internal pipe inspection is warranted



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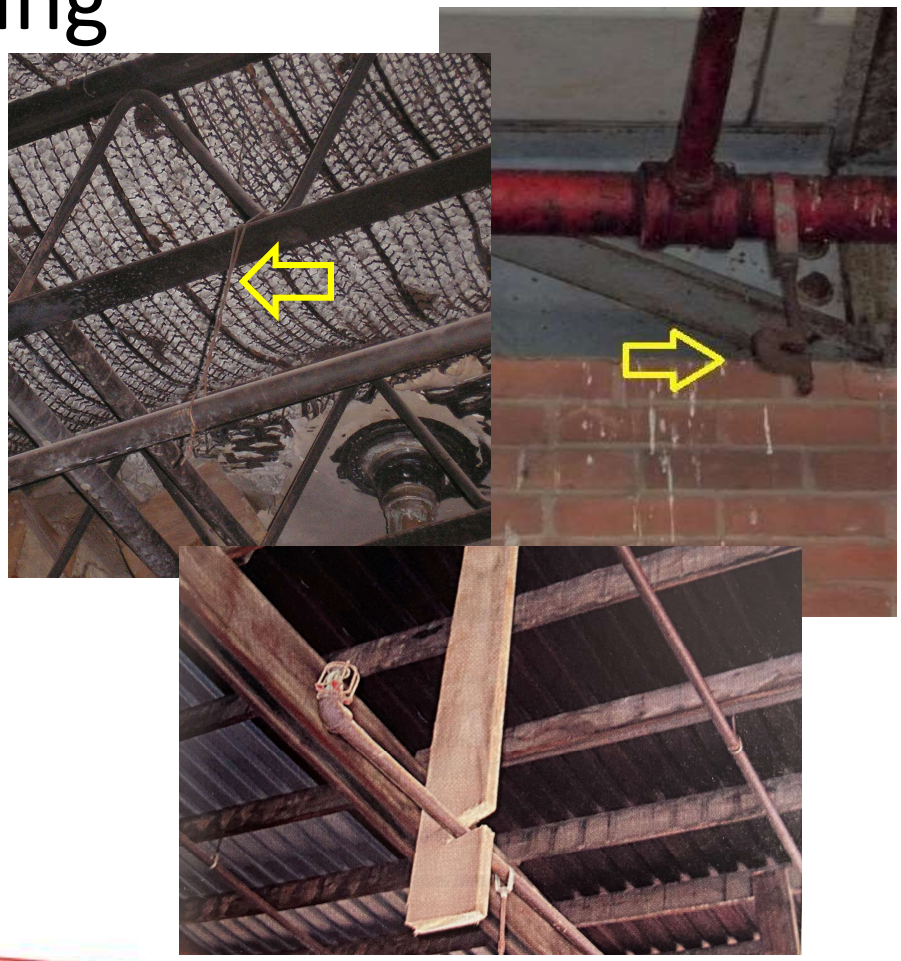
Maintaining

Pipe Hangers

- During renovations, pipe hangers and bracing should be examined
  - Was pipe supported properly to begin with
  - Have supports been removed
- Renovations may require seismic considerations



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Maintaining

Alarm Valves

- Shall be inspected internally every 5 years
  - Includes strainers, filters and restricted orifices
- Older valves may be susceptible to corrosion

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Maintaining

Water Motor Gongs

- Verify that WMG functions
- Is there a building alarm connection
- Is there off site monitoring

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Maintaining

Exhausters

- Was an easy way to discharge a large volume of air from dry system quickly
  - 2 psi imbalance opens vent, approximating 15 open sprinkler heads
- Very complex/difficult to maintain and set
- Very heavy, requiring additional bracing
- Could be located anywhere on the sprinkler system

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Maintaining

Fire Department Connection (FDC)

- 2 hour, 150 psi hydrotest every 5 years
- FDC's that penetrate down through sidewalk

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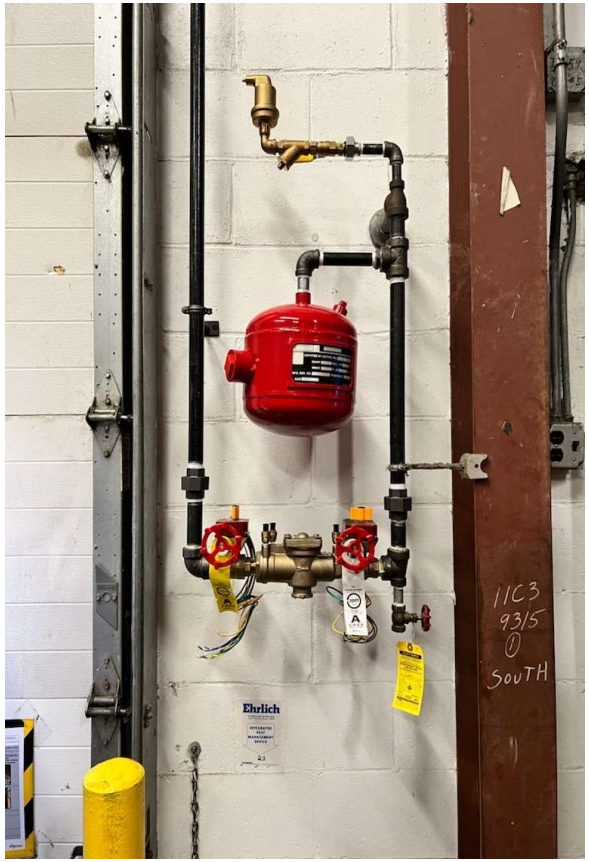
Maintaining

Antifreeze Solution

- As of September 30, 2022, all antifreeze systems shall use “listed” antifreeze solution



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Maintaining

Standpipe Systems

- Need hydraulic name plate to confirm original design of 65 psi or 100 psi at most demanding outlet
  - Fire department preplanning information
- Class II systems
  - AHJ can allow removal of hose and system

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Maintaining

Water Supplies

- Does municipal system still meet water supply demands of older systems
  - Municipal infrastructure not keeping pace with growth of municipality

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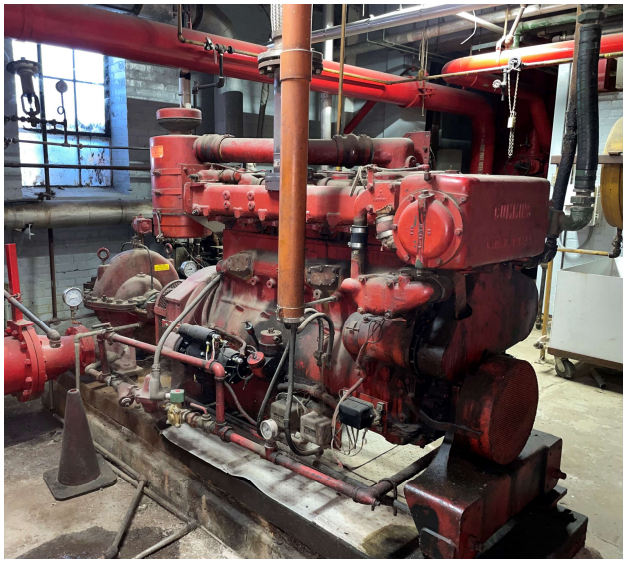
Maintaining

Fire Pumps

- Steam driven still acceptable
  - Probably not in Pennsylvania
- Gasoline drivers not allowed since 1974
- Horizontal, split case pumps must have a positive water source since 1974
  - Vertical pump only pumps allowed to not have positive source



Thank You

Future Questions

Steven Schneider
sschneider@kobfire.com