Fire Protection

Fire Protection

Automatic Sprinkler System

Fire Definition

- **Fire** is the rapid oxidation of a combustible material releasing heat, light, and various reaction products such as carbon dioxide and water.

- **Oxidation** is a common process. Rust is formed on iron through its interaction with oxygen in the air.

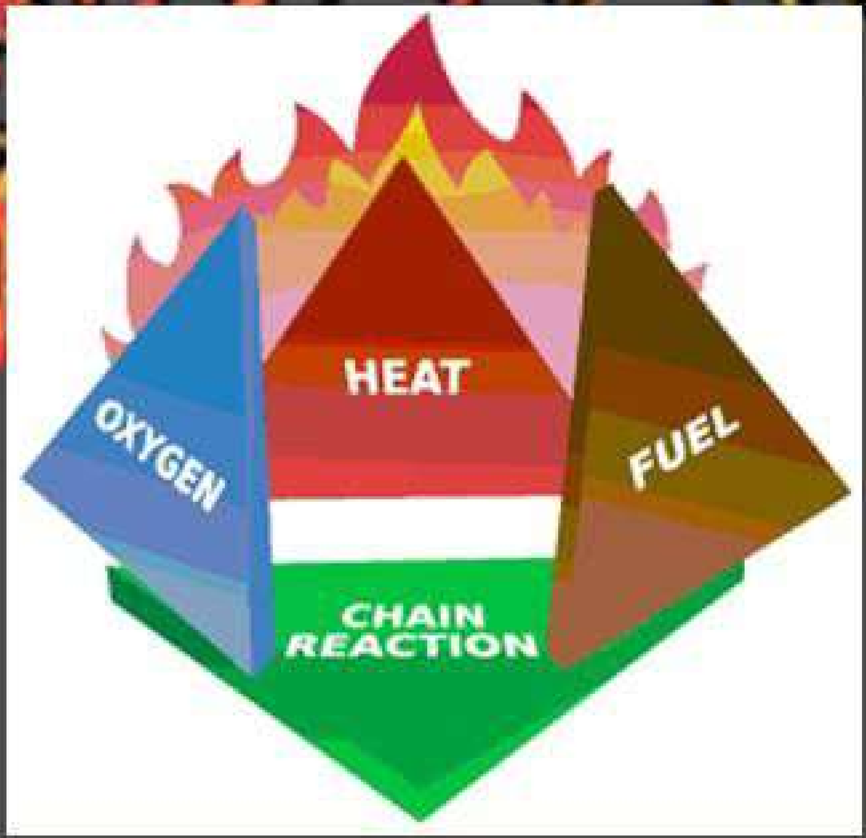
- The difference between fire and other oxidation processes is speed. Fire is the process of very rapid oxidation, which releases greater amounts of heat and other forms of energy in a given time.

- **Fires** start when a flammable combustible material with an adequate supply of oxygen is subjected to enough heat and is able to sustain a chain reaction.

Introduction

Fire Tetrahedron

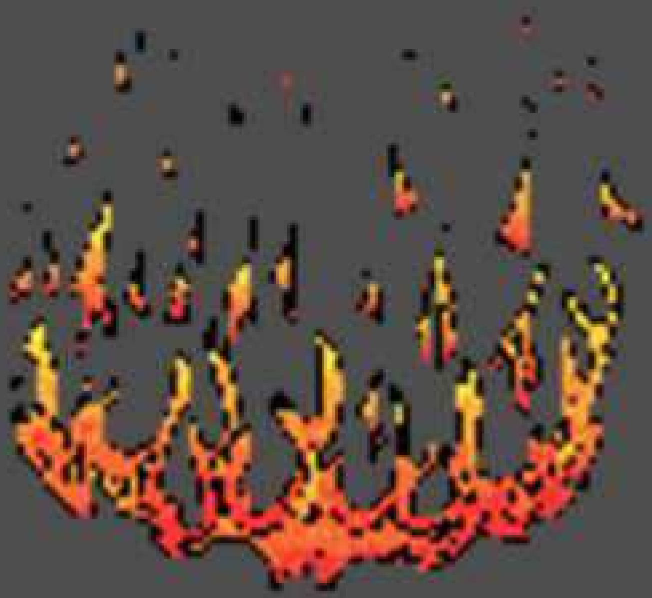
- **The fire tetrahedron** is a four-sided geometric representation of the four factors necessary for fire;
  - **Fuel** (any substance that can undergo combustion).
  - **Heat** (heat energy sufficient to release vapor from the fuel and cause ignition).
  - **Oxidizing agent** (air containing oxygen).
  - **Uninhibited chemical chain reaction** (sufficient exothermic reaction energy to produce ignition).



Fire Definition

Once a fire starts, the fire tetrahedron model shows that it will continue to burn until:

- All the fuel or oxygen has been used.
- The fuel and / or the oxygen have been removed.
- The temperature of the materials is reduced below the ignition temperature.
- The chain reaction is broken by reducing the number of excited molecules



Fire Fighting Defintion

- **Fire fighting** is the attempt to minimize injury or loss of life, or damage to property, caused by a fire.

- **Fire fighting** involves a range of methods and equipment for fighting fires, depending on the circumstances and availability.

Fire Fighting Methodology

Gases
CO2 - FM200

Smothering

Cooling

Water

Starving

Isolate Combustible Fuel

Interruption

Potassium Bicarbonate
Halon 1301

Fire Fighting Systems (Methods)

Fire fighting involves a range of methods and equipment for fighting fires, depending on the circumstances and availability:

- **Water**

  The standard method is to pour water onto the fire. This reduces the heat, hopefully to the point that the fires can no longer burn. However, water is not suitable for liquid fuel fires, because it is likely to spread the fuel and make the fire larger, nor for electrical fires, because of the risk of electric shock.

Fire Fighting Systems (Methods)

Fire fighting involves a range of methods and equipment for fighting fires, depending on the circumstances and availability:

- **Foam**
  Foam is put onto fires fueled by liquid fuel. It works by preventing oxygen getting to the fire, but does not spread the fuel around.

Fire Fighting Systems (Methods)

Fire fighting involves a range of methods and equipment for fighting fires, depending on the circumstances and availability:

- **Gases**
  Non-combustible gases are sometimes used in fire-suppression systems installed in buildings. They work by being heavier than air, thus displacing the oxygen. However, because the oxygen is displaced from the building, humans are unable to survive for long either, so gas systems are only used in special circumstances.

Introduction

Fire Fighting Systems (Methods)

Fire fighting involves a range of methods and equipment for fighting fires, depending on the circumstances and availability:

- **Powder**

  Powder is used on electrical fires, as it does not conduct electricity. Like foam, it works by cutting off the oxygen supply to the fire

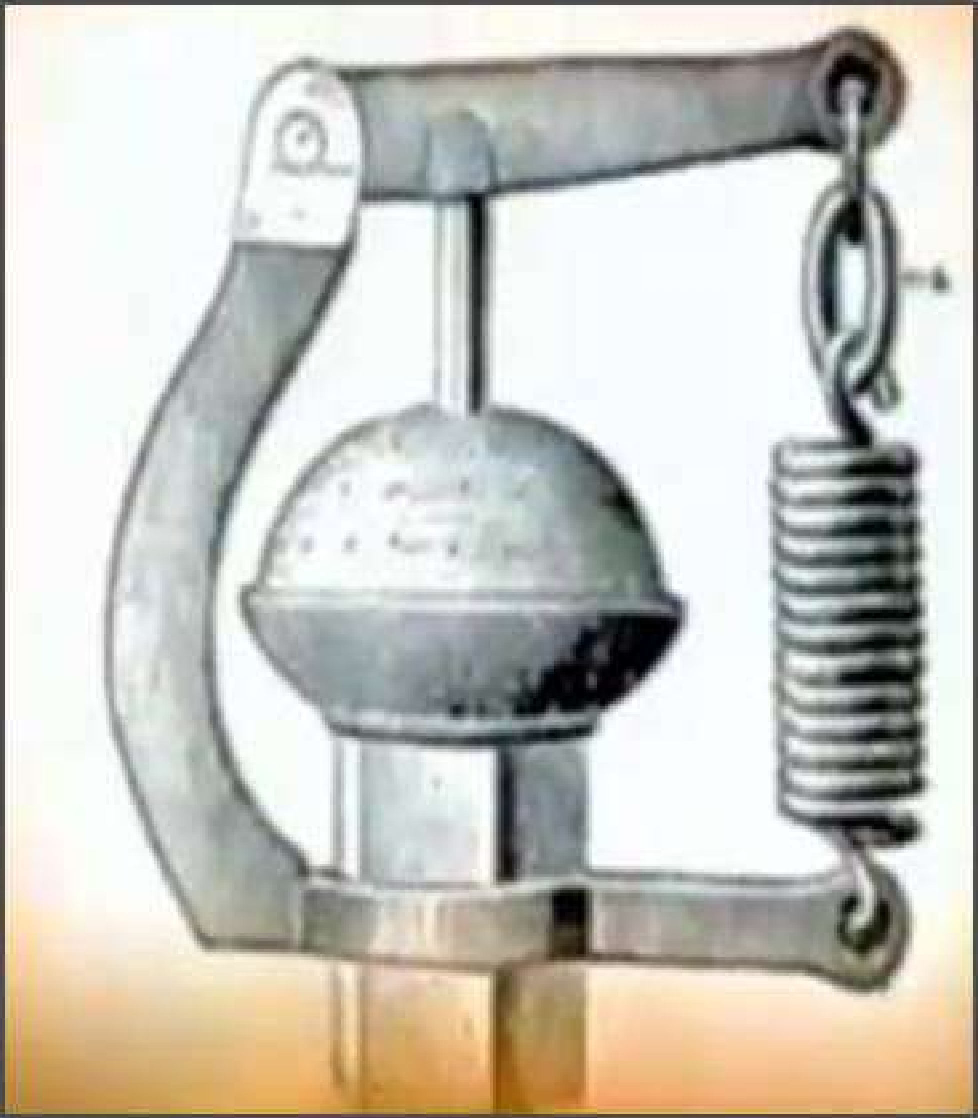
CLASSES OF FIRES	TYPES OF FIRES	PICTURE SYMBOL
A	Wood, paper, cloth, trash & other ordinary materials.	
B	Gasoline, oil, paint and other flammable liquids.	
C	May be used on fires involving live electrical equipment without danger to the operator.	
D	Combustible metals and combustible metal alloys.	D
K	Cooking media (Vegetable or Animal Oils and Fats)	

Automatic Sprinkler System

History

- The first automatic sprinkler system was created in England in the 1806 by John Carey.

- It was made up of a pipe with several valves held closed by counterweights attached by string. When flames burned through the string the counterweight dropped to the floor, which opened the valve that released the water and extinguished the fire.



History

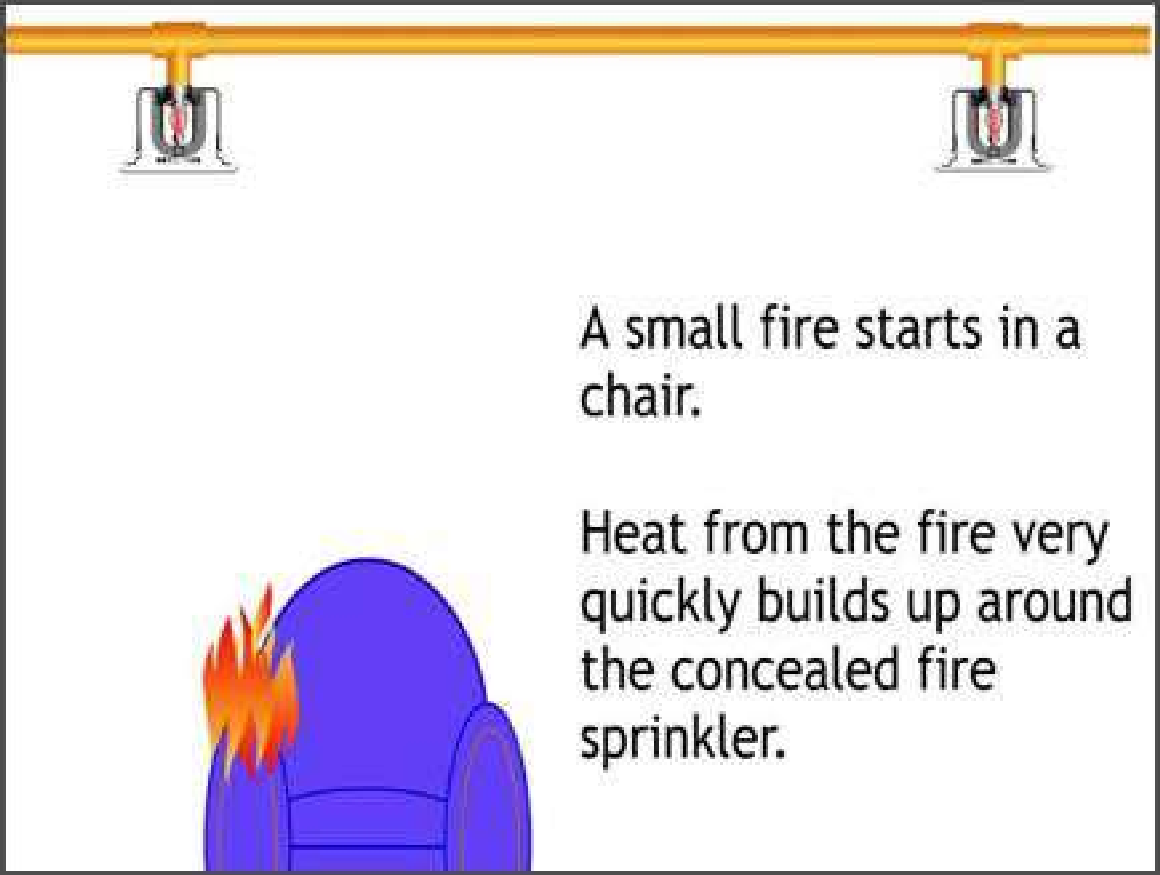
Fire Sprinkler System Time Line

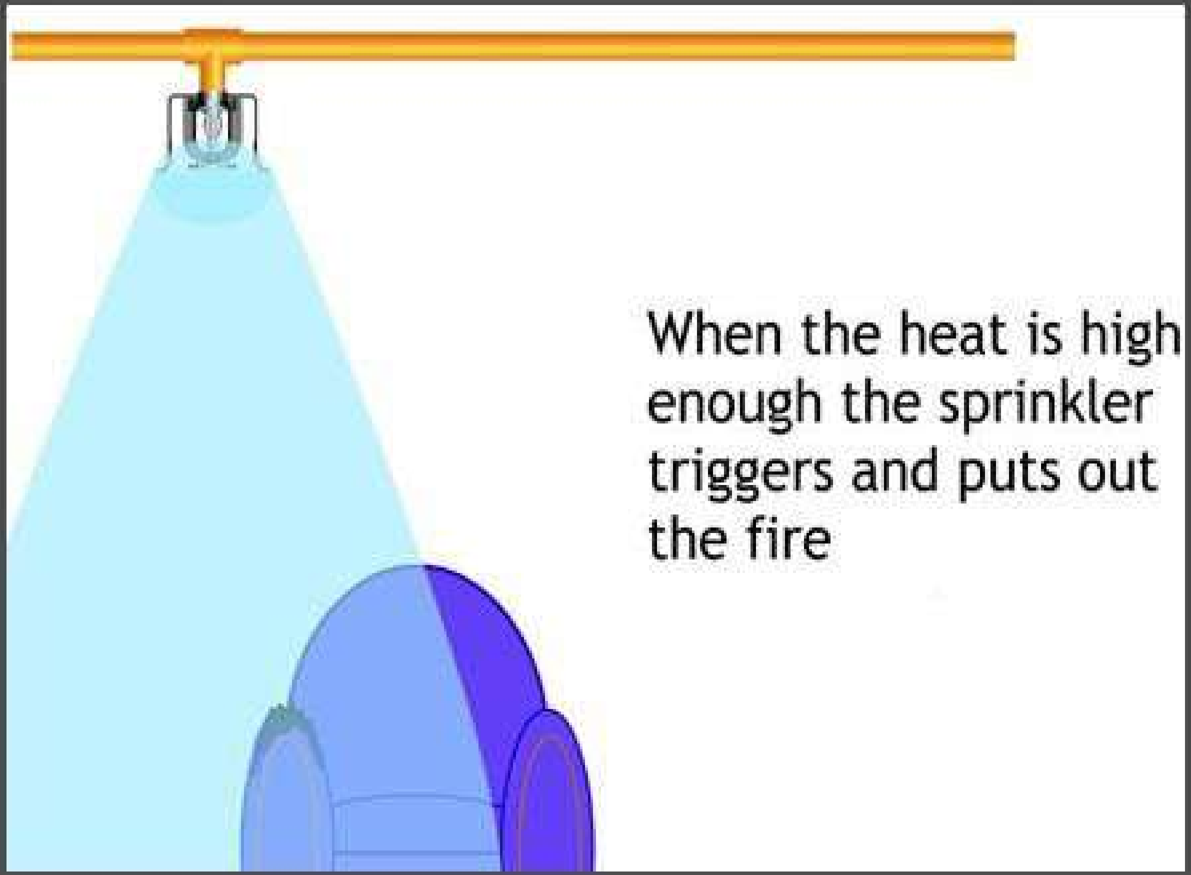
- 1806 - John Carey designs a system of perforated pipes, plungers, and burning strings.
- 1812 - Colonel William Congreve designs perforated pipes with valves.
- 1875 - Parmelee invents the first modern sprinkler. It consists of shell and soldered brass cap.
- 1882 - Grinnell invents an improved sprinkler that can withstand higher pressures and distributes water more evenly.
- 1885 - John R. Freeman performs extensive tests on sprinkler systems.
- 1895 - Insurance representatives meet in New York to establish fire protection standards.
- 1896 - N.F.P.A. is officially formed and publishes codes for automatic sprinkler installation.

Fire Sprinkler System

Theory of Operation

- **Fire sprinkler** systems were developed to protect buildings from fire by producing a discharge of water. The sprinkler piping is usually run near the ceiling directing the water down on the flames.





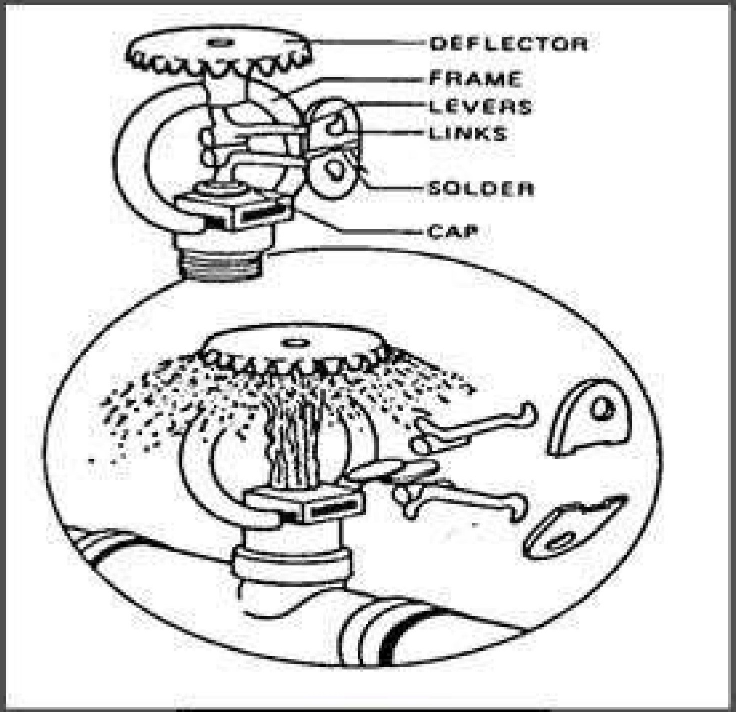
Theory of Operation

- Head sprinkler is held closed by either a **heat-sensitive glass bulb** or a **two-part metal link held together with fusible alloy** .

- The **glass bulb** or **link** applies pressure to a pip cap which acts as a plug that prevents water from flowing until the ambient temperature around the sprinkler reaches the design activation temperature of the individual sprinkler head .

Release Mechanism

- **Fusible link** holds the levers together until the link is melted during the fire after which the water pushes the levers and cap out of the way and strikes the deflector on the end of the frame.



- **Glass Bulb** uses a small bulb filled with liquid and an air bubble to hold the orifice shut. Heat expands the liquid until the bubble is absorbed into the liquid. This increase the internal pressure until the bulb shatters at a proper temperature.

Sprinkler characteristics

- **Thermal Sensitivity** A measure of the rapidity with which the thermal element operates as installed in a specific sprinkler or sprinkler assembly- "Response Time Index (RTI)" – Standard response sprinkler and Fast response sprinkler *(RTI for fast response approx 1.6 for standard)*
- **Temperature rating** (color coding).
- **Orifice Size.**
- **Installation Orientation.**
- **Special Service Conditions** (special applications "dry pipe sp. OR special service such as corrosion resistance sp.)

Fire Sprinkler System Components

1-Sprinkler Head Types

Temperature Characteristics

Maximum Ceiling Temperature		Temperature Rating		Temperature Classification
°F	°C	°F	°C	
100	38	135–170	57–77	Ordinary
150	66	175–225	79–107	Intermediate
225	107	250–300	121–149	High
300	149	325–375	163–191	Extra high
375	191	400–475	204–246	Very extra high
475	246	500–575	260–302	Ultra high
625	329	650	343	Ultra high

Fire Sprinkler System

Fire Sprinkler System Components

1-Sprinkler Head Types

Sprinkler Discharge Characteristics

K- factor

Nominal K-factor [gpm/(psi)$^{1/2}$]	K-factor Range [gpm/(psi)$^{1/2}$]	K-factor Range [dm^3/min/(kPa)$^{1/2}$]	Percent of Nominal K-5.6 Discharge	Thread Type
1.4	1.3–1.5	1.9–2.2	25	½ in. NPT
1.9	1.8–2.0	2.6–2.9	33.3	½ in. NPT
2.8	2.6–2.9	3.8–4.2	50	½ in. NPT
4.2	4.0–4.4	5.9–6.4	75	½ in. NPT
5.6	5.3–5.8	7.6–8.4	100	½ in. NPT
8.0	7.4–8.2	10.7–11.8	140	¾ in. NPT or ½ in. NPT
11.2	11.0–11.5	15.9–16.6	200	½ in. NPT or ¾ in. NPT
14.0	13.5–14.5	19.5–20.9	250	¾ in. NPT
16.8	16.0–17.6	23.1–25.4	300	¾ in. NPT
19.6	18.6–20.6	27.2–30.1	350	1 in. NPT
22.4	21.3–23.5	31.1–34.3	400	1 in. NPT
25.2	23.9–26.5	34.9–38.7	450	1 in. NPT
28.0	26.6–29.4	38.9–43.0	500	1 in. NPT

Fire Sprinkler System Components

1-Sprinkler Head Types

The following sprinklers are defined according to according to orientation:

1- Pendent Sprinkler

A sprinkler designed to be installed in such a way that the water stream is directed downward against the deflector.

2- Recessed Sprinkler

A sprinkler in which all or part of the body, other than the shank thread, is mounted within a recessed housing.

3- Concealed Sprinkler

A recessed sprinkler with cover plates.

4- Sidewall Sprinkler

A sprinkler having special deflectors that are designed to discharge most of the water away from the nearby wall in a *pattern resembling one-quarter* of a sphere, with a small portion of the discharge directed at the wall behind the sprinkler.

Fire Sprinkler System Components

1-Sprinkler Head Types

The following sprinklers are defined according to according to orientation:

5- Upright Sprinkler

A sprinkler designed to be installed in such a way that the water spray is directed upwards against the deflector.

Fire Sprinkler System

Side Wall Horizontal Type

Pendent Type

Upright Sprinkler Head

Concealed Type

Recessed Type

Fire Sprinkler System Components

1-Sprinkler Head Types

The following sprinklers are defined according to design and performance characteristics.

1- Extended Coverage Sprinkler

Designed to wet the widest possible area and can be installed as a residential or quick-response system.

2- Suppression Sprinkler

Preferred in buildings with highly combustible contents as release water directly on the core of the fire

3- Water Mist Sprinkler

Usually used on offshore oil drilling platforms in areas where water damage must be prevented.

Fire Sprinkler System Components

1-Sprinkler Head Types

The following sprinklers are defined according to design and performance characteristics.

4- Nozzle

A device for use in applications requiring special water discharge patterns, directional spray, or other unusual discharge characteristics.

5- Open Sprinkler

A sprinkler that does not have actuators or heat-responsive elements.

6- Residential Sprinkler

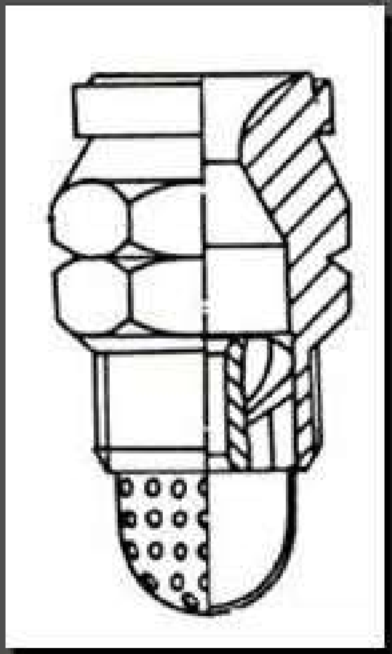
A type of fast-response sprinkler that has been specifically investigated for its ability to enhance survivability in the room of fire origin and is listed for use in the protection of dwelling units.

Extended Coverage
Sprinkler

Residential Sprinkler

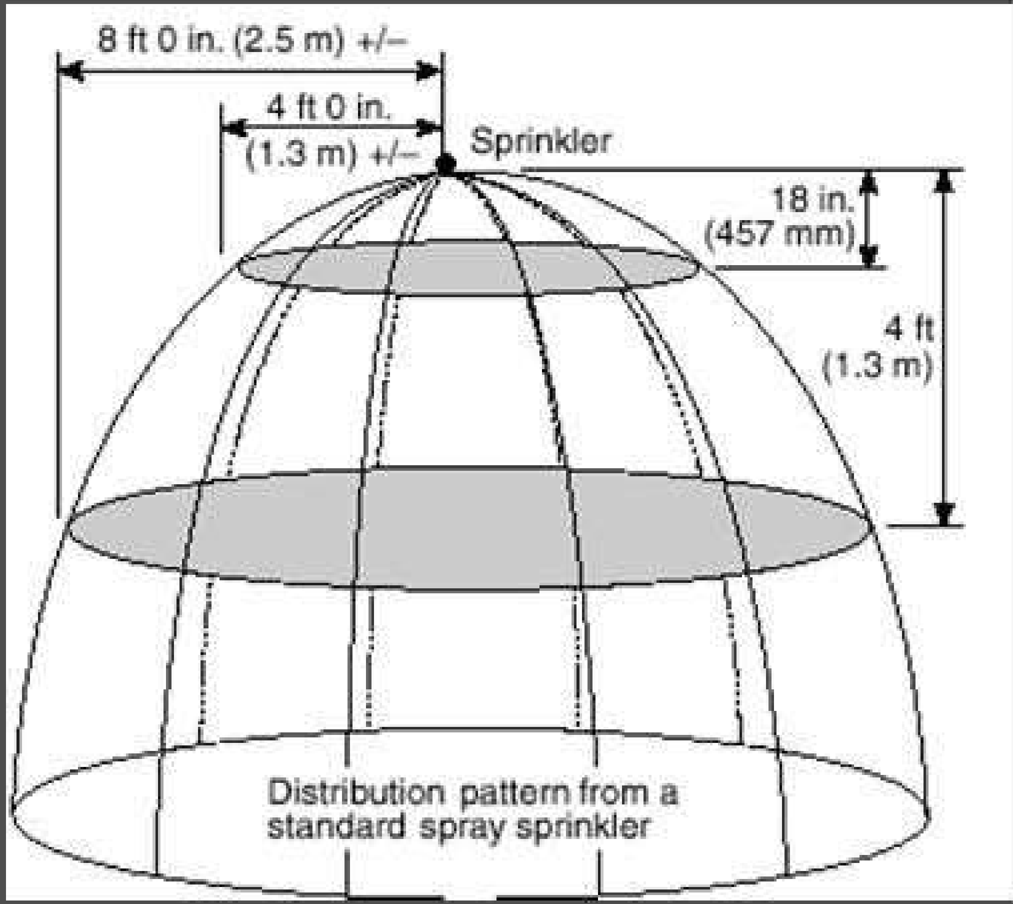
Extended Coverage
Sprinkler

Open Sprinkler

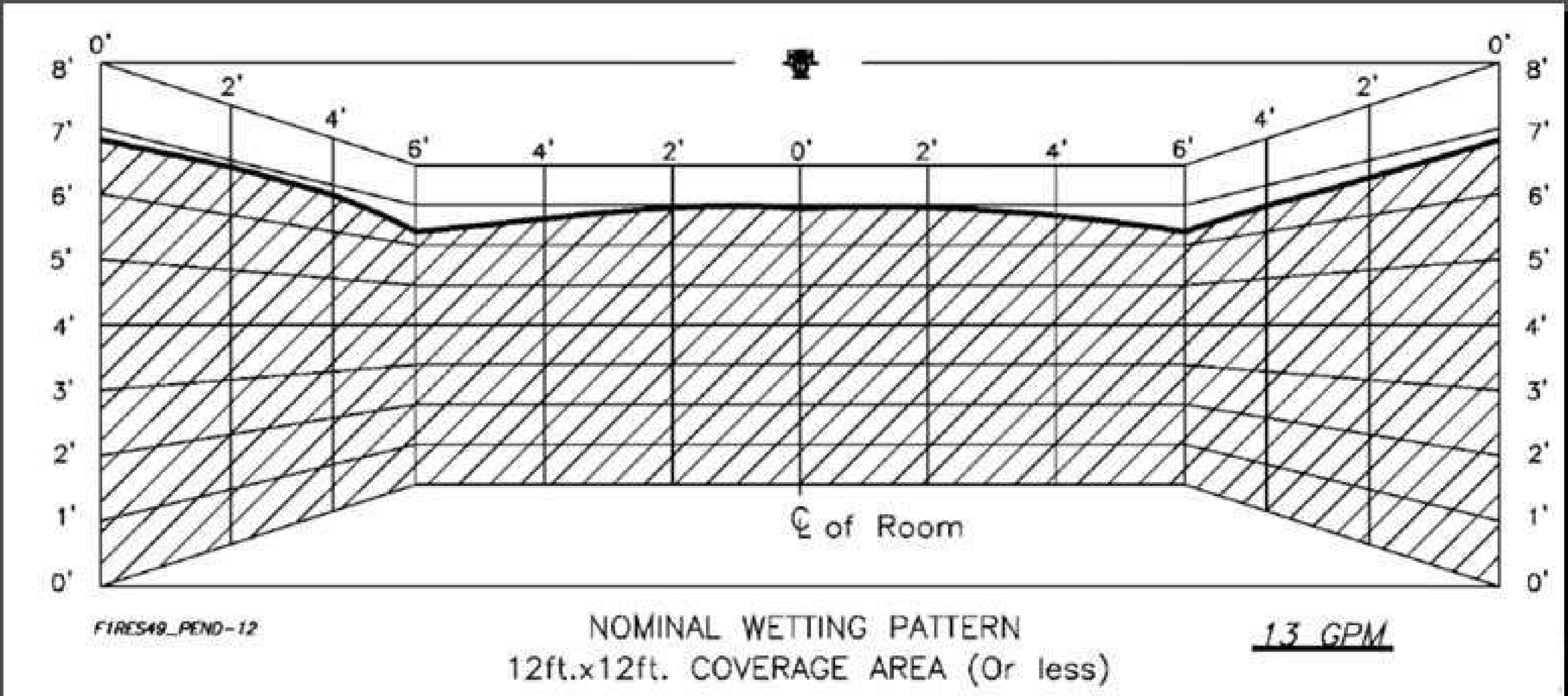


High velocity spray
Nozzle

spray Nozzle



8 ft 0 in. (2.5 m) +/–
4 ft 0 in.
(1.3 m) +/–
Sprinkler
18 in.
(457 mm)
4 ft
(1.3 m)
Distribution pattern from a
standard spray sprinkler



0'
8'
7'
6'
5'
4'
3'
2'
1'
0'
2'
4'
6'
4'
2'
0'
2'
4'
6'
4'
2'
℄ of Room
FIRES49_PEND-12
NOMINAL WETTING PATTERN
12ft.x12ft. COVERAGE AREA (Or less)
13 GPM

Fire Sprinkler System Types

- **Fire sprinkler system** is an active fire protection measure, consisting of a water supply, providing adequate pressure and flow rate to a water distribution piping system, onto which fire sprinklers are connected.
- Note

Each Sprinkler system includes a device for actuating an alarm when the system is in operation The system is usually activated by heat from a fire and discharges water over the fire area.

Fire Sprinkler System Types

1- Wet pipe systems.

2- Anti Freeze System.

3- Circulating Closed Loop System.

4- Dry Pipe System.

5- Pre-action System.

6- Deluge System.

Fire Sprinkler System Types

1 -Wet pipe systems

- An automatic water supply provides water under pressure to the system piping .
- All of the piping is filled with water . Until sufficient heat is applied , causing one or more sprinklers to fuse (open).
- The water discharged immediately.
- Automatic alarm is actuated (Alarm check valve, water flow detector or detection system).

WET pipes system

- Wet pipe sprinkler systems contain water in the riser and piping at all times. As soon as a sprinkler head activates due to the heat of a fire, water is immediately discharged through the open head .

Wet Pipe System Components

- *MAIN CONTROL VALVE*
- Butterfly Valve
- ***OBJECTIVE :-***
- Shut down system for service

Fire Sprinkler System Components

2-Sprinkler System Valves

Alarm Check Valve

-Alarm Check Valves are installed in either the vertical or horizontal position in the main supply to the wet pipe system.

- It acts as a check valve in the system and also used to give an alarm (with its trim).

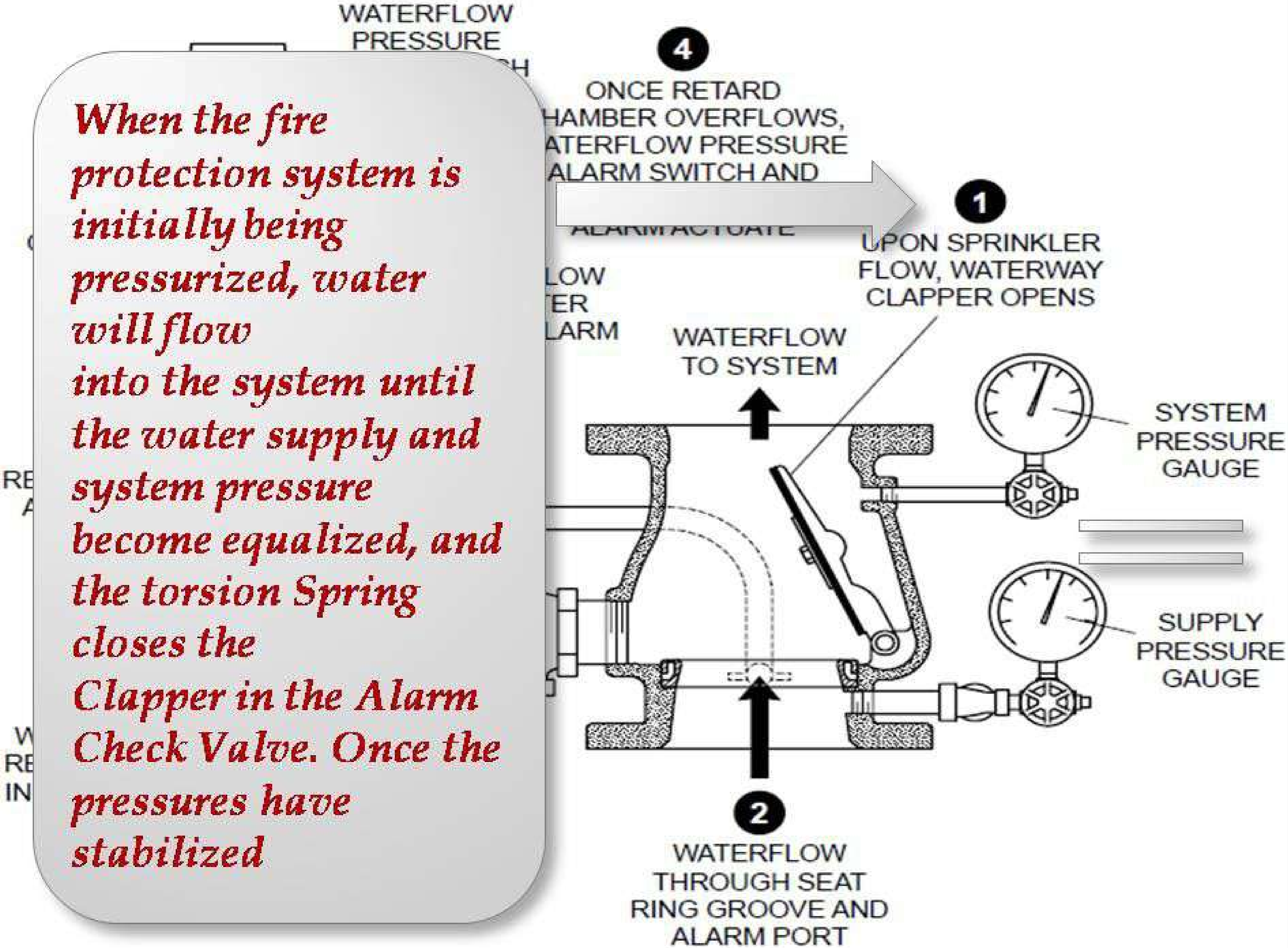
- Pressure switch can be used to give the alarm.

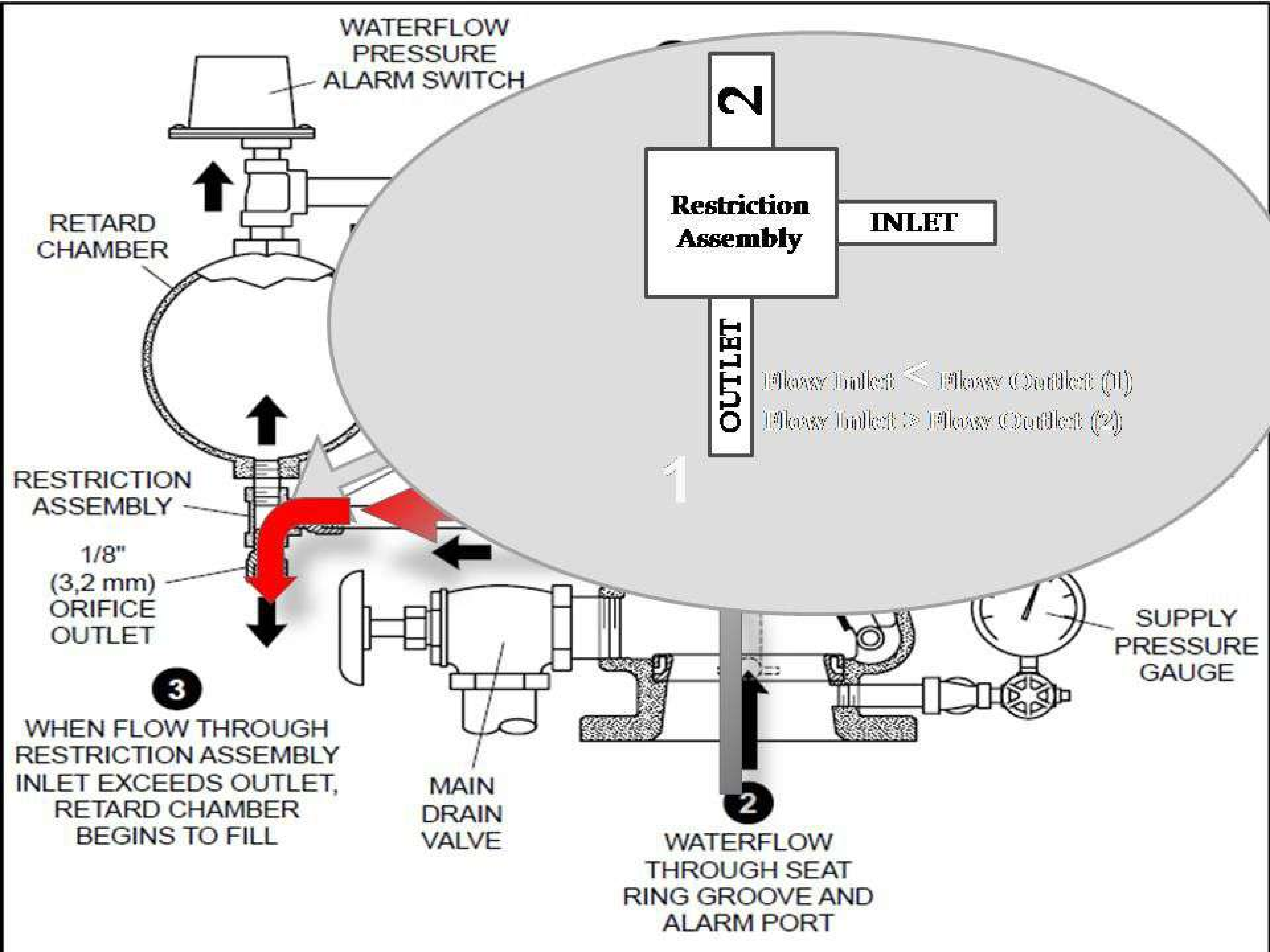
- Mechanical water motor gong can be used to give the alarm.

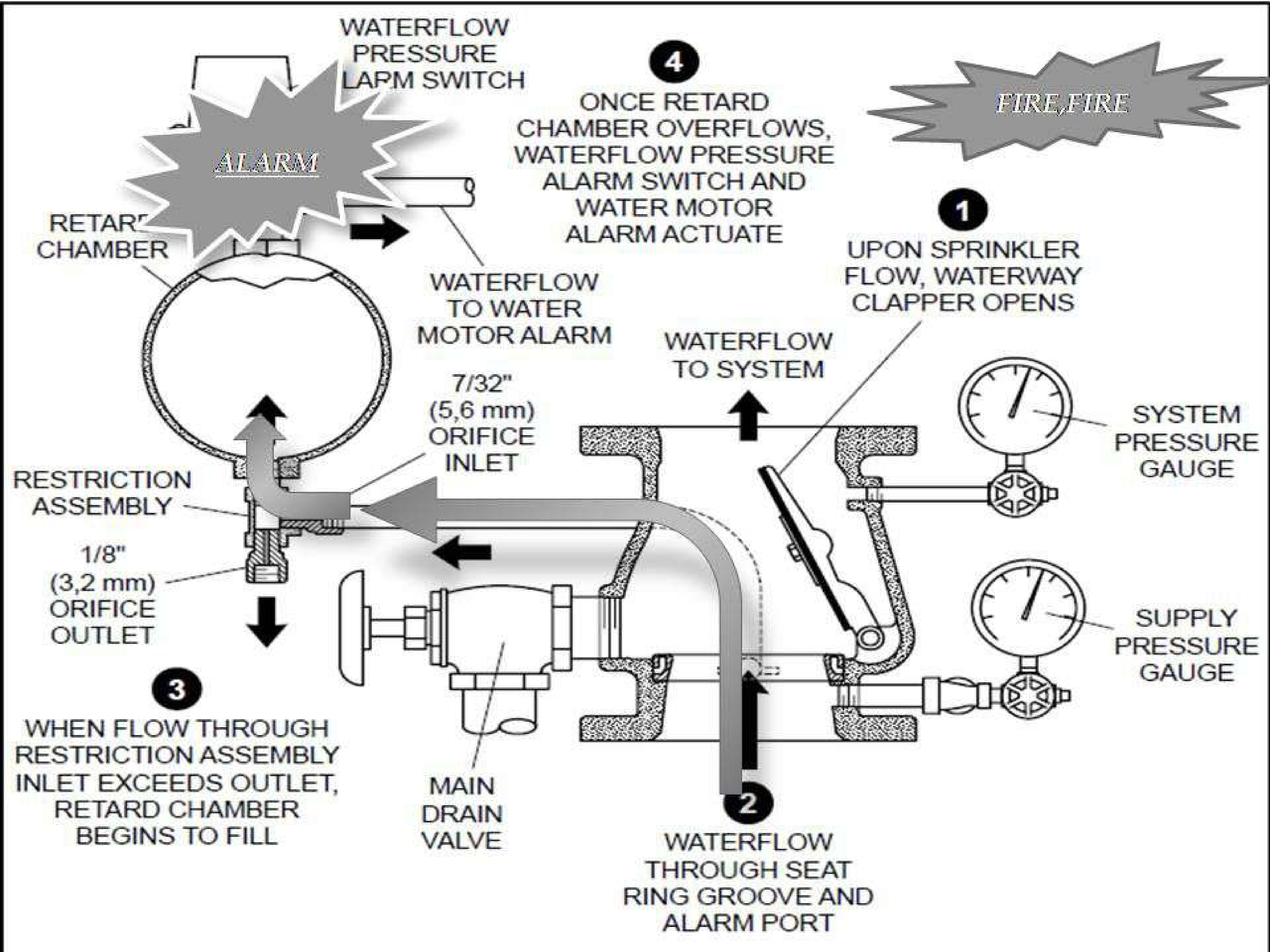
Wet Pipe System Components

- CONTROL VALVE

When the fire protection system is initially being pressurized, water will flow into the system until the water supply and system pressure become equalized, and the torsion Spring closes the Clapper in the Alarm Check Valve. Once the pressures have stabilized

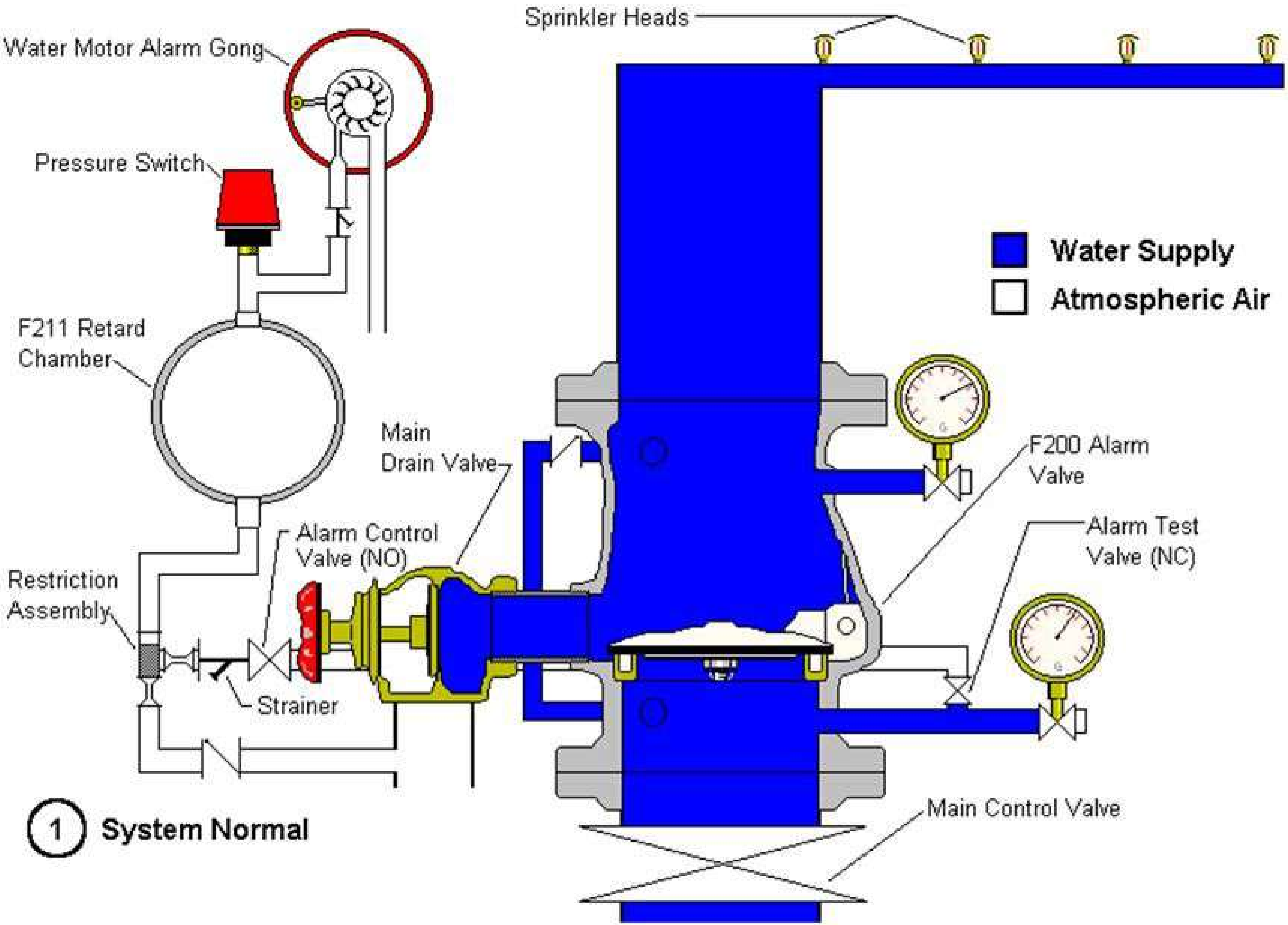


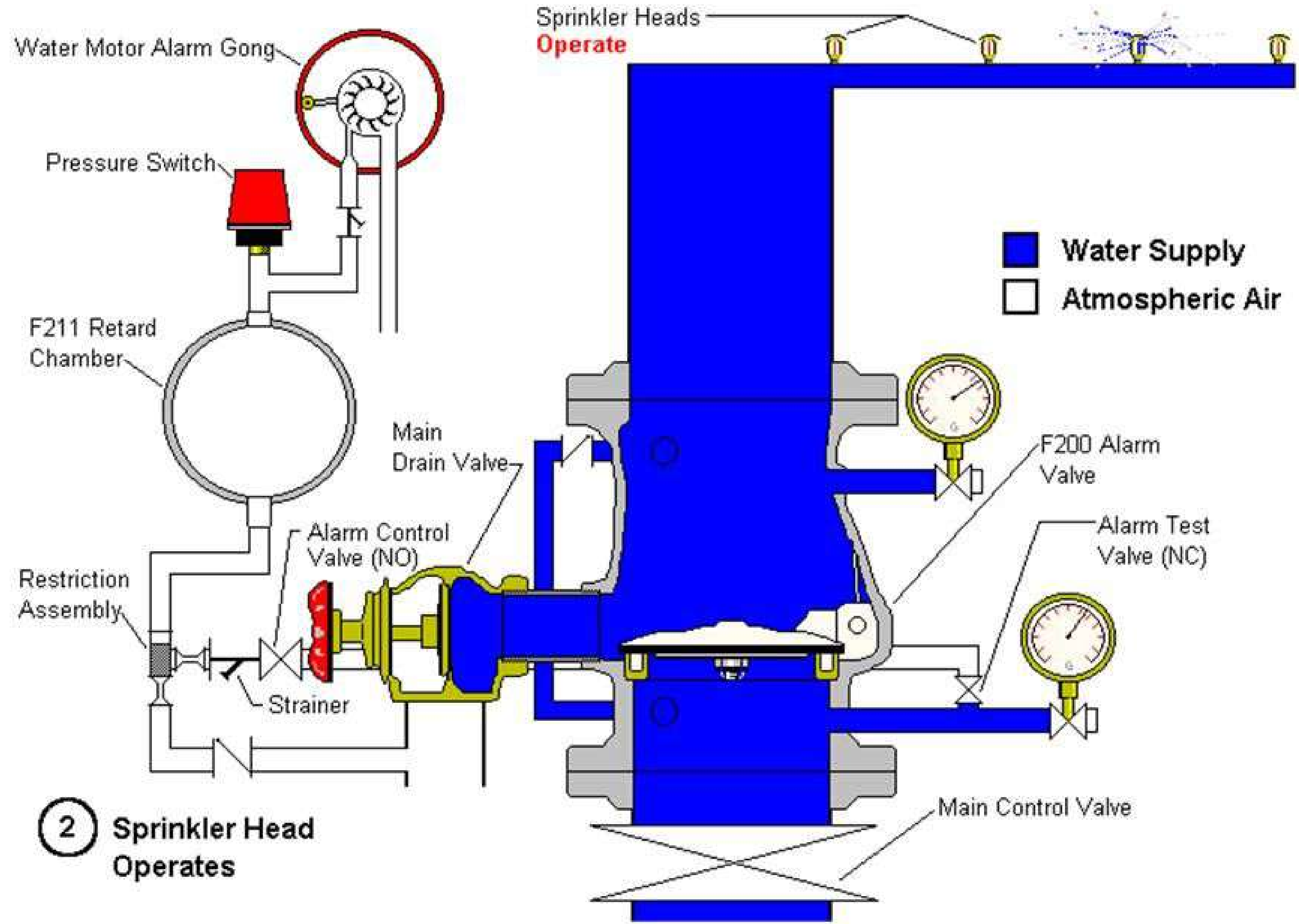

WATERFLOW PRESSURE ALARM SWITCH
RETARD CHAMBER
RESTRICTION ASSEMBLY
1/8" (3,2 mm) ORIFICE OUTLET
3
WHEN FLOW THROUGH RESTRICTION ASSEMBLY INLET EXCEEDS OUTLET, RETARD CHAMBER BEGINS TO FILL
MAIN DRAIN VALVE
2
WATERFLOW THROUGH SEAT RING GROOVE AND ALARM PORT
SUPPLY PRESSURE GAUGE
2
Restriction Assembly
INLET
OUTLET
Flow Inlet < Flow Outlet (1)
Flow Inlet > Flow Outlet (2)
1

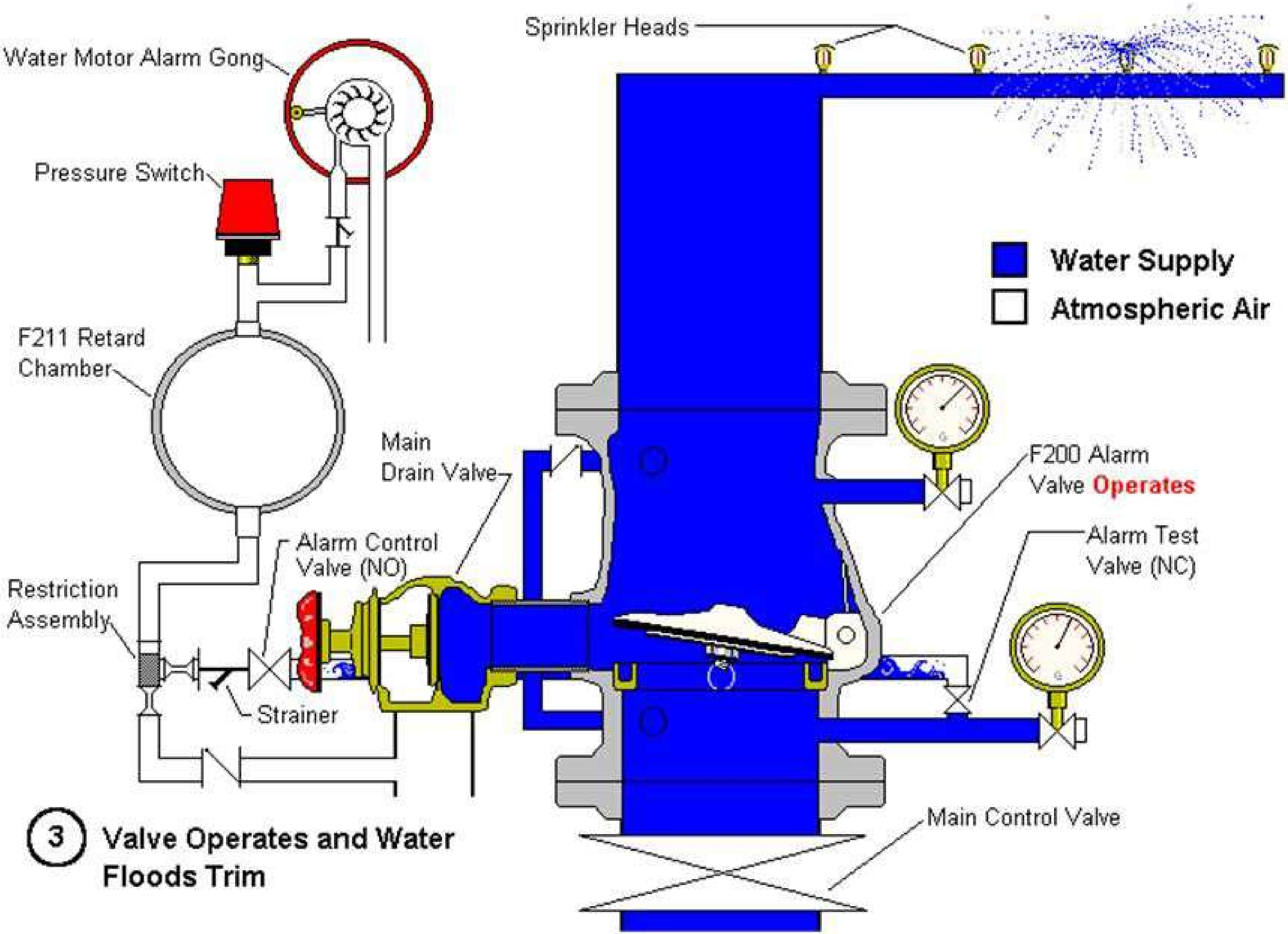


WATERFLOW PRESSURE LARM SWITCH
4
ONCE RETARD CHAMBER OVERFLOWS, WATERFLOW PRESSURE ALARM SWITCH AND WATER MOTOR ALARM ACTUATE
FIRE,FIRE
ALARM
RETARD CHAMBER
WATERFLOW TO WATER MOTOR ALARM
1
UPON SPRINKLER FLOW, WATERWAY CLAPPER OPENS
WATERFLOW TO SYSTEM
7/32" (5,6 mm) ORIFICE INLET
SYSTEM PRESSURE GAUGE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

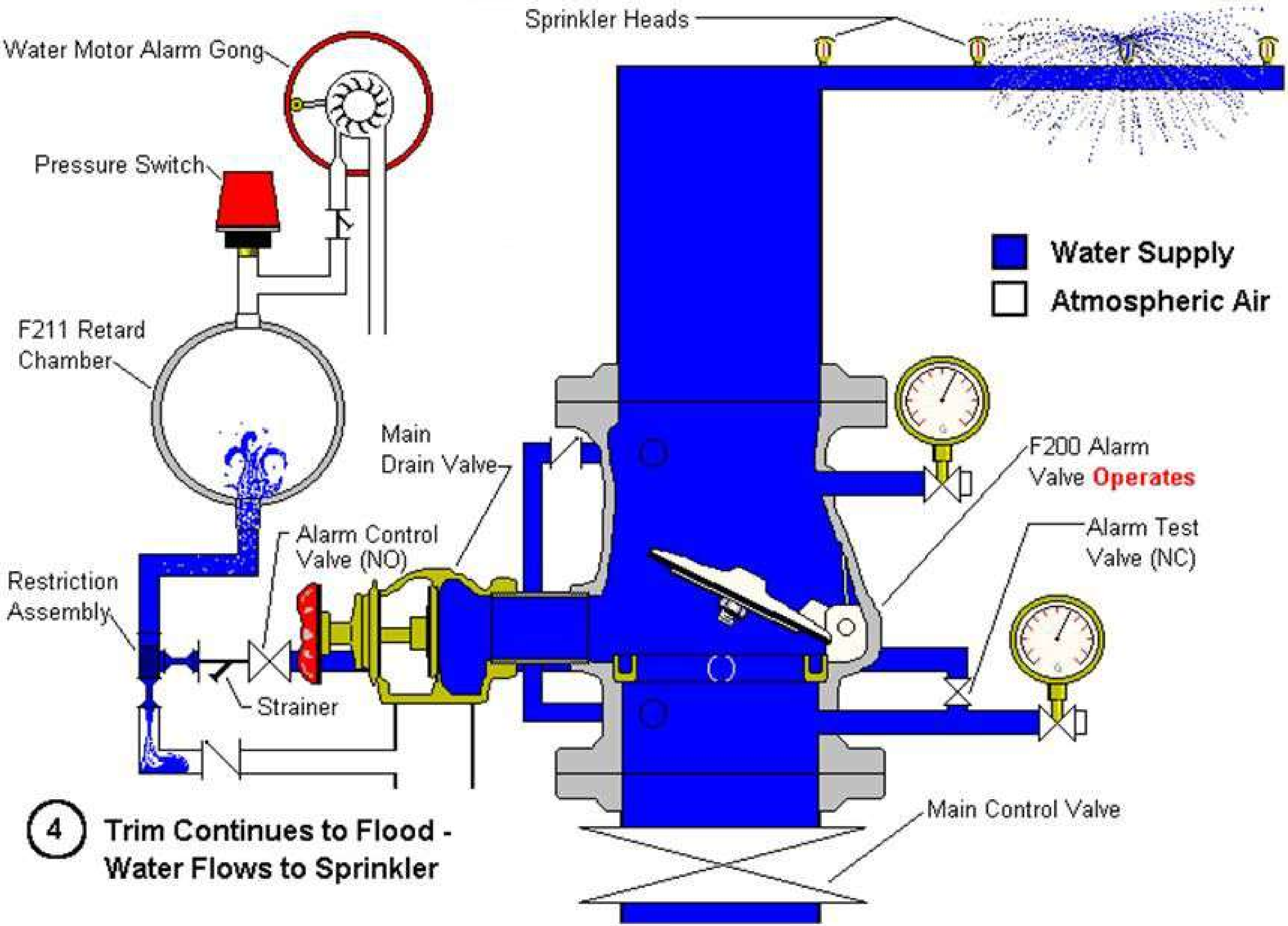
- ***CHECK VALVE SYMBOL.***
- ***CHECK VALVE.***
- ***CHECK VALVE BLOCK.***


Sprinkler Heads
Water Motor Alarm Gong
Pressure Switch
Water Supply
Atmospheric Air
F211 Retard Chamber
Main Drain Valve
F200 Alarm Valve
Alarm Control Valve (NO)
Alarm Test Valve (NC)
Restriction Assembly
Strainer
Main Control Valve
1 System Normal

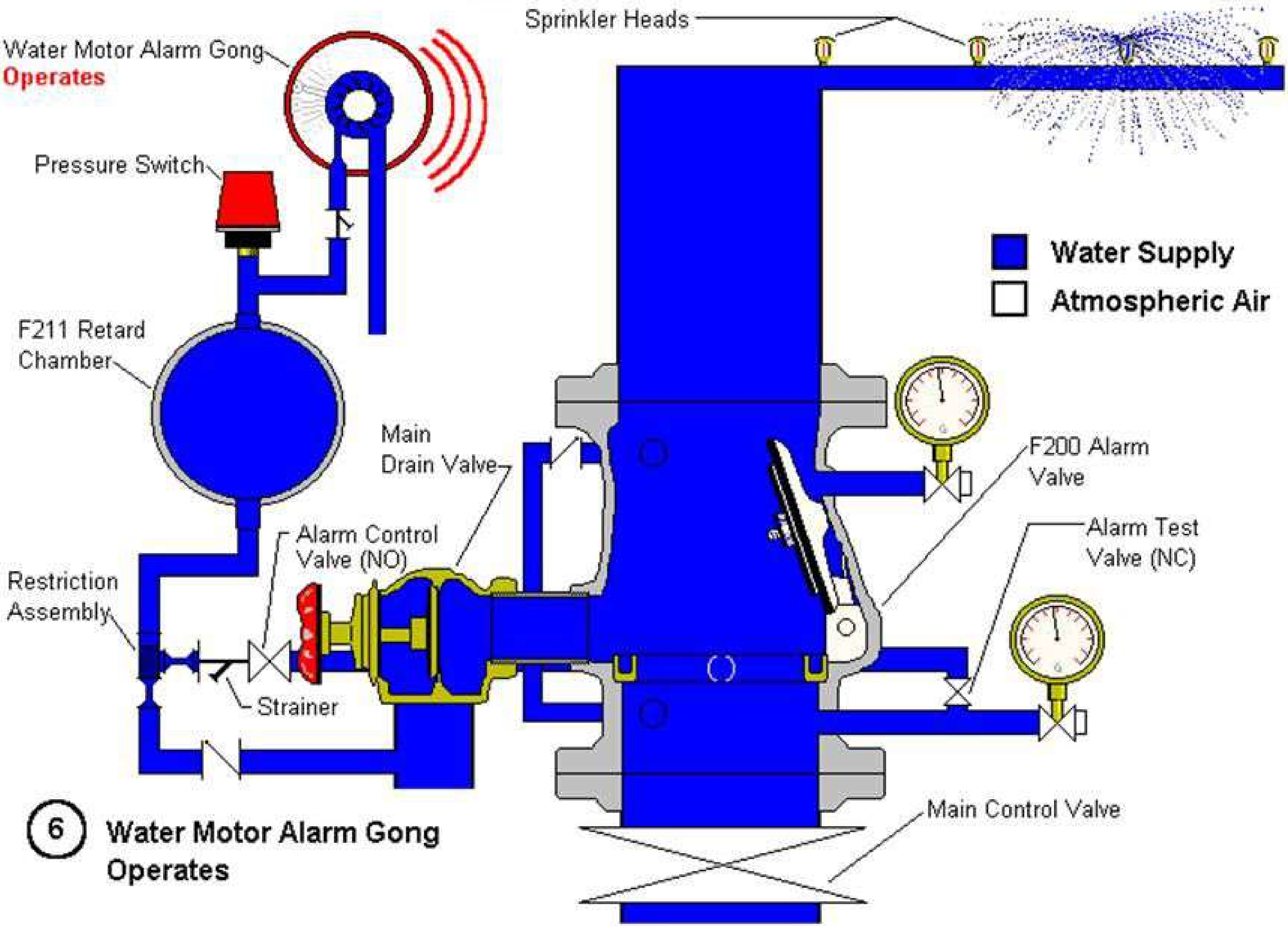

Sprinkler Heads
Operate
Water Motor Alarm Gong
Pressure Switch
Water Supply
Atmospheric Air
F211 Retard
Chamber
Main
Drain Valve
F200 Alarm
Valve
Alarm Control
Valve (NO)
Alarm Test
Valve (NC)
Restriction
Assembly
Strainer
Main Control Valve
2
Sprinkler Head
Operates

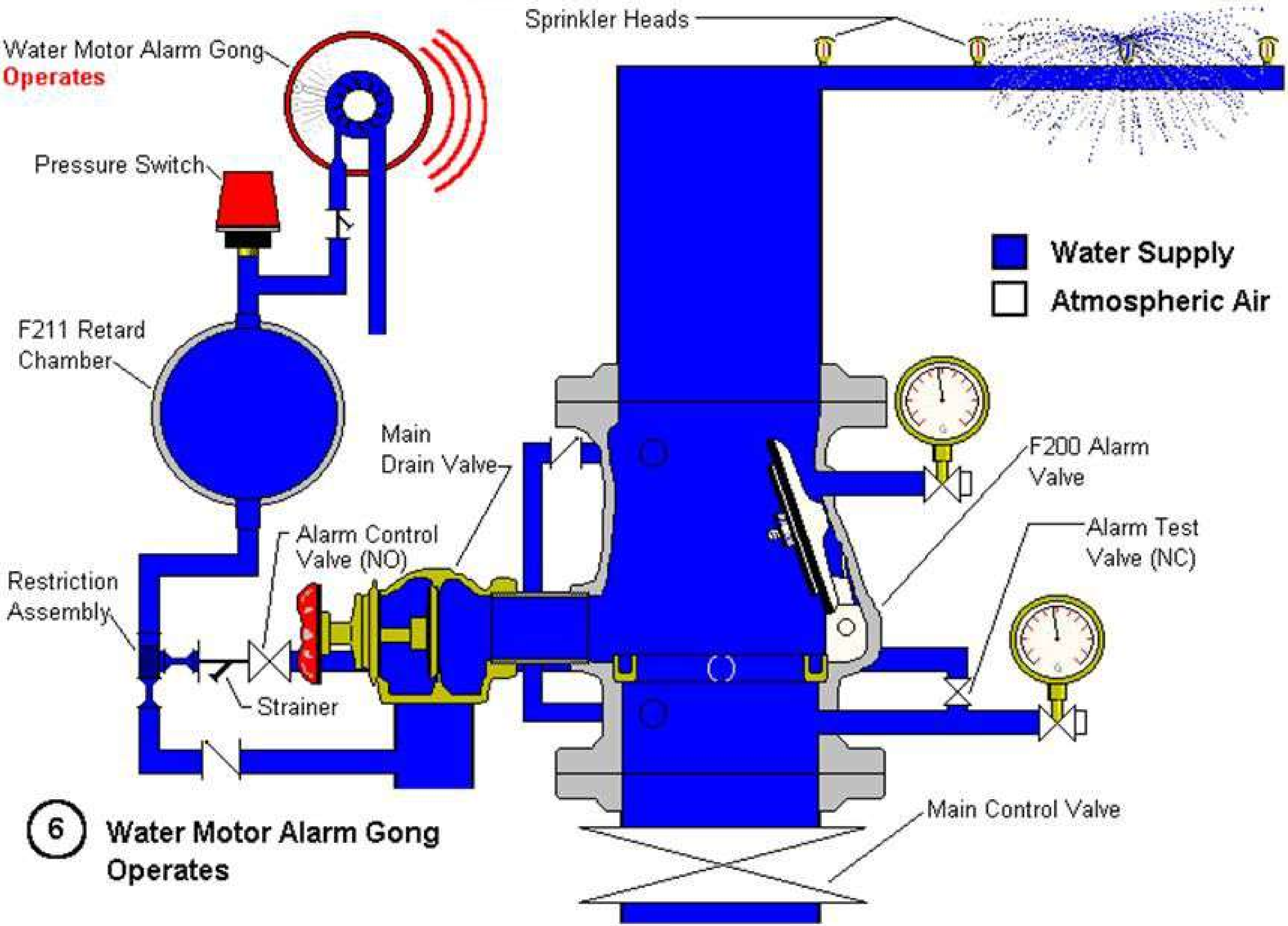


3 **Valve Operates and Water Floods Trim**



4 **Trim Continues to Flood - Water Flows to Sprinkler**


Water Motor Alarm Gong
Operates
Sprinkler Heads
Pressure Switch
Water Supply
Atmospheric Air
F211 Retard Chamber
Main Drain Valve
F200 Alarm Valve
Alarm Control Valve (NO)
Alarm Test Valve (NC)
Restriction Assembly
Strainer
Main Control Valve
6
Water Motor Alarm Gong Operates


Sprinkler Heads
Water Motor Alarm Gong
Operates
Pressure Switch
Water Supply
Atmospheric Air
F211 Retard Chamber
Main Drain Valve
F200 Alarm Valve
Alarm Control Valve (NO)
Alarm Test Valve (NC)
Restriction Assembly
Strainer
Main Control Valve
6
Water Motor Alarm Gong Operates

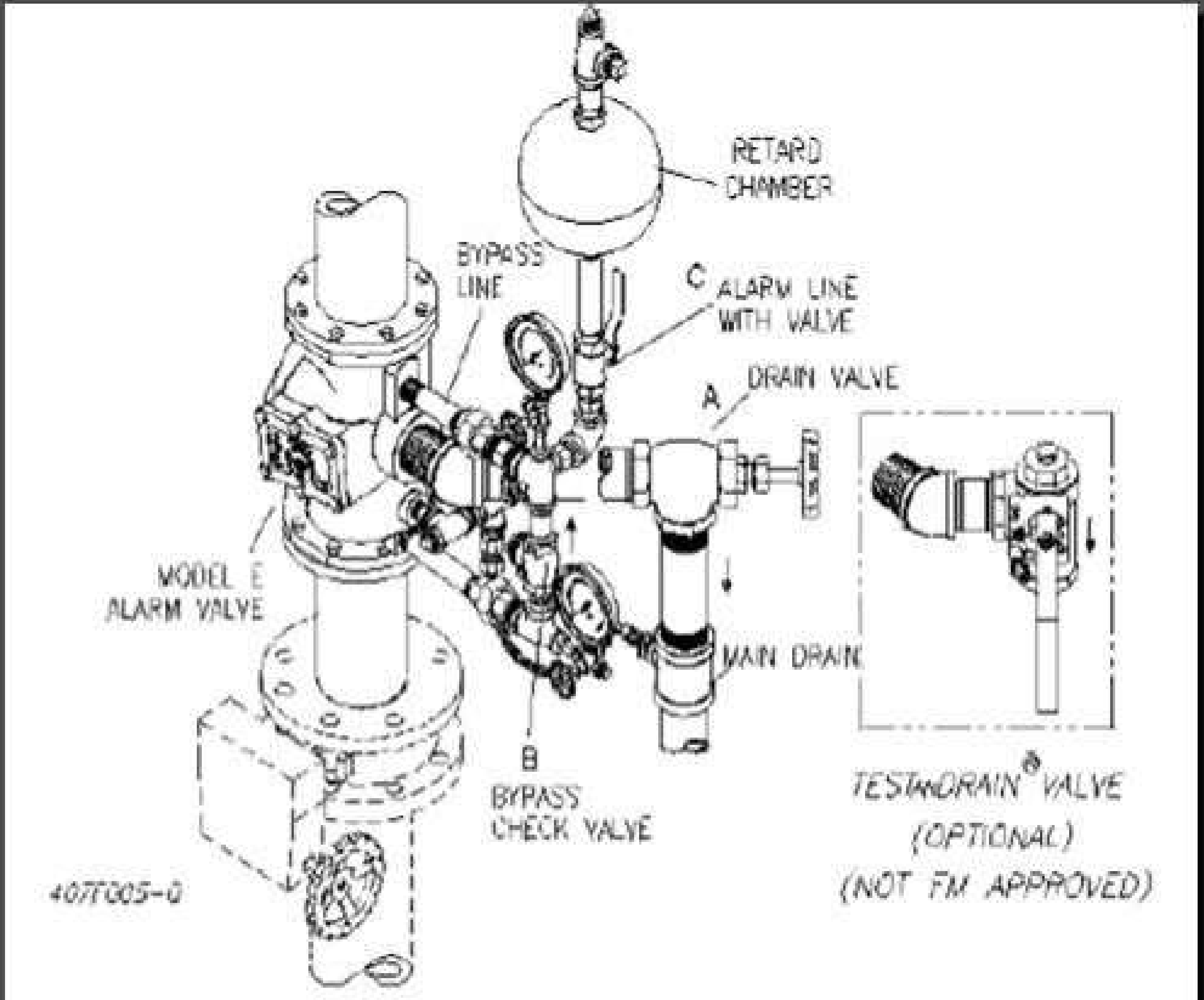
Fire Sprinkler System Components

2-Sprinkler System Valves

Alarm Check Valve

Main components

- The check valve
- Retard chamber.
- By pass check valve.
- Drain valve.



Fire Sprinkler Systems Types

2- Dry pipe systems

Dry pipe systems can only be used in spaces in which the ambient temperature may be cold enough to freeze the water in a wet pipe system. Dry pipe systems are most often used in unheated buildings, or in parking garages .

- **Operation**

  When one or more of the automatic sprinklers is exposed to sufficient heat; it opens, allowing the trapped air to vent from that sprinkler, allowing water to enter the piping system.

- **Advantages:**

  1- In protection of collections and other water sensitive area in case of wet pipe is physically damaged and water leakgae may be excited while dry pipe system will not.

- **Disdvantages:**

  1- Increased complexity.

  2- Higher installation and maintenance costs.

  3- Increased fire response time.

  4- Increased corrosion potential.

Fire Sprinkler System Components

Sprinkler System Valves

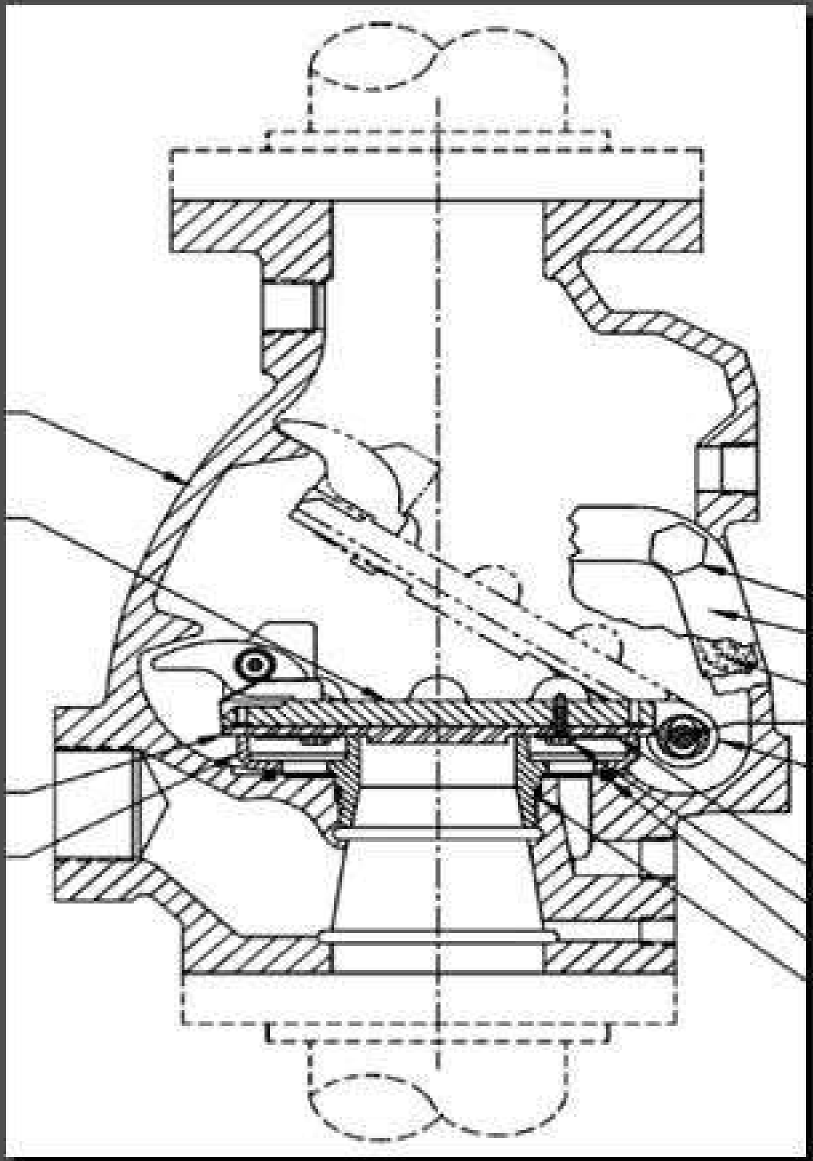
Dry Pipe Valve

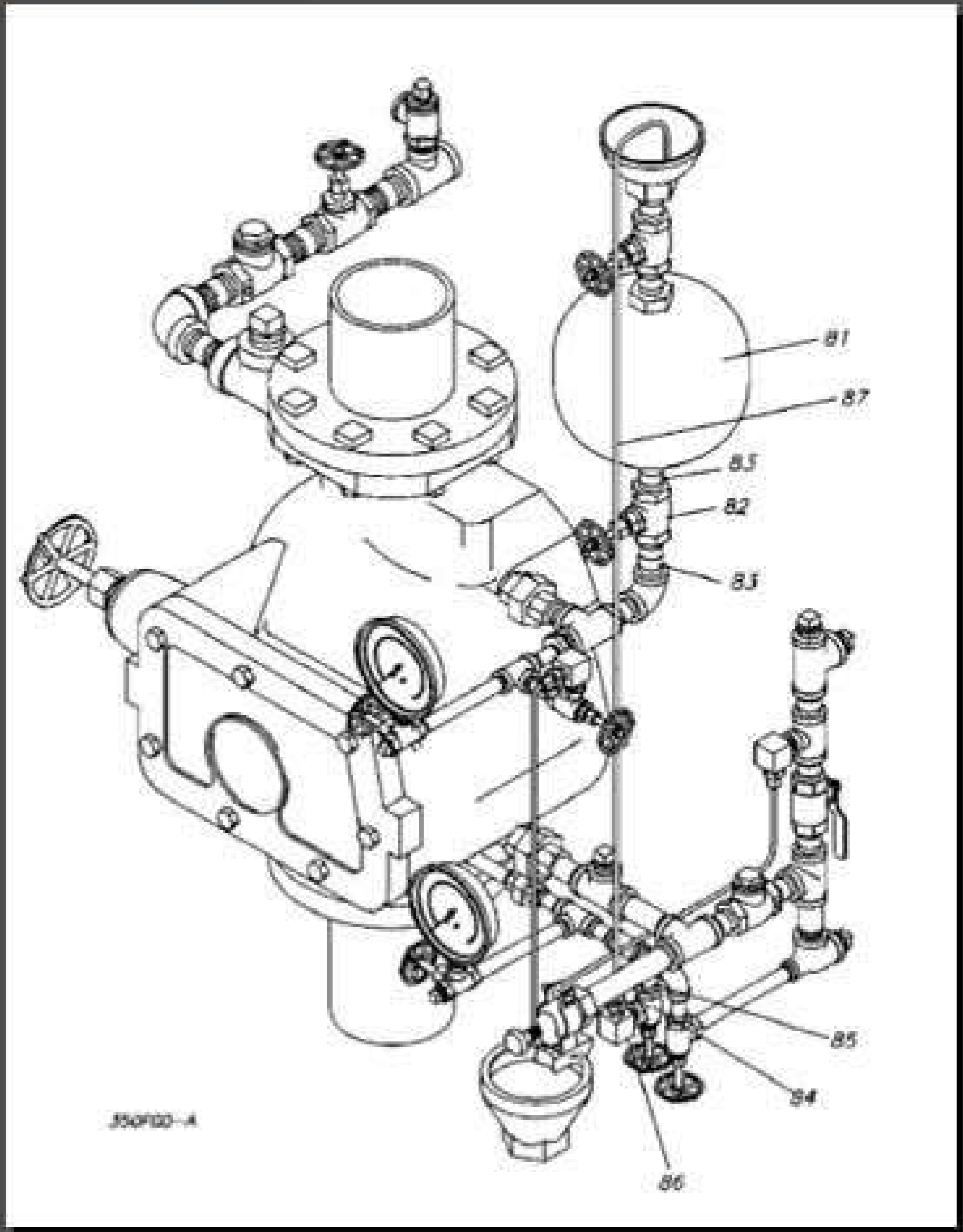
- When air pressure in the system drops due opening of one or more sprinklers, the Clapper Assembly through the greater force exerted on its underside by the water supply pressure, moves upward Water from the supply instantly flows through the dry pipe valve into the sprinkler system
- Water also flows through the alarm outlet to the electric alarm switch and water motor causing alarms to be sounded.

Fire Sprinkler System Components

Sprinkler System Valves

Dry Pipe Valve



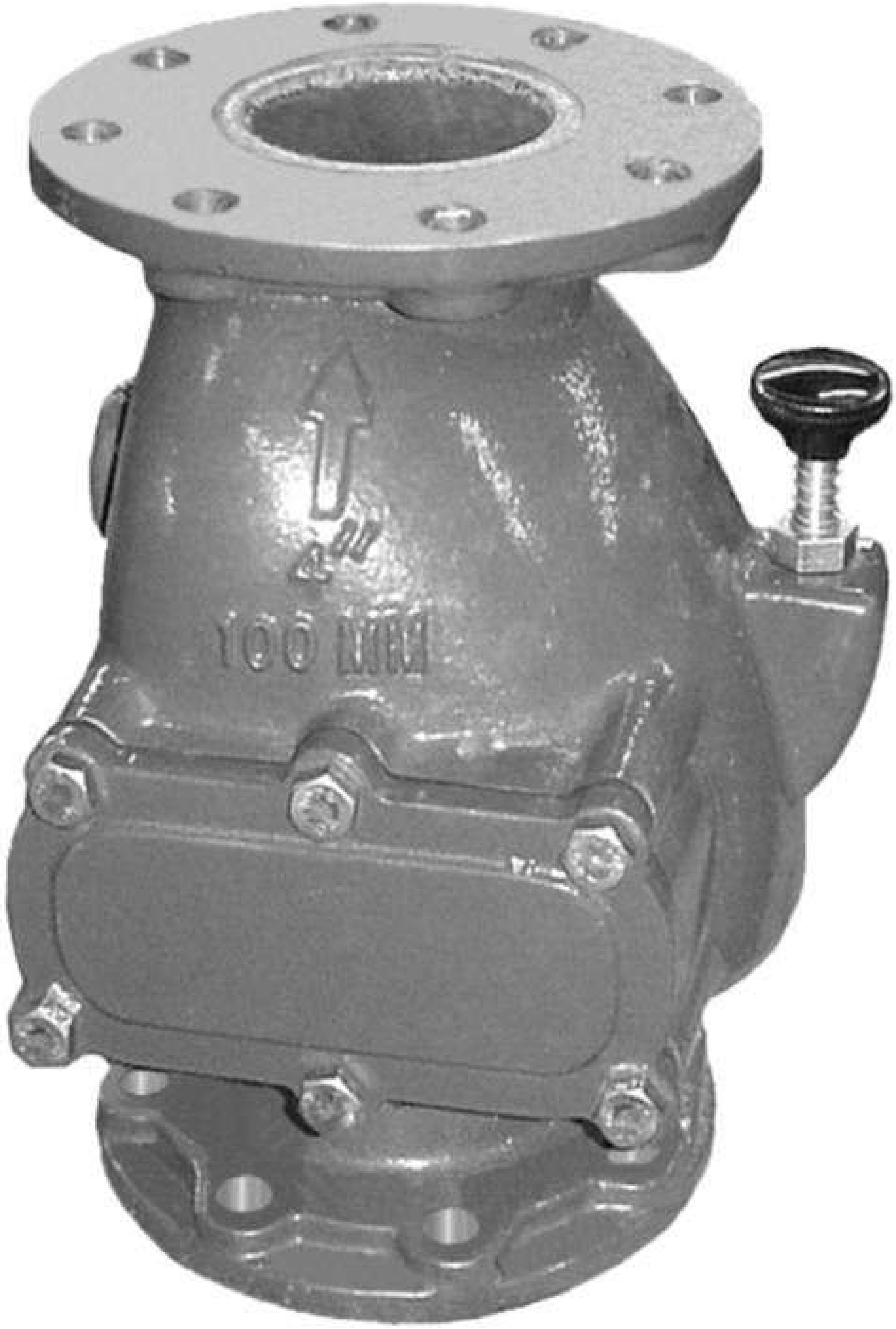


DRY pipes system

- Some dry pipe systems are equipped with quick opening devices (QOD's) which assist in exhausting the air or nitrogen from the system thus allowing water to reach the open head more quickly. Dry pipe systems are installed where there is a danger of freezing.

Maximum Water Supply Pressure, psi	System Air Pressure Range, psi
20	10
60	15 - 23
80	20 - 28
100	25 - 33
120	30 - 38
145	35 - 43
165	40 - 48
185	45 - 53
205	50 - 58
225	55 - 63
250	60 - 68

TABLE A
SYSTEM AIR PRESSURE REQUIREMENTS



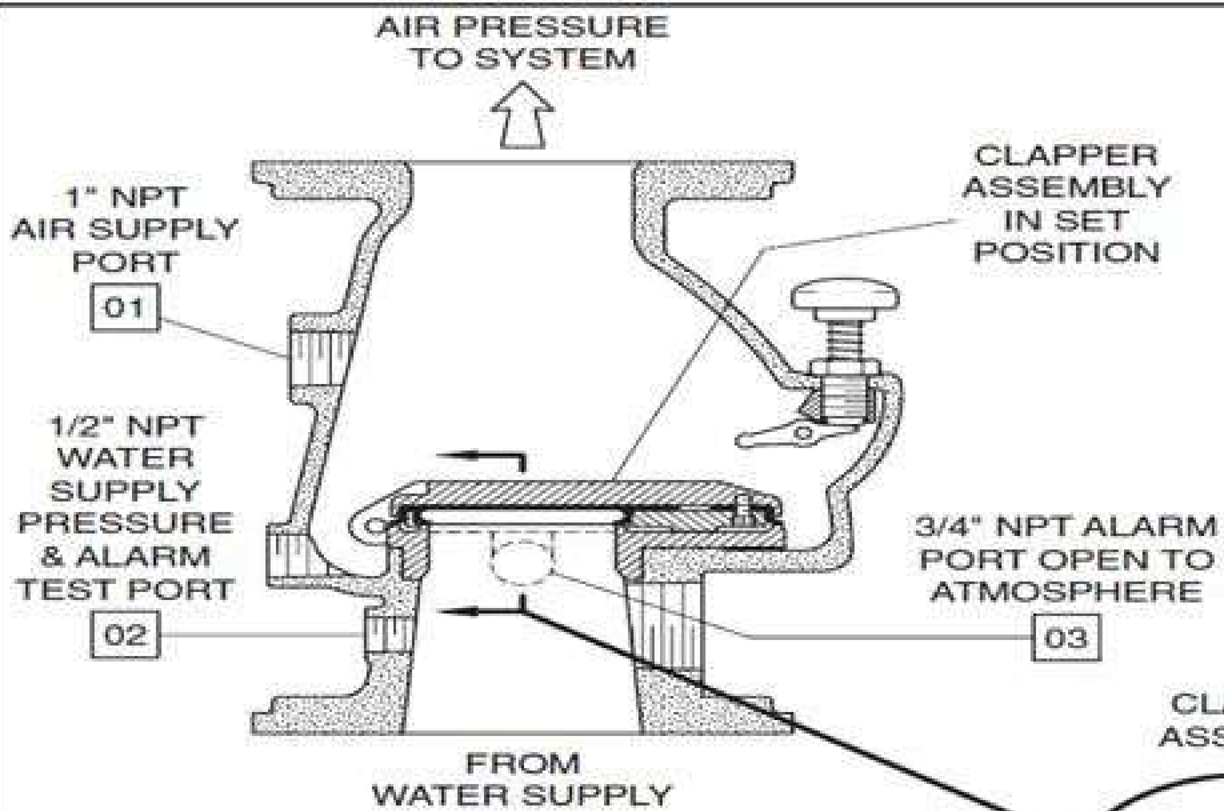


FIGURE 3A
SET POSITION

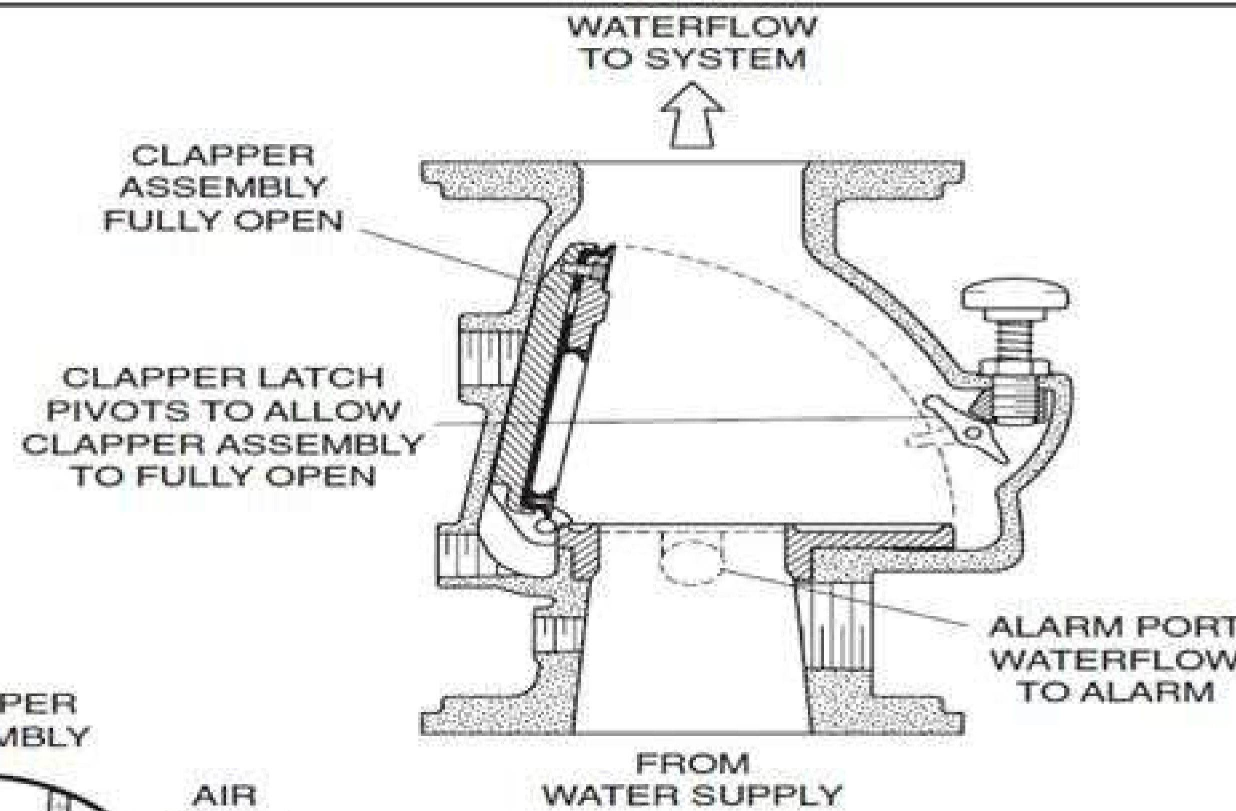


FIGURE 3C
OPERATED POSITION

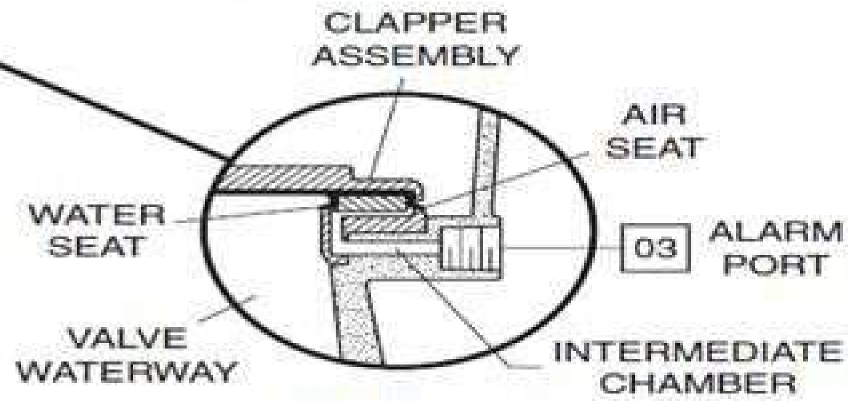


FIGURE 3B
SET POSITION INTERMEDIATE CHAMBER

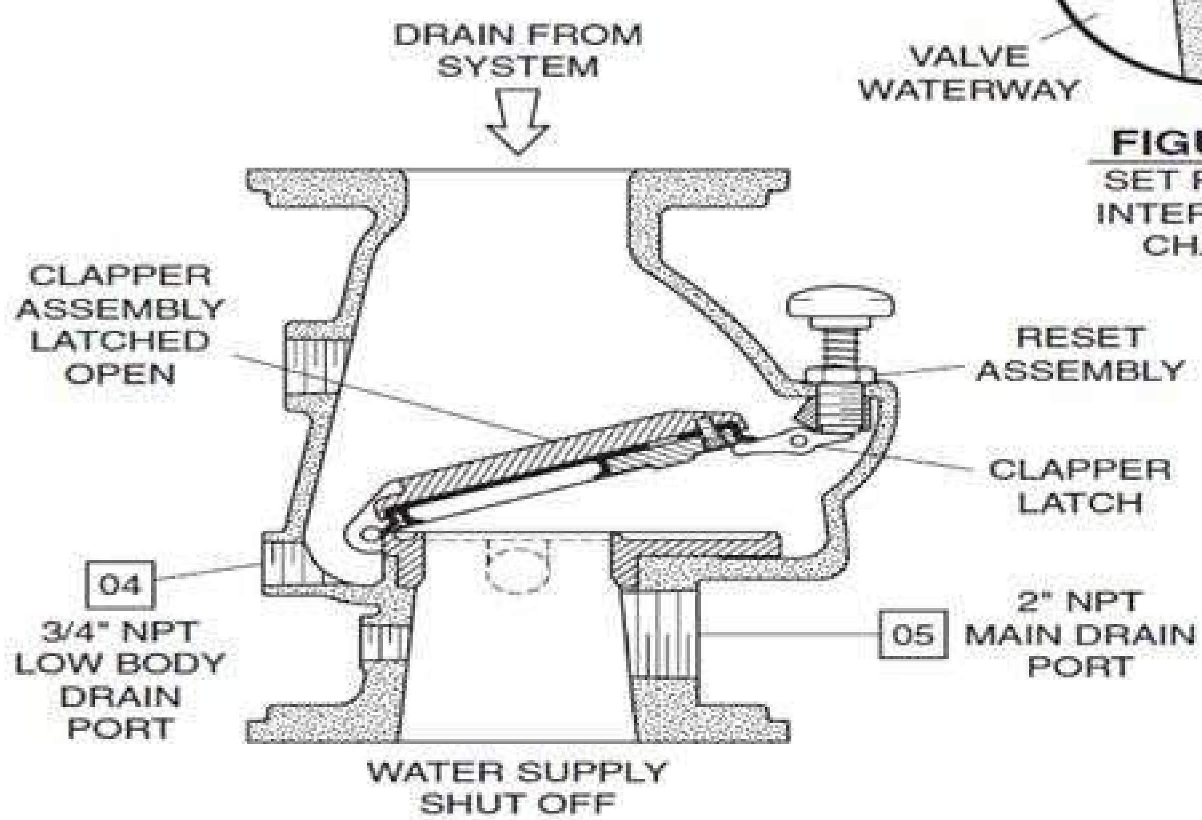


FIGURE 3D
DRAIN POSITION

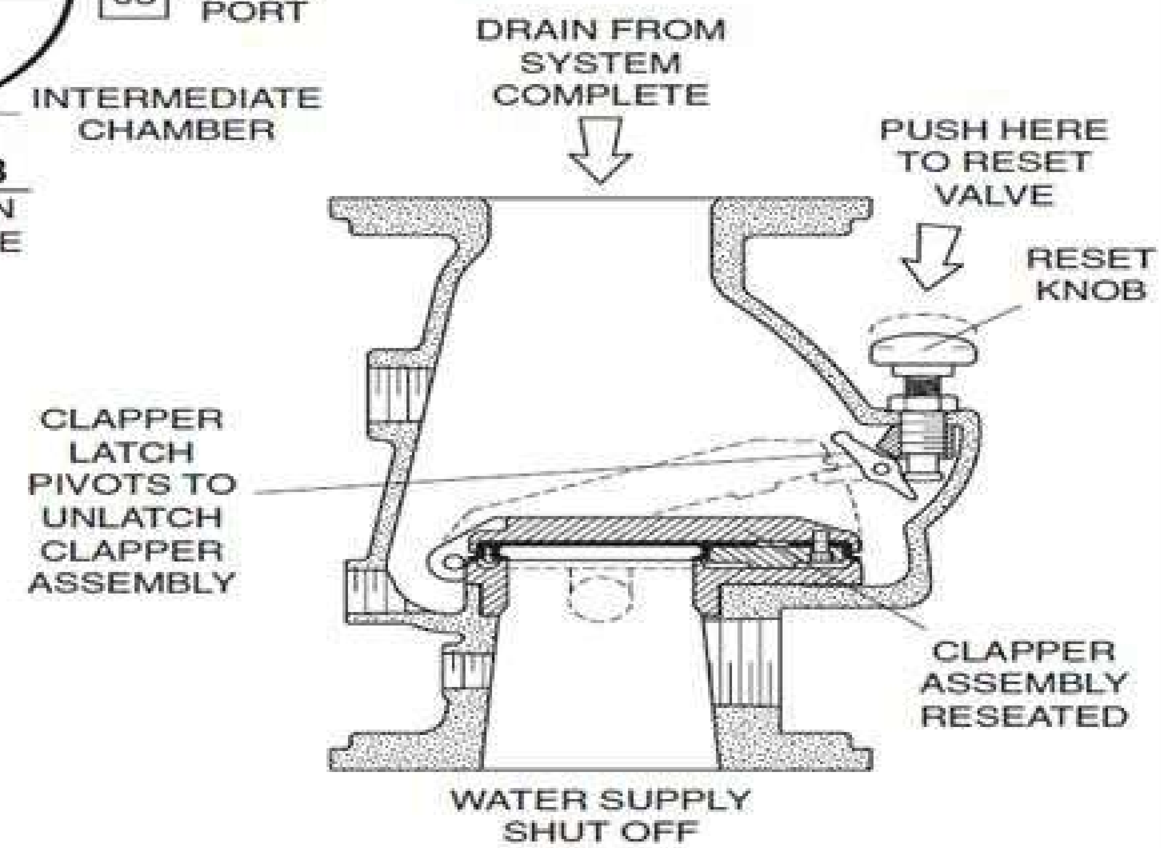


FIGURE 3E
RESET POSITION

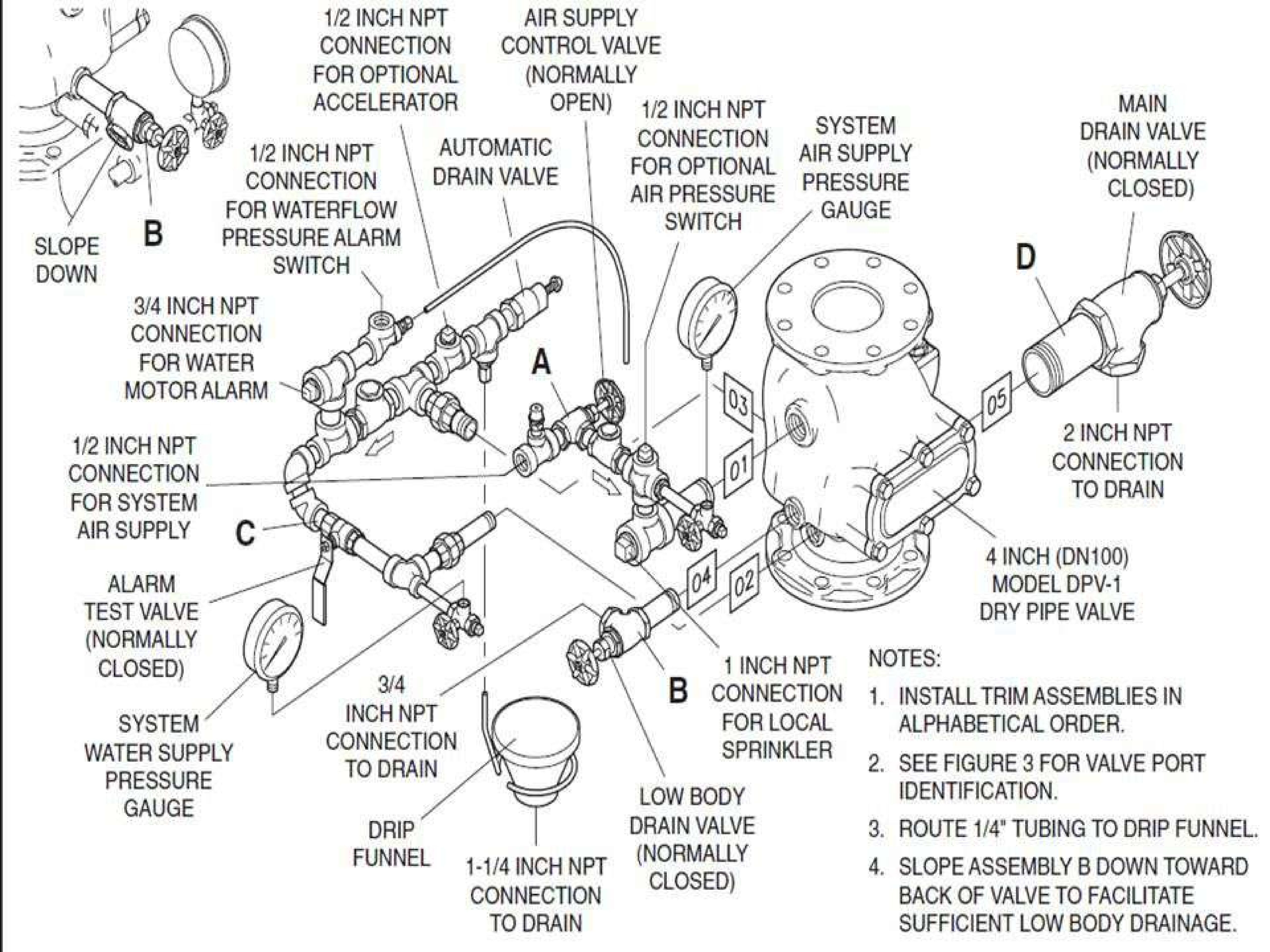
procedure

- When one or more automatic sprinklers operate in response to a fire, air pressure within the system piping is relieved through the open sprinklers.
- When the air pressure is sufficiently reduced, the water pressure overcomes the differential holding the Clapper Assembly closed and the Clapper Assembly swings clear of the water seat,
- This action permits water flow into the system piping and subsequently to be discharged from any open sprinklers. Also, with the Clapper Assembly open, the intermediate chamber is pressurized and water flows through the alarm port.

procedure

- After a valve actuation and upon subsequent closing of a system main control valve to stop water flow, the Clapper Assembly will latch open Latching open of the DPV-1 will permit complete draining of the system through the main drain port. During the valve resetting procedure and after the system is completely drained, the external reset knob can be easily depressed to externally unlatch the Clapper Assembly
- . As such, the Clapper Assembly is returned to its normal set position to facilitate setting of the dry pipe sprinkler system, without having to remove the Hand hole Cover.


tyco
Fire Products
FIRE STANDPIPE
FIRE STANDPIPE



NOTES:

1. INSTALL TRIM ASSEMBLIES IN ALPHABETICAL ORDER.
2. SEE FIGURE 3 FOR VALVE PORT IDENTIFICATION.
3. ROUTE 1/4" TUBING TO DRIP FUNNEL.
4. SLOPE ASSEMBLY B DOWN TOWARD BACK OF VALVE TO FACILITATE SUFFICIENT LOW BODY DRAINAGE.

Dry Pipe System Requirements and Limitations As Per NFPA

Pressure Gauges :

Listed pressure gauges shall be connected as follows:

(1) On the water side and air side of the dry pipe valve.

(2) At the air Compressor supplying the air receiver where one is provided.

(3) At the air receiver where one is provided

(4) In each independent pipe from air supply to dry pipe system

Dry Pipe System Requirements and Limitations As Per NFPA

Pressure Gauges :

Listed pressure gauges shall be connected as follows:

(1) On the water side and air side of the dry pipe valve.

(2) At the air Compressor supplying the air supply.

(3) At the air receiver where one is provided

(4) In each independent pipe from air supply to dry pipe system

Dry Pipe System Requirements and Limitations As Per NFPA

- Not more than 750 gal (2839 L) system capacity shall be controlled by one dry pipe valve.
- The system design is such that water is delivered to the system in not more than 60 seconds.
- The dry pipe valve and supply pipe shall be protected against freezing and mechanical injury.
- The compressed air supply shall be from a source available at all times.
- The air supply shall have a capacity capable of restoring normal air pressure in the system within 30 minutes.

Dry Pipe System Requirements and Limitations As Per NFPA

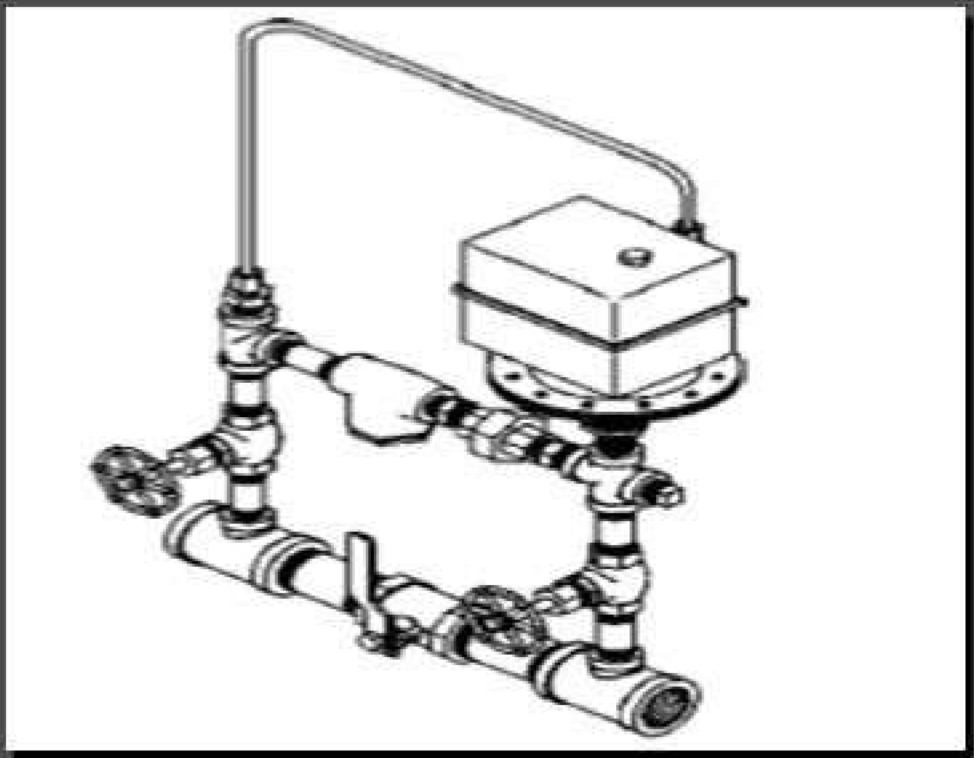
- A listed relief valve shall be provided between the compressor and controlling valve and shall be set to relieve at a pressure 10 psi (0.7 bar) in excess of the operating air pressure of the system.

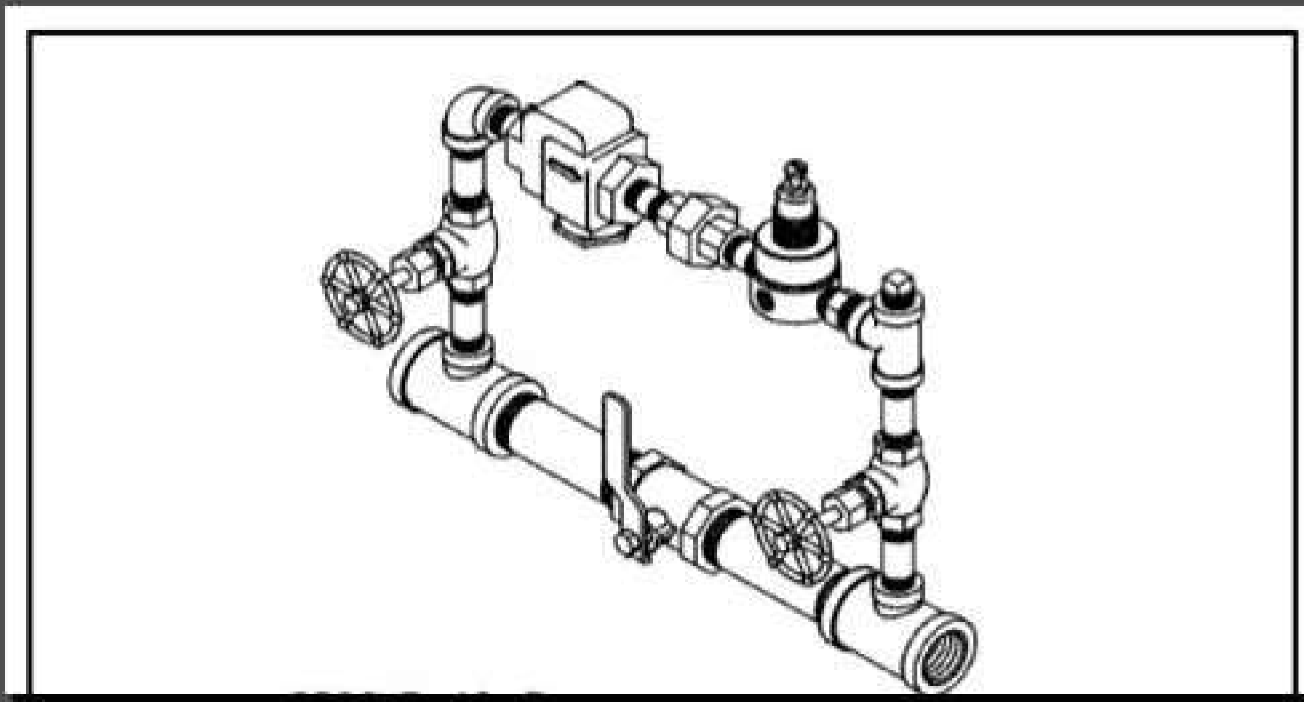
Fire Sprinkler System Components

Dry Pipe Valve

Air Maintenance Device

- They eliminate the need for manual filling to overcome small leaks or temperature changes.





Fire Sprinkler System Types

3 -Deluge System

A sprinkler system employing open sprinklers that are attached to a piping system that is connected to a water supply through a valve that is opened by the operation of a detection system installed in the same areas as the sprinklers.

When this valve opens, water flows into the piping system and discharges from all sprinklers

Deluge systems:

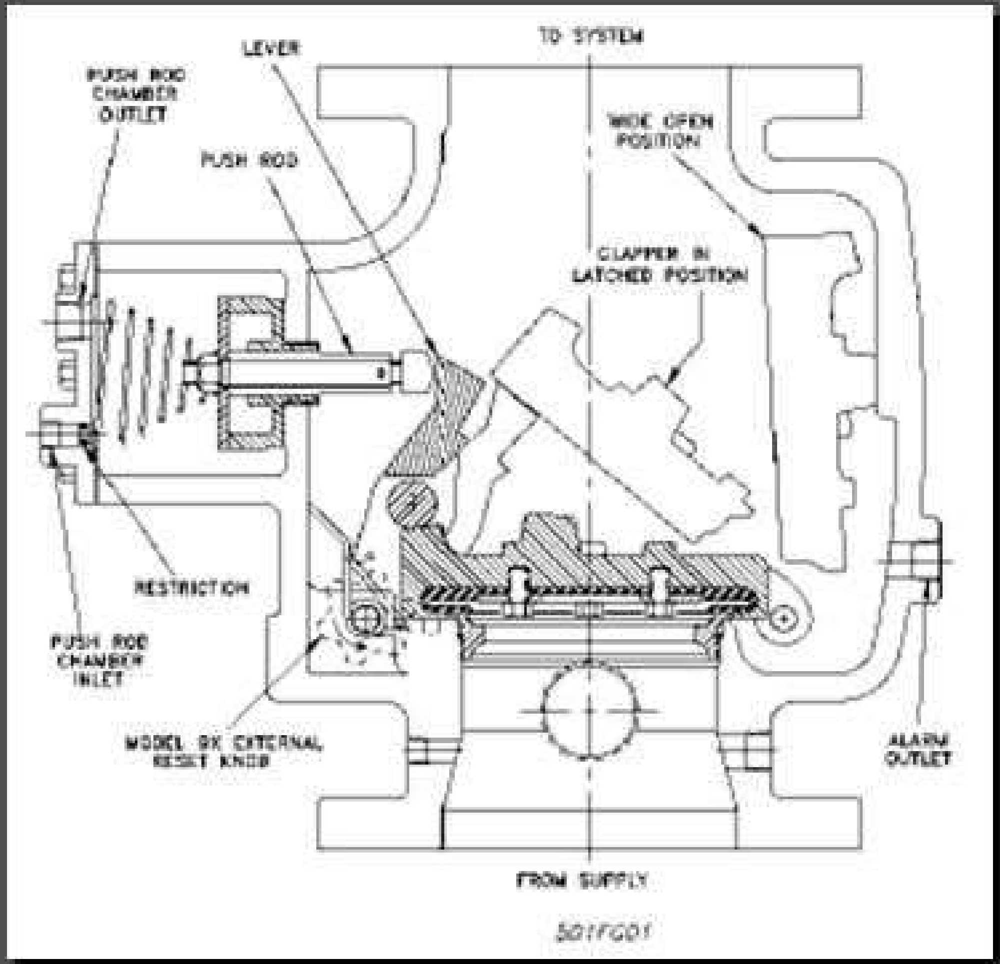
- A deluge system is similar to a pre-action system except the sprinkler heads are open and the pipe is not pressurized with air. Deluge systems are connected to a water supply through a deluge valve that is opened by the operation of a smoke or heat detection system. The detection system is installed in the same area as the sprinklers. When the detection system is activated water discharges through all of the sprinkler heads in the system. Deluge systems are used in places that are considered high hazard areas such as power plants, aircraft hangars and chemical storage or processing facilities. Deluge systems are needed where high velocity suppression is necessary to prevent fire spread

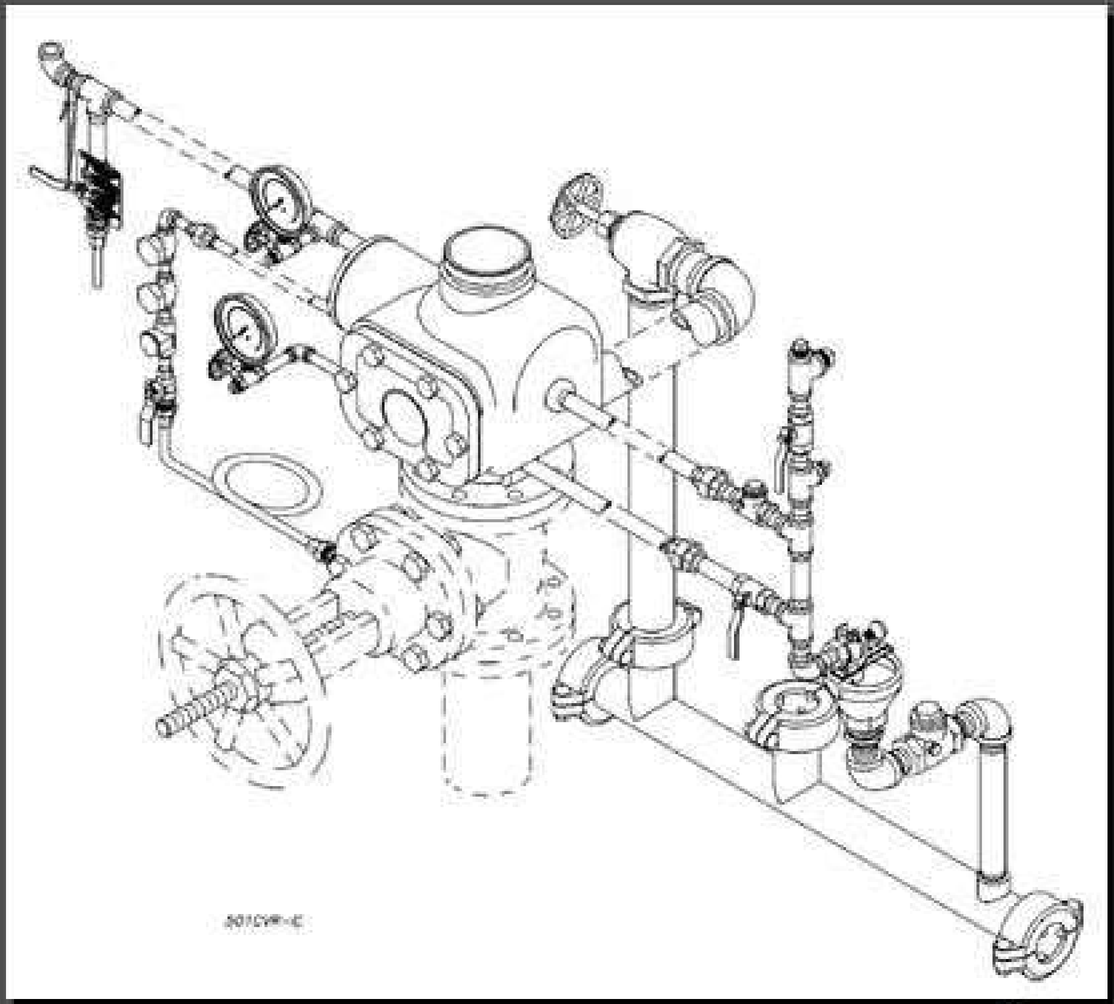
Fire Sprinkler System Components

Sprinkler System Valves

Deluge Valve

Deluge Valves are hydraulically operated differential type valves designed for use as primary control valves in deluge, Preaction or special types of fire protection systems.





Fire Sprinkler System Components

Sprinkler System Valves

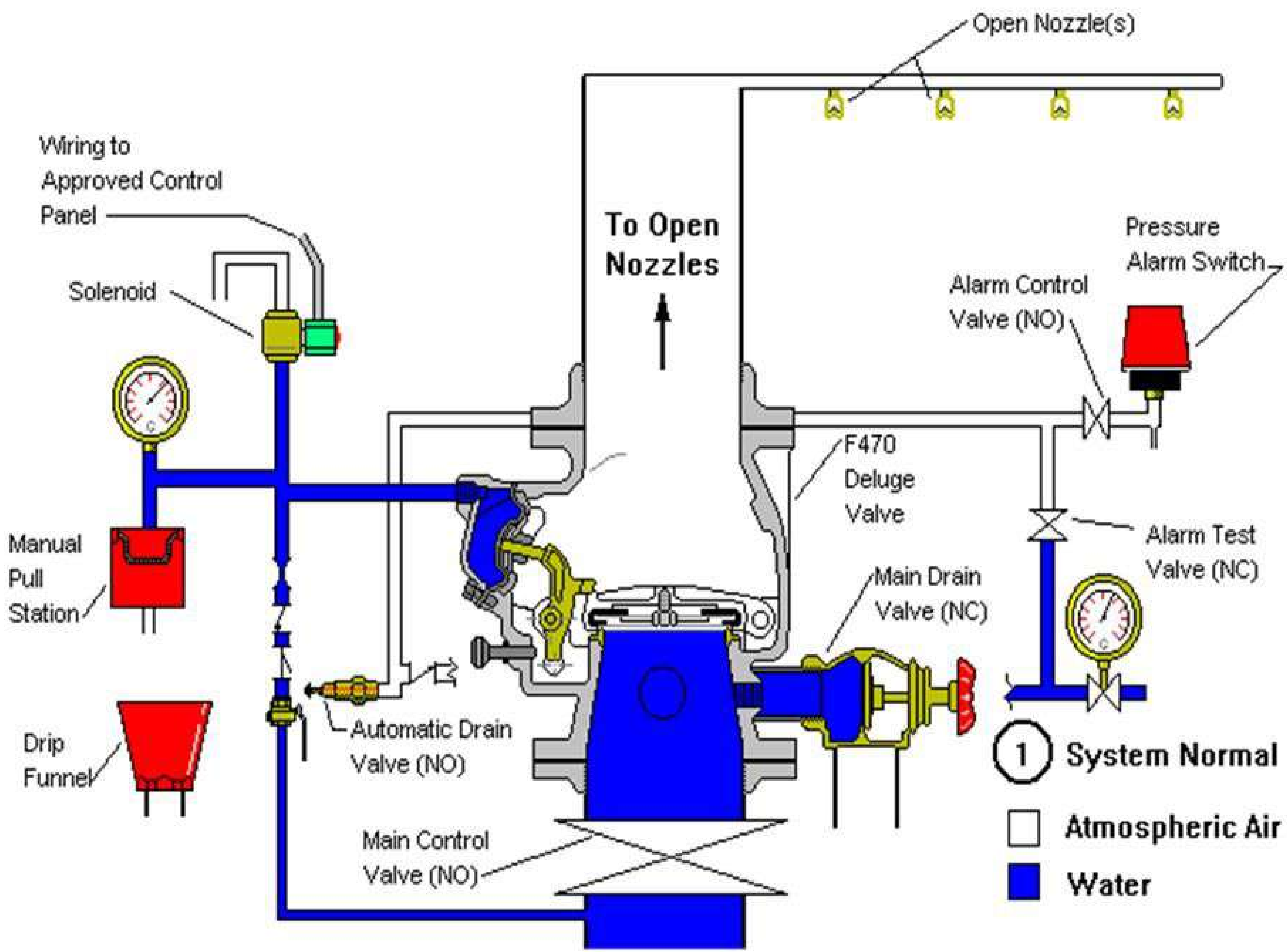
Deluge Valve

Deluge Valves can be actuated by :

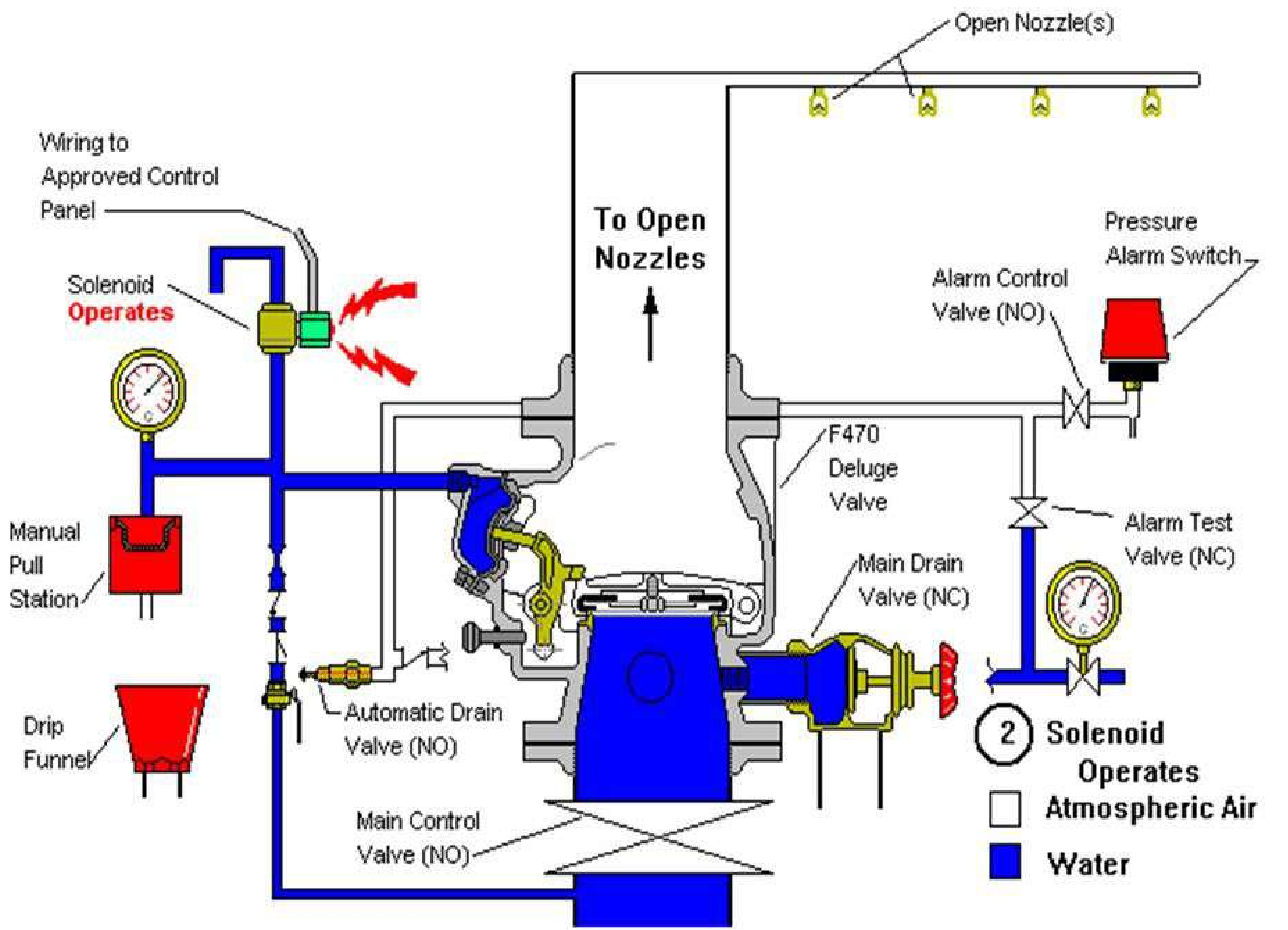
- Wet Pilot Trim.
- Dry Pilot Trim.
- Electrical Pilot Trim

Deluge systems:

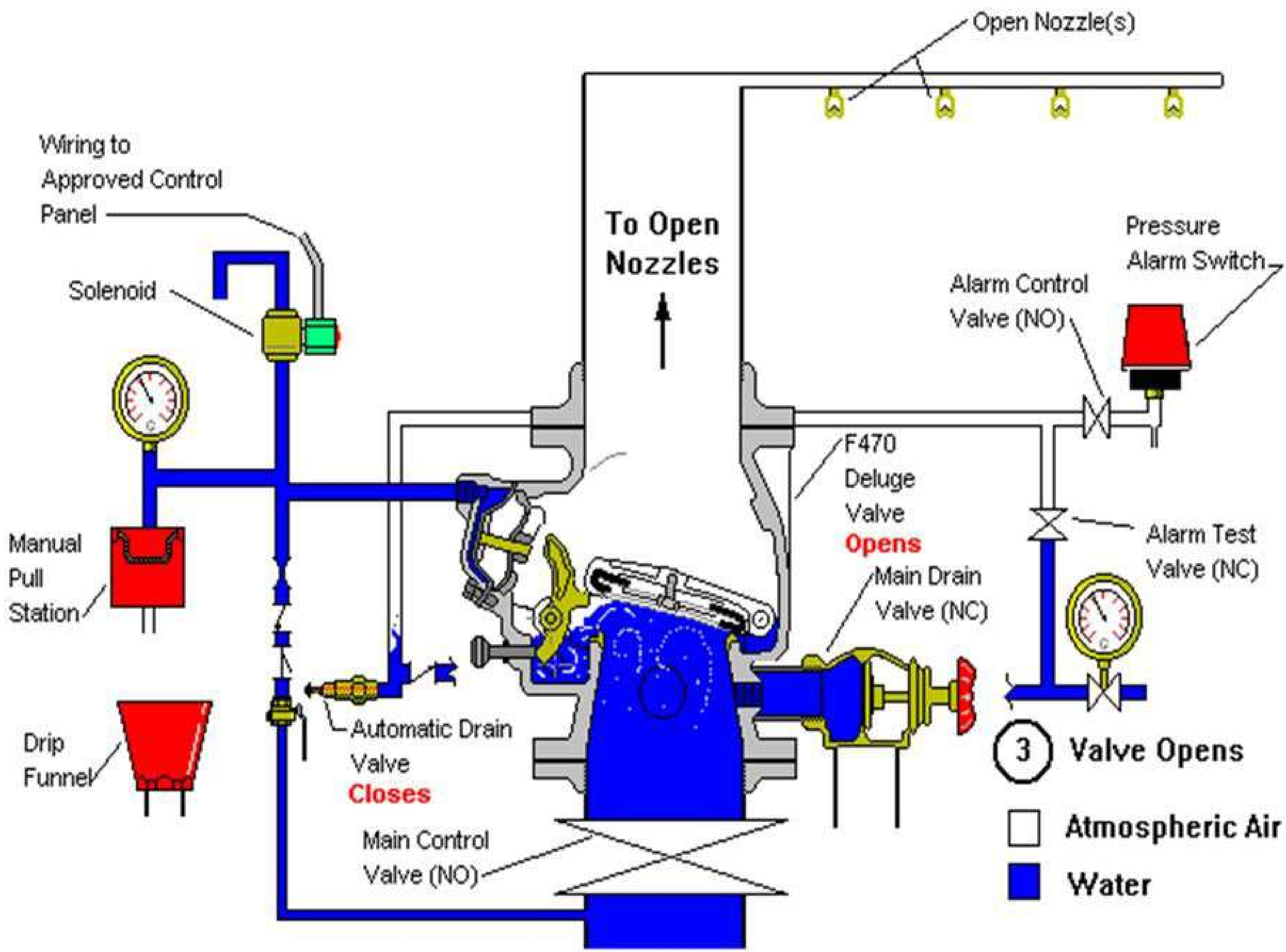
- Deluge System with Electric actuated

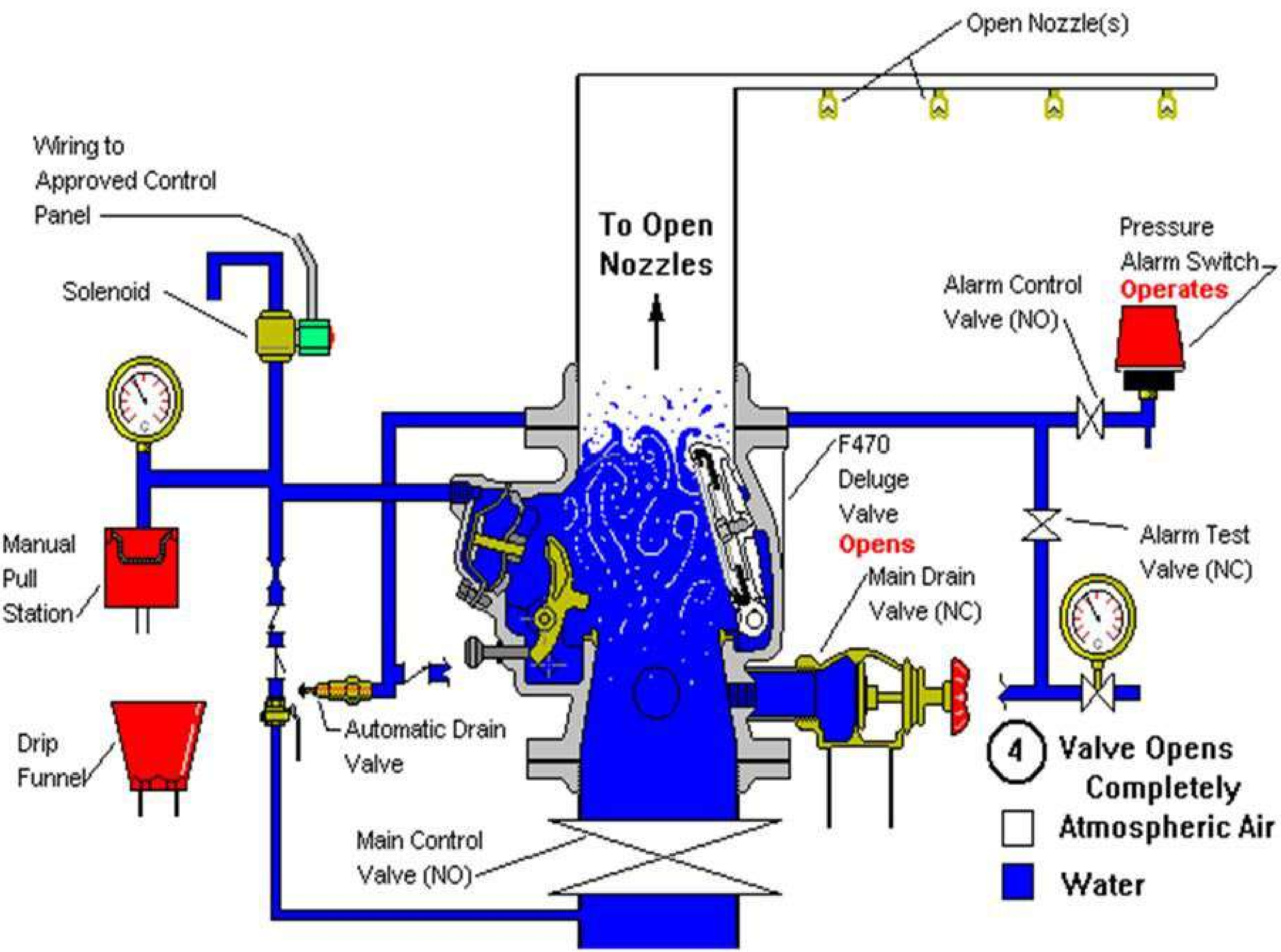


Open Nozzle(s)
Wiring to Approved Control Panel
To Open Nozzles
Pressure Alarm Switch
Alarm Control Valve (NO)
Solenoid
F470 Deluge Valve
Alarm Test Valve (NC)
Manual Pull Station
Main Drain Valve (NC)
Automatic Drain Valve (NO)
Drip Funnel
1 System Normal
Atmospheric Air
Water
Main Control Valve (NO)

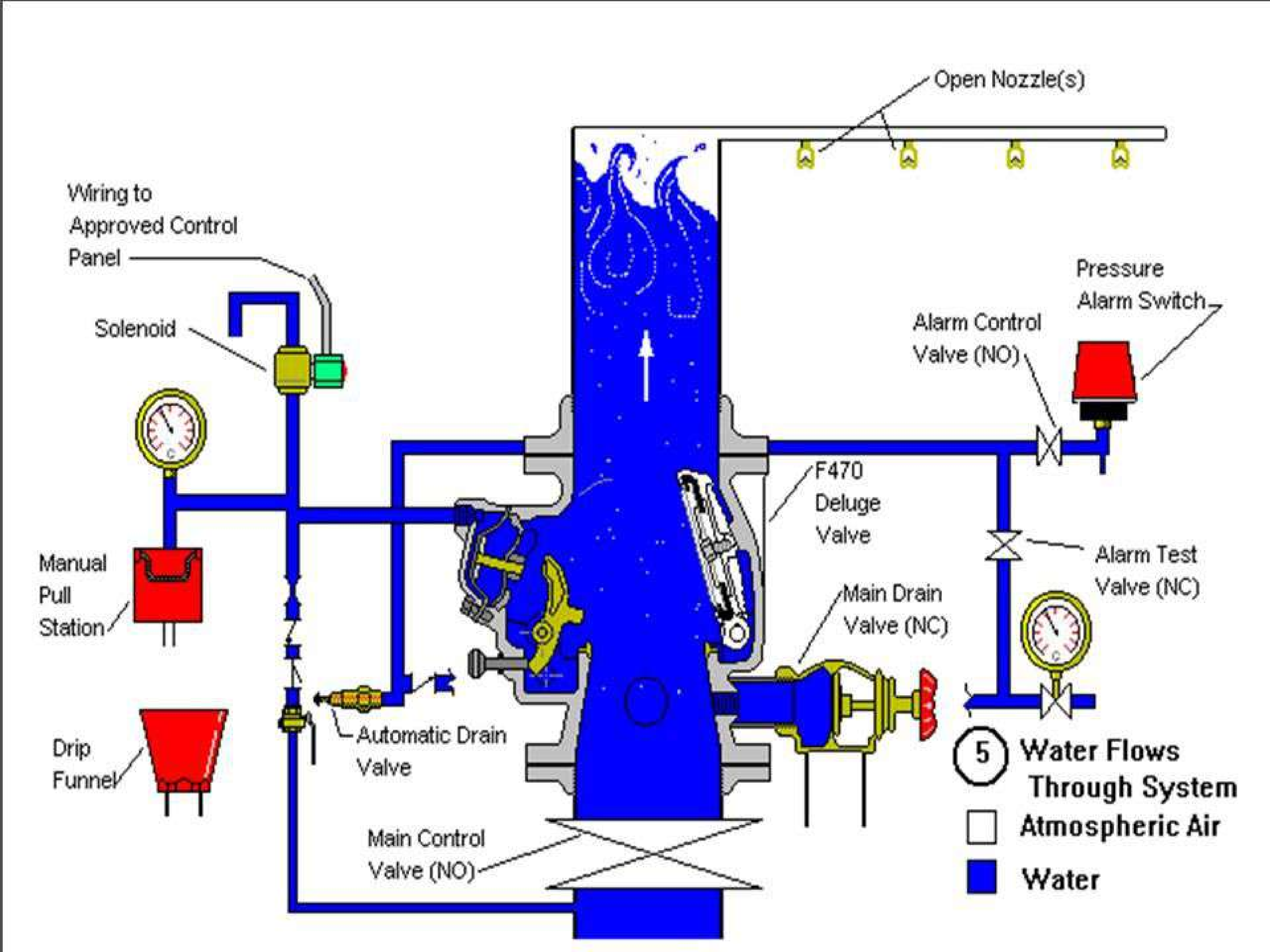


Open Nozzle(s)
Wiring to Approved Control Panel
To Open Nozzles
Pressure Alarm Switch
Solenoid Operates
Alarm Control Valve (NO)
F470 Deluge Valve
Alarm Test Valve (NC)
Manual Pull Station
Main Drain Valve (NC)
Automatic Drain Valve (NO)
Drip Funnel
2 Solenoid Operates
Atmospheric Air
Water
Main Control Valve (NO)

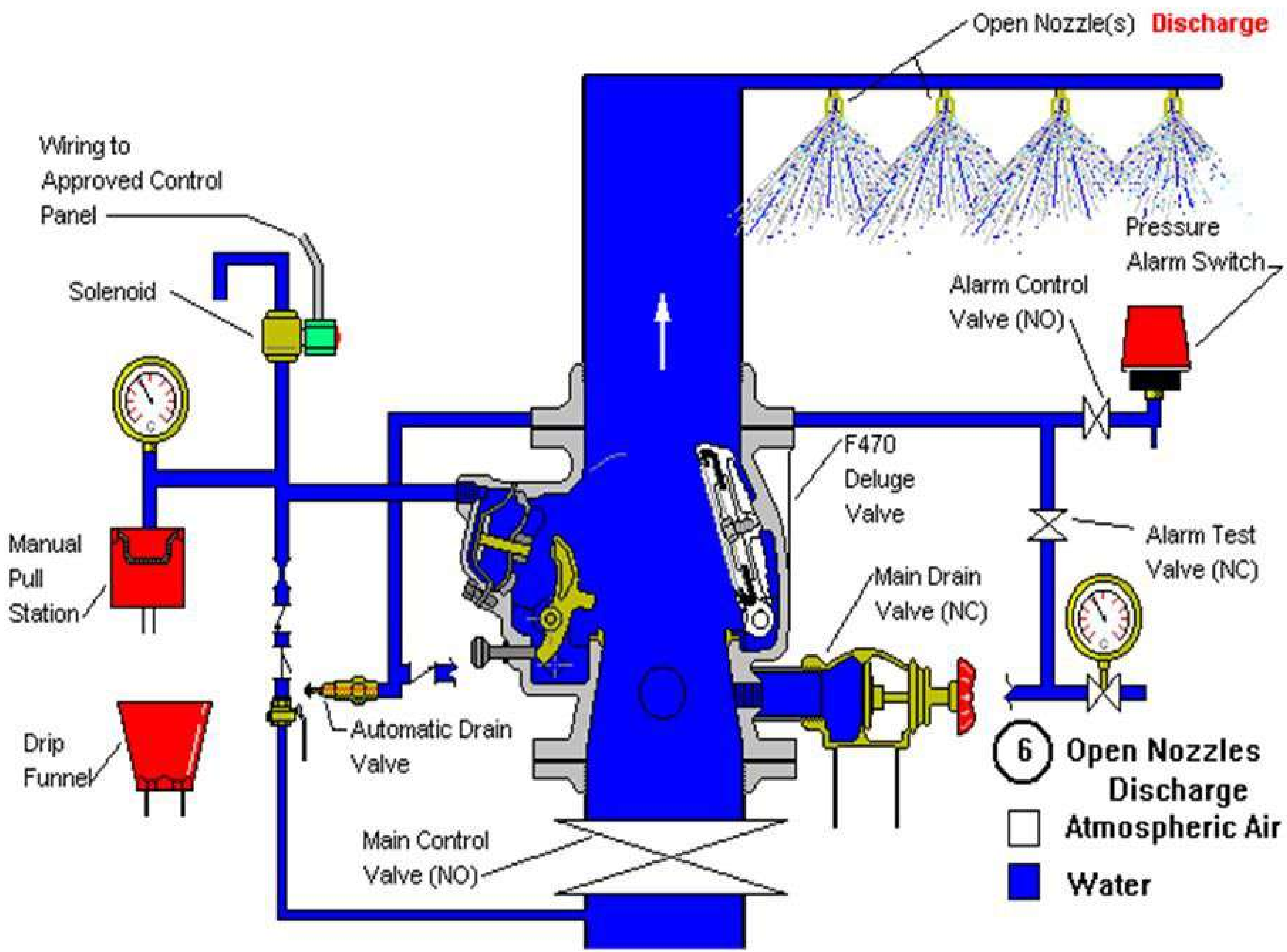

Open Nozzle(s)
Wiring to
Approved Control
Panel
To Open
Nozzles
Pressure
Alarm Switch
Alarm Control
Valve (NO)
Solenoid
F470
Deluge
Valve
Opens
Manual
Pull
Station
Alarm Test
Valve (NC)
Main Drain
Valve (NC)
Automatic Drain
Valve
Closes
3
Valve Opens
Drip
Funnel
Atmospheric Air
Main Control
Valve (NO)
Water



Open Nozzle(s)
Wiring to
Approved Control
Panel
To Open
Nozzles
Pressure
Alarm Switch
Operates
Solenoid
Alarm Control
Valve (NO)
F470
Deluge
Valve
Opens
Manual
Pull
Station
Alarm Test
Valve (NC)
Main Drain
Valve (NC)
Automatic Drain
Valve
Drip
Funnel
4
Valve Opens
Completely
Atmospheric Air
Water
Main Control
Valve (NO)



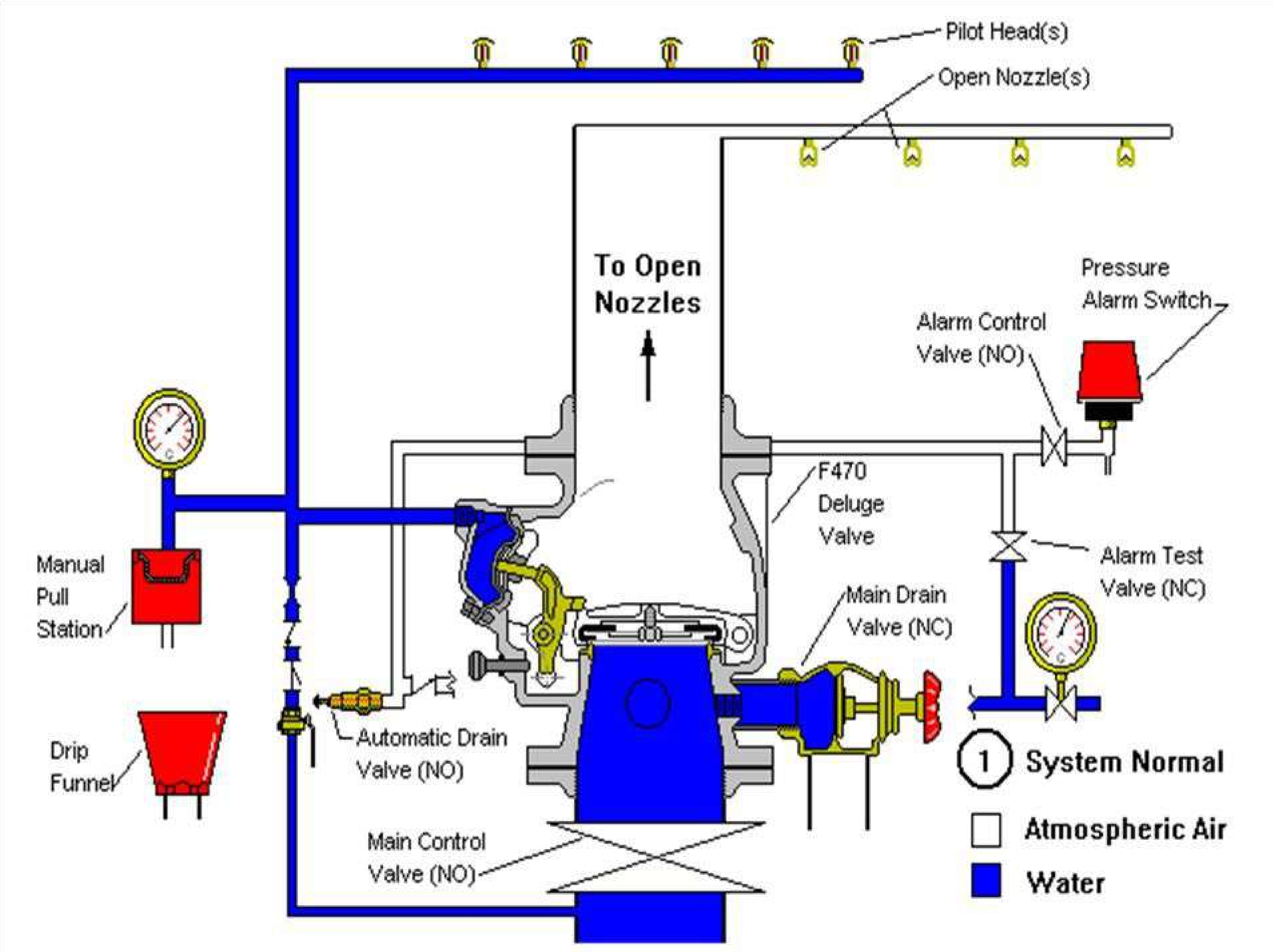
Open Nozzle(s)
Wiring to Approved Control Panel
Solenoid
Pressure Alarm Switch
Alarm Control Valve (NO)
F470 Deluge Valve
Alarm Test Valve (NC)
Manual Pull Station
Main Drain Valve (NC)
Automatic Drain Valve
Drip Funnel
5 Water Flows Through System
Atmospheric Air
Water
Main Control Valve (NO)



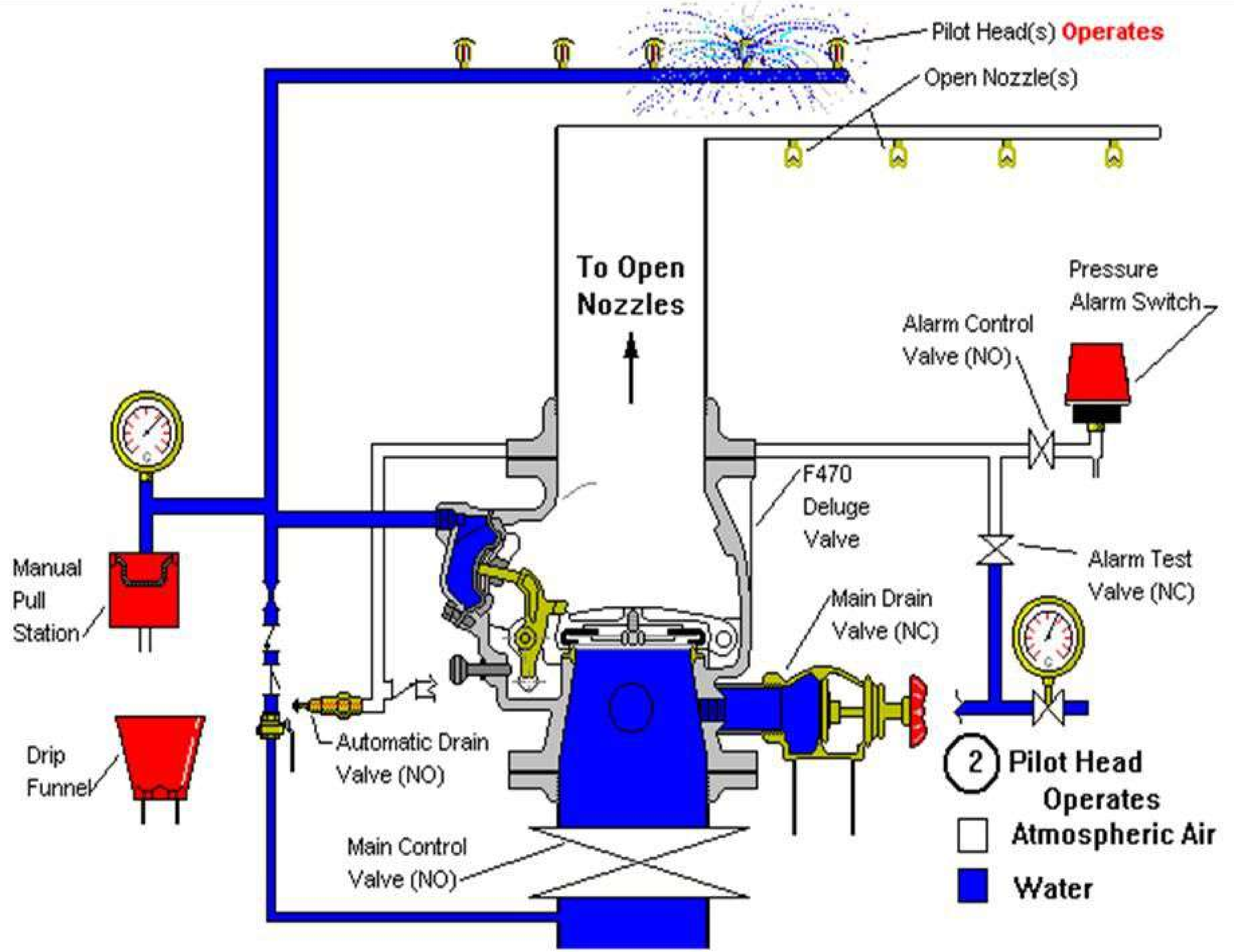
Open Nozzle(s)
Discharge
Wiring to
Approved Control
Panel
Solenoid
Pressure
Alarm Switch
Alarm Control
Valve (NO)
F470
Deluge
Valve
Manual
Pull
Station
Alarm Test
Valve (NC)
Main Drain
Valve (NC)
Automatic Drain
Valve
Drip
Funnel
6
Open Nozzles
Discharge
Atmospheric Air
Water
Main Control
Valve (NO)

Deluge systems:

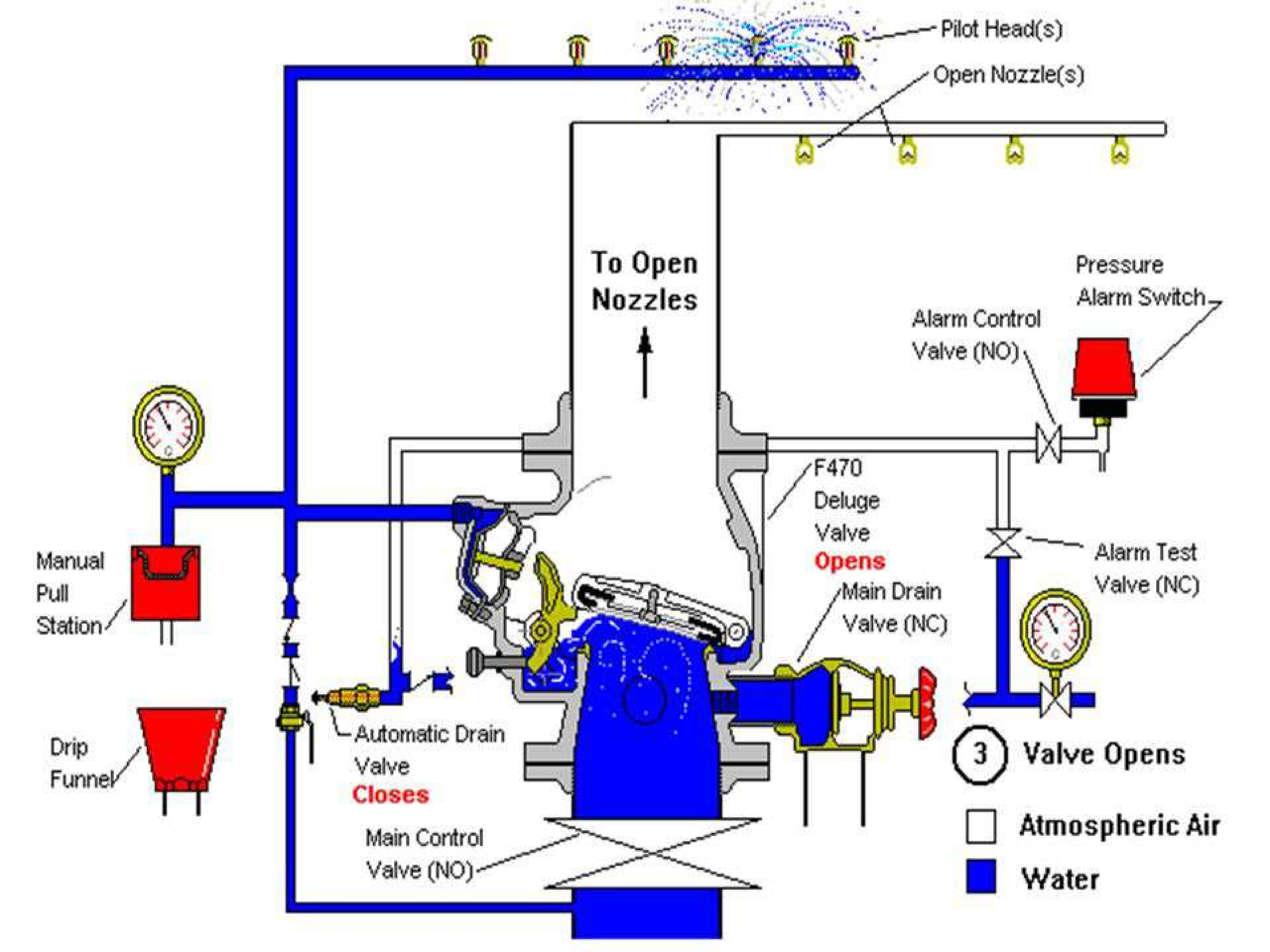
- Deluge System with wet pilot actuated



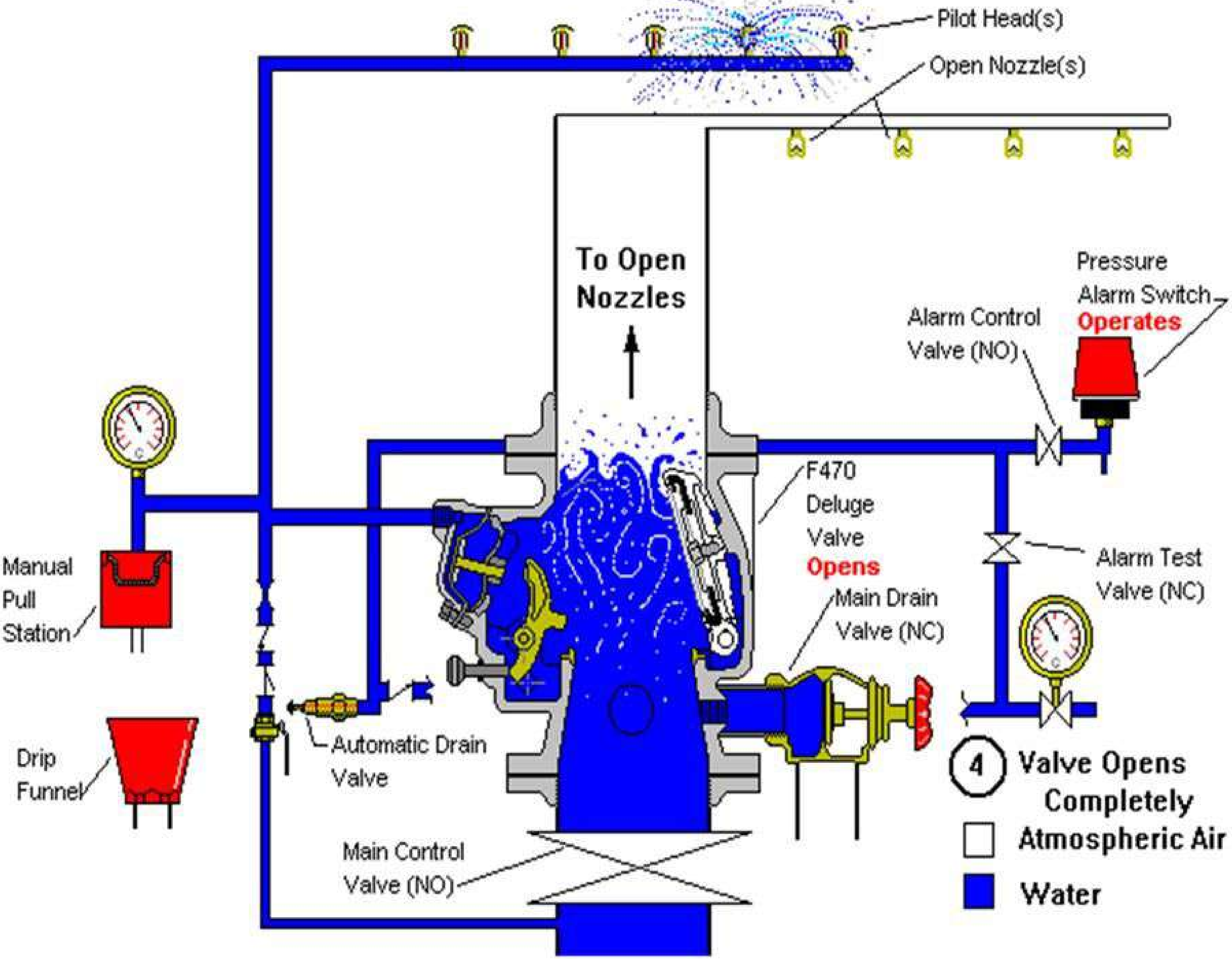
Pilot Head(s)
Open Nozzle(s)
To Open Nozzles
Pressure Alarm Switch
Alarm Control Valve (NO)
F470 Deluge Valve
Alarm Test Valve (NC)
Main Drain Valve (NC)
Manual Pull Station
Drip Funnel
Automatic Drain Valve (NO)
Main Control Valve (NO)
1 System Normal
Atmospheric Air
Water

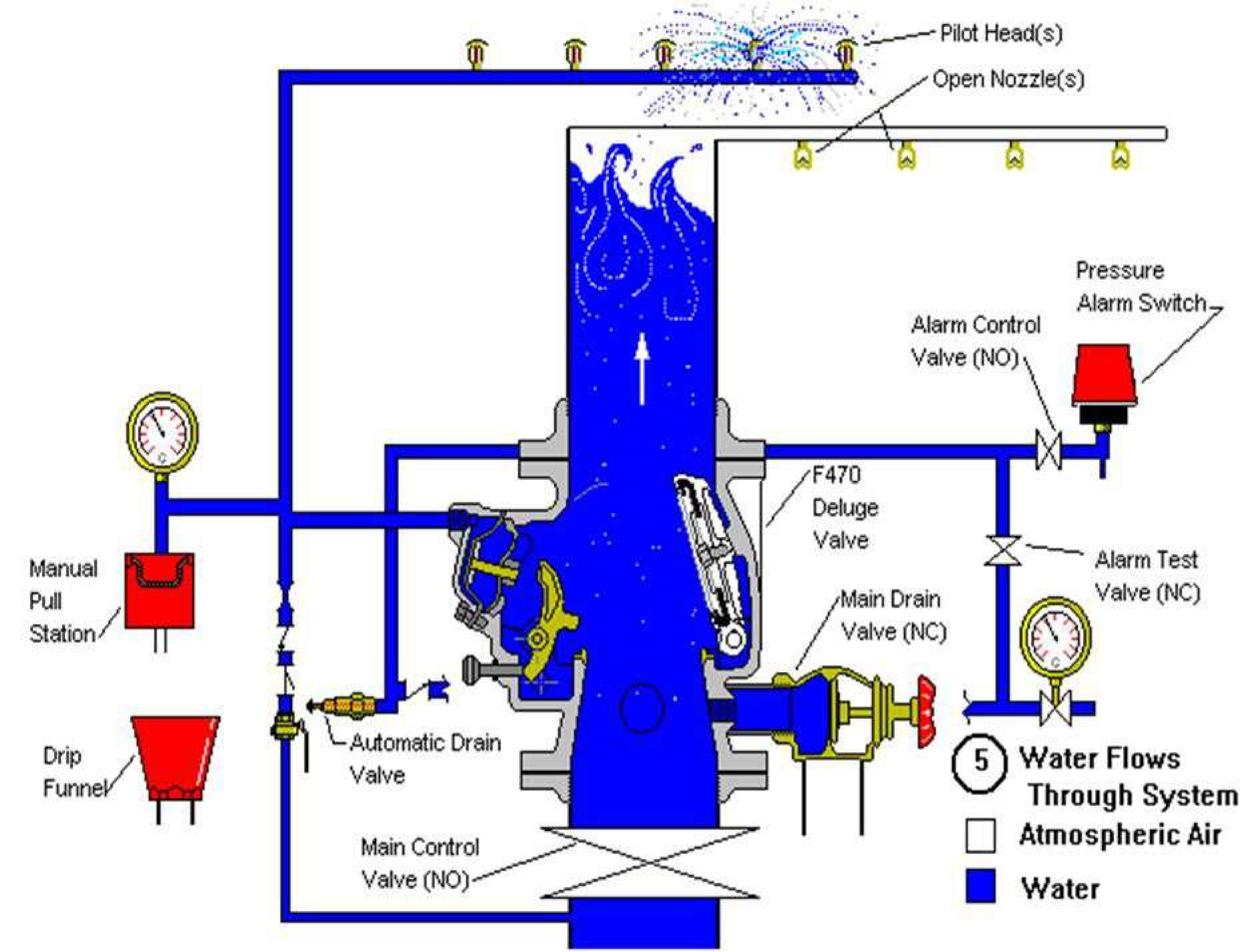


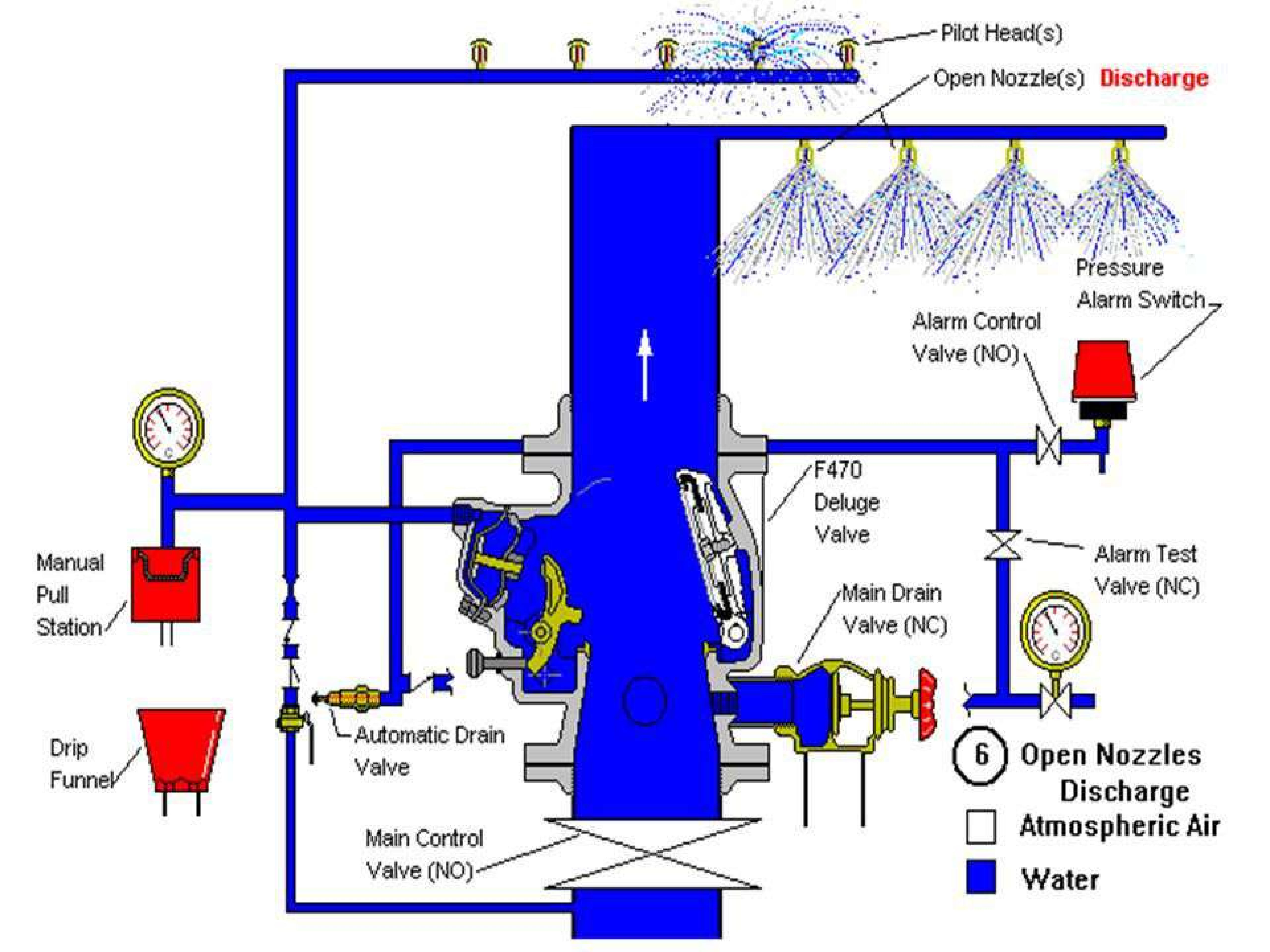
Pilot Head(s) Operates
Open Nozzle(s)
To Open Nozzles
Pressure Alarm Switch
Alarm Control Valve (NO)
F470 Deluge Valve
Alarm Test Valve (NC)
Main Drain Valve (NC)
Manual Pull Station
Drip Funnel
Automatic Drain Valve (NO)
Main Control Valve (NO)
2 Pilot Head Operates
Atmospheric Air
Water



Pilot Head(s)
Open Nozzle(s)
To Open Nozzles
Pressure Alarm Switch
Alarm Control Valve (NO)
F470 Deluge Valve Opens
Alarm Test Valve (NC)
Main Drain Valve (NC)
Manual Pull Station
Automatic Drain Valve Closes
Drip Funnel
Main Control Valve (NO)
3 Valve Opens
Atmospheric Air
Water

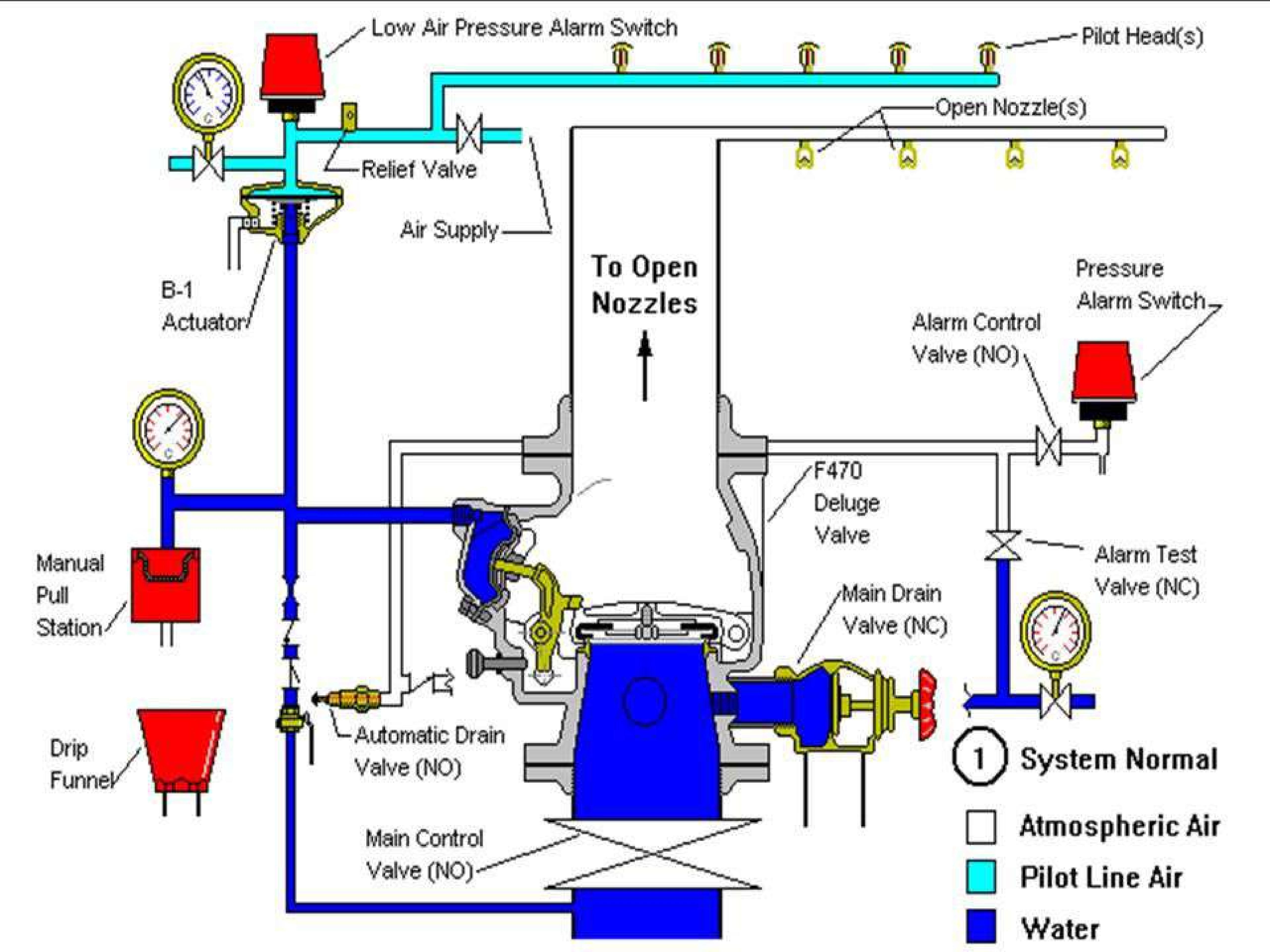

Pilot Head(s)
Open Nozzle(s)
To Open Nozzles
Pressure Alarm Switch
Operates
Alarm Control Valve (NO)
F470 Deluge Valve
Opens
Alarm Test Valve (NC)
Main Drain Valve (NC)
Manual Pull Station
Automatic Drain Valve
Drip Funnel
Main Control Valve (NO)
4 Valve Opens Completely
Atmospheric Air
Water

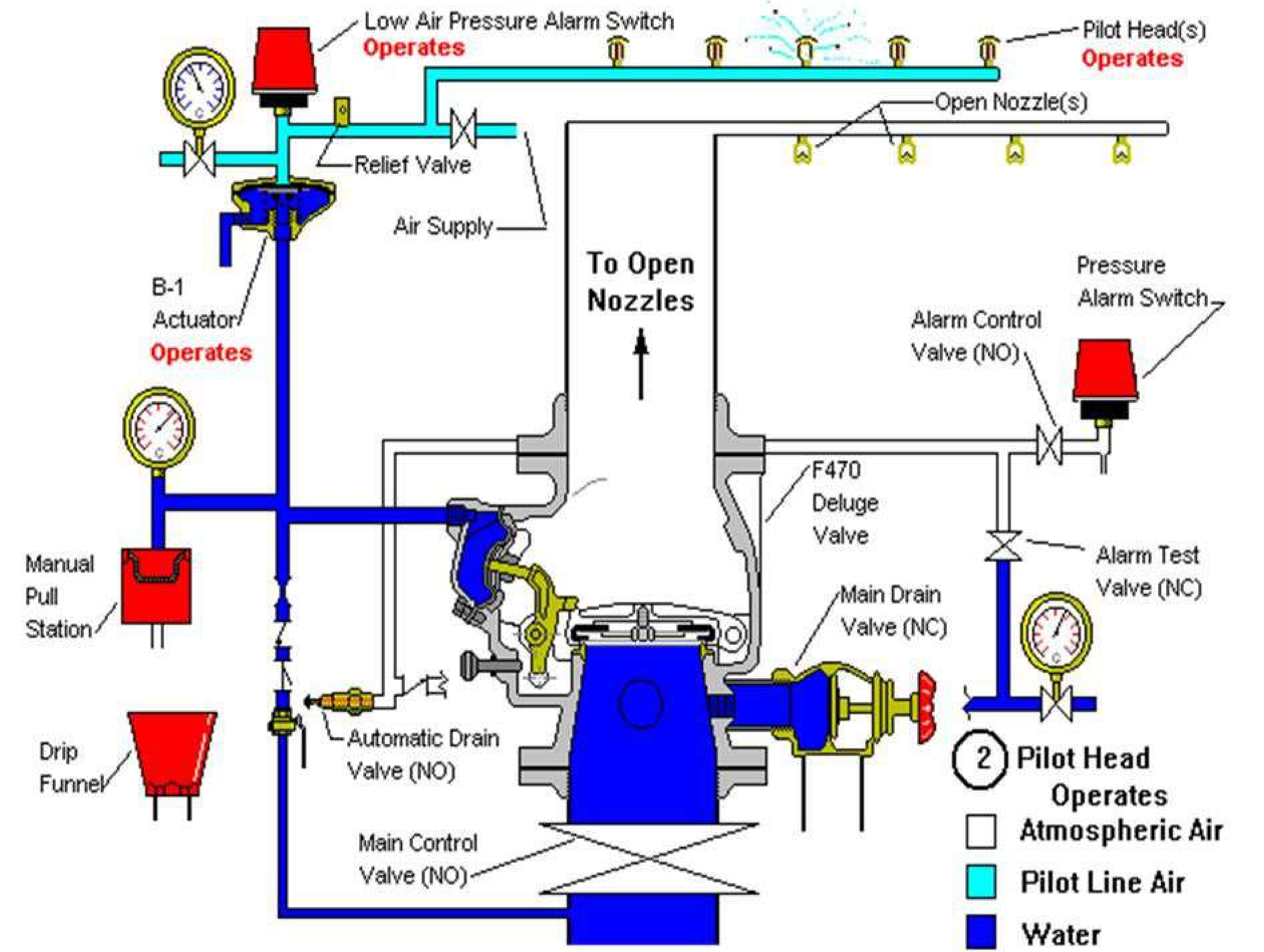

Pilot Head(s)
Open Nozzle(s)
Pressure
Alarm Switch
Alarm Control
Valve (NO)
F470
Deluge
Valve
Alarm Test
Valve (NC)
Main Drain
Valve (NC)
Manual
Pull
Station
Drip
Funnel
Automatic Drain
Valve
Main Control
Valve (NO)
5 Water Flows
Through System
Atmospheric Air
Water

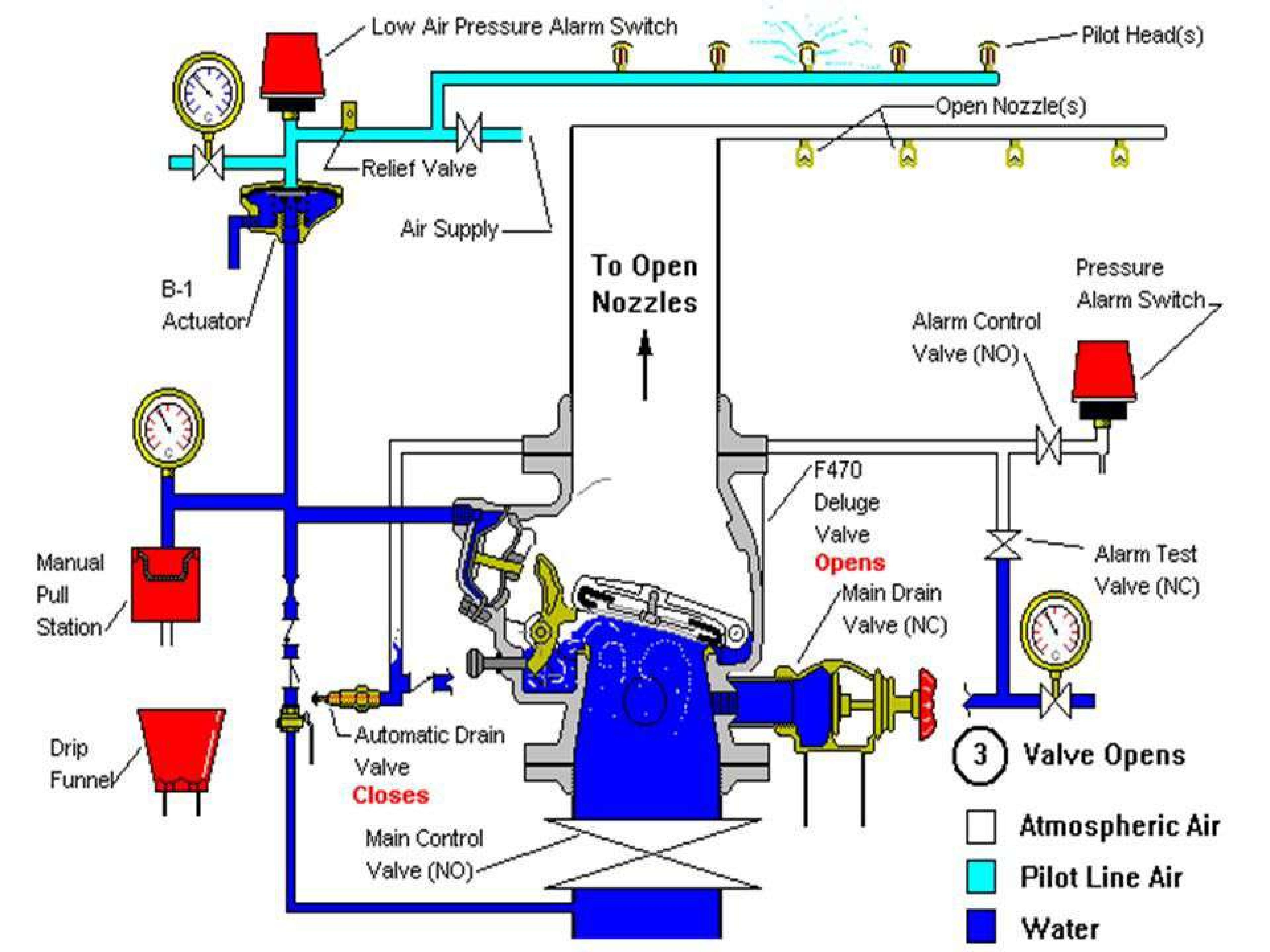

Pilot Head(s)
Open Nozzle(s)
Discharge
Pressure
Alarm Switch
Alarm Control
Valve (NO)
F470
Deluge
Valve
Alarm Test
Valve (NC)
Manual
Pull
Station
Main Drain
Valve (NC)
Automatic Drain
Valve
Drip
Funnel
6 Open Nozzles
Discharge
Atmospheric Air
Water
Main Control
Valve (NO)

Deluge systems:

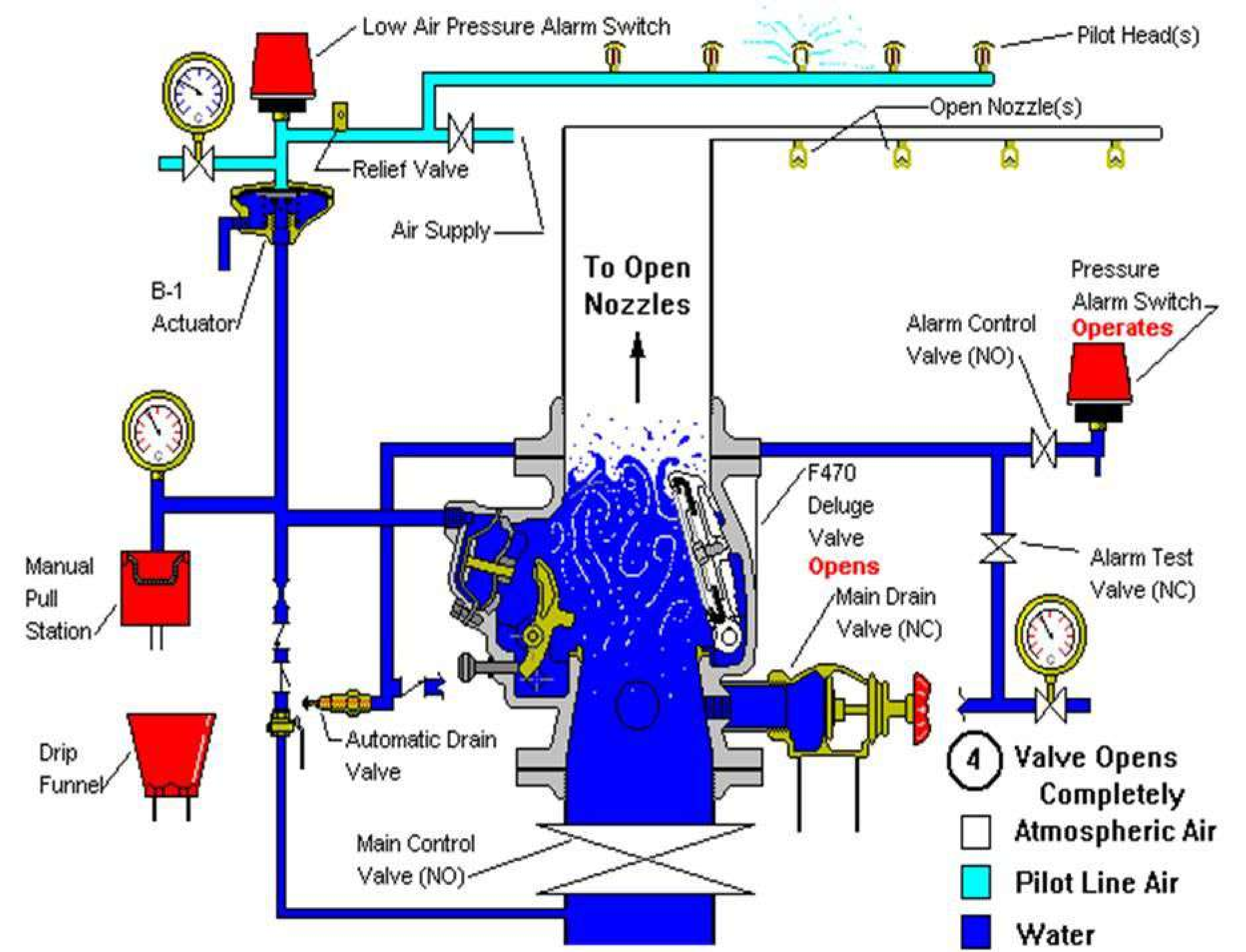
- Deluge System with Dry pilot actuated


Low Air Pressure Alarm Switch
Pilot Head(s)
Open Nozzle(s)
Relief Valve
Air Supply
B-1 Actuator
To Open Nozzles
Pressure Alarm Switch
Alarm Control Valve (NO)
F470 Deluge Valve
Alarm Test Valve (NC)
Manual Pull Station
Main Drain Valve (NC)
Automatic Drain Valve (NO)
Drip Funnel
Main Control Valve (NO)
1 System Normal
Atmospheric Air
Pilot Line Air
Water

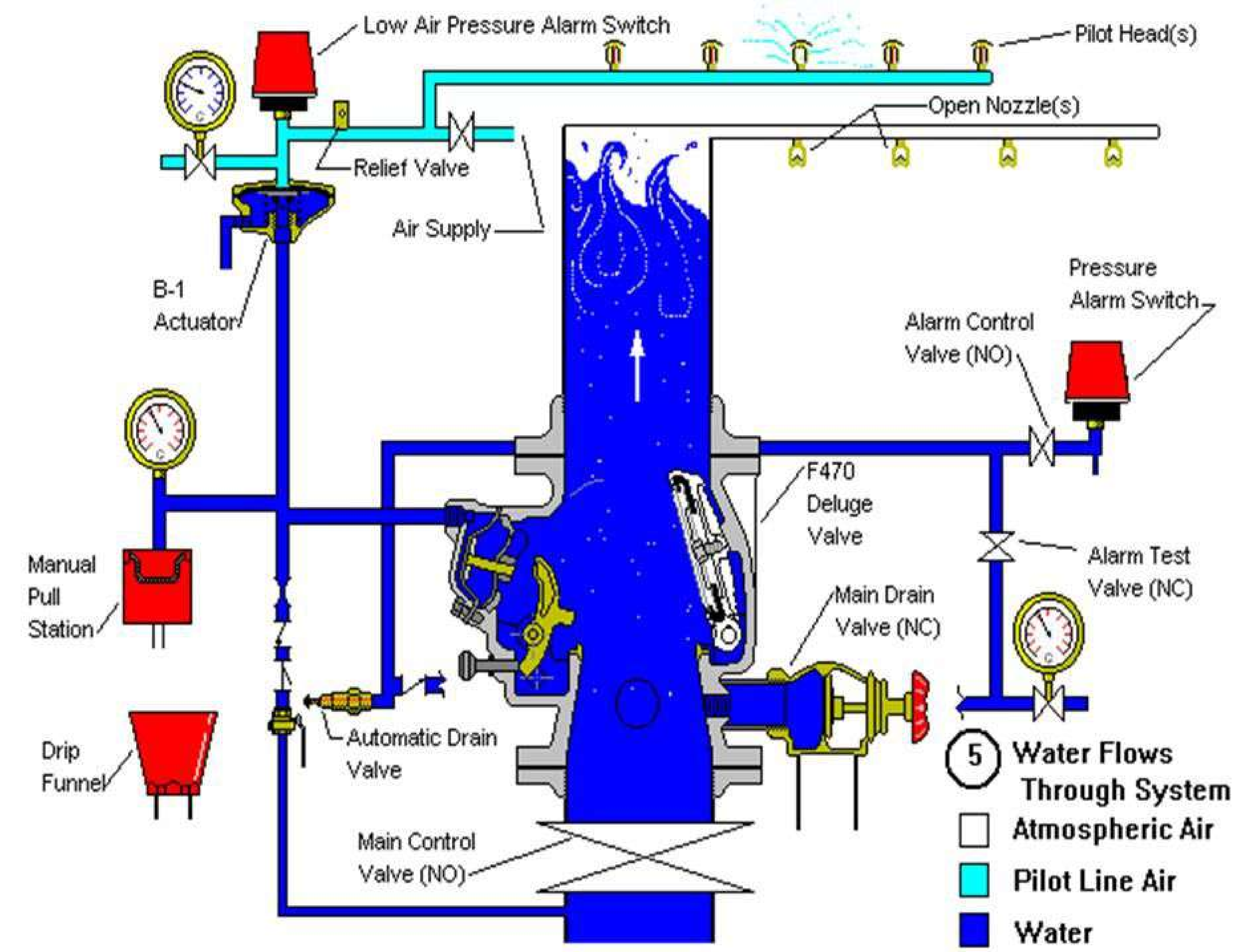

Low Air Pressure Alarm Switch
Operates
Pilot Head(s)
Operates
Open Nozzle(s)
Relief Valve
Air Supply
B-1
Actuator
Operates
To Open
Nozzles
Pressure
Alarm Switch
Alarm Control
Valve (NO)
F470
Deluge
Valve
Alarm Test
Valve (NC)
Manual
Pull
Station
Main Drain
Valve (NC)
Automatic Drain
Valve (NO)
Drip
Funnel
2 Pilot Head
Operates
Atmospheric Air
Pilot Line Air
Water
Main Control
Valve (NO)



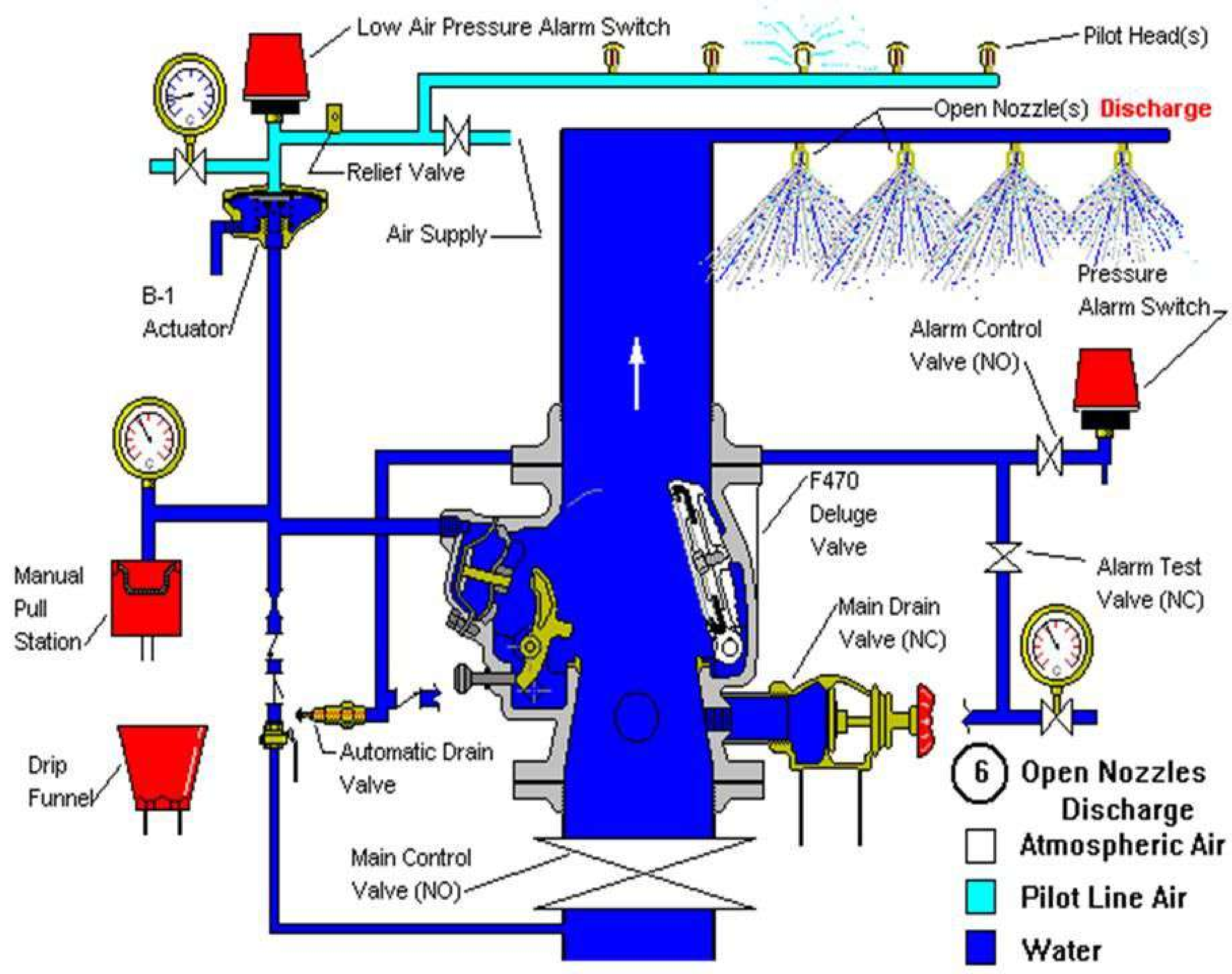
Low Air Pressure Alarm Switch
Pilot Head(s)
Open Nozzle(s)
Relief Valve
Air Supply
B-1 Actuator
To Open Nozzles
Pressure Alarm Switch
Alarm Control Valve (NO)
F470 Deluge Valve
Opens
Manual Pull Station
Alarm Test Valve (NC)
Main Drain Valve (NC)
Automatic Drain Valve
Closes
Drip Funnel
3
Valve Opens
Main Control Valve (NO)
Atmospheric Air
Pilot Line Air
Water



Low Air Pressure Alarm Switch
Pilot Head(s)
Open Nozzle(s)
Relief Valve
Air Supply
B-1
Actuator
To Open
Nozzles
Pressure
Alarm Switch
Operates
Alarm Control
Valve (NO)
F470
Deluge
Valve
Opens
Alarm Test
Valve (NC)
Main Drain
Valve (NC)
Manual
Pull
Station
Automatic Drain
Valve
Drip
Funnel
Main Control
Valve (NO)
4
Valve Opens
Completely
Atmospheric Air
Pilot Line Air
Water



Low Air Pressure Alarm Switch
Pilot Head(s)
Open Nozzle(s)
Relief Valve
Air Supply
B-1
Actuator
Pressure
Alarm Switch
Alarm Control
Valve (NO)
F470
Deluge
Valve
Alarm Test
Valve (NC)
Manual
Pull
Station
Main Drain
Valve (NC)
Automatic Drain
Valve
Drip
Funnel
Main Control
Valve (NO)
5
Water Flows
Through System
Atmospheric Air
Pilot Line Air
Water



Low Air Pressure Alarm Switch
Pilot Head(s)
Open Nozzle(s) Discharge
Relief Valve
Air Supply
B-1
Actuator
Pressure
Alarm Switch
Alarm Control
Valve (NO)
F470
Deluge
Valve
Alarm Test
Valve (NC)
Manual
Pull
Station
Main Drain
Valve (NC)
Drip
Funnel
Automatic Drain
Valve
6 Open Nozzles
Discharge
Atmospheric Air
Pilot Line Air
Water
Main Control
Valve (NO)

Fire Sprinkler System Types

4 -Preaction Sprinkler System

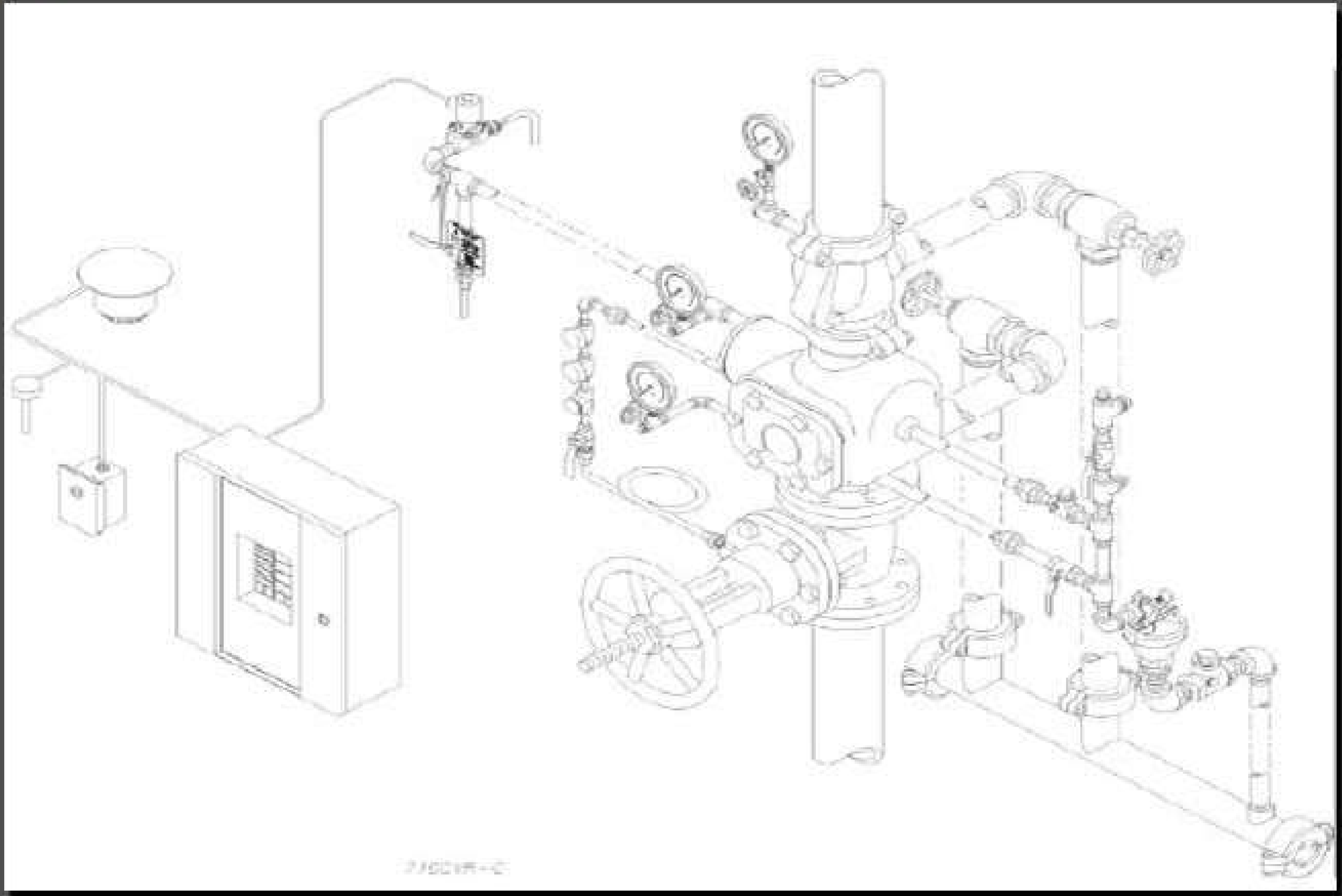
A sprinkler system employing automatic sprinklers that are attached to a piping system that contains air with a supplemental detection system installed in the same areas as the sprinklers.

Fire Sprinkler System Components

Sprinkler System Valves

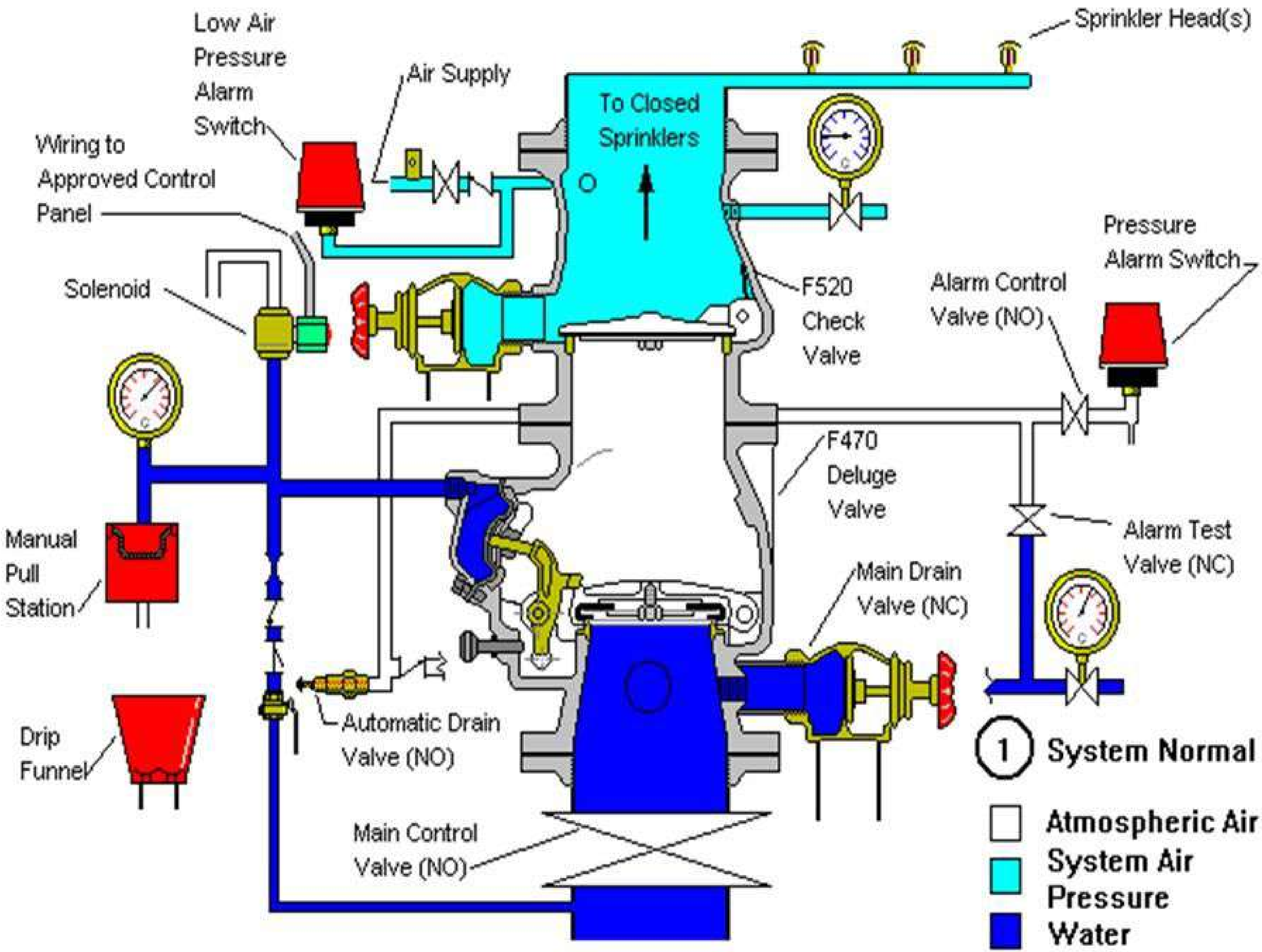
Preaction System

Single Interlock

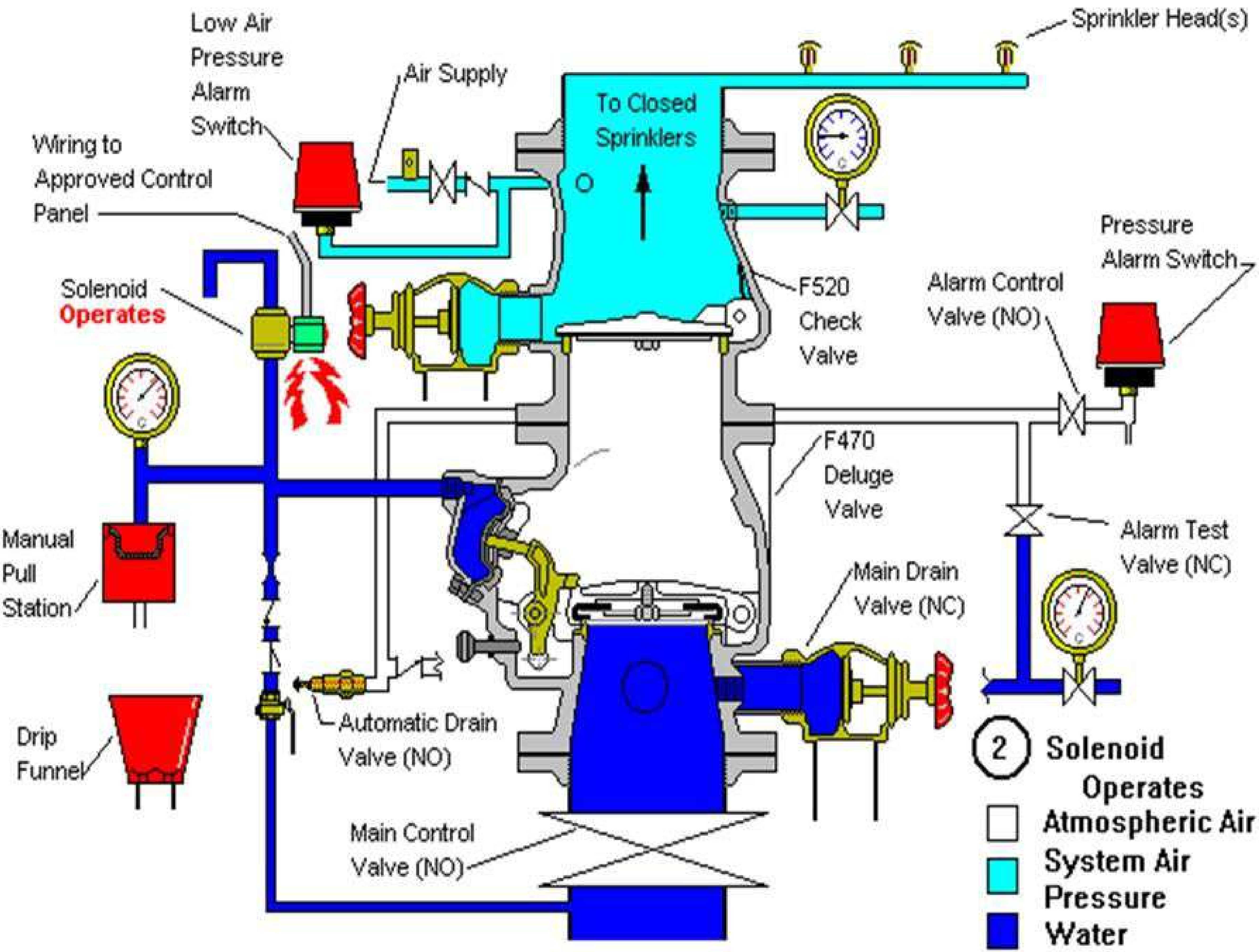


preaction systems:

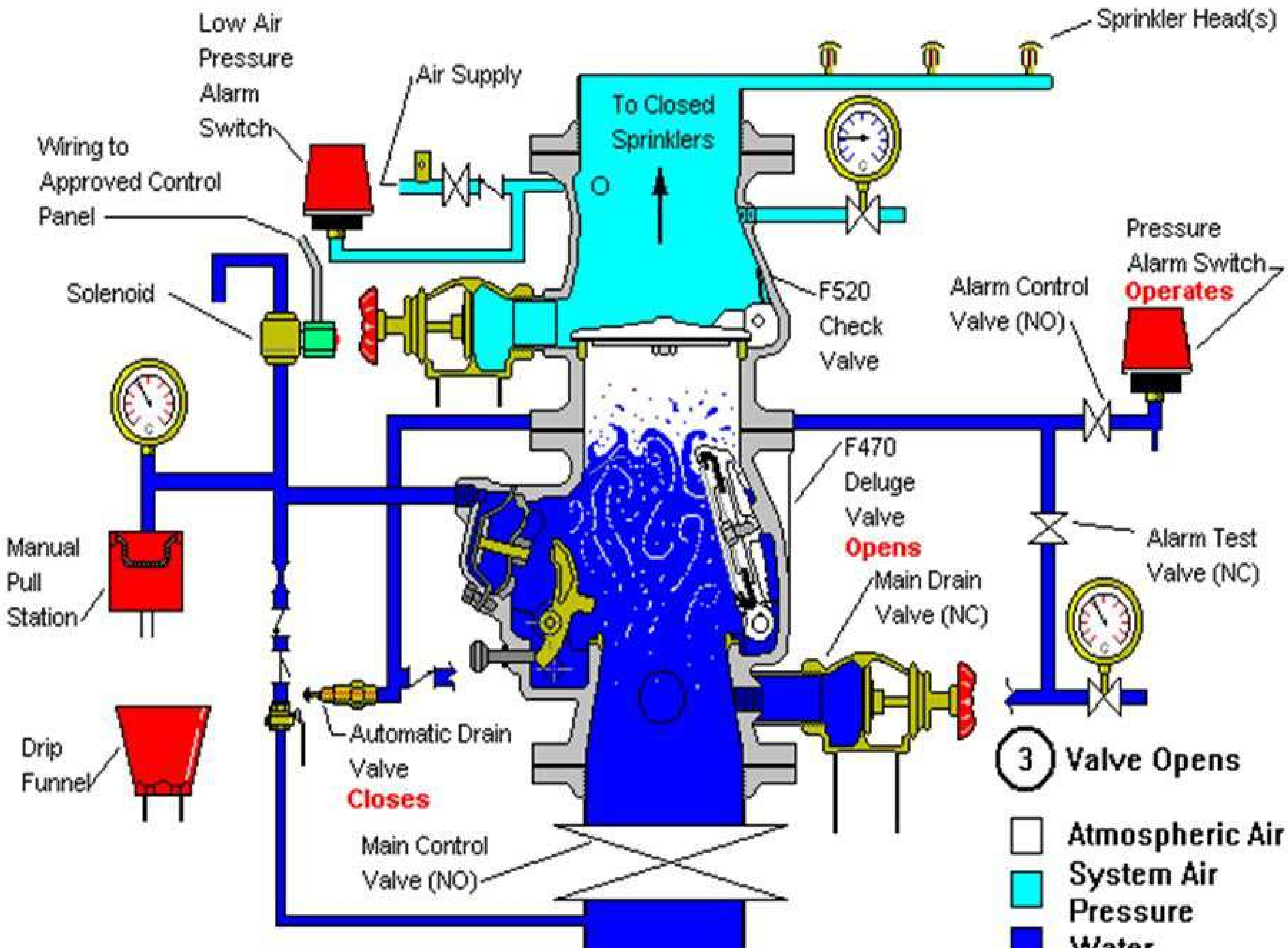
- *Single Interlocked*



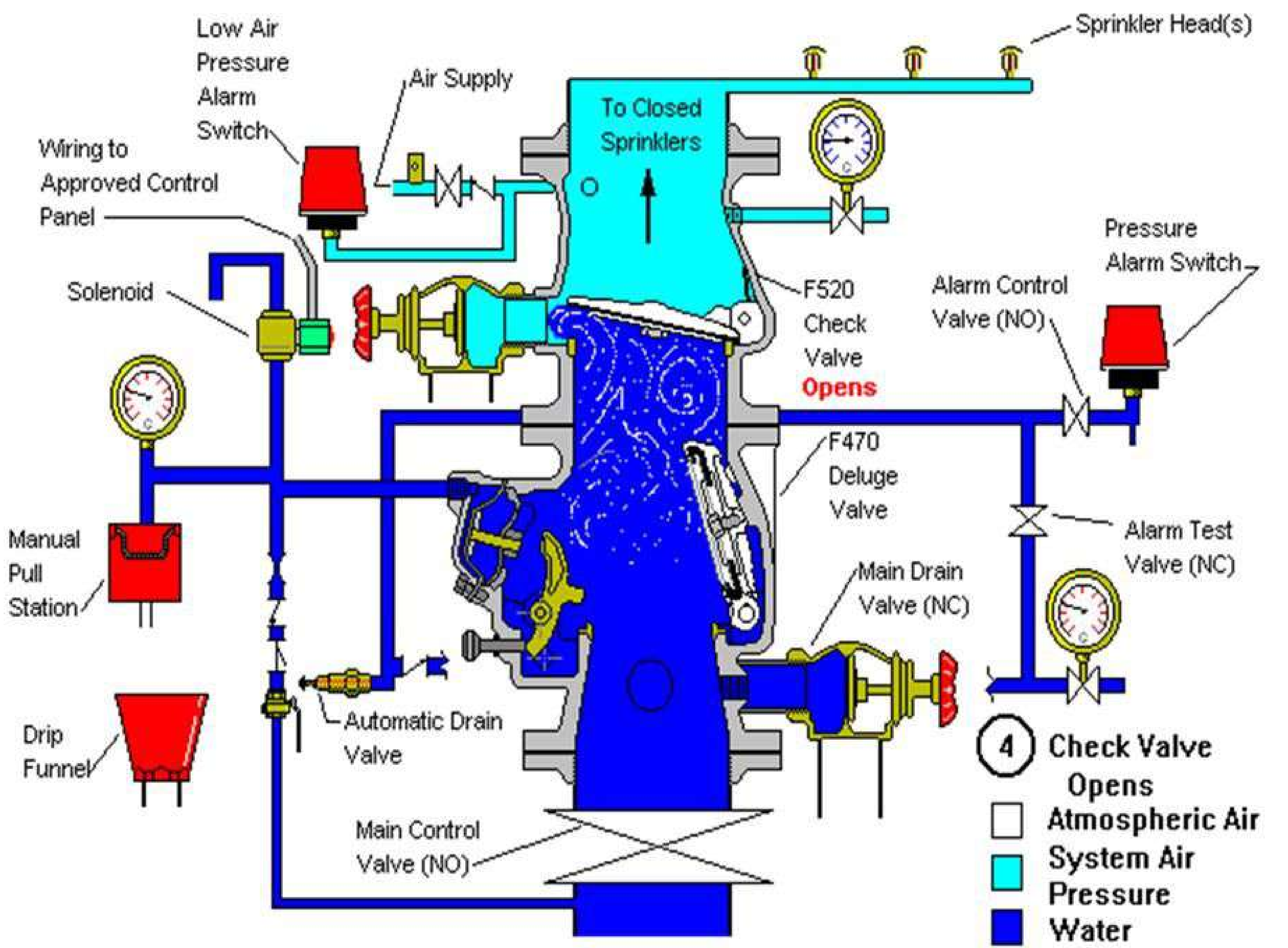
Low Air
Pressure
Alarm
Switch
Air Supply
Sprinkler Head(s)
To Closed
Sprinklers
Wiring to
Approved Control
Panel
Solenoid
F520
Check
Valve
Pressure
Alarm Switch
Alarm Control
Valve (NO)
F470
Deluge
Valve
Alarm Test
Valve (NC)
Manual
Pull
Station
Main Drain
Valve (NC)
Automatic Drain
Valve (NO)
Drip
Funnel
1 System Normal
Main Control
Valve (NO)
Atmospheric Air
System Air
Pressure
Water



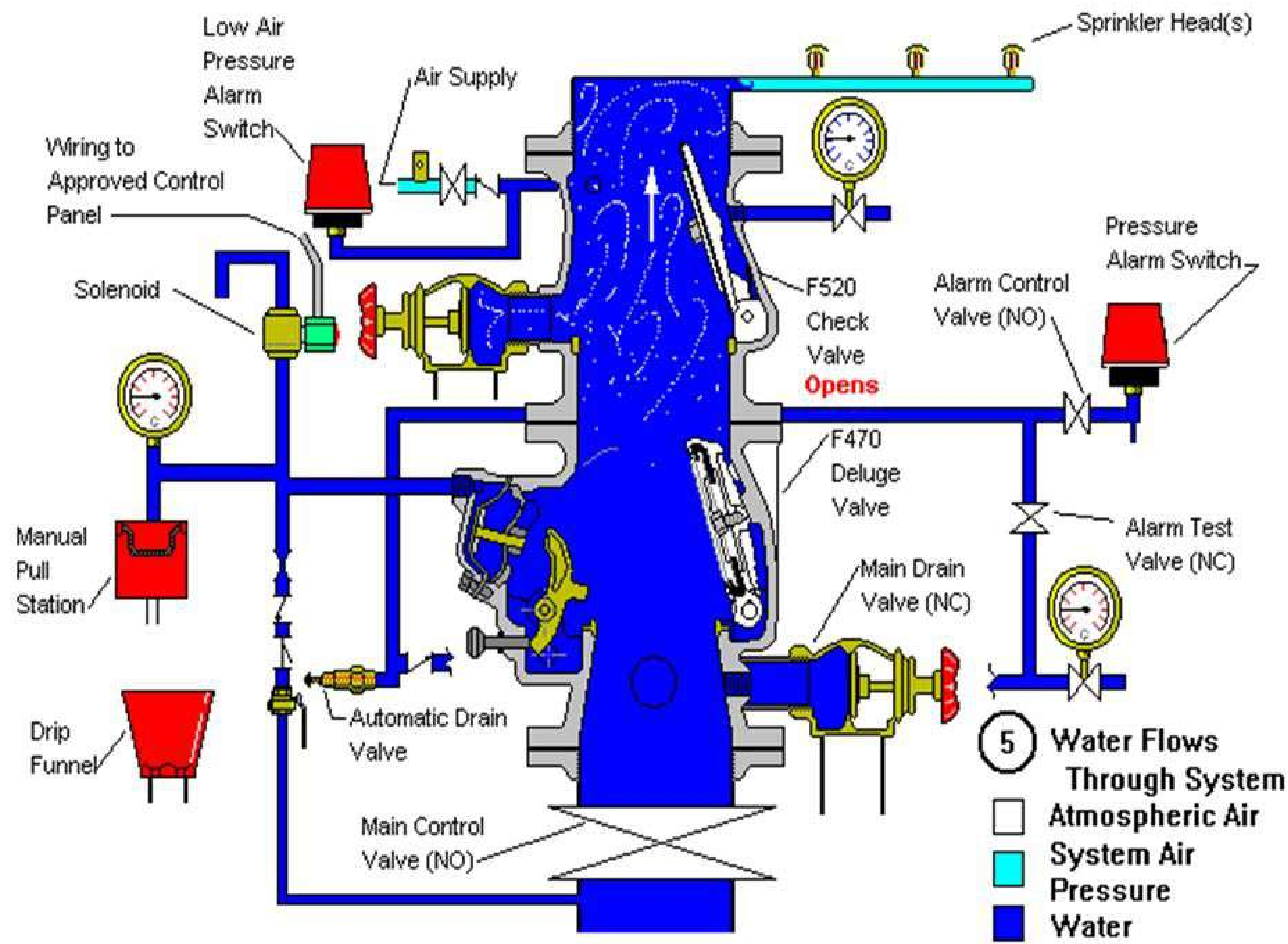
Low Air Pressure Alarm Switch
Air Supply
Sprinkler Head(s)
To Closed Sprinklers
Wiring to Approved Control Panel
Solenoid Operates
Pressure Alarm Switch
F520 Check Valve
Alarm Control Valve (NO)
F470 Deluge Valve
Alarm Test Valve (NC)
Manual Pull Station
Main Drain Valve (NC)
Automatic Drain Valve (NO)
Drip Funnel
Main Control Valve (NO)
2 Solenoid Operates
Atmospheric Air
System Air Pressure
Water



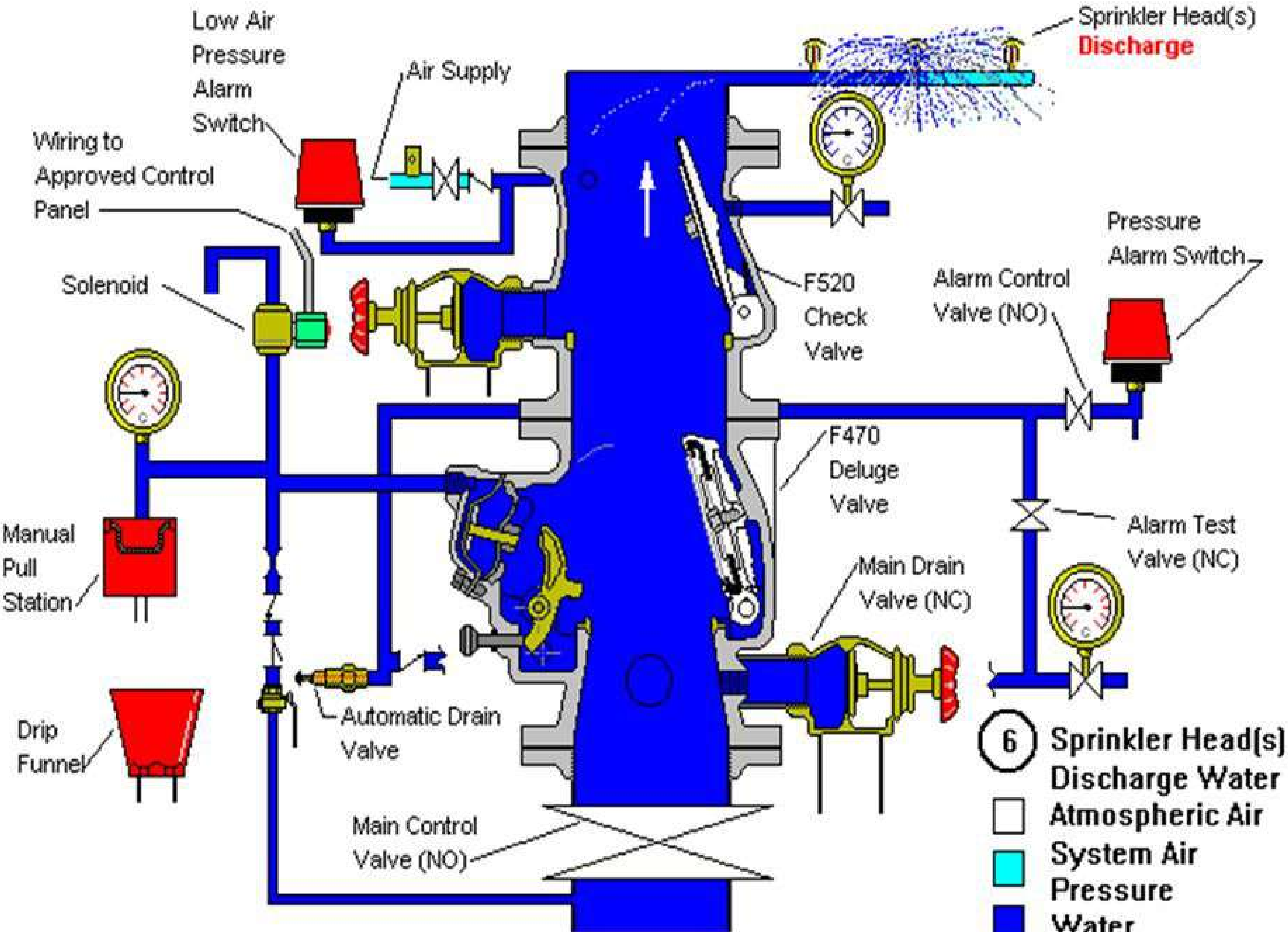
Low Air Pressure Alarm Switch
Air Supply
Sprinkler Head(s)
To Closed Sprinklers
Wiring to Approved Control Panel
Solenoid
F520 Check Valve
Alarm Control Valve (NO)
Pressure Alarm Switch
Operates
F470 Deluge Valve
Opens
Alarm Test Valve (NC)
Manual Pull Station
Main Drain Valve (NC)
Drip Funnel
Automatic Drain Valve
Closes
Main Control Valve (NO)
3 Valve Opens
Atmospheric Air
System Air Pressure
Water



Low Air Pressure Alarm Switch
Air Supply
Sprinkler Head(s)
To Closed Sprinklers
Wiring to Approved Control Panel
Solenoid
F520 Check Valve Opens
Alarm Control Valve (NO)
Pressure Alarm Switch
F470 Deluge Valve
Alarm Test Valve (NC)
Manual Pull Station
Main Drain Valve (NC)
Automatic Drain Valve
Drip Funnel
Main Control Valve (NO)
4 Check Valve Opens
Atmospheric Air
System Air Pressure
Water



Sprinkler Head(s)
Low Air Pressure Alarm Switch
Air Supply
Wiring to Approved Control Panel
Solenoid
F520 Check Valve Opens
Pressure Alarm Switch
Alarm Control Valve (NO)
F470 Deluge Valve
Alarm Test Valve (NC)
Manual Pull Station
Main Drain Valve (NC)
Automatic Drain Valve
Drip Funnel
Main Control Valve (NO)
5
Water Flows Through System
Atmospheric Air
System Air Pressure
Water

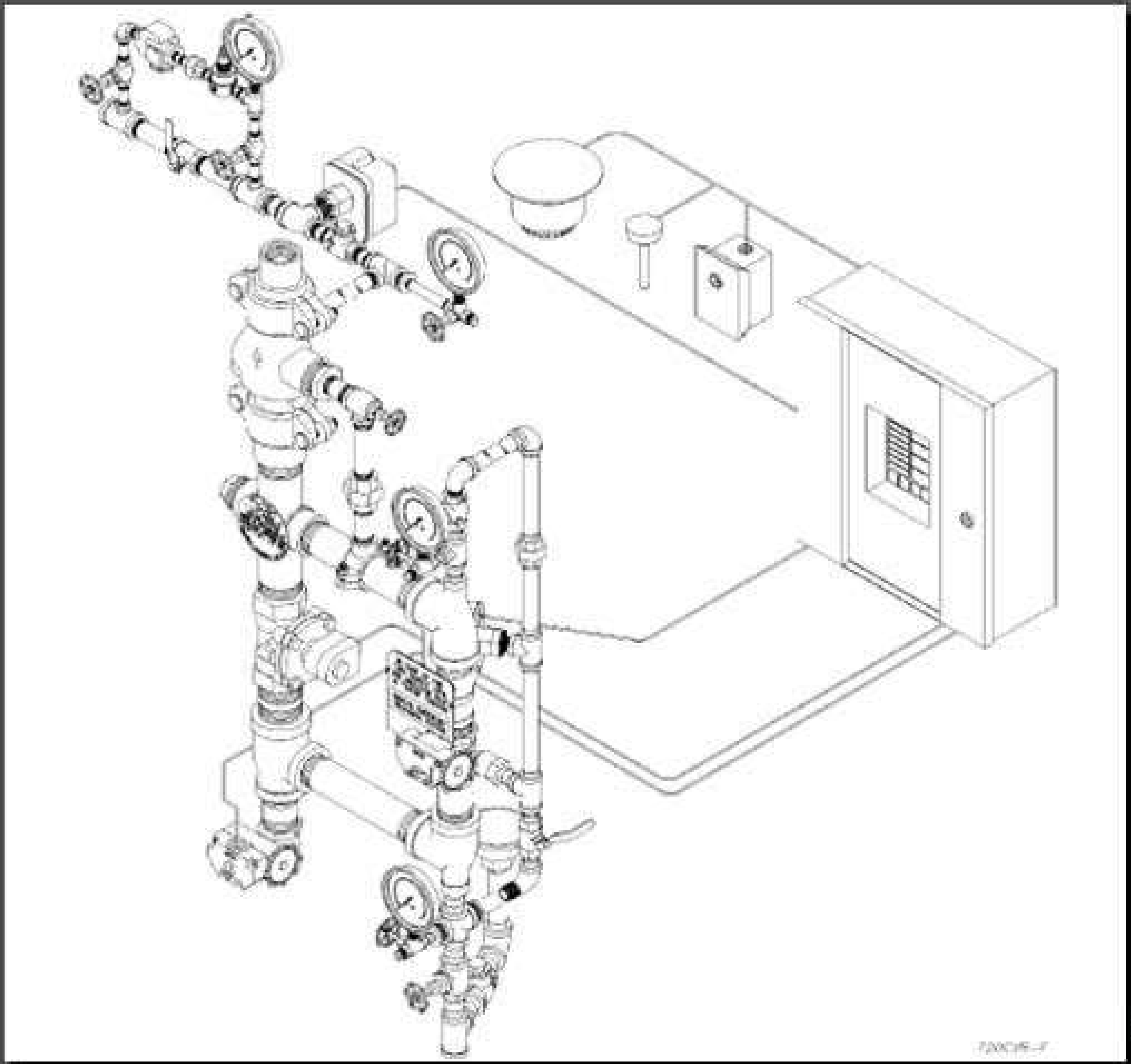


Low Air Pressure Alarm Switch
Air Supply
Sprinkler Head(s)
Discharge
Wiring to Approved Control Panel
Solenoid
F520 Check Valve
Alarm Control Valve (NO)
Pressure Alarm Switch
F470 Deluge Valve
Alarm Test Valve (NC)
Manual Pull Station
Main Drain Valve (NC)
Drip Funnel
Automatic Drain Valve
Main Control Valve (NO)
6
Sprinkler Head(s) Discharge Water
Atmospheric Air
System Air Pressure
Water

Fire Sprinkler System Components

Preaction System

double Interlock

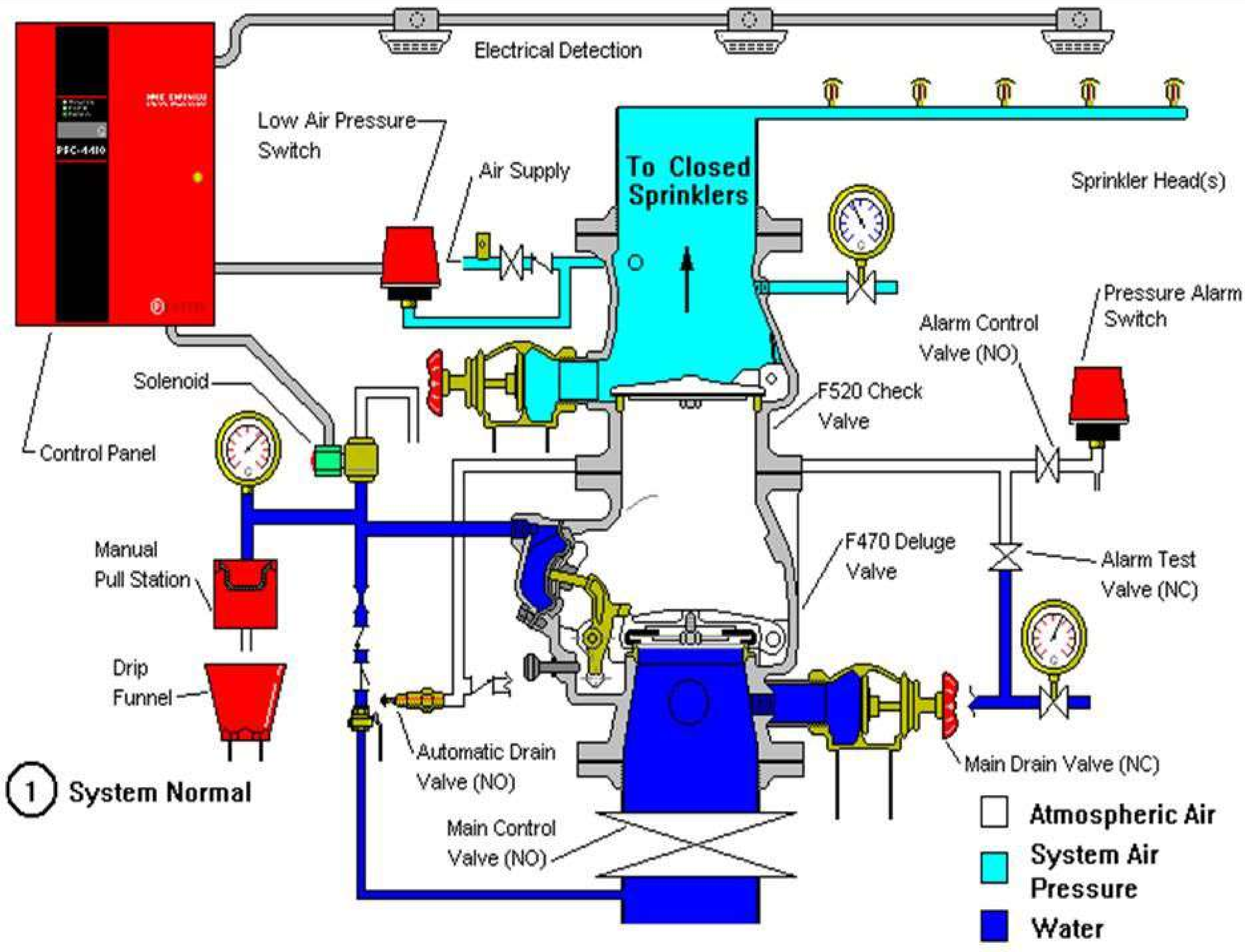


Preaction systems:

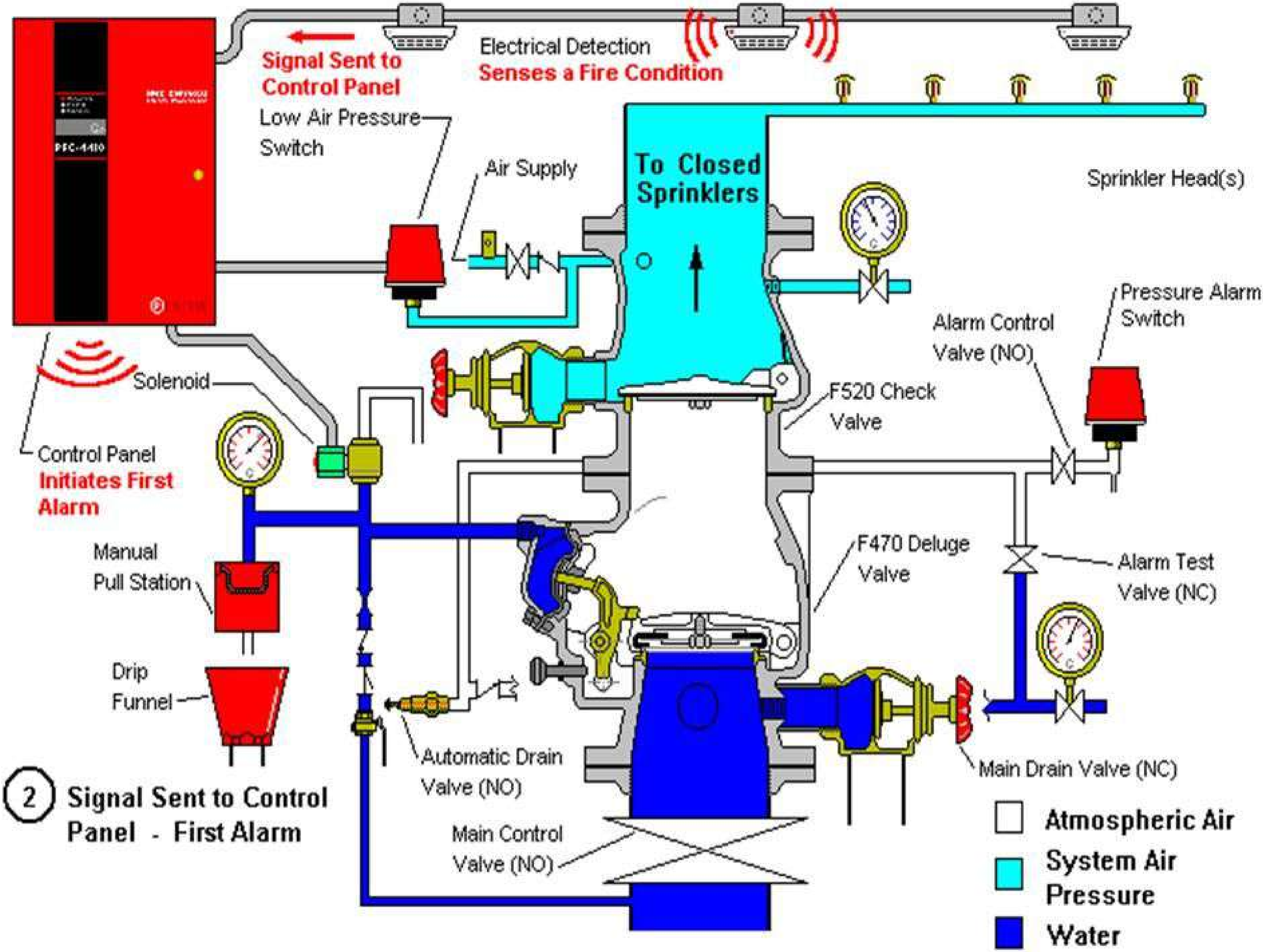
- The double interlock preaction system utilizes a detector system and pressurized air or nitrogen in the sprinkler system piping. This system is arranged so that the deluge valve will open only when both pressure is reduced in the sprinkler piping and the detection system operates.

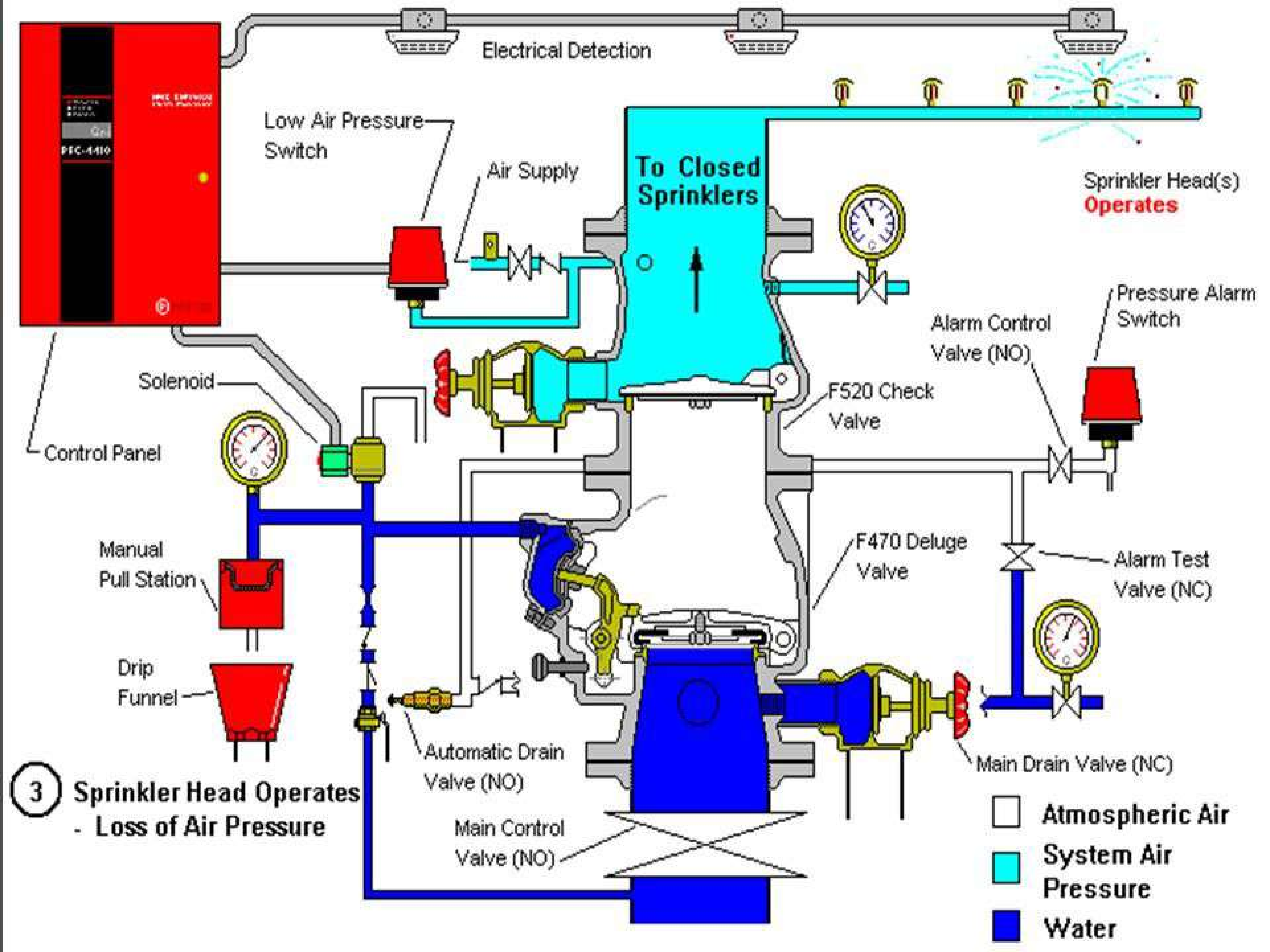
Preaction systems:

- If the detection system operates due to damage or malfunction, the valve will not open, but an alarm will sound. If the sprinkler piping is damaged or sprinkler is broken, the valve will not open but a supervisory alarm will sound. The operation of both a sprinkler and a detector (or release) is required before the valve will open, allowing water to enter the system piping.

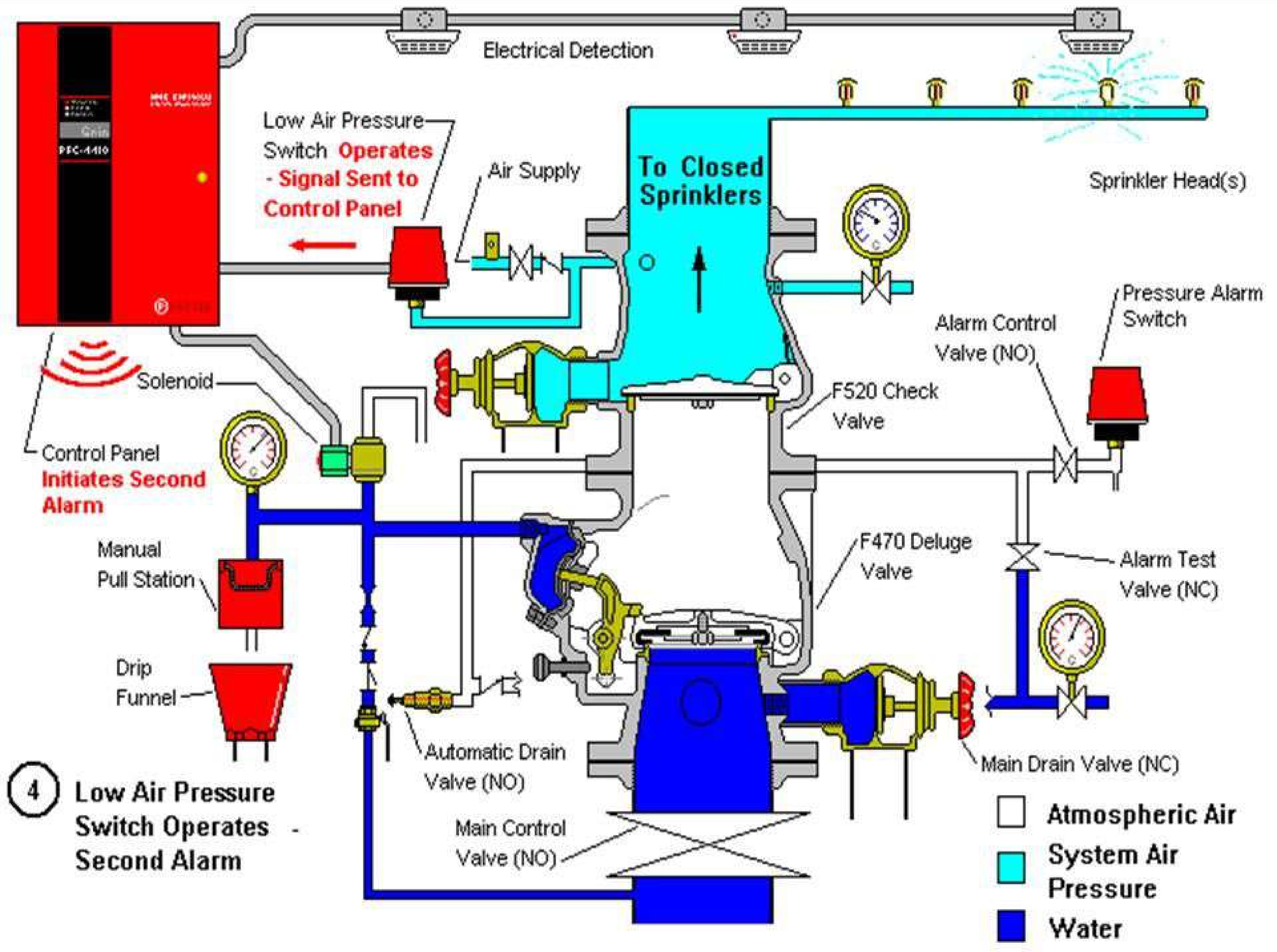


Electrical Detection
Low Air Pressure Switch
Air Supply
To Closed Sprinklers
Sprinkler Head(s)
PFC-4410
Pressure Alarm Switch
Alarm Control Valve (NO)
Solenoid
F520 Check Valve
Control Panel
Manual Pull Station
F470 Deluge Valve
Alarm Test Valve (NC)
Drip Funnel
Automatic Drain Valve (NO)
Main Drain Valve (NC)
1 System Normal
Main Control Valve (NO)
Atmospheric Air
System Air Pressure
Water

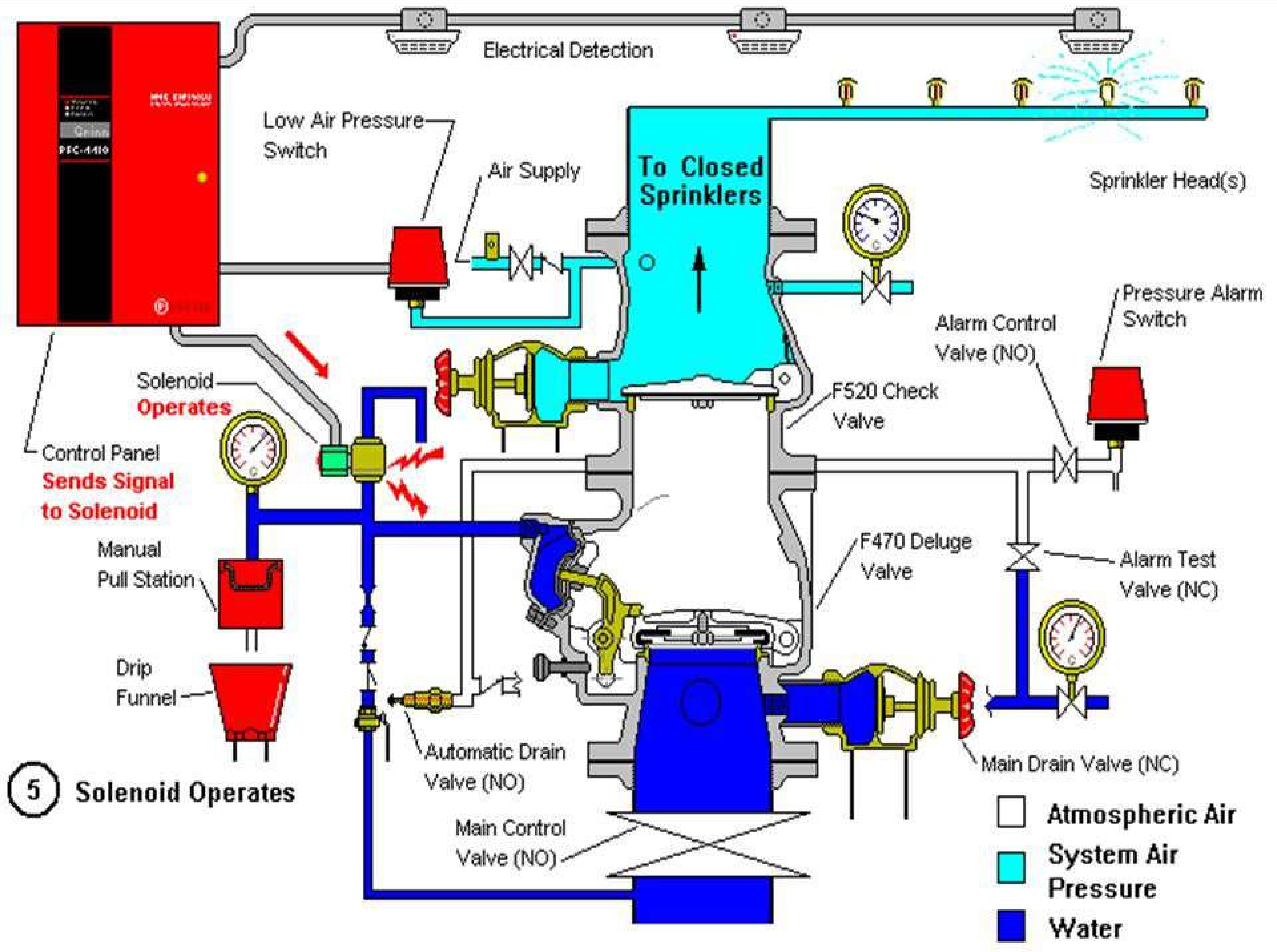

Signal Sent to Control Panel
Electrical Detection
Senses a Fire Condition
Low Air Pressure Switch
Air Supply
To Closed Sprinklers
Sprinkler Head(s)
PFC-4410
Pressure Alarm Switch
Alarm Control Valve (NO)
Solenoid
F520 Check Valve
Control Panel
Initiates First Alarm
Manual Pull Station
F470 Deluge Valve
Alarm Test Valve (NC)
Drip Funnel
Automatic Drain Valve (NO)
Main Drain Valve (NC)
2
Signal Sent to Control Panel - First Alarm
Main Control Valve (NO)
Atmospheric Air
System Air Pressure
Water



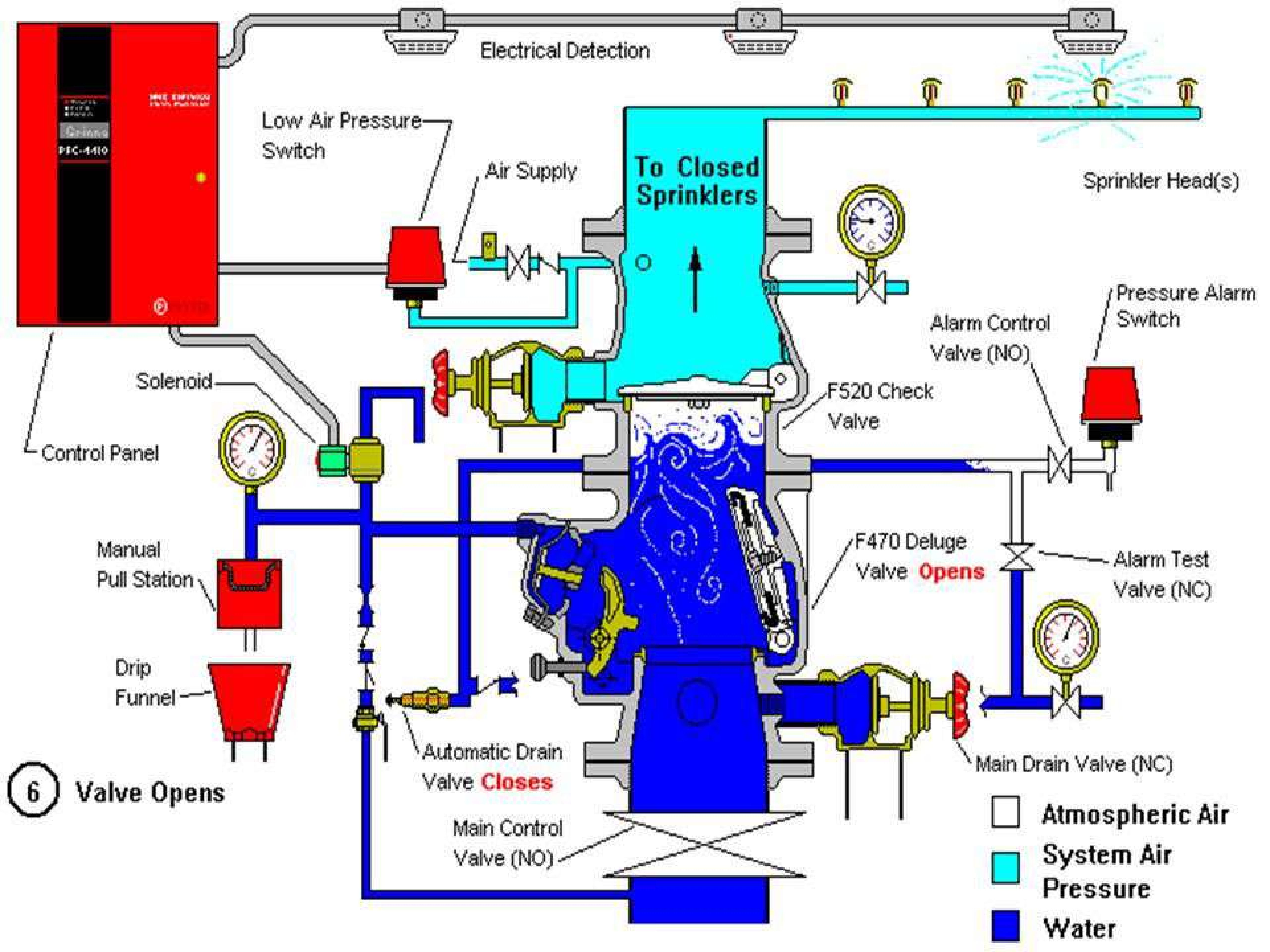
Electrical Detection
Low Air Pressure Switch
Air Supply
To Closed Sprinklers
Sprinkler Head(s) Operates
PFC-4410
Pressure Alarm Switch
Alarm Control Valve (NO)
Solenoid
F520 Check Valve
Control Panel
Manual Pull Station
F470 Deluge Valve
Alarm Test Valve (NC)
Drip Funnel
Automatic Drain Valve (NO)
Main Drain Valve (NC)
3 Sprinkler Head Operates - Loss of Air Pressure
Main Control Valve (NO)
Atmospheric Air
System Air Pressure
Water



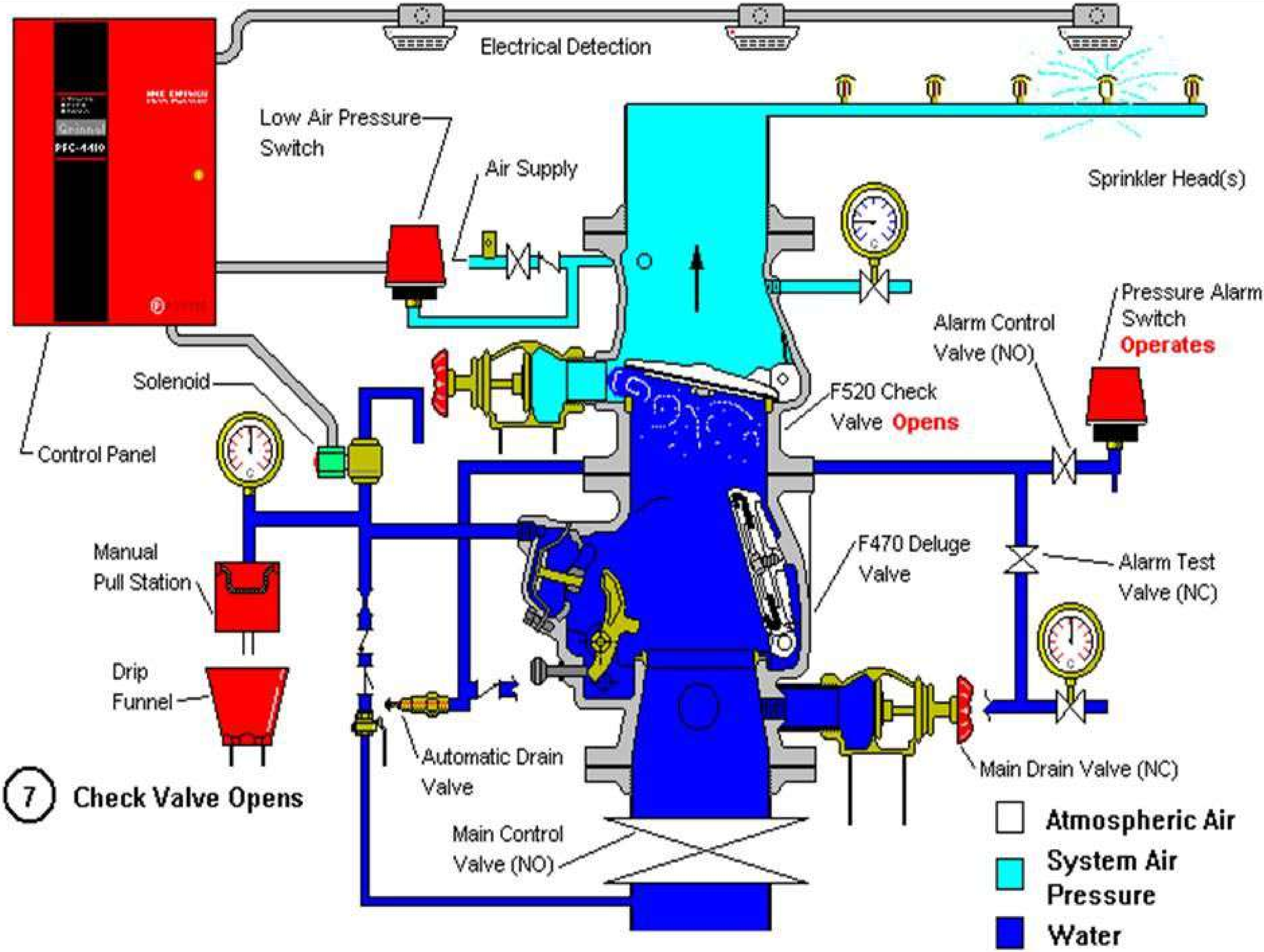
Electrical Detection
Low Air Pressure Switch Operates - Signal Sent to Control Panel
Air Supply
To Closed Sprinklers
Sprinkler Head(s)
Pressure Alarm Switch
Alarm Control Valve (NO)
Solenoid
F520 Check Valve
Control Panel Initiates Second Alarm
Manual Pull Station
F470 Deluge Valve
Alarm Test Valve (NC)
Drip Funnel
Automatic Drain Valve (NO)
Main Drain Valve (NC)
4
Low Air Pressure Switch Operates - Second Alarm
Main Control Valve (NO)
Atmospheric Air
System Air Pressure
Water



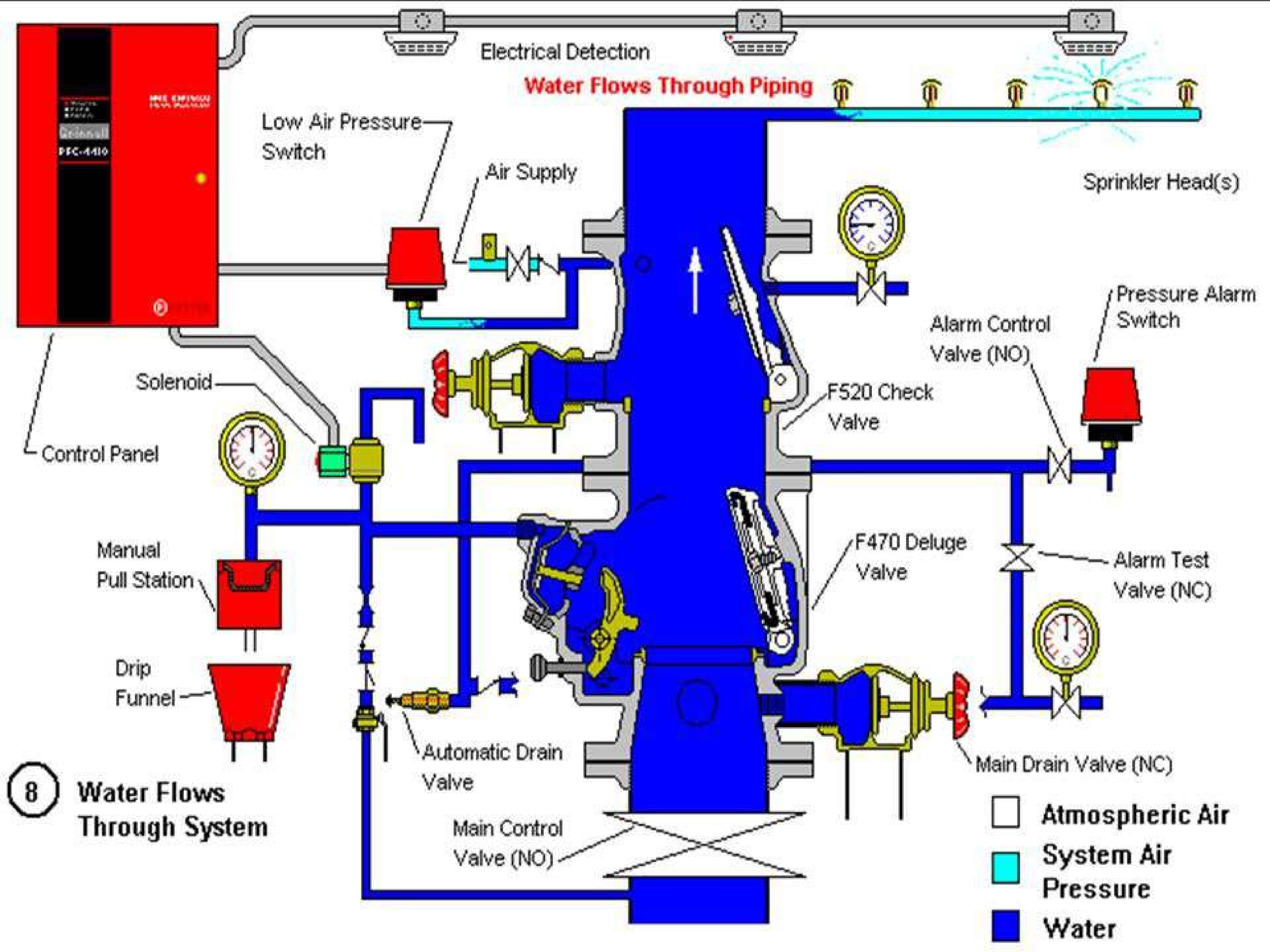
Electrical Detection
Low Air Pressure Switch
Air Supply
To Closed Sprinklers
Sprinkler Head(s)
PFC-4410
Pressure Alarm Switch
Alarm Control Valve (NO)
Solenoid Operates
F520 Check Valve
Control Panel Sends Signal to Solenoid
Manual Pull Station
F470 Deluge Valve
Alarm Test Valve (NC)
Drip Funnel
Automatic Drain Valve (NO)
Main Drain Valve (NC)
5 Solenoid Operates
Main Control Valve (NO)
Atmospheric Air
System Air Pressure
Water



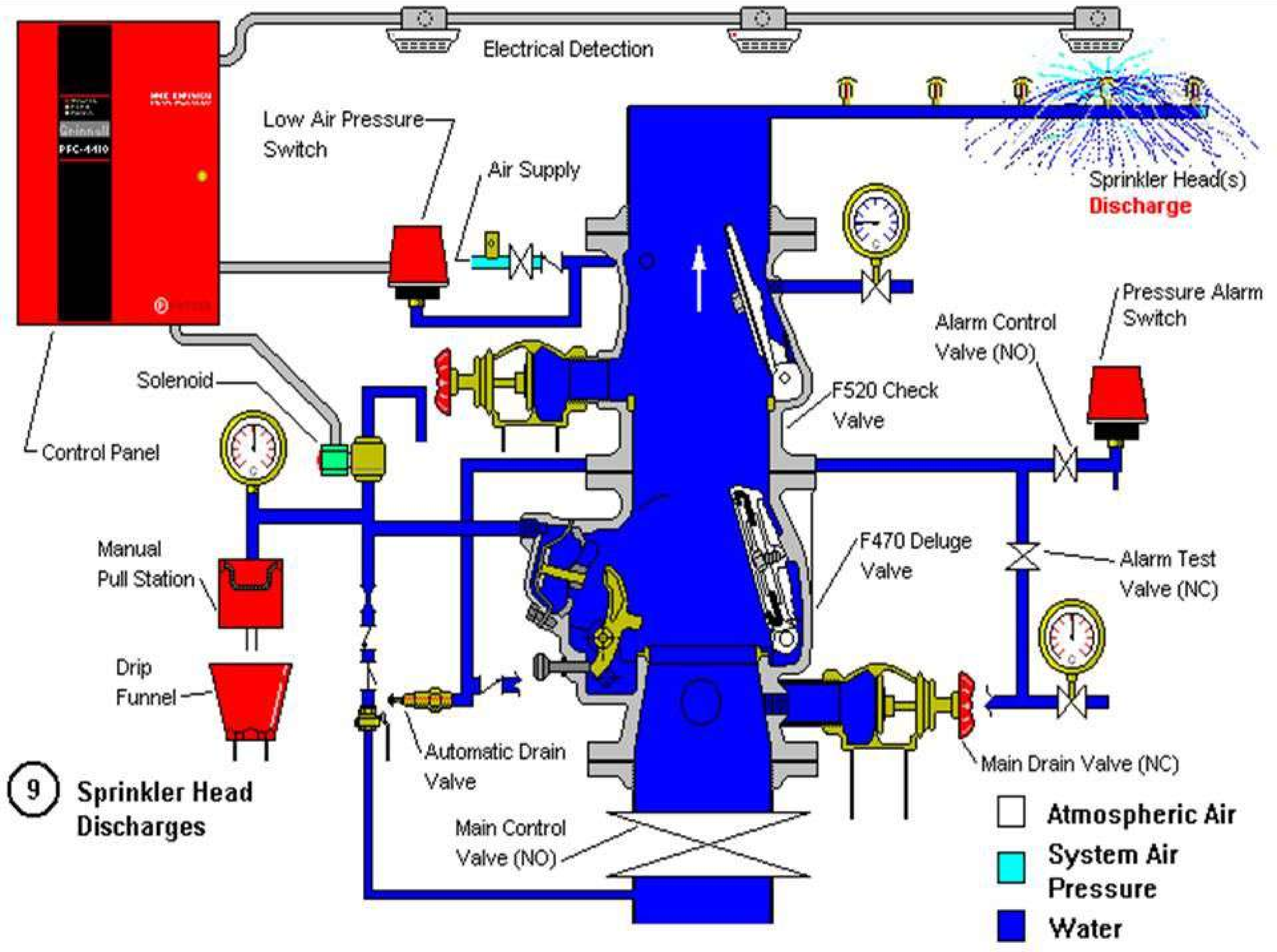
Electrical Detection
Low Air Pressure Switch
Air Supply
To Closed Sprinklers
Sprinkler Head(s)
Pressure Alarm Switch
Alarm Control Valve (NO)
Solenoid
F520 Check Valve
Control Panel
Manual Pull Station
F470 Deluge Valve Opens
Alarm Test Valve (NC)
Drip Funnel
Automatic Drain Valve Closes
Main Drain Valve (NC)
6 Valve Opens
Main Control Valve (NO)
Atmospheric Air
System Air Pressure
Water



7 Check Valve Opens



Electrical Detection
Water Flows Through Piping
Low Air Pressure Switch
Air Supply
Sprinkler Head(s)
Pressure Alarm Switch
Alarm Control Valve (NO)
Solenoid
F520 Check Valve
Control Panel
Manual Pull Station
F470 Deluge Valve
Alarm Test Valve (NC)
Drip Funnel
Automatic Drain Valve
Main Drain Valve (NC)
8
Water Flows Through System
Main Control Valve (NO)
Atmospheric Air
System Air Pressure
Water



Electrical Detection
Low Air Pressure Switch
Air Supply
Sprinkler Head(s)
Discharge
PFC-4410
Pressure Alarm Switch
Alarm Control Valve (NO)
F520 Check Valve
Solenoid
Control Panel
F470 Deluge Valve
Alarm Test Valve (NC)
Manual Pull Station
Drip Funnel
Automatic Drain Valve
Main Drain Valve (NC)
9
Sprinkler Head Discharges
Main Control Valve (NO)
Atmospheric Air
System Air Pressure
Water

Fire Sprinkler System Types

5 -Anti Freeze System

- Is a wet pipe sprinkler system employing automatic sprinklers that are attached to a piping system that contains an antifreeze solution.

- The antifreeze solution is discharged, followed by water, immediately upon operation of sprinklers opened by heat from a fire.

Fire Sprinkler System Types

6 -Circulating Closed Loop System

Is a wet pipe sprinkler system having non-fire protection connections to automatic sprinkler systems in a closed-loop piping arrangement for the purpose of utilizing sprinkler piping to conduct water for heating or cooling, where water is not removed or used from the system but only circulated through the piping system.

Fire Sprinkler System Components

2-Sprinkler System Valves

Zone Control Valves

- OS&Y gate valve.
- Tamper Switch.
- Check Valve.
- Water Flow Detector.
- Test / Drain Valve.
- Pressure Gauge

Stand pipe & Hose System

Standpipe and hose system

Standpipe System is an arrangement of piping, valves, hose connections, and allied equipment installed in a building or structure, with the hose connections located in such a manner that water can be discharged in streams or spray patterns through attached hose and nozzles, for the purpose of extinguishing a fire, thereby protecting a building or structure and its contents

Standpipe and hose system Components

Standpipe System Components are as follows:

- Pipes and fitting.
- Valves.
- Hose Station.
- Fire department Inlet Connection (Siamese connection).
- Fire department Outlet Connection Fire Hydrant.

Standpipe and hose system Components

Pipes and fitting :

Pipe or tube used in standpipe systems shall meet or exceed one of the standards.

Pipe or Tube Materials and Dimensions

Material and Dimensions (Specifications)	Standard
Ferrous Piping	
Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids	AWWA C151
Electric-Resistance Welded Steel Pipe	
Standard Specification for Electric-Resistance-Welded Steel Pipe	ASTM A 135
Welded and Seamless Steel	
Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use	ASTM A 795
Welded and Seamless Steel Pipe	
Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless	ASTM A 53
Welded and Seamless Wrought Steel Pipe	ANSI B36.10M
Copper Tube (Drawn, Seamless)	
Standard Specification for Seamless Copper Tube	ASTM B 75
Standard Specification for Seamless Copper Water Tube	ASTM B 88

Standpipe and hose system Components

Valves:

All valves controlling connections to water supplies and standpipes shall be listed indicating valves.

* OS&Y Gate Valves.
* Post indicator Valves
* Check Valves.
* Angle Valves.

Standpipe and hose system Components

Hose Station :

The hose station including the following components:

- Cabinet : should have sufficient size to allow installation all its equipment.

Note : cabinets may be exposed, recessed or flush type.

- Hose : Hose size 1.5″ or 2.5″ dia. And have length 30meter.
  Hoses can be arranged as hose reel or hose rack.
  Each hose ended with its Spray Nozzle.
  Each hose ended with quick/threaded connection.

Note : hose station may be hose reel or rack

Standpipe and hose system Components

Fire Department Connection:

Each fire department connection shall have at least two 2.5″

Standpipe and hose system Components

Fire Department Connection:

Each fire department connection shall have at least two 2.5″

Standpipe system Classes

Class I - Systems

A Class I standpipe system shall provide 21/2-in. (63.5-mm) hose connections to supply water for use by fire departments and those trained in handling heavy fire streams.

Class II Systems.

A Class II standpipe system shall provide 11/2-in. (38.1-mm) hose stations to supply water for use primarily by the building occupants or by the fire department during initial response.

Class III Systems.

A Class III standpipe system shall provide 11/2-in. (38.1-mm) hose stations to supply water for use by building occupants and 21/2-in. (63.5-mm) hose connections to supply a larger volume of water for use by fire departments and those trained in handling heavy fire streams.

Standpipe system Types

<u>Standpipe System Types:</u>

- Automatic-Dry.
- Automatic-Wet.
- Manual-Dry.
- Manual-Wet.

Standpipe system Types

Automatic-Dry System

An automatic-dry standpipe system shall be a dry standpipe system, normally filled with pressurized air, that is arranged through the use of a device, such as a dry pipe valve, to admit water into the system piping automatically upon the opening of a hose valve. The water supply for an automatic-dry standpipe system shall be capable of supplying the system demand.

Automatic-Wet System

An automatic-wet standpipe system shall be a wet standpipe system that has a water supply that is capable of supplying the system demand automatically.

Standpipe system Types

Manual-Dry System

A manual-dry standpipe system shall be a dry standpipe system that does not have a permanent water supply attached to the system. Manual-dry standpipe systems need water from a fire department pumper (or the like) to be pumped into the system through the fire department connection in order to supply the system demand.

Standpipe system Types

Manual-Wet System

A manual-wet standpipe system shall be a wet standpipe system connected to a small water supply for the purpose of maintaining water within the system but does not have a water supply capable of delivering the system demand attached to the system.

Manual-wet standpipe systems need water from a fire department pumper (or the like) to be pumped into the system in order to supply the system demand.

Standpipe system Types

Notes

Requirements for Manual Standpipe Systems:

- Manual standpipe systems shall not be used in high- rise buildings.
- Manual standpipes shall not be used for Class II or Class III systems.

Requirements for Dry Standpipe Systems:

- Dry standpipes shall be used only where piping is subject to *freezing*.
- Dry standpipes shall not be used for Class II or Class III systems.

Automatic Sprinkler System
Design

Sprinkler system Design

Occupancy (Hazard) Classifications (*Occupancy classifications for (NFPA Standard) to sprinkler installations and their water supplies only).*

Occupancies or portions of occupancies (see NFPA 13 page 440) shall be classified according to:

- The quantity and combustibility of contents,
- the expected rates of heat release,
- The heights of stockpiles,
- The presence of flammable and combustible liquids.

Sprinkler system Design

Occupancy (Hazard) Classifications are as follows

1- Light Hazard Occupancies

- Occupancies or portions of other occupancies where the quantity and/or combustibility of contents is low, and fires with relatively low rates of heat release are expected.
- Light hazard having conditions similar to :

clubs, Mosques, churches, Educational, Hospitals, Institutional, libraries, museums, office, restaurant seating area, theaters -----etc.

Sprinkler system Design

Occupancy (Hazard) Classifications are as follows

2- Ordinary Hazard Occupancies

- **Ordinary Hazard (Group 1) :**

  Occupancies or portions of other occupancies where *combustibility is low, quantity of combustibles is moderate*, stockpiles of combustibles do not exceed 2.4 m, and fires with *moderate rates of heat release* are expected.

- **Ordinary Hazard (Group 2) :**

  Occupancies or portions of other occupancies where quantity and combustibility of *contents is moderate to high*, stockpiles do not exceed 3.7 m , and fires with *moderate to high rates of heat release* are expected.

Sprinkler system Design

Occupancy (Hazard) Classifications are as follows

2- Ordinary Hazard Occupancies

- Ordinary Hazard (Group 1) are similar to the following:

  Automobile parking, Bakeries, Beverage manufacturing, canneries, Dairy products, Electronic Plants, glass products, laundries , Restaurant service areas.

- Ordinary Hazard (Group 2) are similar to the following: :

  Cereal mills , sweet products, dry cleaners, feed mills, leather goods, machine shops, metal working, paper mills, post offices, printing and publishing, repair garage, Textile manufacture, tires manufacture, wood machining, Tobacco products , wood product assy.,--------etc.

Occupancy (Hazard) Classifications are as follows

3- Extra Hazard Occupancies

Occupancies or portions of other occupancies where quantity and combustibility of contents is very high and flammable and combustible liquids, dust, lint, or other materials are present, introducing the probability of rapidly developing tires with high rates of heat release.

Extra Hazard Occupancies are divided into Two Groups

Extra hazard Group1

Extra hazard Group 2

Sprinkler system Design

Occupancy (Hazard) Classifications are as follows

Extra Hazard Occupancies Group1

Air craft hangers, combustible hydraulic fluids, Die casting, metal extruding, printing (using inks with flash point lower than 100of (37.5C), Rubber reclaiming, Saw mills, Textile ----etc.

Extra Hazard Occupancies Group2

Asphalt saturating, Flammable liquids spray, oil quenching, plastics processing, solvent cleaning, paint dipping, -------etc.

Sprinkler system Design

Occupancy (Hazard) Classifications are as follows

Extra Hazard Occupancies Group1

Air craft hangers, combustible hydraulic fluids, Die casting, metal extruding, printing (using inks with flash point lower than 100of (37.5C), Rubber reclaiming, Saw mills, Textile ----etc.

Extra Hazard Occupancies Group2

Asphalt saturating, Flammable liquids spray, oil quenching, plastics processing, solvent cleaning, paint dipping, -------etc.

Review

Flow Through Pipes

Flow through pipes may be :

Laminar Flow , Transient Flow, Turbulent Flow ---- based on Renold No.

RN <2000 ------------- Laminar flow

2000< RN <3000 ------ Transient flow

RN >3000 ------------- Turbulent Flow

Sprinkler system Design

Review

Losses Through Pipes

Losses through pipes are due to :

1- The fluid viscosity----- Friction Losses.

2- the change in velocity Vector *(Magnitude & direction)* -------- Eddy Losses.

Eddy losses are due to :

A- Enlargement losses.

B- Contraction losses.

C- Bends losses.

D- Valves losses.

$$\frac{\Delta P}{L} = \frac{4.52 \cdot Q^{1.85}}{C^{1.85} \cdot d^{4.87}}$$

C factor page page 380

Equiv length 378

Equivalent Schedule 40 Steel Pipe Length Chart

Fittings and Valves	Fittings and Valves Expressed in Equivalent Feet of Pipe													
	$^1/_2$ in.	$^3/_4$ in.	1 in.	$1^1/_4$ in.	$1^1/_2$ in.	2 in.	$2^1/_2$ in.	3 in.	$3^1/_2$ in.	4 in.	5 in.	6 in.	8 in.	10 in.
45° Elbow		1	1	1	2	2	3	3	3	4	5	7	9	11
90° Standard elbow	1	2	2	3	4	5	6	7	8	10	12	14	18	22
90° Long turn elbow	0.5	1	2	2	2	3	4	5	5	6	8	9	13	16
Tee or cross (flow turned 90°)	3	4	5	6	8	10	12	15	17	20	25	30	35	50
Butterfly valve		-	-	-	-	6	7	10	-	12	9	10	12	19
Gate valve		-	-	-	-	1	1	1	1	2	2	3	4	5
Swing check*		-	5	7	9	11	14	16	19	22	27	32	45	55

For SI Units: 1 in. = 25.4 mm; 1 ft = 0.3048 m.

Fire Sprinkler System Components

Branch Lines

The pipes in which the sprinklers are placed, either directly or through risers

Cross Mains

The pipes supplying the branch lines, either directly or through risers

Feed Mains

The pipes supplying cross mains either directly or through risers

Risers

The vertical supply pipes in a sprinkler system which contains a control valve.

Fire Sprinkler System Components

Sprig-up

A line that rises vertically and supplies a single sprinkler

Supervisory Devices

Devices arranged to supervise the operative condition of automatic sprinkler systems such as :

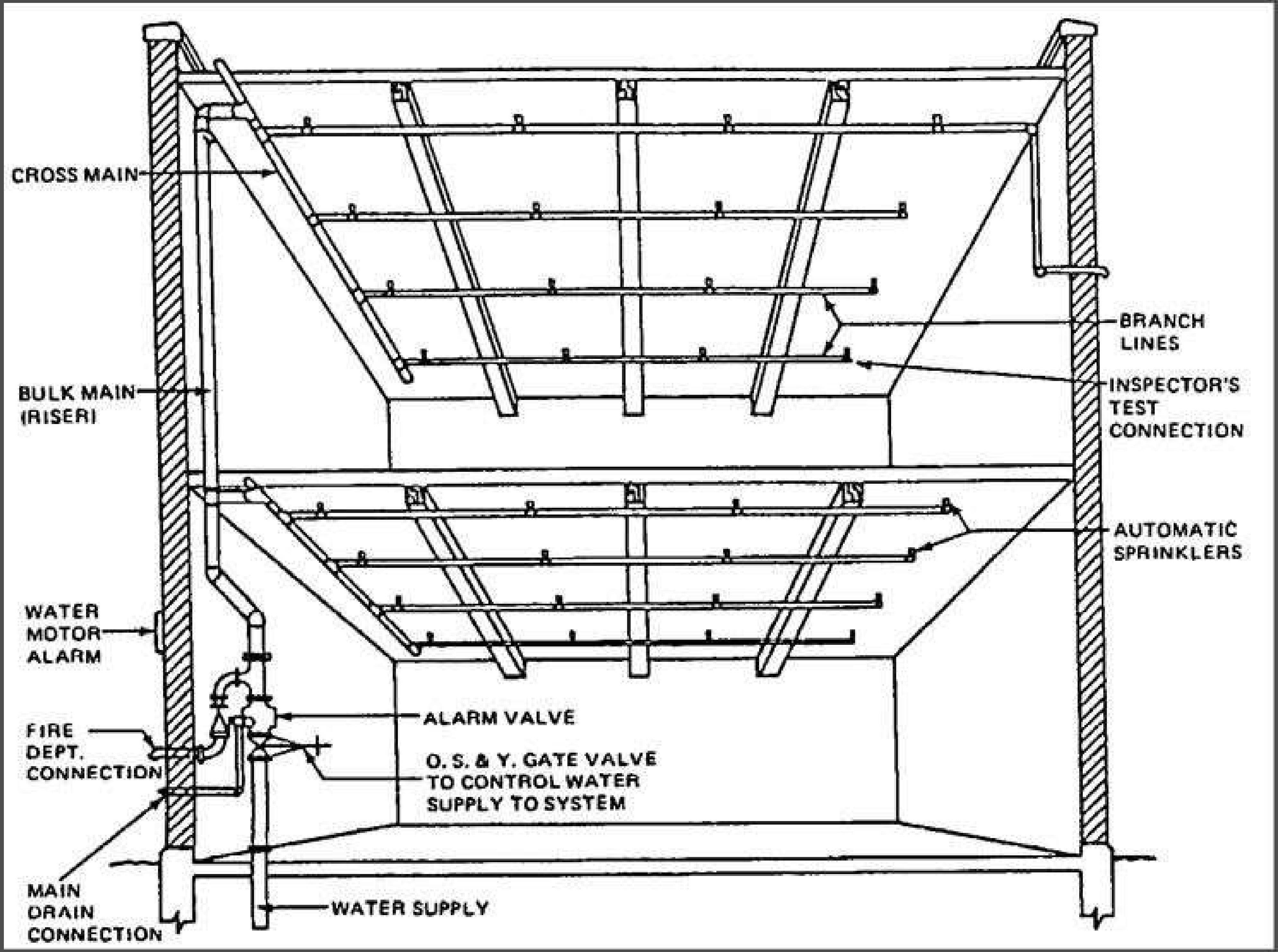
* Pressure Switches.
* Tamper Switches.
* water flow detectors.

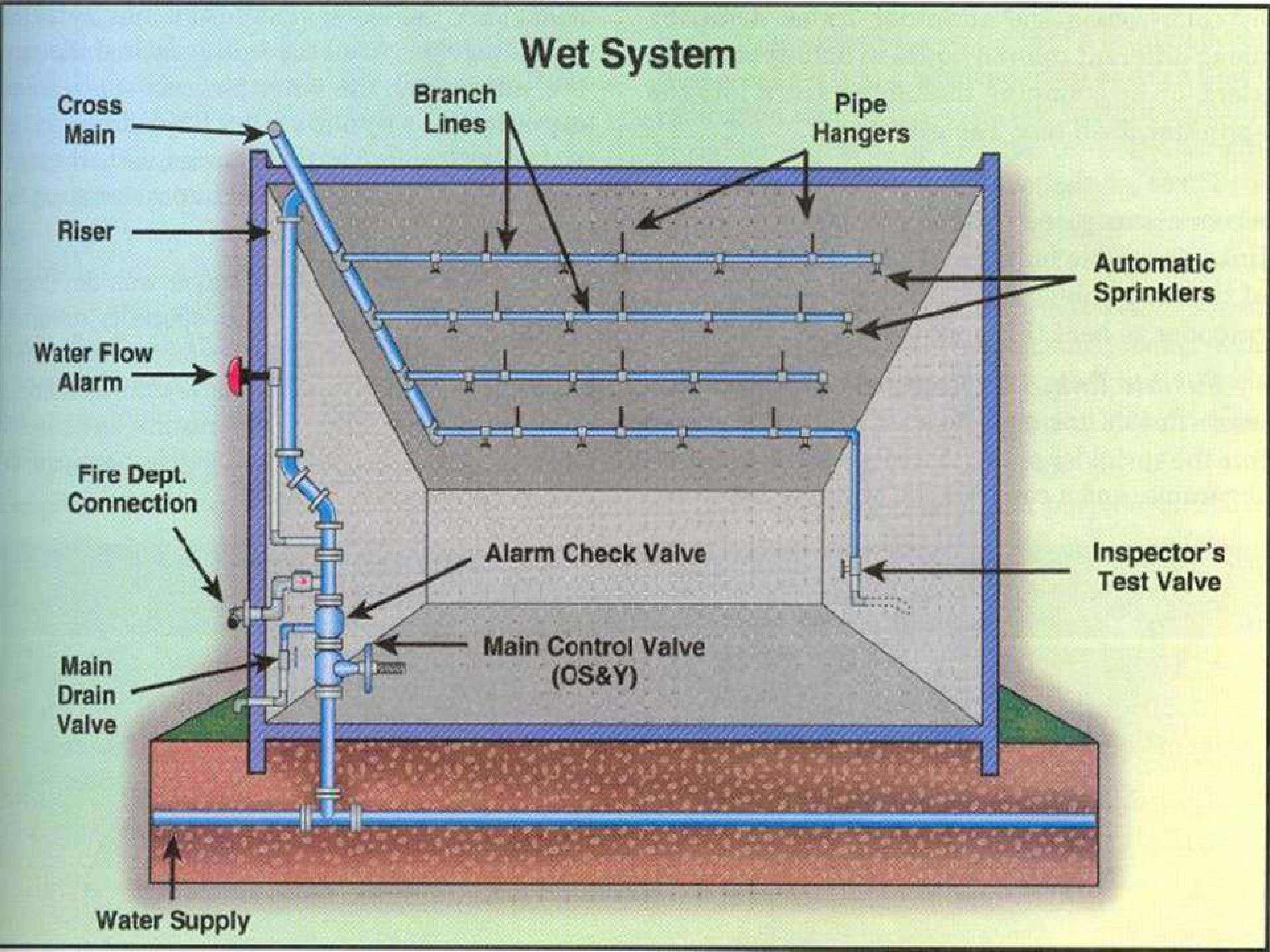
Fire water pumps

Sprinkler head

System Control valves

Fire Sprinkler System Components




Wet System
Cross Main
Branch Lines
Pipe Hangers
Riser
Automatic Sprinklers
Water Flow Alarm
Fire Dept. Connection
Alarm Check Valve
Inspector's Test Valve
Main Control Valve (OS&Y)
Main Drain Valve
Water Supply

Sprinkler system Design

There is more than one method used to determine the water demand requirements

- Pipe Schedule Method
- Hydraulic Calculation Method

Sprinkler system Design

Pipe Schedule Method

- shall be used in determining the minimum water supply requirements for light and ordinary hazard occupancies protected by systems with pipe sized according to the pipe schedules.

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
4 in.	See Section 8.2	4 in.	See Section 8.2

For SI units, 1 in. = 25.4 mm.

Sprinkler system Design

Pipe Schedule Method

System Protection Area Limitations

- The maximum floor area on any one floor to be protected by sprinklers supplied by any one sprinkler system riser or combined system riser shall be as follows:

  (1) Light hazard — 52,000 ft2 (4831 m2)

  (2) Ordinary hazard — 52,000 ft2 (4831 m2)

  (3) Extra hazard

  (a) Pipe schedule — 25,000 ft2 (2323 m2)

  (b) Hydraulically calculated — 40,000 ft2 (3716 m2)

Ordinary Hazard Pipe Schedule

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..	20 sprinklers	2½ in.	25 sprinklers
3 in.	40 sprinklers	3 in.	45 sprinklers
3½ in.	65 sprinklers	3½ in.	75 sprinklers
4 in.	100 sprinklers	4 in.	115 sprinklers
5 in.	160 sprinklers	5 in.	180 sprinklers
6 in.	275 sprinklers	6 in.	300 sprinklers
8 in.	See Section 8.2	8 in.	See Section 8.2

For SI units, 1 in. = 25.4 mm.

Pipe Schedule Method

determining the minimum water supply requirements

Occupancy Classification	Minimum residual pressure requirements	Acceptable Flow at base of Riser	Duration in minutes
Light Hazard	15 psi	500-750 gpm	30-60
Ordinary Hazard	20 psi	850-1500 gpm	60-90

Water Supply Requirements for Pipe Schedule Sprinkler Systems

Hazard Classification	Inside Hose (gpm)	Total Combined inside & outside Hose (gpm)	Duration in Minutes
Light	0, 50, or 100	100	30
Ordinary	0, 50, or 100	250	60-90
Extra Hazard	0, 50, or 100	500	90-120

Hose Stream Demand and Water Supply Duration Requirements

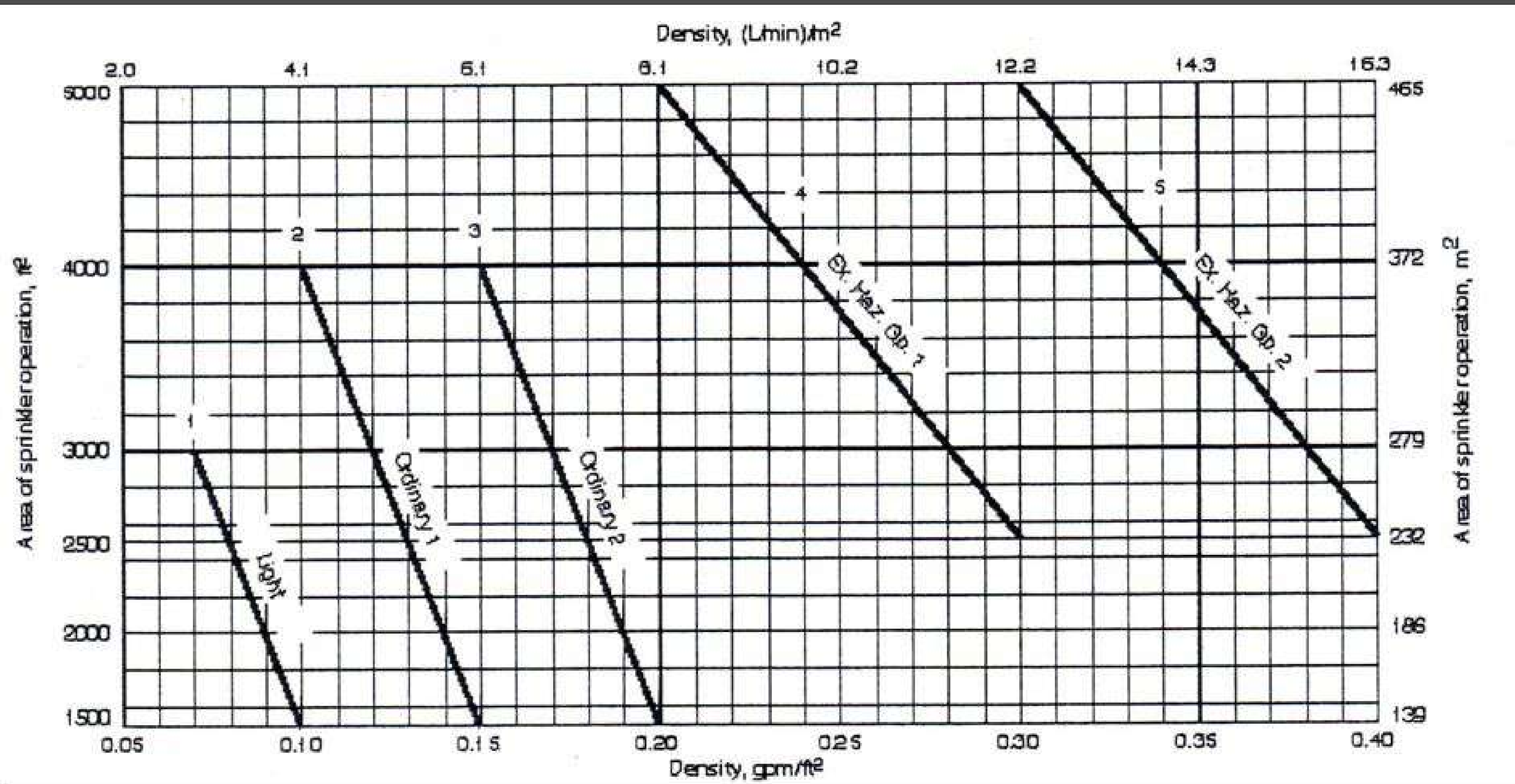
Sprinkler system Design

Hydraulic Calculations Method

- The water supply requirement for sprinklers only shall be calculated from the area/density curves in . The calculations shall satisfy any single point on the appropriate area/density curve as follows:
  - Light Hazard Area/Density Curve 1
  - Ordinary Hazard (Group 1) Area/Density Curve 2
  - Ordinary Hazard (Group 2) Area/Density Curve 3
  - Extra Hazard (Group 1) Area/Density Curve 4
  - Extra Hazard (Group 2) Area/Density Curve 5.

Sprinkler system Design

Hydraulic Calculations Method



Hydraulic Calculations Method

Maximum Sprinkler Spacing	
Light hazard occupancies	15 ft.
Ordinary hazard occupancies	15 ft.
Extra hazard occupancies	12 ft.

Maximum Coverage Area of Sprinkler Head (sq. ft.)			
	Light hazard	Ordinary hazard	Extra hazard
Unobstructed construction	225	130	100
Non-combustible, obstructed construction	225	130	100
Combustible, obstructed construction	170	130	100

Sprinkler System Design

Automatic Fire Sprinkler System Network Design Procedures

1. **Rate your building's hazard level (light, ordinary, or extra).**

Hazard classifications for (NFPA Standard) shall be classified according to:

A- The quantity and combustibility of contents. B- The expected heat release rates.

C-The heights of stockpiles. D- The presence of flammable and combustible liquids.

Classifications are as follows:

A- Light Hazard	B- Ordinary Hazard	C- Extra Hazard
Where the quantity of combustibility contents is low, and fires with relatively low rates of heat release are expected.	-Ordinary Hazard (Group 1) Where combustibility is low stockpiles of combustibles do not exceed 2.4 m. -Ordinary Hazard (Group 2) Where combustibility is moderate to high, stockpiles do not exceed 3.7 m.	Where combustibility is very high and flammable and combustible liquids are present. -Extra Hazard (Group 1) -Extra Hazard (Group 2)

2. **Find your design area (The worst possible place in the building to be benchmark in calculating how much water in fire sprinkler design).**

3. **Decide the fire sprinkler design that needed (hydraulic calculation to find out water capacity and pressure demand).**

Sprinkler system Design

Hydraulic Calculations Method Procedure

- Determine the type of hazard and select values for density and area per sprinkler that are applicable to the design area.
- Density multiplied by area per sprinkler gives the flow required at the most remote sprinkler.
- Use this value along with sprinkler K-Factor to check the minimum starting pressure, which should exceed 7 psi.
- Select the next point upstream, calculate the pressure due to elevation and friction loss and add this to the minimum starting pressure at the most remote sprinkler.
- Extend this process to each and every node all the way back to the source node.

Sprinkler System Design

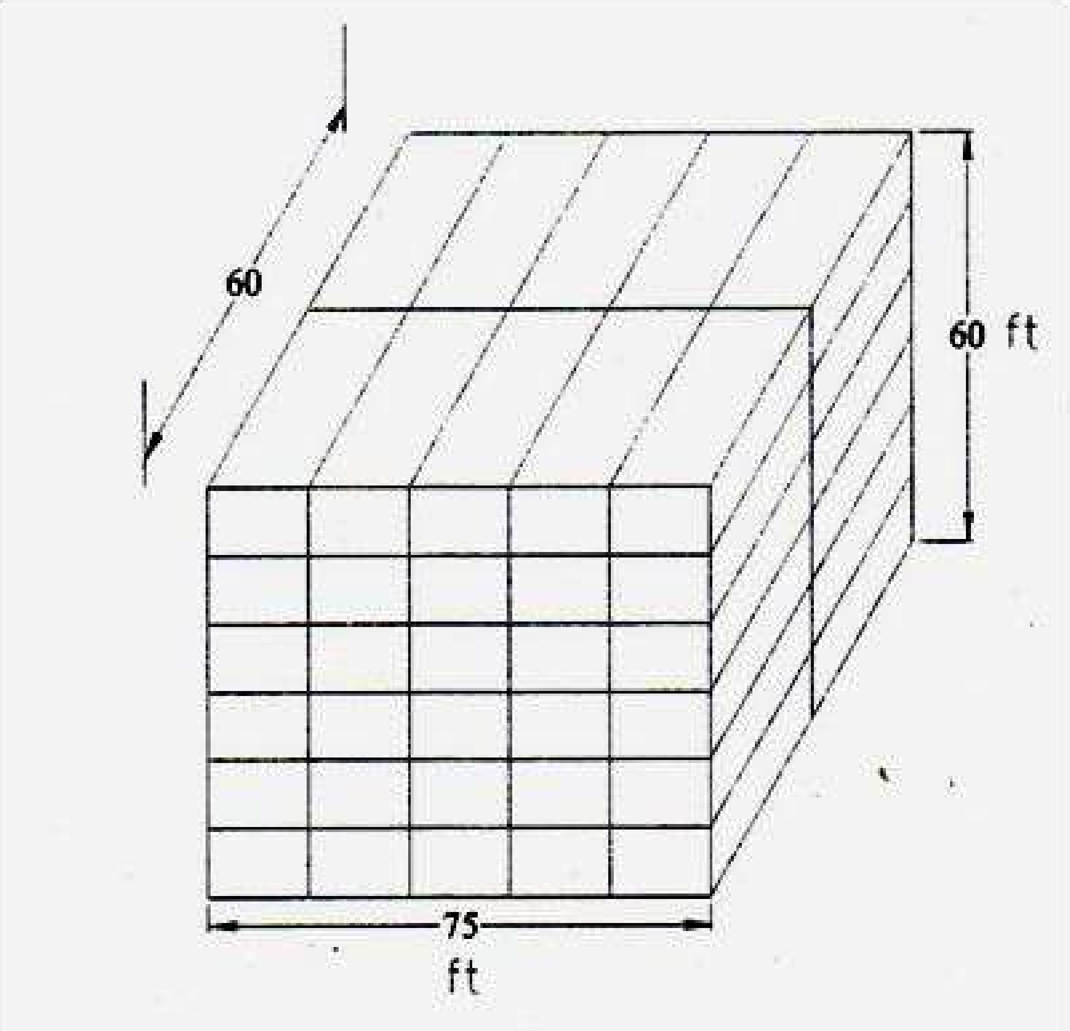
Demonstration Case Study

Input Data:

An office building having 60 rooms as shown consists of;

6 stories high, 5 rooms wide and 2 rooms long

Each room area is
15 ft. wide X 30 ft. long X 10 ft. high



Design Procedures:

1- Sprinkler system type
(Wet Type)

2- Classification of Building Hazard
(An office building is classified as light hazard)

Sprinkler System Design

Demonstration Case Study

3- Spacing of Sprinklers

Due to the type of building hazard, the spacing between sprinkler heads and between lines is taken 15 ft. (from given table).

Maximum Sprinkler Spacing	
Light hazard occupancies	15 ft.
Ordinary hazard occupancies	15 ft.
Extra hazard occupancies	12 ft.

4. Coverage Area of Sprinkler Head

The coverage area per sprinkler head is 225 ft^2 (from given table).

Maximum Coverage Area of Sprinkler Head (sq. ft.)			
	Light hazard	Ordinary hazard	Extra hazard
Unobstructed construction	225	130	100
Non-combustible, obstructed construction	225	130	100
Combustible, obstructed construction	170	130	100

Demonstration Case Study

5- Total Number of Sprinkler Required

(Total room area X no. of rooms) / coverage area per sprinkler

= [(15 X 30) X 10 rooms)] / 225

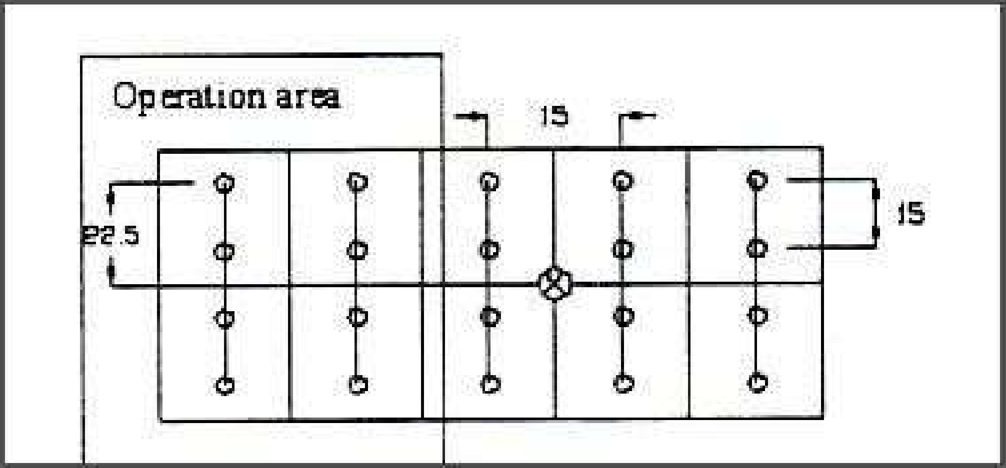
= 4500 / 225 = 20 sprinkler heads

So, each floor requires 20 sprinklers installed.

6- Area of Operation of sprinklers

- This area establishes the number of sprinklers required open to extinguish the fire within the area of operation. It also establishes the number of heads to be hydraulically calculated.

- The operation area in our case is selected as 1800 ft^2. (40 % of the total area). The figure shows (6th floor layout).

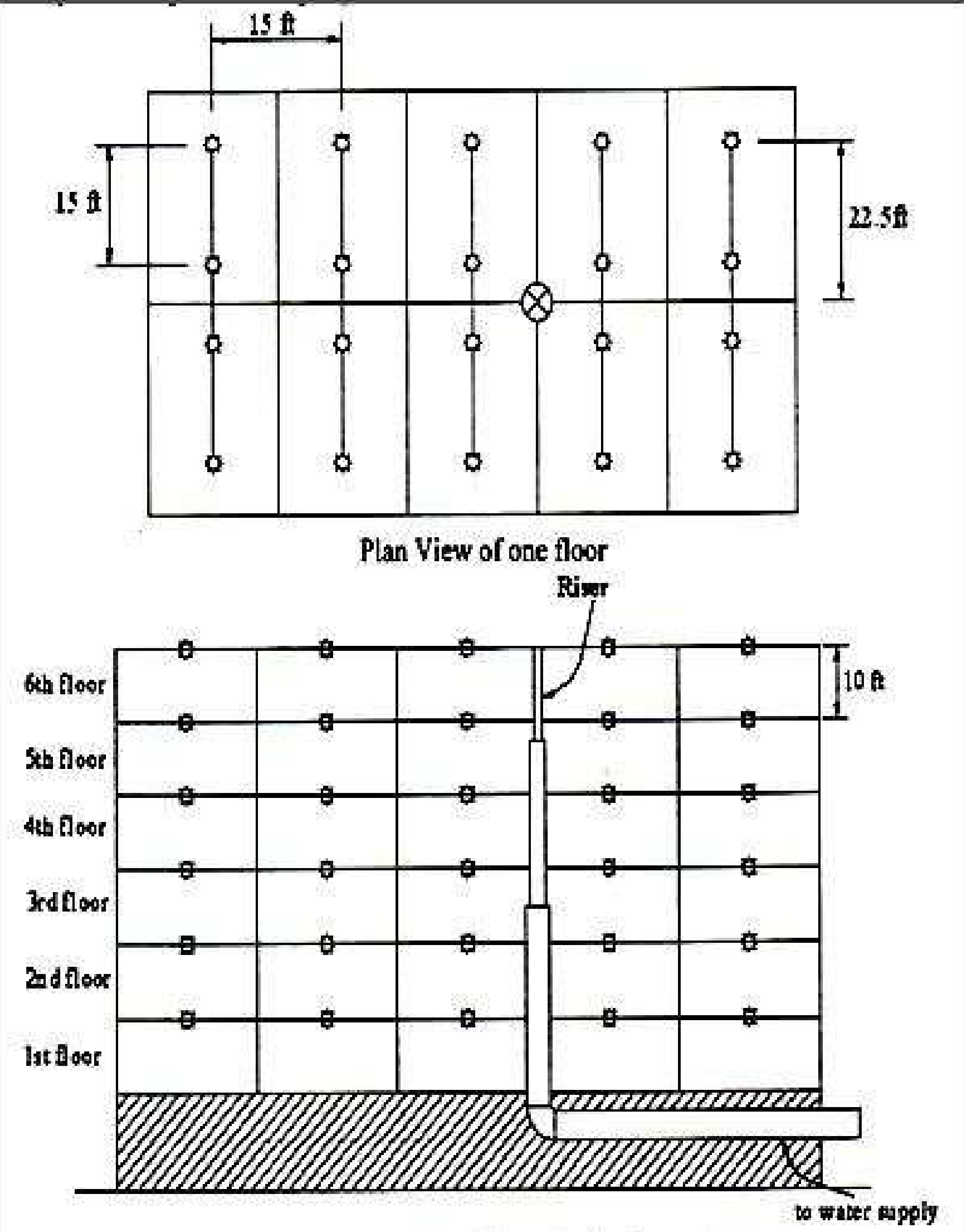


Demonstration Case Study

7- Layout of Sprinkler Piping

The number of sprinklers in the operation area =
= (Operation area / coverage area per sprinkler)
= 1800 / 225 = 8

So, 8 sprinklers are expected (as a maximum) to open in case of fire this is the only number of sprinklers which are to be hydraulically calculated.



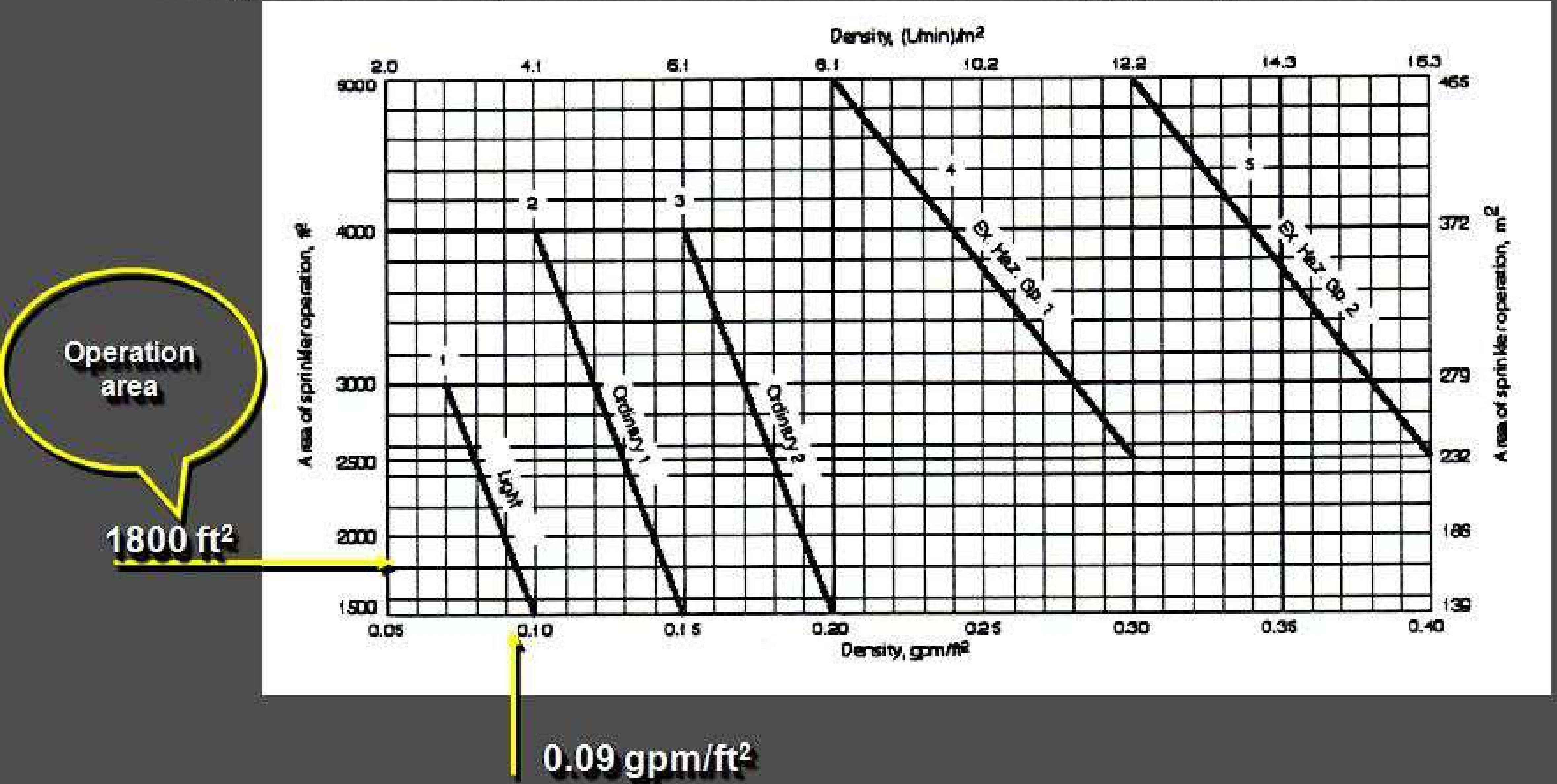
Front view of the building (Typical Layout)
"Note size reduction of the riser where possible"

Sprinkler System Design

Demonstration Case Study

8- Flow of water required

Using area/density curve to find out the water supply requirement



Demonstration Case Study

Water demand per single sprinkler =

0.09 gpm/ ft^2 X 225 ft^2 (sprinkler coverage area) = 20 gpm

This is to say that the furthest sprinkler head from the supply must deliver 20 gpm

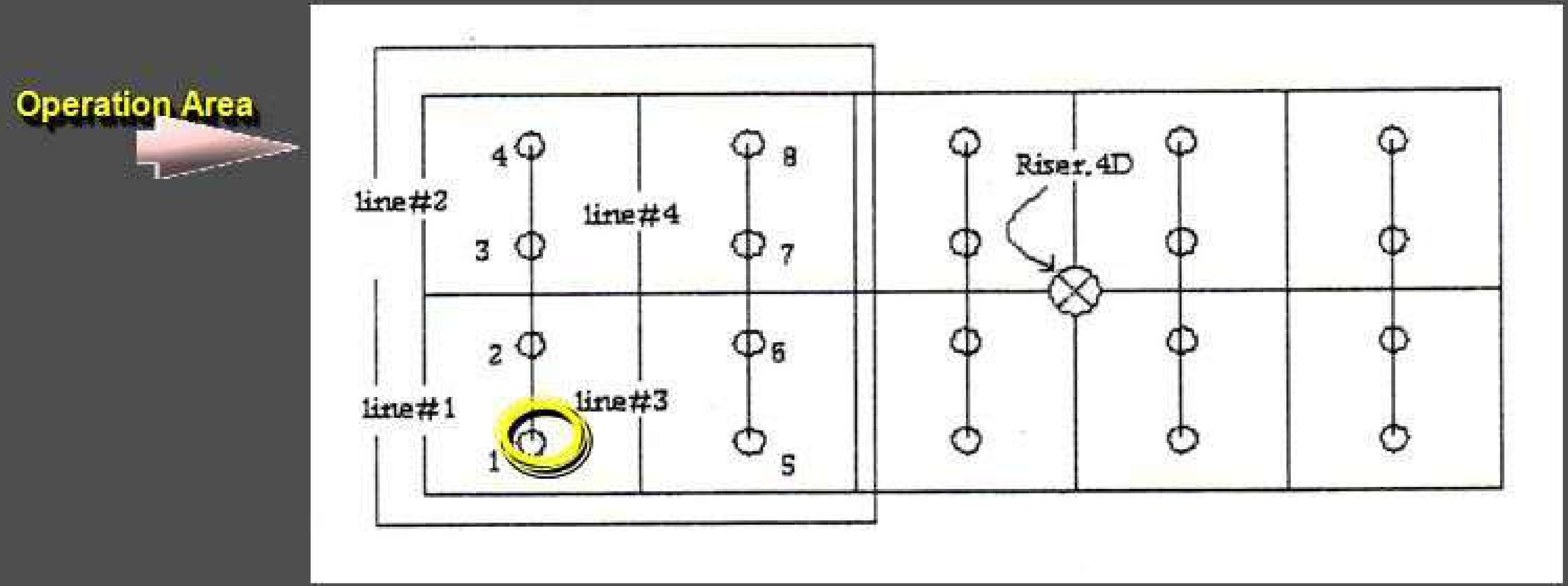
The total flow required for this 6^{th} floor
= flow density X operation area X 1.15 = 190 gpm

Note: The factor 1.15 is called the flow fraction and this is to account for friction loss in pipes.

Now, the hydraulic calculations begin

Sprinkler System Design

Hydraulic Calculations



1. Sprinkler head (1) , the furthest from the supply, is required to delivered 20gpm.
2. What pressure at head (1) is needed to deliver 20 gpm?
3. Using the flow characteristics formula:

$$Q = K \cdot (P)^{1/2}$$

Where,

Q = gpm, K-Factor = constant, P = psi and taking a standard orifice (0.5 diameter) in our example, with K = 5.6, we get P = 12.76 psi.

i.e. it requires 12.76 psi at head (1) to deliver 20 gpm.

K - Factor

K-Factor formula

When starting any hydraulic calculation for a water based fire protection systems such as fire sprinklers, water mist, hose reel and deluge systems the k-factor formula is one formula which all fire protection engineers must know and understand. It allows us to calculate the discharge flow from any type of nozzle (fire sprinkler, water mist or a deluge nozzle) for which we have a k-factor.

Table 1. Sprinkler Discharge Characteristics

Nominal K-factor, gpm/psi$^{1/2}$	K-factor range, gpm/psi$^{1/2}$	Percent of Nominal K- 5.6 Discharge	Thread Type
5.6	5.3 – 5.8	100	½ inch NPT
8.0	7.4 – 8.2	140	½ or ¾ inch NPT
11.2	11.0 – 11.5	200	½ or ¾ inch NPT
14.0	13.5 – 14.5	250	¾ inch NPT
16.8	16.0 –17.6	300	¾ inch NPT
19.6	18.6 – 20.6	350	1 inch NPT
22.4	21.3 –23.5	400	1 inch NPT
25.2	23.9 – 26.5	450	1 inch NPT

Hydraulic Calculation

4. Select 1-inch size for the supply pipe of head (1).

Note that we may have to change the pipe size if it turns that the friction loss is large.

5- Calculate friction loss in pipe (1) using the HAZEN WILLIAM'S equation:

$$\frac{\Delta P}{L} = \frac{4.52 \cdot Q^{1.85}}{C^{1.85} \cdot d^{4.87}}$$

Where:

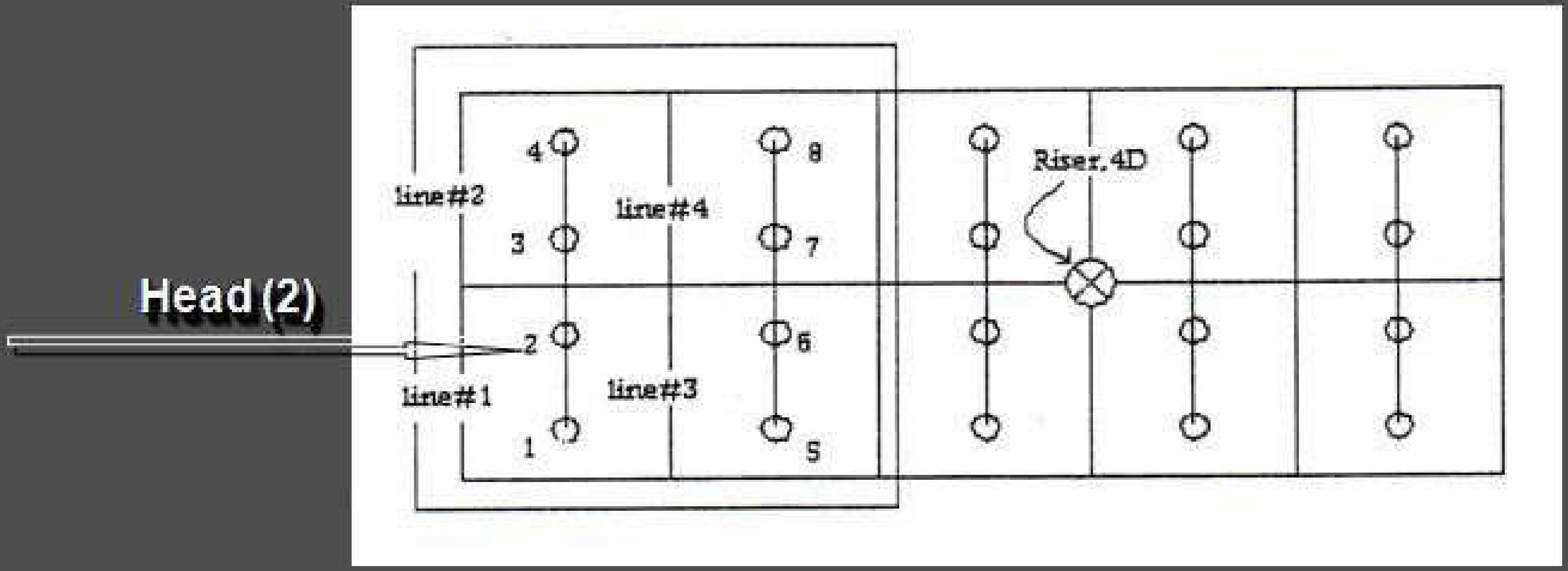
P / L =friction loss per unit length, psi/ft   Q =flow rate, gpm

D= pipe diameter, in   C = friction loss coefficient, material dependent

P/L (friction loss per unit length) = 0.164 psi/ft

Totals friction loss in the pipe (1) = 0.164 X 15 (ft long) = 2.46 psi

Hydraulic Calculation



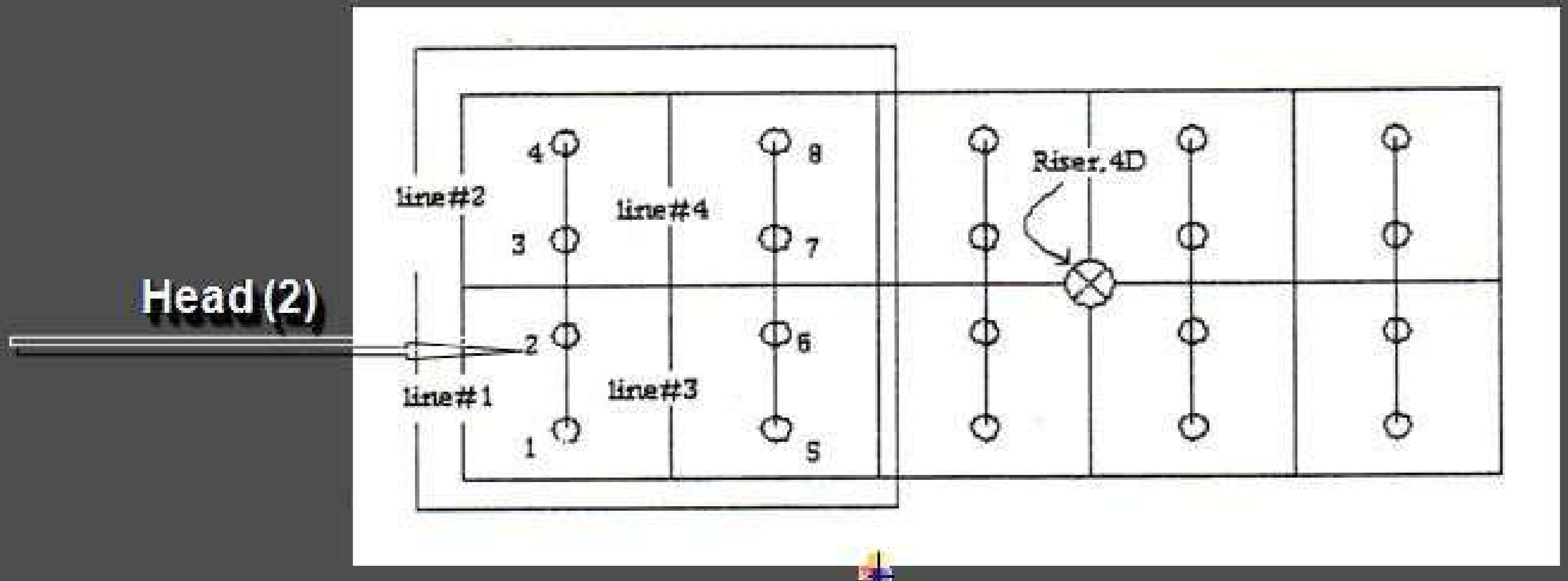
6- Calculate the pressure at sprinkler head (2)
= (pressure at head 1 + friction loss pressure in the pipe supplying head 1)
= 12.76 + 2.46 = 15.22 psi

7- The flow at head (2) is calculated from

$$Q = k\,(P)^{0.5}$$

$$Q = 5.6 \times (15.22)^{0.5} = 21.85 \text{ gpm}$$

Hydraulic Calculation



8- The second piece of the pipe must, now, deliver a total 41.85 gpm (20 gpm for head 1 + 21.85 gpm for head 2).

9- And so on…till you finish the hydraulic calculations for riser all the way down to under ground pipe connection and the city main connection including all the necessary valves and accessories.

Fire Pump Station

Fire Pump Station

A typical fire fighting station may be composed of the following:

Jockey Pump :

- That maintains the desired system pressure within the fire fighting system (this pump called the makeup pump or pressure maintenance pump) .
- Typical performance for a jockey pump is approx. 10 % of the total gpm at approx. same or higher than the system pressure.

Main Fire Pump :

- Main fire fighting pump capable of feeding the system requirement This pump is typically driven by an electrical motor and is fed from a reservoir capable of supplying at least one hour of liquid flow without interruption

Fire Pump Station

A typical fire fighting station may be composed of the following:

Standby (emergency) Fire Pump :

- An fire fighting pump, capable of feeding all available sprinklers, and other supplementary fire fighting equipment, such as fire-hose nozzles.
- This pump is typically driven by a diesel engine and supplied with fire fighting water from a (practically) inexhaustible source.

Fire Pump Station

Fire Pump System Components:

- Fire Water Supply (tank).
- Fire Pumps.
- Pump Drivers (indoor or outdoor).
- Valves , Suction Strainer and Flexible Connections.
- Relief Valve.
- Pressure gauges (suction and discharge).
- Sensing Control Line.
- Test Line with Flow Meter (test line length not exceed 30mt).
- Pump Room Drainage.
- Pump Room Ventilation.
- Pump Room Lighting (normal and Emergency)

Fire Pump Station

Fire Pumps Requirements:

- The pump should be selected to give 150% of its rated capacity @65% of its rated head.
- The pump should be selected to give 110% of its rated head.
- The max. Pump shut off head is 140% of the pump rated capacity
- Centrifugal fire pumps shall have one of the rated capacities in L/min (gpm) identified in Table and shall be rated at net pressures of 2.7 bar (40 psi) or more.
- Centrifugal fire pumps with ratings over 18,925 L/min (5000 gpm) are subject to individual review by either the authority having jurisdiction or a listing laboratory.

Centrifugal Fire Pump Capacities

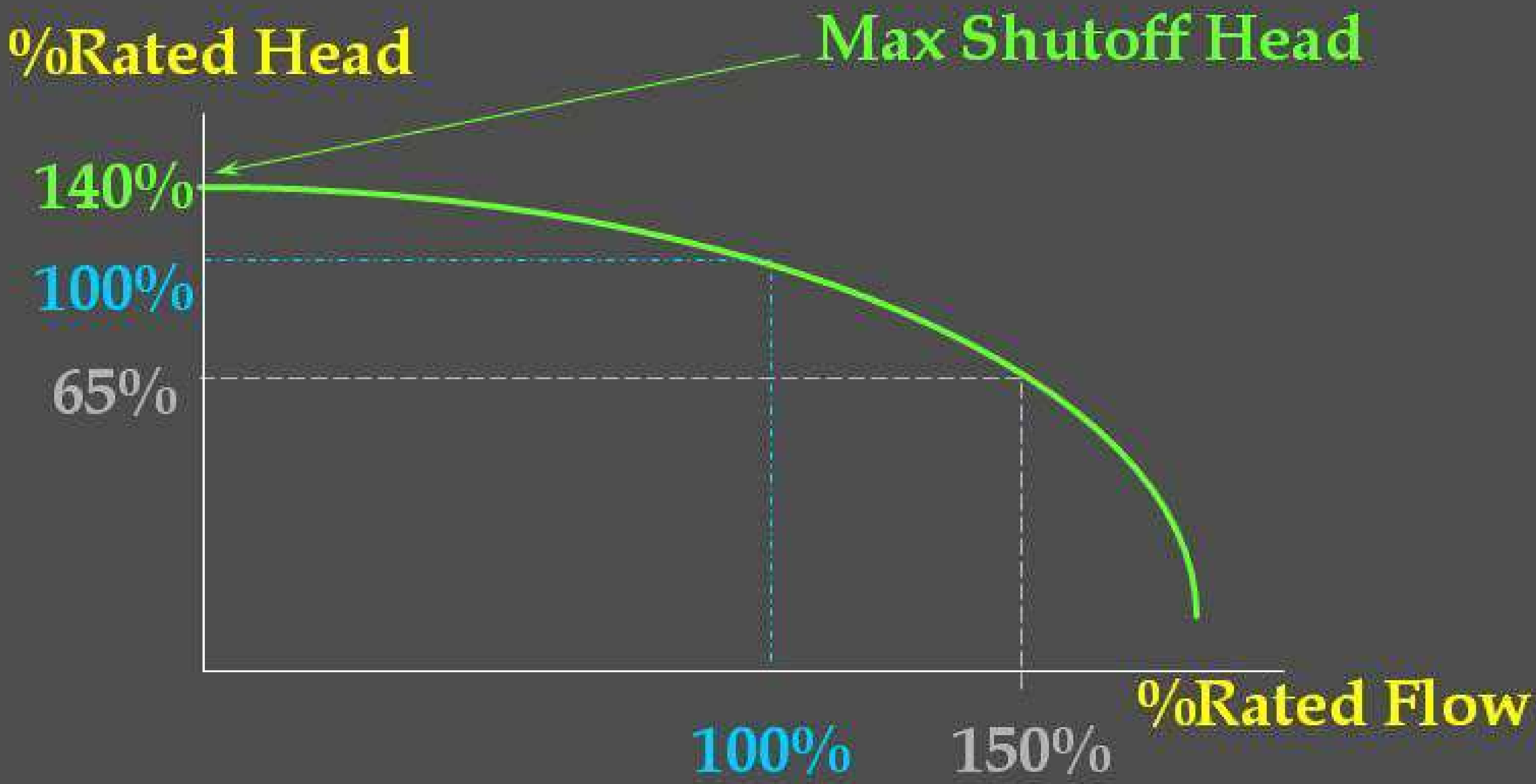
L/min	gpm	L/min	gpm
95	25	3,785	1,000
189	50	4,731	1,250
379	100	5,677	1,500
568	150	7,570	2,000
757	200	9,462	2,500
946	250	11,355	3,000
1,136	300	13,247	3,500
1,514	400	15,140	4,000
1,703	450	17,032	4,500
1,892	500	18,925	5,000
2,839	750		

Fire Pump Station

Types of Fire Pumps:

- Horizontal Split Case.
- End Suction Fire Pumps.
- Vertical Turbine Pump (suitable for use for fire Fighting where the water source is located below ground level and it is difficult to install any other pump type)

Pump Requirements



NFPA Required Pump Accessories

- 3.5 “ with 0.25″ gauge valve Suction gauge must read two times the suction pressure of the pump and not less than 100psi

- 3.5 “ with 0.25″ gauge valve Discharge gauge must read two times the working pressure of the pump and not less than 200psi

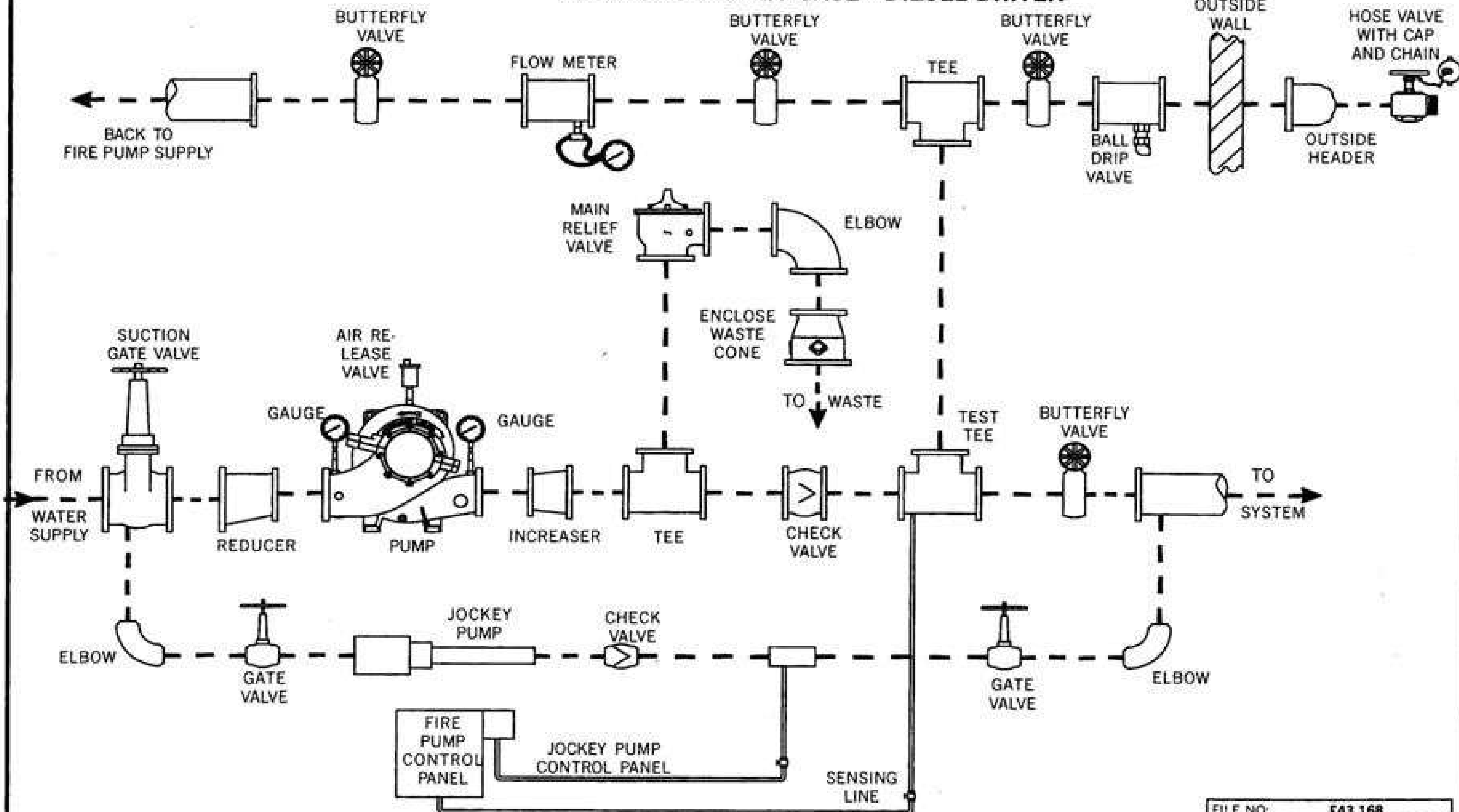
Flow Meters

- Flow meters must be listed for fire protection service
- Gauge reading is a minimum of 175% the pump rated flow
- Provides a testing means without wasting water
- Flow meter is installed in bypass back to suction
- Must be installed with isolation valves per manufacturer's specifications
- RULE OF THUMB:
  installation shall be 10Ø upstream - 5Ø downstream

ARMSTRONG

TYPICAL FIRE PUMP & CONTROLLER ARRANGEMENT

HORIZONTAL SPLIT CASE - DIESEL DRIVEN

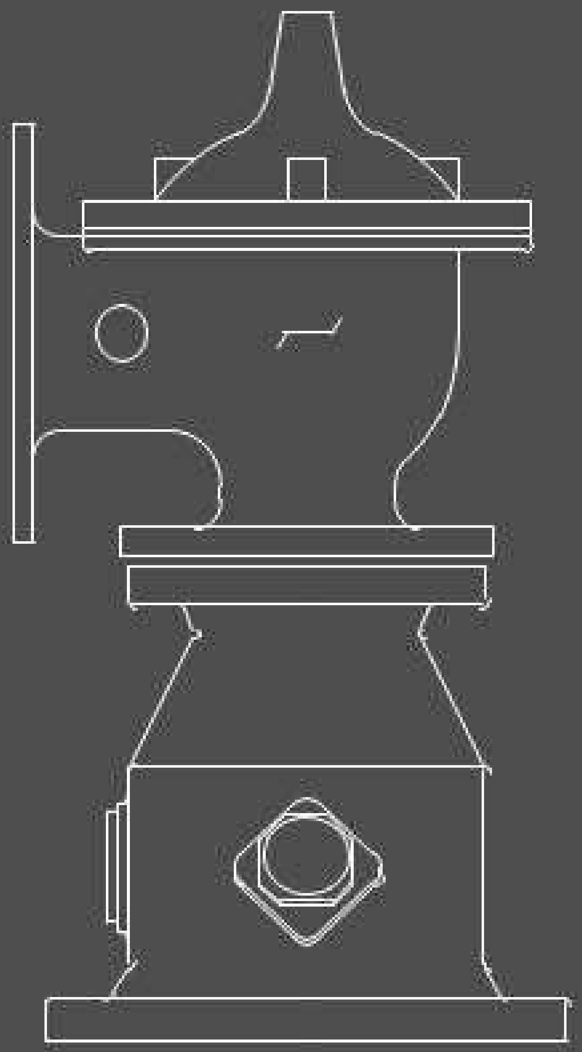


FILE NO:	**F43.168**
ISSUE DATE:	February 16, 1998
SUPERSEDES:	F43.168
DATE:	April 1,1996

This drawing is a suggested arrangement and is issued for information purposes only.

File:\systems\firepump\f_43_168.pm5

Main Relief Valves and Waste Cones



- Sized by pump rated capacity
- Spring or pilot operated
- Waste cone provides visibility of flow through the valve
- When it is used:

1) Diesel driven systems

2) Electric systems ???

NFPA Required Pump Accessories

Fire Pump Rating GPM (L/s)	Suction Size (in.)	Discharge Size (in.)	Relief Valve Size (in.)	Relief Valve Discharge (in.)	Flow Meter Size (in.)	Number & Size of Hose Valves	Hose Valve Manifold Size (in.)
25 (95)	1	1	¾	1	1¼	1 - 1½"	1
50 (189)	1½	1¼	1¼	1½	2	1 - 1½"	1½
100 (379)	2	2	1½	2	2½	1 - 2½"	2½
150 (568)	2½	2½	2	2½	3	1 - 2½"	2½
200 (757)	3	3	2	2½	3	1 - 2½"	2½
250 (946)	3½	3	2	2½	3½	1 - 2½"	3
300 (1136)	4	4	2½	3½	3½	2 - 2½"	3
400 (1514)	4	4	3	5	4	2 - 2½"	4
450 (1703)	5	5	3	5	4	2 - 2½"	4
500 (1892)	5	5	3	5	5	2 - 2½"	4
750 (2839)	6	6	4	6	5	3 - 2½"	6
1000 (3785)	8	6	4	8	6	4 - 2½"	6
1250 (4731)	8	8	6	8	6	6 - 2½"	8
1500 (5677)	8	8	6	8	8	6 - 2½"	8
2000 (7570)	10	10	6	10	8	6 - 2½"	8
2500 (9462)	10	10	6	10	8	8 - 2½"	10
3000 (11,355)	12	12	8	12	8	12 - 2½"	10

Carbon Dioxide Fire Extinguishing System

Co2 System

General:

- Carbon Dioxide is an odorless, colorless, electrically non-conductive, non-corrosive, and non-deteriorating inert suppression agent.
- Carbon Dioxide is heavier than air, and is normally present in the atmosphere at about 0.03% by volume.
- Carbon Dioxide extinguishes fire by reducing the oxygen content of the protected space and/or local flame front to a point where it will not support combustion *(Oxygen reduction below 16% by volume will extinguish most fires).*
- In addition, Carbon Dioxide has a cooling effect on the surrounding atmosphere that has been found to be a benefit to fire extinguishment.

Co2 System

STORAGE AND PRESSURE

- When used as a fire-fighting agent, Carbon Dioxide is stored under pressure in a liquid/vapor state.
- The temperature of liquid Carbon Dioxide is approximately (-78.8oC.) as it is discharged from a nozzle , The liquid phase of the agent vaporizes quite rapidly when coming into contact with the atmosphere.
- There are two forms of Carbon Dioxide storage:

  1- Low Pressure storage : 300 PSI @ -18° C.

  2- High Pressure Cylinders : 750 PSI @ 21° C "Ambient Temperature".

Co2 System

VISIBILITY

The discharge of Carbon Dioxide resembles a cloud as liquid Carbon Dioxide vaporizes. The low temperature of the agent chilling the moisture in the atmosphere causes this cloud effect, or fogging.

NOISE

The high pressure/velocity discharge from the system nozzles(s) can cause noise loud enough to be startling, but is ordinarily insufficient to cause traumatic injury.

CLEANUP

The cleanup costs and downtime associated with a Carbon Dioxide system discharge are negligible (compared with sprinkler system)

It does not cause metals to deteriorate or corrode as it is inert gas.

Co2 System

AREAS OF USE :

- Carbon Dioxide systems can be used on :

  Class "A" fires involving wood, paper, cloth, or any product that leaves a carbon ash when it burns.

  Class "B" fires involving flammable liquids or vapors.

  Class "C" fires involving live electrical equipment can also be protected with Carbon Dioxide.

Some of the hazard types and equipment that can be satisfactorily protected with Carbon Dioxide include:

Battery Rooms	Electric Generators	Ovens
Flammable Liquids Storage	Coating Machines	Dip Tanks & Drain Boards
Engine Test Cells	Underfloor Areas	Motors
Printing Presses	Fur Storage Vaults	Switchgear Equipment
Solvent Recovery Equipment	Dust Collectors	Transformer Vaults
Record Storage	Wave Solder Machines	Ducts
Wet Benches	Spray Booths	Hydraulic Pump Units

Co2 System

Safety:

- Extinguishing concentrations of Carbon Dioxide create a health hazard to area personnel.
- High concentrations of Carbon Dioxide will cause suffocation. In addition, fogging during and after discharge can limit visibility in protected areas. Carbon Dioxide does NOT contain Oxygen in any form or quantity and WILL NOT sustain life.
- The following human reactions to Carbon Dioxide have been documented:-

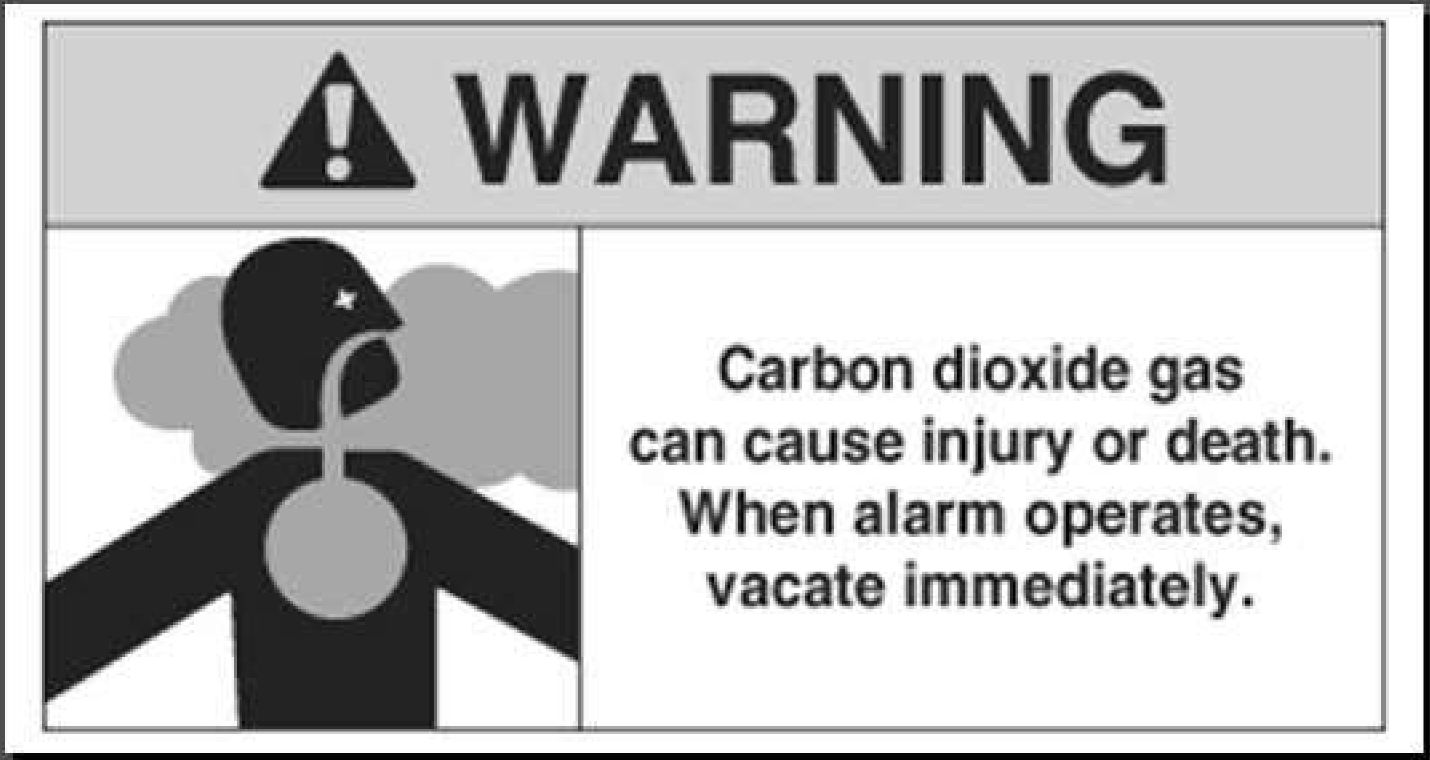
  a) At concentrations of 3 to 4% by volume in the atmosphere, the breathing rate increases and headaches may occur.

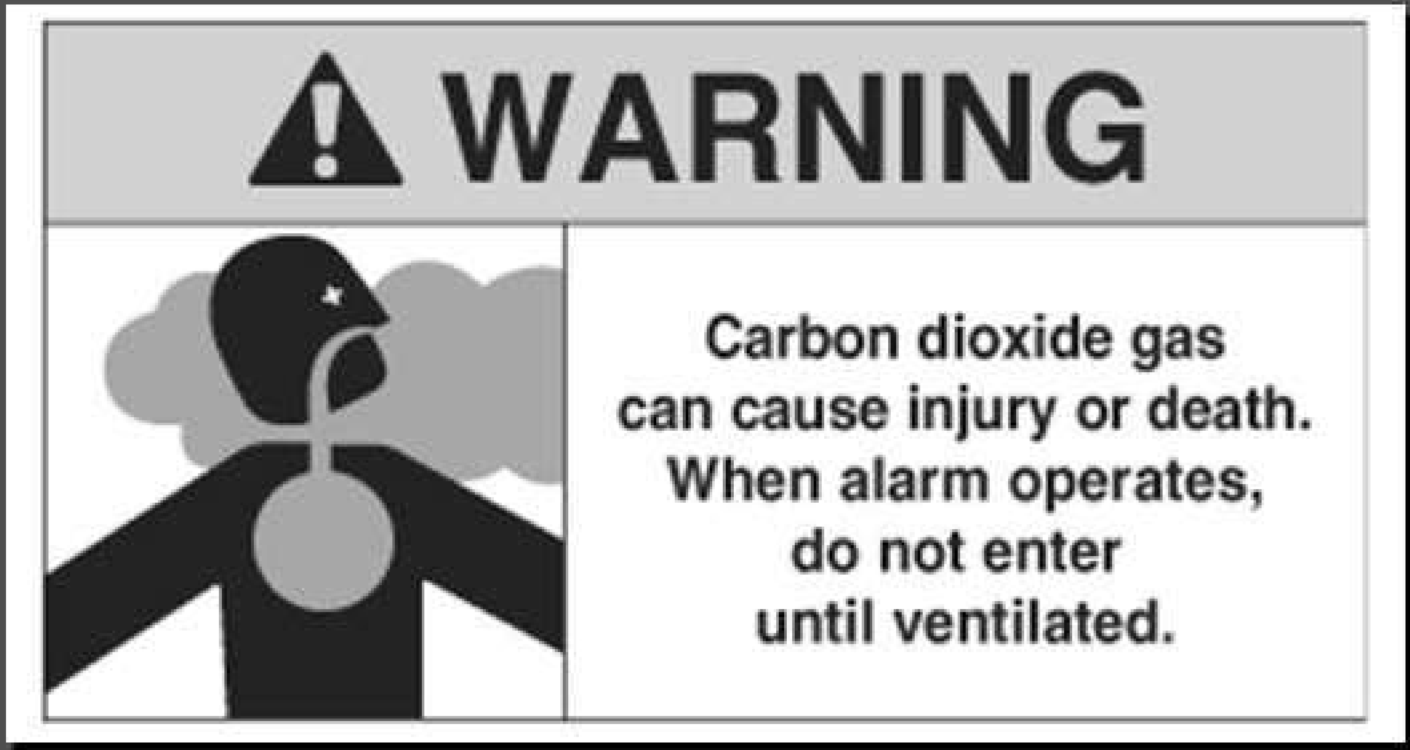
  b) At concentrations exceeding 9% by volume, personnel can lose consciousness within minutes.

  c) At concentrations greater than 20% by volume, death is likely

Co2 System

Safety:





Co2 System Equipment

CARBON DIOXIDE CYLINDERS

- Carbon Dioxide cylinders are steel containers finished with a red gloss, baked enamel paint
- Individual cylinders shall be used having a standard weight capacity of 5, 10, 15, 20, 25, 35, 50, 75, 100, or 120 lb (2.3, 4.5, 6.8, 9.1, 11.4, 15.9, 22.7, 34.1, 45.4, or 54.4 kg).
- Carbon Dioxide cylinders are equipped with a siphon tube to provide a complete discharge of the cylinder contents.
- Carbon Dioxide cylinders must be floor mounted, with the discharge valve in the vertical (up) position.

Horizontal mounting of cylinders IS NOT allowed.

Co2 System Equipment

CYLINDER VALVE

- Carbon Dioxide cylinders are equipped with a cylinder valve designed to hold the Carbon Dioxide agent in the cylinder until actuated, either automatically or manually.
- cylinders are divided in to "Slave" or "Master"
- "Master" cylinder valve can be actuated by several methods:-

  A-Electric Solenoid Actuator (12 or 24VDC)

  B- Local manual/mechanical actuation using Local Lever Actuators

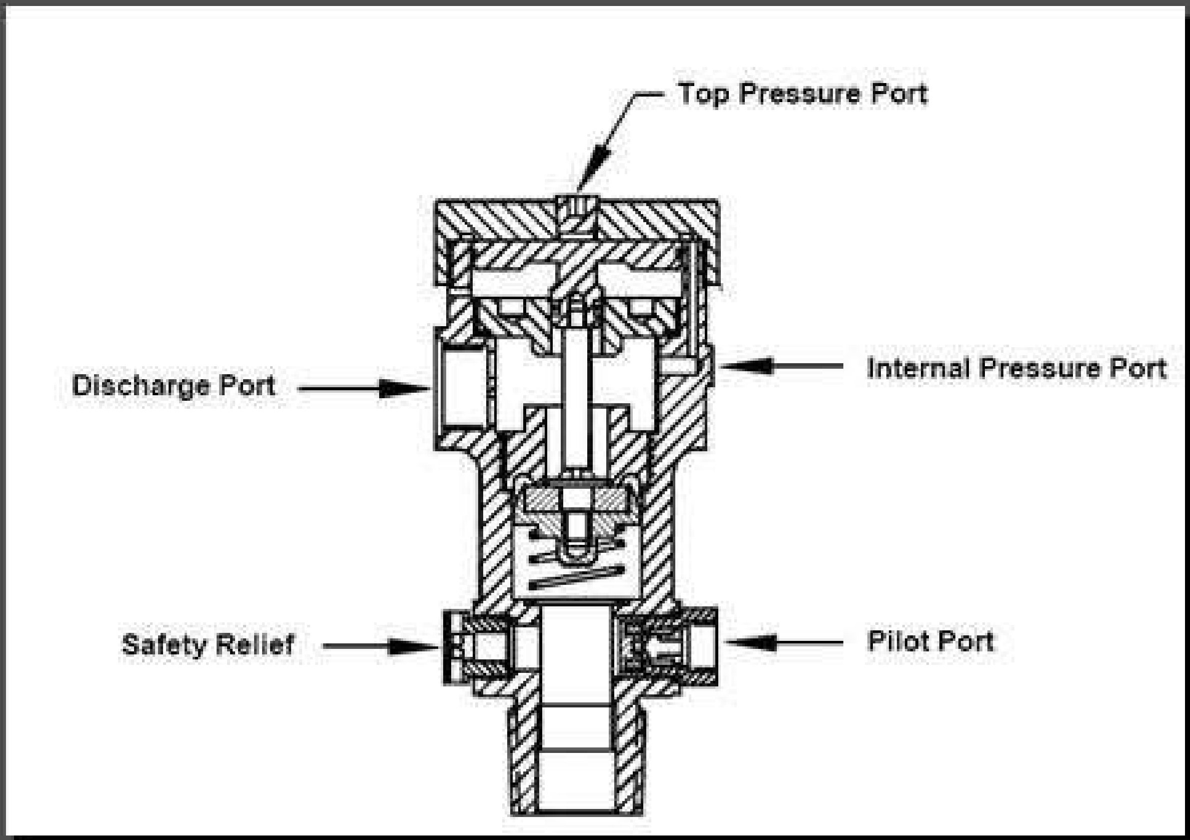
  C-Remote manual/pneumatic actuation using Pneumatic Actuators

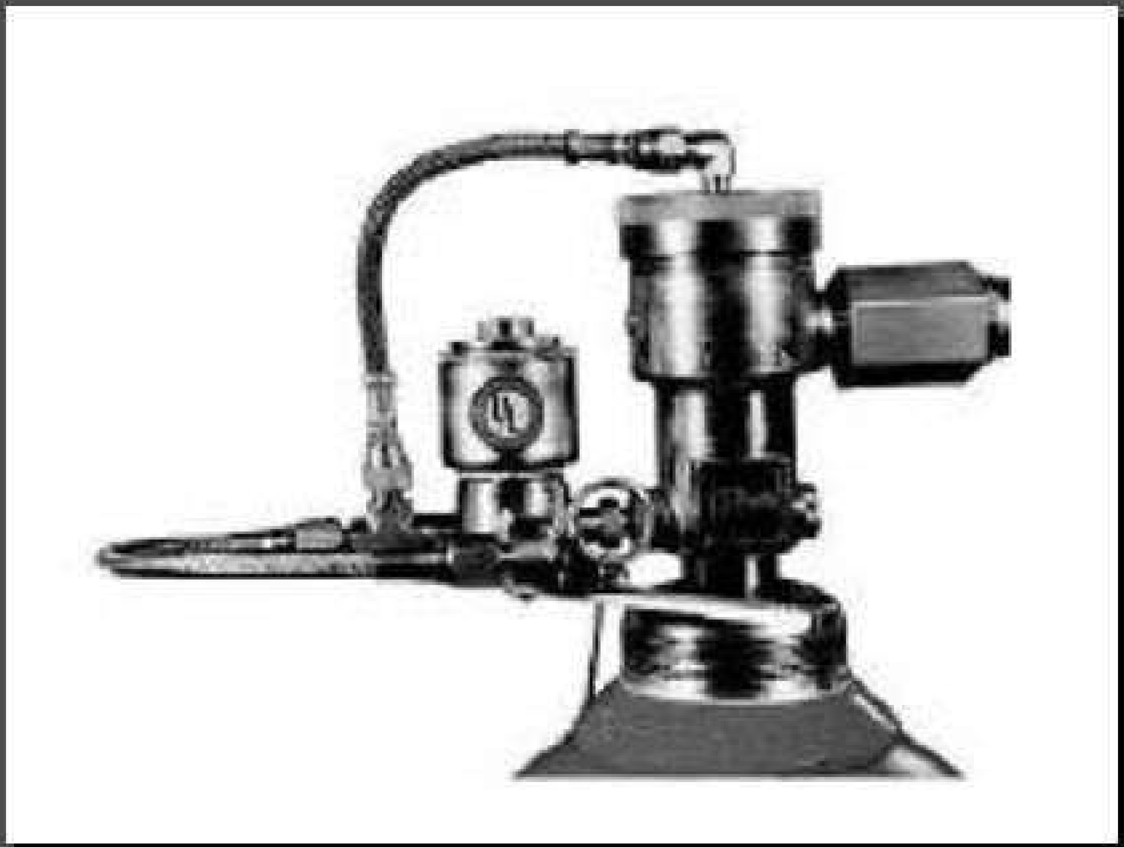
  D-Remote manual/mechanical actuation using cable pull devices

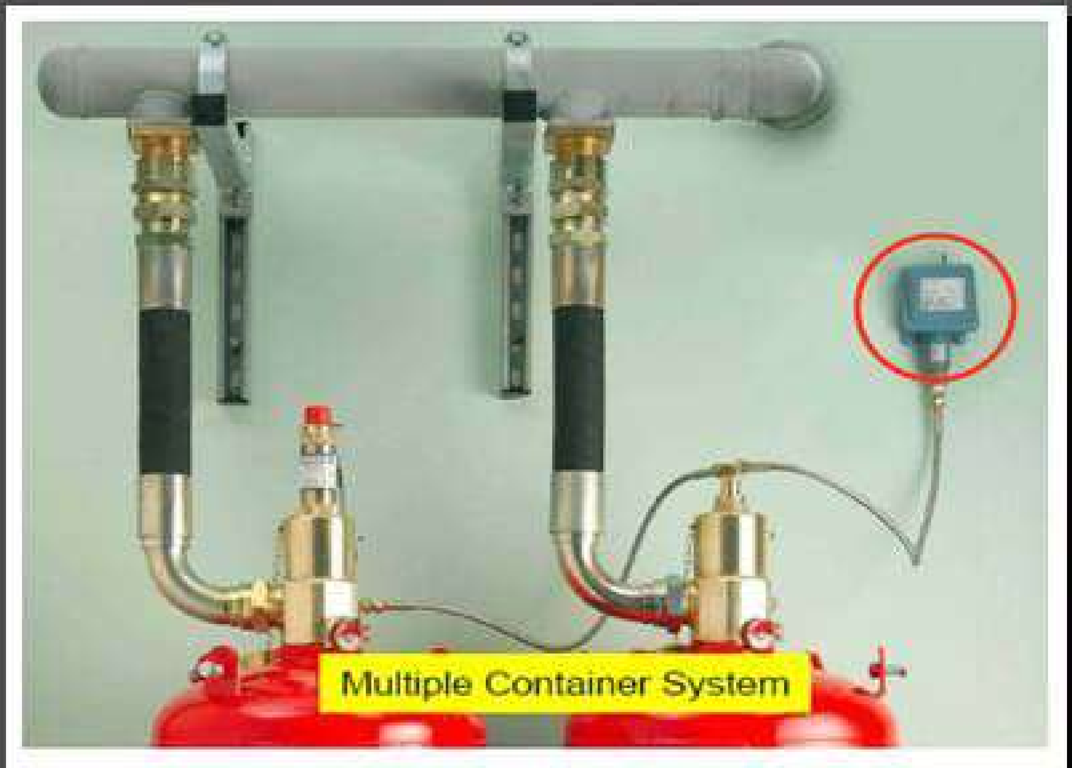
- cylinders are divided in to "Main" or "Reserve"

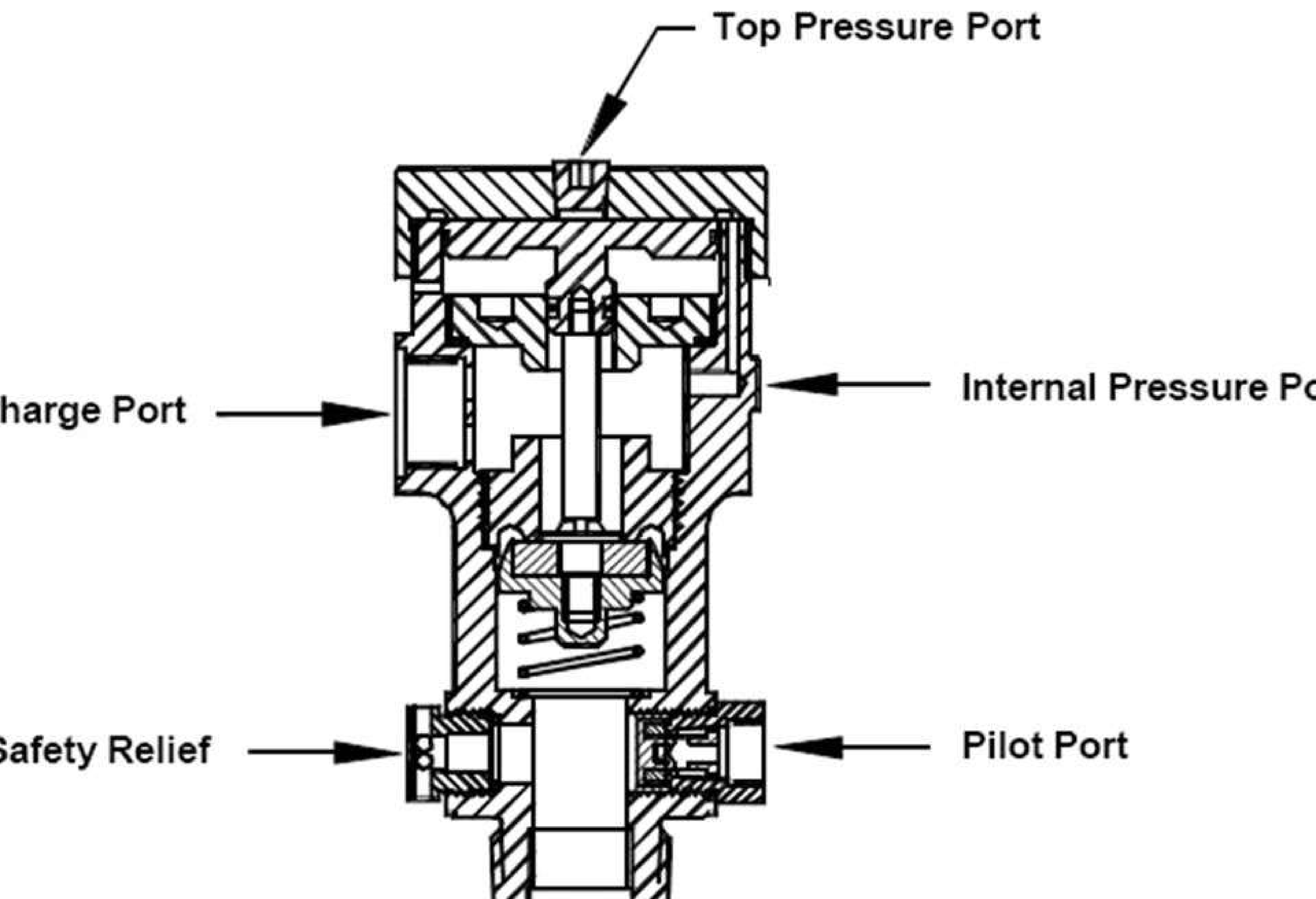
Co2 System Equipment

CYLINDER VALVE









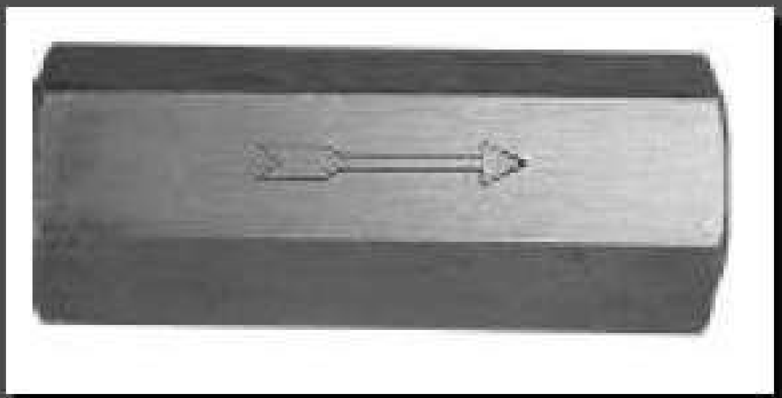
Top Pressure Port
harge Port
Internal Pressure Po
Safety Relief
Pilot Port

Co2 System Equipment

Other Components

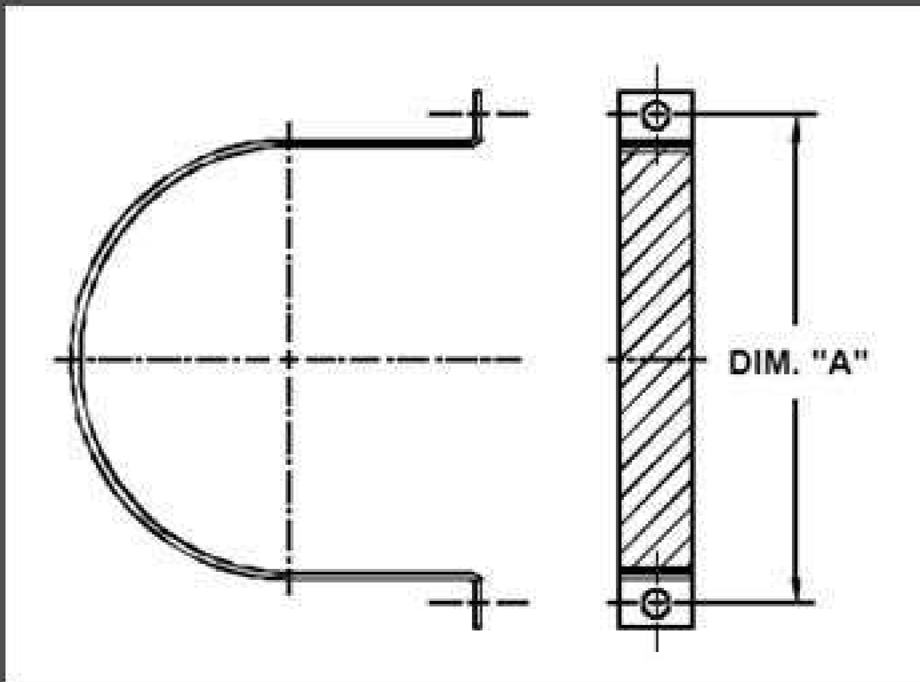
Pressure Switch

Safety Relief valve



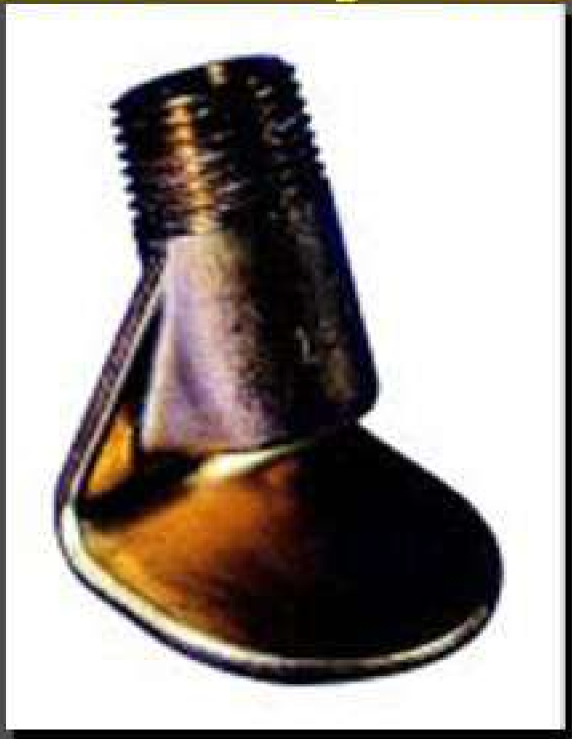
Check valve

Weight bracket



Cylinder bracket

Other Components



Baffle Nozzle

Radial Nozzle

Vent Nozzle

S-type Nozzle

CO2 System Design

Co2 System

General:

- Carbon Dioxide is effective in areas where flammable solids, liquids, and vapors are present. Fires in these hazards spread very rapidly.
- Carbon Dioxide systems consist of single or multiple cylinders discharging into a system of distribution piping that terminates at special Carbon Dioxide discharge nozzles.
- Carbon Dioxide systems can be actuated automatically, pneumatically, or manually. Automatically operated systems incorporate the use of smoke, thermal, or flame detectors connected to a system control panel to actuate electrical solenoids; thus releasing the Carbon Dioxide from the cylinders. Pneumatically operated systems utilize

Co2 System

General:

- Carbon Dioxide systems are designed to comply with specific design criteria in accordance with NFPA 12 .

Co2 System

Total Flood Application:

A Total Flood Carbon Dioxide System design can be defined as follows:

A fixed supply of Carbon Dioxide agent discharging through piping and nozzles into a permanent enclosure that is capable of containing the Carbon Dioxide agent.

Therefore, an extinguishing concentration of Carbon Dioxide can be established and maintained for a specific period of time.

Types of Fires.

Fires that can be extinguished by total flooding methods shall be divided into the following two categories:

(1) Surface fires involving flammable liquids, gases, and solids

(2) Deep-seated fires involving solids subject to smoldering

Co2 System

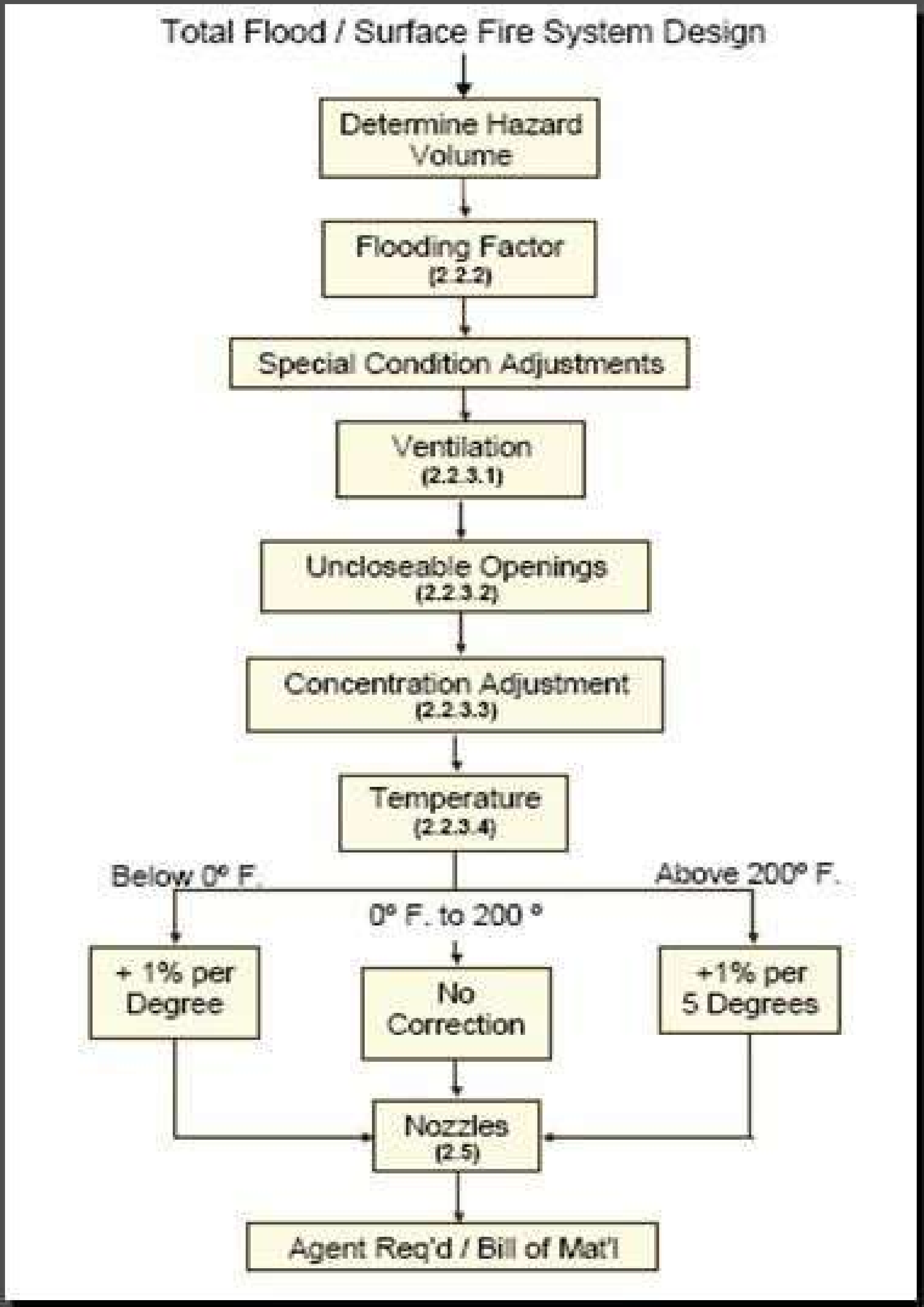
Total Flood Application:

- **Surface fires are subject to prompt extinguishment when carbon dioxide is quickly** introduced into the enclosure in a quantity to overcome leakage and provide an extinguishing concentration for the particular materials involved.
- **Deep-seated fires, the required extinguishing concentration shall be maintained** for a period of time to allow the smoldering to be extinguished and the material to cool to a point at which re-ignition will not occur when the inert atmosphere is dissipated.

Co2 System

TOTAL FLOOD/ SURFACE FIRE SYSTEMS

The necessary steps that need to be taken into consideration when designing a total flood / surface fire system:



Co2 System

HAZARD VOLUME

- Determine the volume of the hazard by multiplying (length) x (width) x (height).
- For total-flood applications, the volume can be reduced to exclude any permanent, non-removable, or impermeable structures from the overall volume of the protected space.

FLOODING FACTORS FOR SURFACE FIRES

- The minimum extinguishing concentration required for Surface fires is 34% by volume.
- To determine the base Carbon Dioxide agent requirement, multiply the hazard volume by the flooding factors in the following table:

FLOODING FACTORS FOR SURFACE FIRES			
Metric Values			
Vol. of Space m^3.	Vol. Factor m^3 / kg. CO_2	Vol. Factor kg. CO_2 / m^3.	Min. Qty. CO_2 kg.
Up to 3.96	0.86	1.15	***
3.97 – 14.15	0.93	1.07	4.5
14.16 – 45.28	0.99	1.01	15.1
45.29 – 127.35	1.11	0.90	45.4
127.36 – 1,415.0	1.25	0.80	113.5
Over 1,415.0	1.38	0.77	1135.0

Co2 System

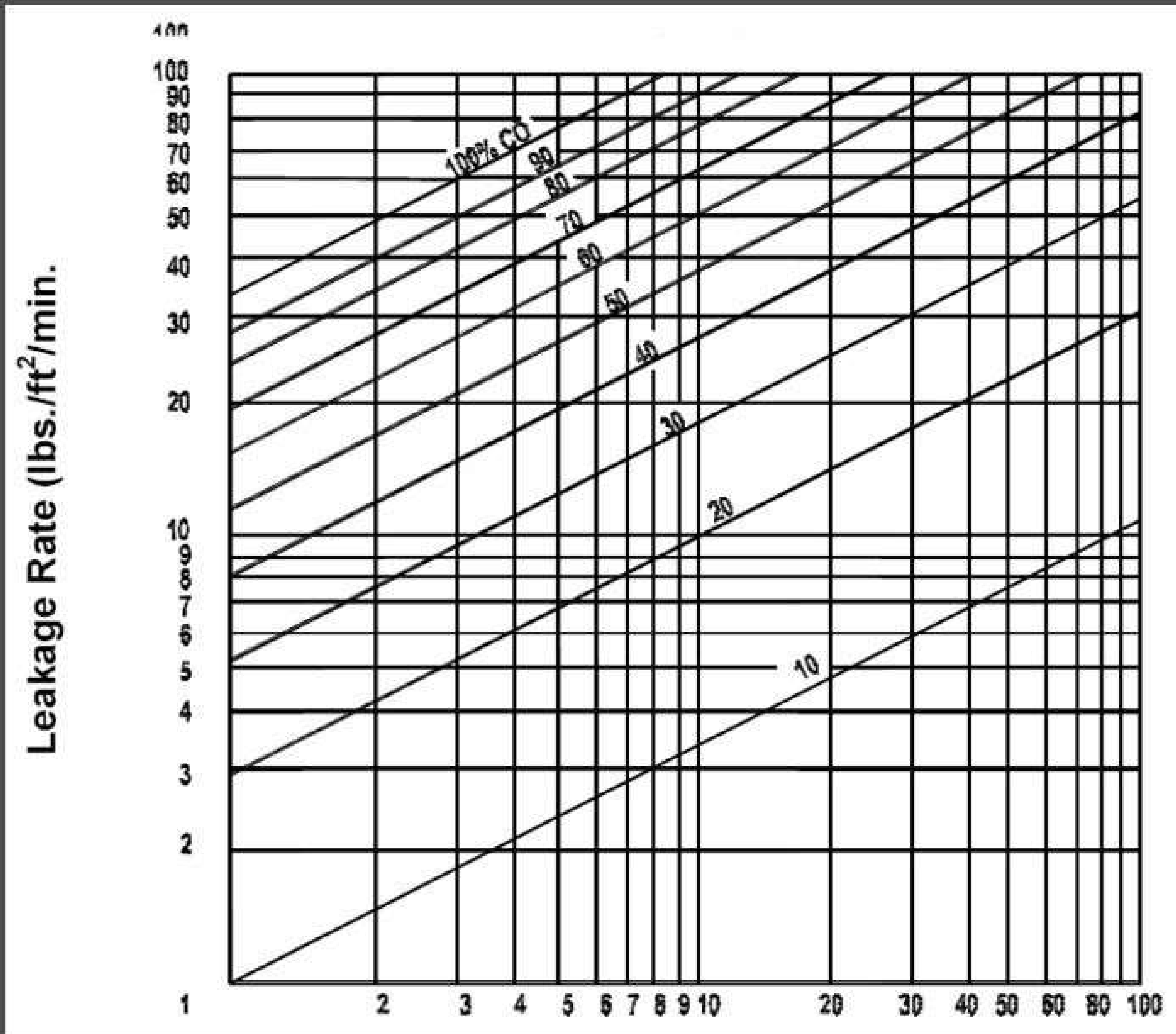
VENTILATION

- The amount must be determined by multiplying the volume moved (cfm) during the required holding period by the flooding factor used to determine the base quantity required.
- It is recommendation to shutdown and/or damper the ventilation system for the Carbon Dioxide system discharges.

UNCLOSEABLE OPENINGS

- All uncloseable openings in a protected hazard must be compensated by providing additional Carbon Dioxide.

Co2 System



100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
Leakage Rate (lbs./ft^2/min.
100% CO
90
80
70
60
50
40
30
20
10
2
3
4
5
6
7
8
9
10
20
30
40
50
60
80
100
Center of Opening to Ceiling (ft.)

Co2 System

To determine the additional amount of Carbon Dioxide required to compensate for the leakage, proceed as follows:

1- Find the intersection of the vertical line (representing the distance from the center of an opening to the top of the enclosure) in feet and the diagonal line (representing the design concentration of Carbon Dioxide).

2- Follow a horizontal line left to the "Leakage Rate" axis to determine the leakage rate value in lbs./min./ft.2 *(the equivalent metric value by using the conversion value of 1 lb./min./ft.2 = 4.89 kg/min./m2)*

EXCEPTION: If the opening(s) is in the side wall(s) only, the area of the wall openings can be divided by two.

- If the opening(s) is in the ceiling, no additional Carbon Dioxide is required to compensate for this opening(s).

Co2 System

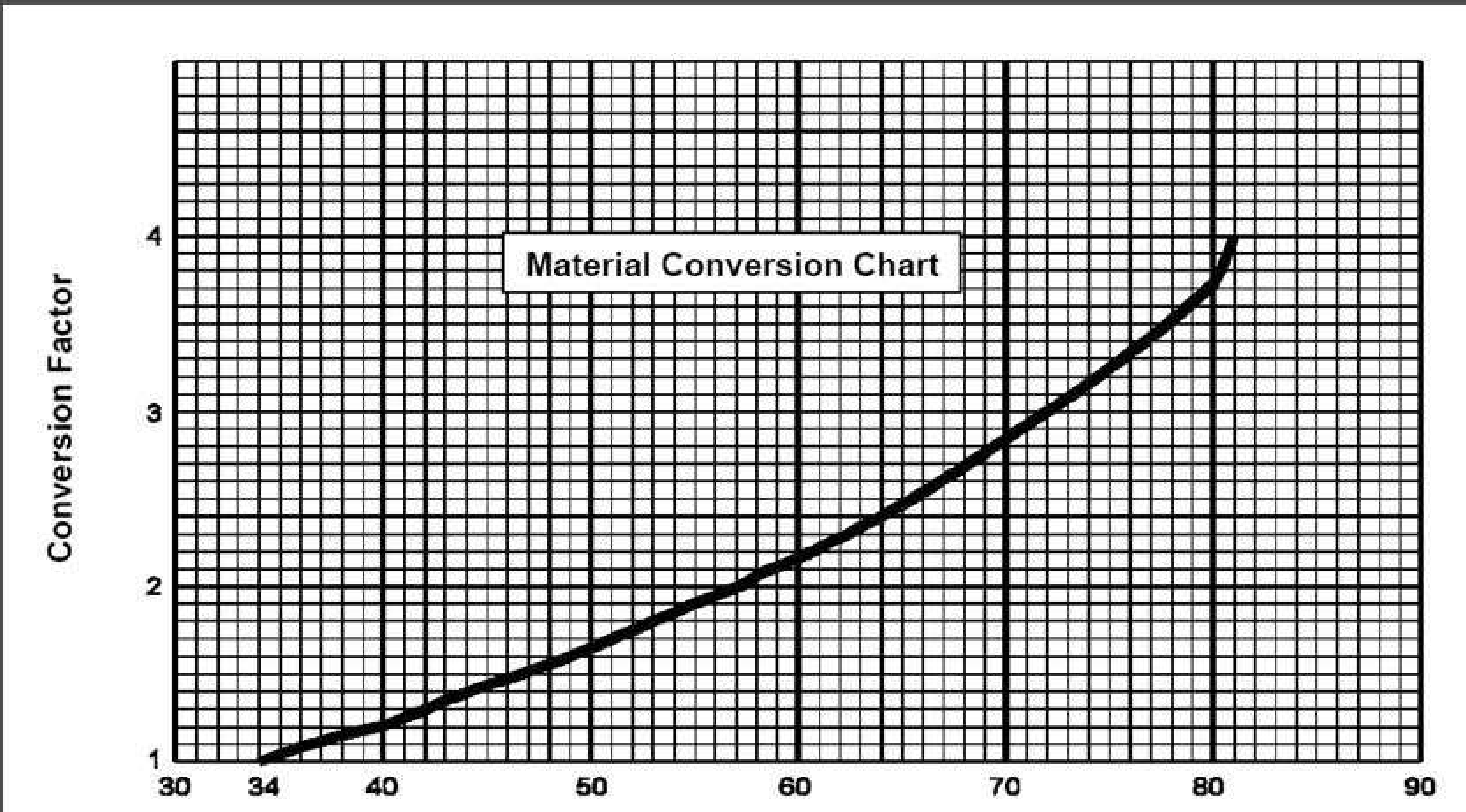
CONCENTRATION ADJUSTMENT FOR SPECIAL MATERIALS

- Some products and / or materials require a higher extinguishing concentration of Carbon Dioxide due to their specific chemical characteristics. Therefore, the design concentration must be adjusted by a "Material Conversion Factor" if any of these materials are present

MINIMUM CARBON DIOXIDE EXTINGUISHING CONCENTRATIONS					
Material or Product	Min. Conc. %	Material or Product	Min. Conc. %	Material or Product	Min. Conc. %
Acetylene	66	Ethane	40	JP-4	36
Acetone	34	Ethyl Alcohol	43	Kerosene	34
Aviation Gas – Grades 115/145	36	Ethyl Ether	46	Methane	34
Benzol, Benzene	37	Ethylene	49	Methyl Acetate	35
Butadiene	41	Ethylene Dichloride	34	Methyl Alcohol	40
Butane	34	Ethylene Oxide	53	Methyl Butene-I	36
Butane-I	37	Gasoline	34	Methyl Ethyl Ketone (MEK)	40
Carbon Disulfide	72	Hexane	35	Methyl Formate	39
Carbon Monoxide	64	Higher Paraffin Hydrocarbons	34	Pentane	35
Coal or Natural Gas	37	Hydrogen	75	Propane	36
Cyclopropane	37	Hydrogen Sulfide	36	Propylene	36
Diethyl Ether	40	Isobutane	36	Quench/Lube Oils	34
Dimethyl Ether	40	Isobutylene	34	Toluene	40
Dowtherm	46	Isobutyl Formate	34		

Co2 System

CONCENTRATION ADJUSTMENT FOR SPECIAL MATERIALS



MINIMUM DISCHARGE TIME / SURFACE FIRE APPLICATION

For surface-type applications, the calculated agent quantity must be discharged within one (1) minute.

SPECIAL LIQUIDS

If a hazard contains a liquid having an auto-ignition temperature below its boiling point, (i.e. paraffin wax and cooking oils), the Carbon Dioxide concentration shall be maintained for a period sufficient for the liquid temperature to cool below its auto-ignition temperature. In this circumstance, the minimum liquid discharge time shall be three (3) minutes.

Co2 System

TEMPERATURE CONSIDERATIONS

There are two areas of concern as it relates to temperature:

HIGH TEMPERATURES

When protecting hazards where the normal operating temperature is greater than 200°F (93.3°C), the amount of Carbon Dioxide required must be increased. For every five (5) degrees F. above 200°F (93.3°C), an additional one percent (1%) increase in the calculated quantity of Carbon Dioxide agent must be provided.

LOW TEMPERATURES

When the protected hazard has a normal operating temperature of less than 0°F (-17.8°C), the amount of Carbon Dioxide agent required must be increased. For every one (1) degree F. below 0°F (-17.8°C), an additional one percent (1%) increase in the calculated quantity of Carbon Dioxide agent must be provided

Co2 System

Total Flooding Deep Seated Fires:

Deep-Seated hazards are those in which the materials involved are subject to smoldering fire conditions.

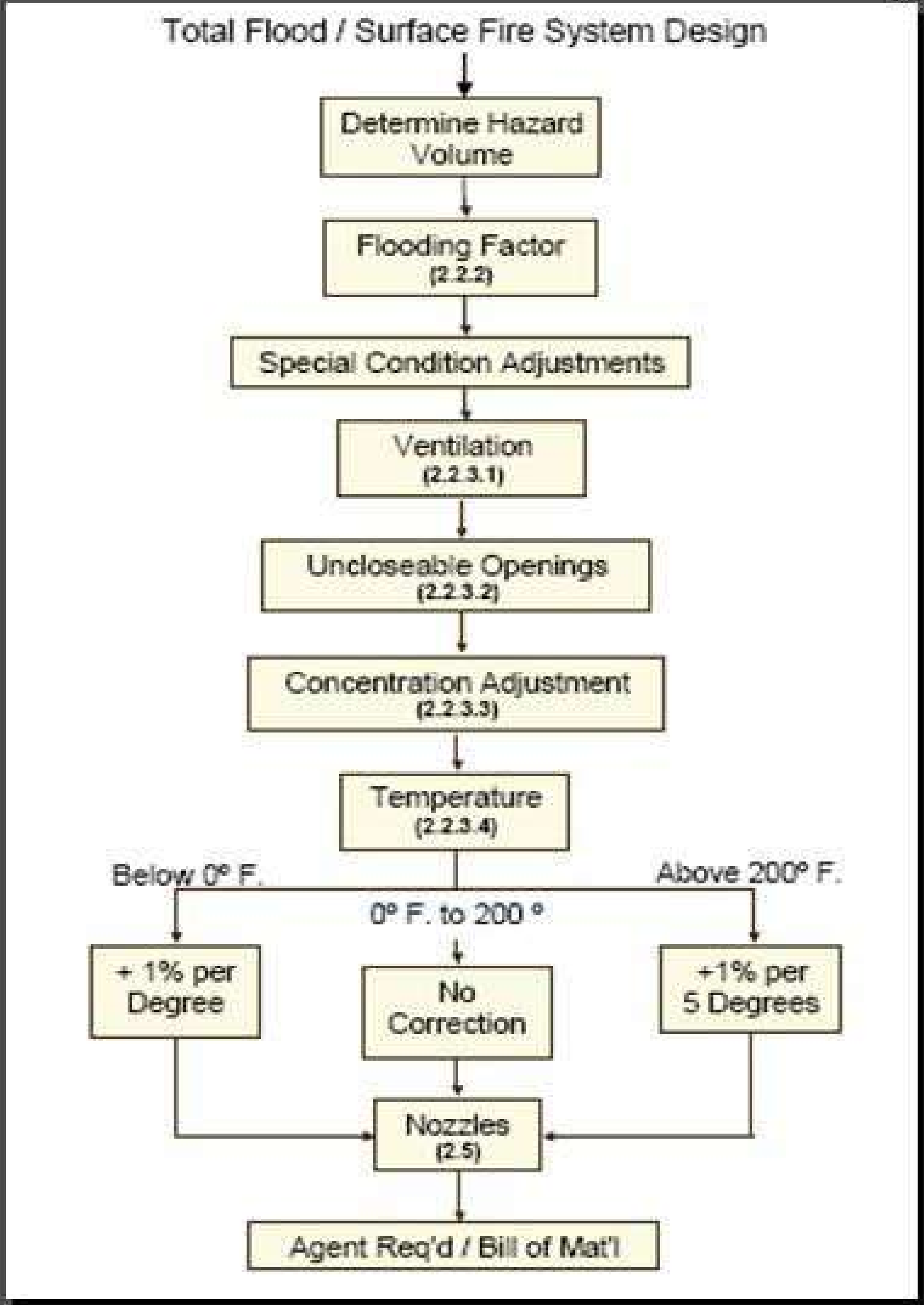
Generally, this involves "Class A" products such as wood, paper, cloth, or any similar material that leaves a carbon ash residue. The quantity of Carbon Dioxide necessary for a Deep-Seated hazard is based on tight enclosures.

After the design concentration is reached, the concentration shall be maintained for a substantial period of time; but not less than twenty (20) minutes.

Co2 System

TOTAL FLOOD/ DEEP SEATED FIRE SYSTEMS

The necessary steps that need to be taken into consideration when designing a total flood / deep seated fire system:



Co2 System

TOTAL FLOOD/ DEEP SEATED FIRE SYSTEMS

HAZARD VOLUME

- Determine the volume of the hazard by multiplying (length) x (width) x (height). *For total-flood applications, the volume can be reduced to exclude any permanent, non-removable, or impermeable structures from the overall*

FLOODING FACTORS FOR DEEP-SEATED FIRES

- The flooding factor used for a system design is based on the specific hazard being protected.

FLOODING FACTORS FOR SPECIFIC HAZARDS					
Design Conc.	ft^3 / lb. CO_2	lb. CO_2 / ft^3	m^3 / kg. CO_2	kg. CO_2 / m^3	Specific Hazard
50%	10	0.100	0.62	1.60	Dry electrical hazards in general. (Spaces 0 - 2,000 ft^3./ 56.6 m^3)
50%	12	0.083 (200 lb/min)	0.75	1.33 (91 kg/min)	Dry electrical hazards (Spaces over 2,000 ft^3 / 56.6 m^3)
65%	8	0.125	0.50	2.00	Record or bulk paper storage, ducts & covered trenches
75%	6	0.166	0.38	2.66	Fur storage vaults, dust collectors, etc.

Co2 System

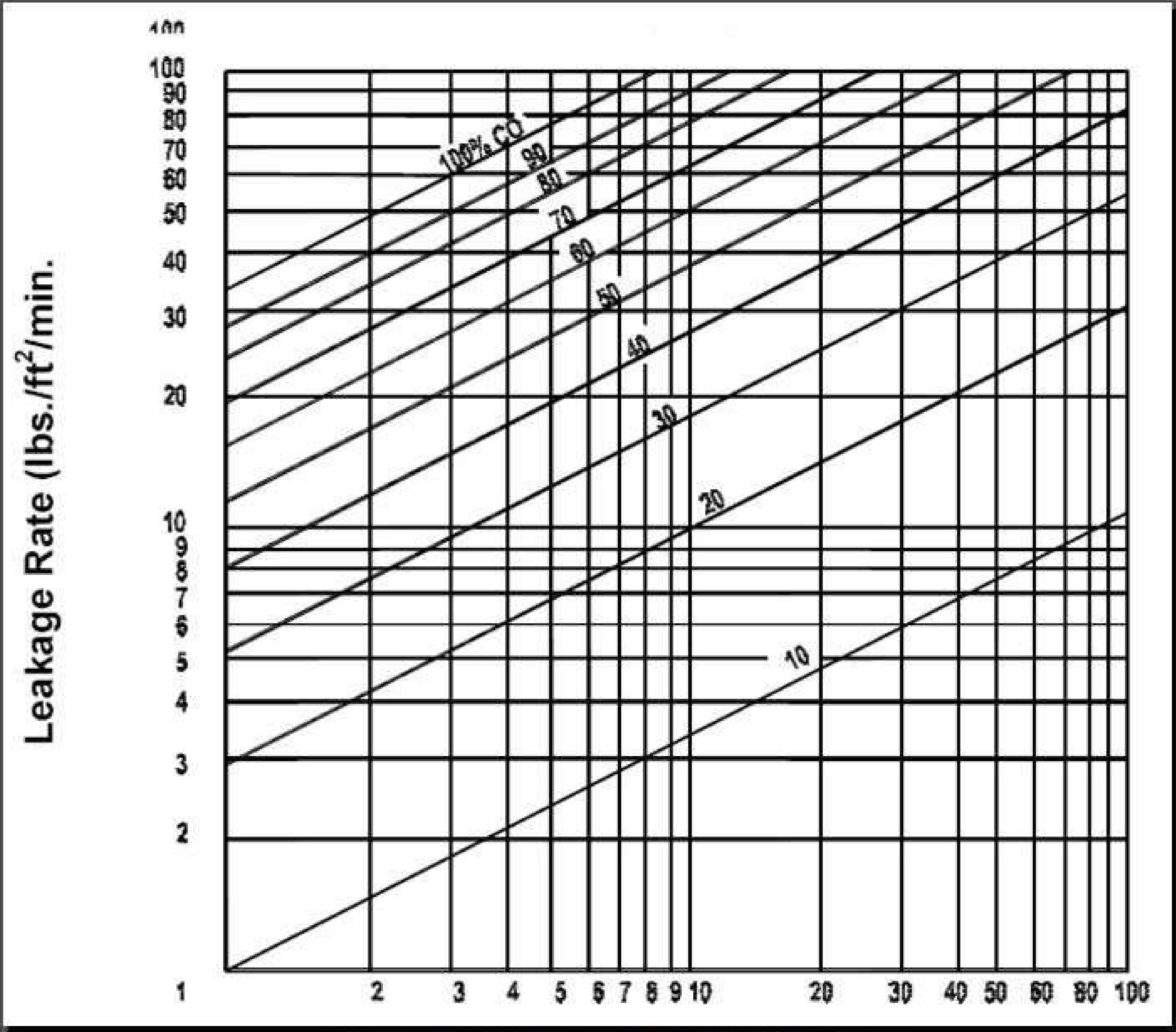
VENTILATION

- The amount must be determined by multiplying the volume moved (cfm) during the required holding period by the flooding factor used to determine the base quantity required.
- It is recommendation to shutdown and/or damper the ventilation system for the Carbon Dioxide system discharges.

UNCLOSEABLE OPENINGS

- All uncloseable openings in a protected hazard must be compensated by providing additional Carbon Dioxide.

Co2 System


Leakage Rate (lbs./ft²/min.
100
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
100% CO
90
80
70
60
50
40
30
20
10
2
3
4
5
6
7
8
9
10
20
30
40
50
60
80
100
Center of Opening to Ceiling (ft.)

Co2 System

To determine the additional amount of Carbon Dioxide required to compensate for the leakage, proceed as follows:

1- Find the intersection of the vertical line (representing the distance from the center of an opening to the top of the enclosure) in feet and the diagonal line (representing the design concentration of Carbon Dioxide).

2- Follow a horizontal line left to the "Leakage Rate" axis to determine the leakage rate value in lbs./min./ft.2 *(the equivalent metric value by using the conversion value of 1 lb./min./ft.2 = 4.89 kg/min./m2)*

EXCEPTION: If the opening(s) is in the side wall(s) only, the area of the wall openings can be divided by two.

- If the opening(s) is in the ceiling, no additional Carbon Dioxide is required to compensate for this opening(s).

Co2 System

CONCENTRATION ADJUSTMENT FOR SPECIAL MATERIALS

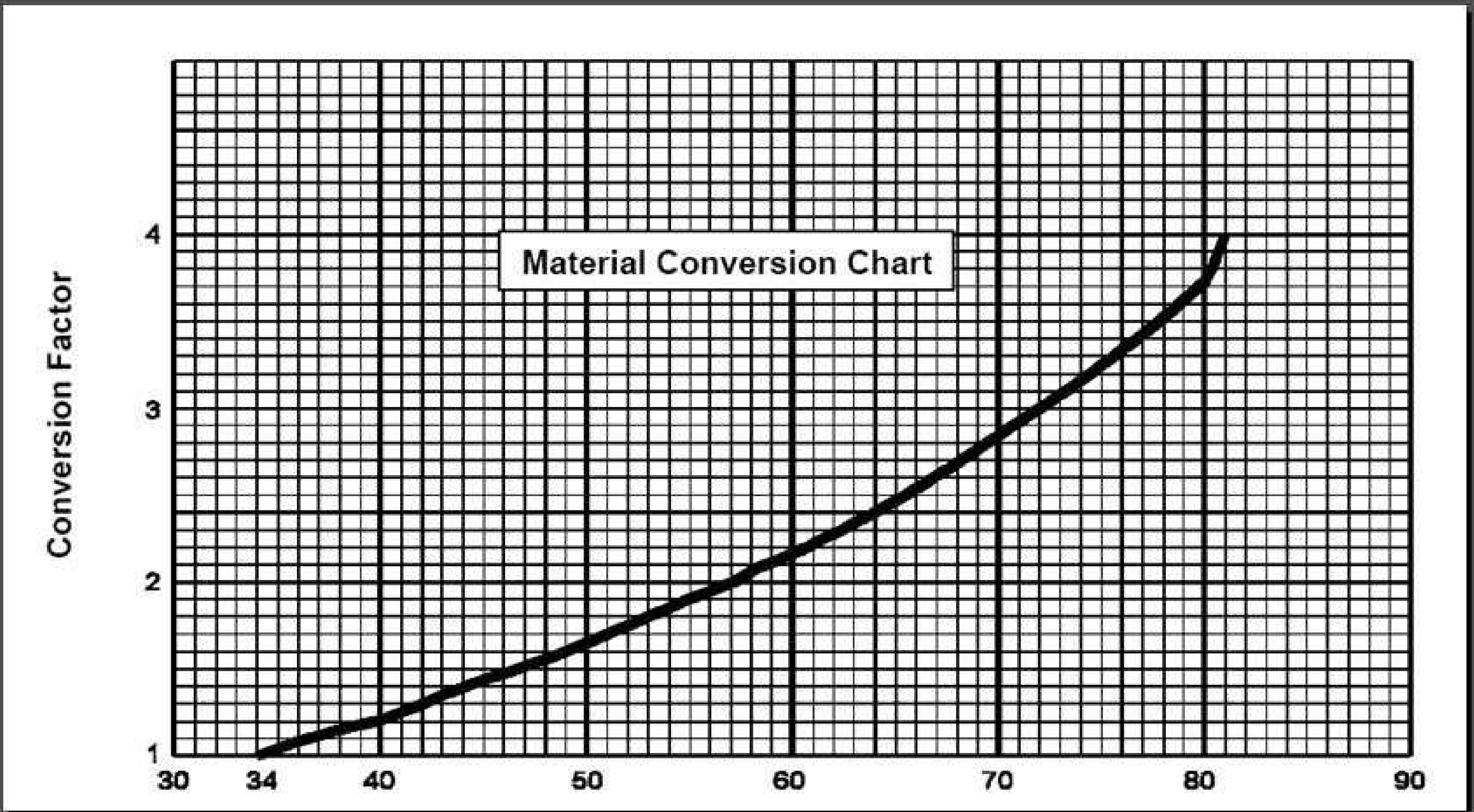
- Some products and / or materials require a higher extinguishing concentration of Carbon Dioxide due to their specific chemical characteristics. Therefore, the design concentration must be adjusted by a "Material Conversion Factor" if any of these materials are present

MINIMUM CARBON DIOXIDE EXTINGUISHING CONCENTRATIONS

Material or Product	Min. Conc. %	Material or Product	Min. Conc. %	Material or Product	Min. Conc. %
Acetylene	66	Ethane	40	JP-4	36
Acetone	34	Ethyl Alcohol	43	Kerosene	34
Aviation Gas – Grades 115/145	36	Ethyl Ether	46	Methane	34
Benzol, Benzene	37	Ethylene	49	Methyl Acetate	35
Butadiene	41	Ethylene Dichloride	34	Methyl Alcohol	40
Butane	34	Ethylene Oxide	53	Methyl Butene-l	36
Butane-l	37	Gasoline	34	Methyl Ethyl Ketone (MEK)	40
Carbon Disulfide	72	Hexane	35	Methyl Formate	39
Carbon Monoxide	64	Higher Paraffin Hydrocarbons	34	Pentane	35
Coal or Natural Gas	37	Hydrogen	75	Propane	36
Cyclopropane	37	Hydrogen Sulfide	36	Propylene	36
Diethyl Ether	40	Isobutane	36	Quench/Lube Oils	34
Dimethyl Ether	40	Isobutylene	34	Toluene	40
Dowtherm	46	Isobutyl Formate	34		

Co2 System

CONCENTRATION ADJUSTMENT FOR SPECIAL MATERIALS



MINIMUM DISCHARGE TIME

Deep-Seated hazard systems are discharged at a slower flow rate and for a longer duration to counter-act the characteristics of a smoldering fire. For Deep-Seated fires, the design concentration shall be achieved within seven (7) minutes.

COMBINED SURFACE FIRE AND DEEP SEATED HAZARDS

Therefore, the Carbon Dioxide must be discharged within one (1) minute to satisfy the Surface Fire requirements and maintain the twenty-(20) minute hold time requirement associated with a Deep-Seated Fire.

Co2 System

TEMPERATURE CONSIDERATIONS

There are two areas of concern as it relates to temperature:

HIGH TEMPERATURES

When protecting hazards where the normal operating temperature is greater than 200°F (93.3°C), the amount of Carbon Dioxide required must be increased. For every five (5) degrees F. above 200°F (93.3°C), an additional one percent (1%) increase in the calculated quantity of Carbon Dioxide agent must be provided.

LOW TEMPERATURES

When the protected hazard has a normal operating temperature of less than 0°F (-17.8°C), the amount of Carbon Dioxide agent required must be increased. For every one (1) degree F. below 0°F (-17.8°C), an additional one percent (1%) increase in the calculated quantity of Carbon Dioxide agent must be provided

Co2 System

NOZZLE SELECTION

All nozzle types are acceptable for use in Total Flood applications. Each nozzle has its own discharge characteristics and recommended range of flow rates.

RADIAL NOZZLES

They are available in 180 degree and 360 degree discharge patterns. Approved for Total Flood applications only.

RADIAL NOZZLES					
Nozzle Description	Flow Rates			Available Orifice Codes	Spacing and/or Height above Floor
	Minimum	Maximum	Recommended		
C80-041 – 360° 1/2" NPT	25 lbs./min. (11.3 kg/min.)	160 lbs./min. (72.6 kg/min.)	100 lbs./min. (45.4 kg/min.)	3.5 thru 13	20 feet (6.1 m)
C80-042 – 180° 1/2" NPT	25 lbs./min. (11.3 kg/min.)	160 lbs./min. (72.6 kg/min.)	100 lbs./min. (45.4 kg/min.)	3.5 thru 13	20 feet (6.1 m)
C80-043 – 360° 3/4" NPT	120 lbs./min. (54.4 kg/min.)	200 lbs./min. (90.7 kg/min.)	150 lbs./min. (68.0 kg/min.)	10 thru 19	25 feet (6.1 m)
C80-044 – 180° 3/4" NPT	120 lbs./min. (54.4 kg/min.)	200 lbs./min. (90.7 kg/min.)	150 lbs./min. (68.0 kg/min.)	10 thru 19	25 feet (6.1 m)
C80-045 – 360° 1" NPT	220 lbs./min. (99.8 kg/min.)	300 lbs./min. (136.1 kg/min.)	250 lbs./min. (113.4 kg/min.)	15 thru 25	30 feet (6.1 m)
C80-046 – 180° 1" NPT	220 lbs./min. (99.8 kg/min.)	300 lbs./min. (136.1 kg/min.)	250 lbs./min. (113.4 kg/min.)	15 thru 25	30 feet (6.1 m)

Co2 System

NOZZLE SELECTION

All nozzle types are acceptable for use in Total Flood applications. Each nozzle has its own discharge characteristics and recommended range of flow rates.

Baffle NOZZLES

The Baffle Nozzle provides a 180-degree, fan-shaped discharge pattern that makes it acceptable for perimeter mounting around the protected hazard space.

BAFFLE NOZZLE – P/N C80-030				
Flow Rates			Available Orifice Codes	Spacing and/or Height above Floor
Minimum	Maximum	Recommended		
25 lbs./min. (11.3 kg/min.)	160 lbs./min. (72.6 kg/min.)	75 lbs./min. (34.0 kg/min.)	1 thru 13.5	20 feet (6.1 m)

Co2 System

NOZZLE SELECTION

All nozzle types are acceptable for use in Total Flood applications. Each nozzle has its own discharge characteristics and recommended range of flow rates.

VENT NOZZLE

Vent Nozzles are primarily installed in ductwork and small enclosures such as shallow ,covered pits; covered trenches, electrical switches and electrical cabinets. The discharge pattern is a narrow, 120-degree cone shape

VENT NOZZLE – P/N C80-020				
Flow Rates			Available Orifice Codes	Spacing and/or Height above Floor
Minimum	Maximum	Recommended		
10 lbs./min. (4.5 kg/min.)	120 lbs./min. (54.4 kg/min.)	60 lbs./min. (27.2 kg/min.)	1 thru 13.5	Special Application

Pipe Size Estimating Table		
Pipe Size (Schedule)	Avg. Flow Rate	
US	lbs./min.	kg/min.
1/2" (40)	15 - 100	6.8 - 45.4
3/4" (40)	101 - 200	45.8 - 90.7
1" (80)	201 - 350	91.2 - 158.8
1-1/4" (80)	351 - 700	159.2 - 317.5
1-1/2" (80)	701 - 1000	318.0 - 453.6
2" (80)	1001 - 1600	454.0 - 725.8
2-1/2" (80)	1601 - 2500	726.2 - 1134.0
3" (80)	2501 - 4000	1134.5 - 1814.4

Clean Agent FM200 (HFC227ea) Fire Extinguishing System

FM 200 System

Agent:

- The extinguishing agent is Heptafluoropropane – more commonly known as HFC-227ea.
- HFC-227ea is a colorless, odorless, liquefied compressed gas
- It is stored as a liquid, but dispensed into the hazard as a colorless, electrically nonconductive, gaseous vapor due to its relatively low boiling point.
- HFC-227ea is safe – and the agent is effective in extinguishing fires at lower concentrations; most of which are well below the NOAEL and LOAEL values.
- HFC-227ea is approved for use in occupied areas up to a 9% concentration (NOAEL) by volume – or up to a 10.5% concentration (LOAEL)

FM 200 System

Agent:

➢ PERFORMANCE

HFC-227ea's mechanism of extinguishing fires is considered active. Its primary action is through physically cooling (*same class of agents used in the refrigeration* industry) the fire at the molecular level.

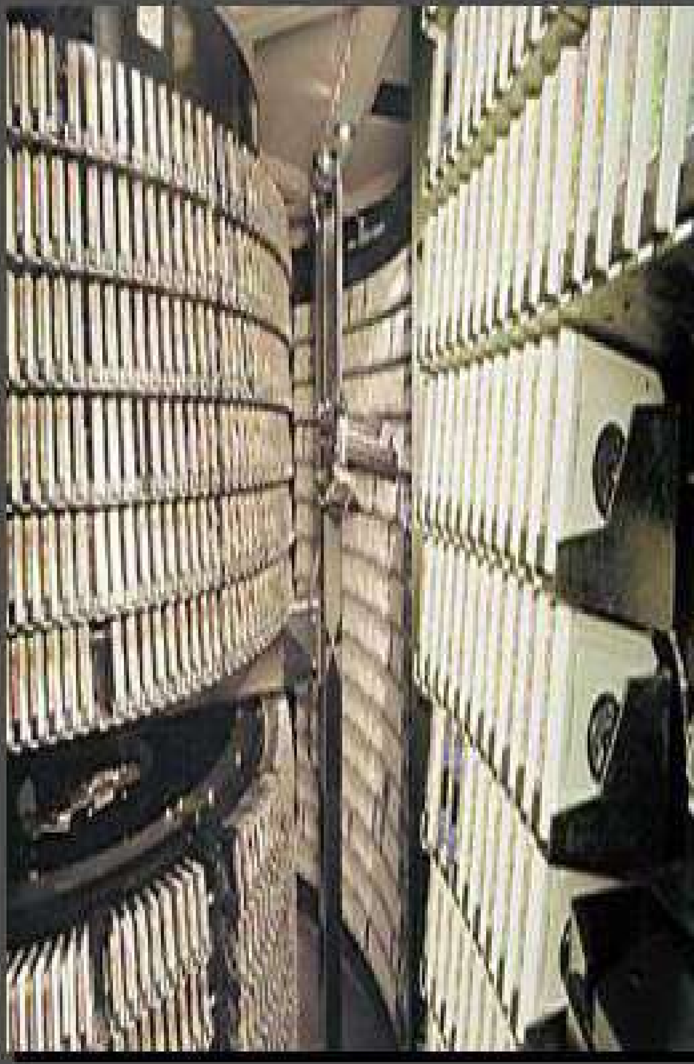
➢PHYSICAL PROPERTIES OF HFC-227ea

Chemical Name	Heptafluoropropane (CF_3CHFCF_3)
Molecular Weight	170.03
Boiling Point @ 760mm Hg	-16.4°C
Freezing Point	-131°C
Critical Temperature	101.7°C
Critical Pressure	29.1 bar
Critical Volume (cc/mole)	274
Critical Density (kg/m^3)	621
Specific Heat, Liquid (kj/kg @ 25°C)	1.184
Specific Heat, Vapor (kj/kg°C) @ constant pressure of 1 ATM @ 25°C	0.808
Heat of Vaporization (kj/kg°C) at Boiling Point	132.6
Thermal Conductivity (W/m°C) of Liquid @ 25°C	0.069
Viscosity, Liquid @ 25°C	0.184 centipoise
Ozone Depletion Potential	0
Estimated Atmospheric Lifetime	31 to 42 years
LC_{50} (Rats; 4 hrs – ppm)	>800,000 ppm

FM 200 System

Applications:

- Electrical Data Processing (EDP)
- Computer facilities
- Data vaults
- Electric Control rooms
- Electrical Cabinets



FM 200 System

Applications:

- Telecommunication.
- Switch rooms.
- UPS / Power rooms.
- Battery rooms.
- Power Plants

  Control rooms.

  Cable spreading vaults.

  Turbine enclosures.
- Hospitals and medical centers

  CT scan rooms

  MRI rooms

  Data center





FM 200 System

Applications:

HFC-227ea Systems shall NOT be used on fires involving the following materials:

- Chemicals or mixtures of chemicals that are capable of rapid oxidation in the absence of air. Examples include Cellulose Nitrate and Gunpowder.
- Reactive metals such as Lithium, Sodium, Potassium, Magnesium, Titanium, Zirconium, Uranium,and Plutonium
- Metal Hydrides such as Sodium Hydride and Lithium Aluminum Hydride

FM 200 System

NOISE :

The high-pressure discharge from the nozzle(s) of a system can cause noise that is loud enough to be startling, but ordinarily insufficient to cause traumatic injury.

CHILLING

Direct contact with the vaporizing agent being discharged from the nozzle(s) will have a chilling effect on objects and can cause frostbite burns to the skin. The liquid phase vaporizes rapidly when mixed with air, thus limiting the hazard to the immediate vicinity of the discharge nozzle.

VISIBILITY

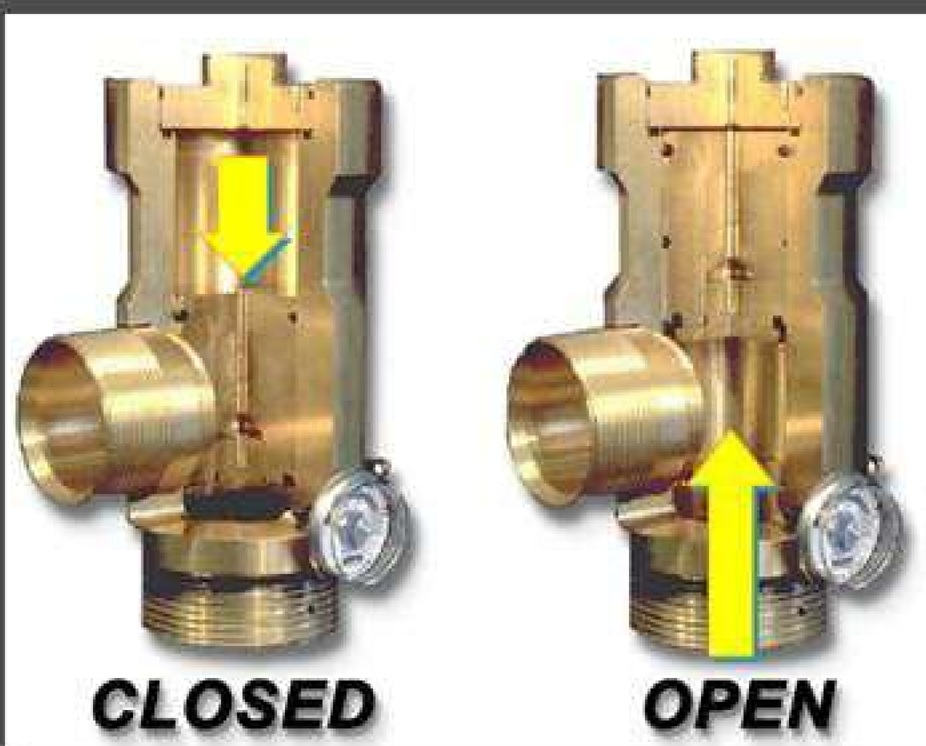
Although HFC-227ea is odorless, discharging the agent into a humid atmosphere may cause a reduction in visibility for a brief period of time due to condensation of water vapor normally present in the room atmosphere.

FM 200 System

Storage Container:

Agent is stored as a liquid Super-pressurized with nitrogen to 25 bar @ 21°C

- Different container sizes with min./max. fill range.
- Container with siphon tube
- Pressure gauge
- Low pressure switch (optional)



FM 200 System

Storage Container:

Small Capacity Container

CONTAINER DATA TABLE

Container Size	Container Part Number	Fill Range (kg)	Container Approval	Container Type	Mounting Position	Valve Size	Tare Weight
5 Liter	70-159	2.5 – 5.5	UL LIsted FM Approved	Seamless	Horizontal or Upright	25mm	9.0kg
9 Liter	70-160	4.5 – 10.0	UL Listed FM Approved	Seamless	Horizontal or Upright	25mm	11.5kg
16 Liter	70-161	8.0 – 17.5	UL Listed FM Approved	Seamless	Horizontal or Upright	25mm	23.0kg
26 Liter	70-162	12.5 – 29.0	UL Listed FM Approved	Seamless	Horizontal or Upright	25mm	28.0kg
26 Liter	70-131	12.5 – 28.0	UL / FM	Welded	Upright (Valve Up)	25mm	24.0kg
45 Liter	70-128	22.0 – 48.5	UL / FM	Welded	Upright (Valve Up)	25mm	34.0kg

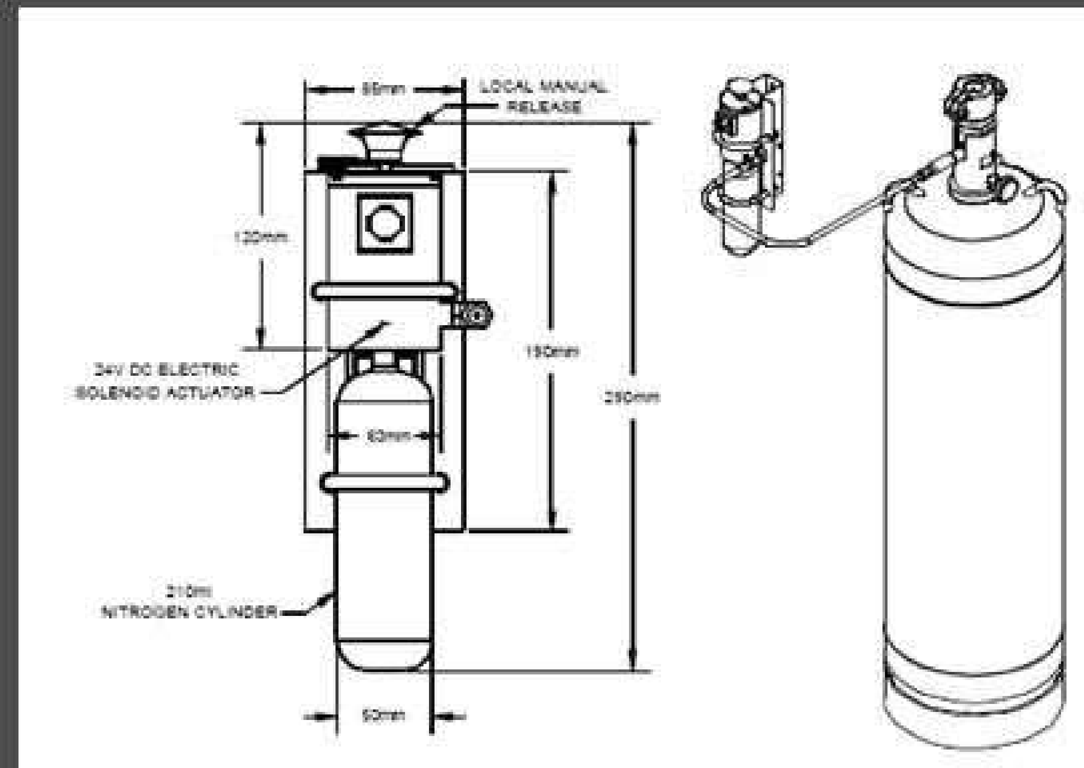
High Capacity Container

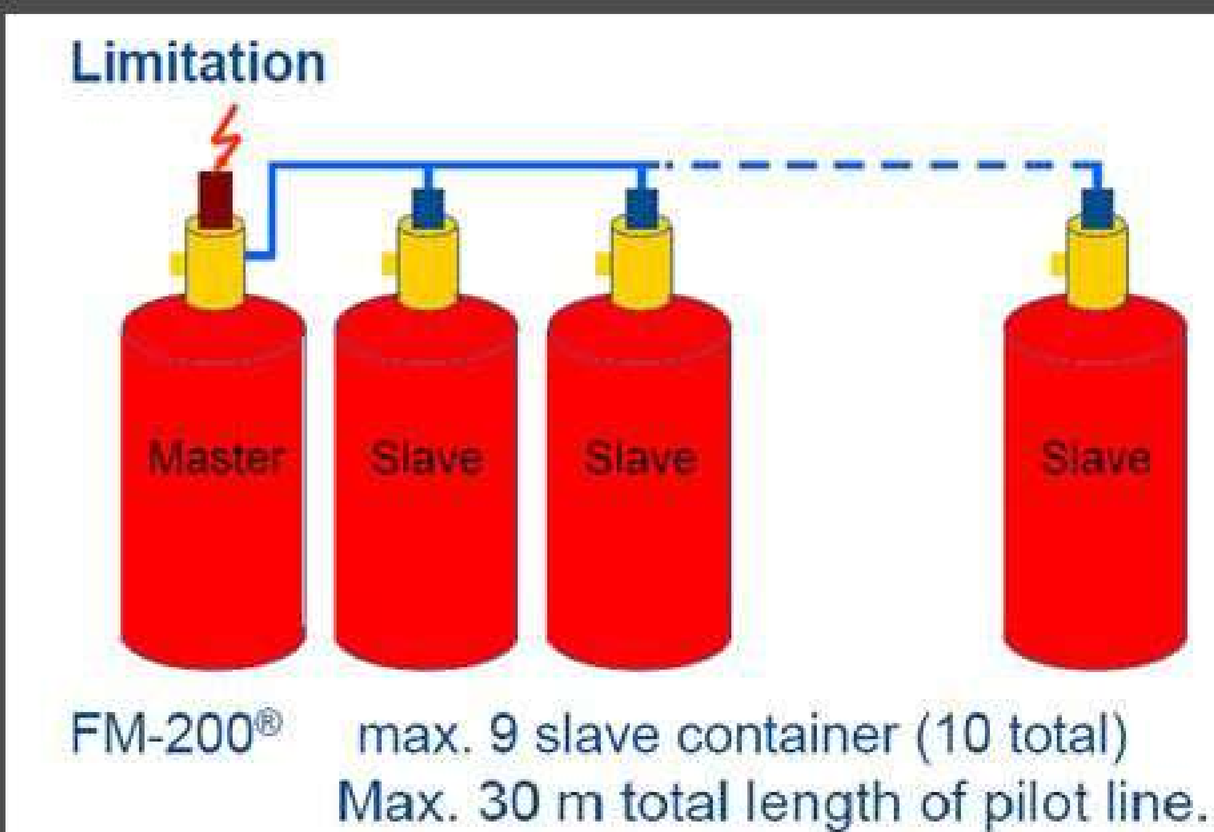
Container Size	Container Part Number	Fill Range (kg)	Container Approval	Mounting Position	Valve Size	Approx. Tare Weight
83 Liter	70-129	40.0 – 89.5	UL / FM	Upright (Valve Up)	50mm	54.0kg
150 Liter	70-130	72.0 – 162.0	UL / FM	Upright (Valve Up)	50mm	87.0kg

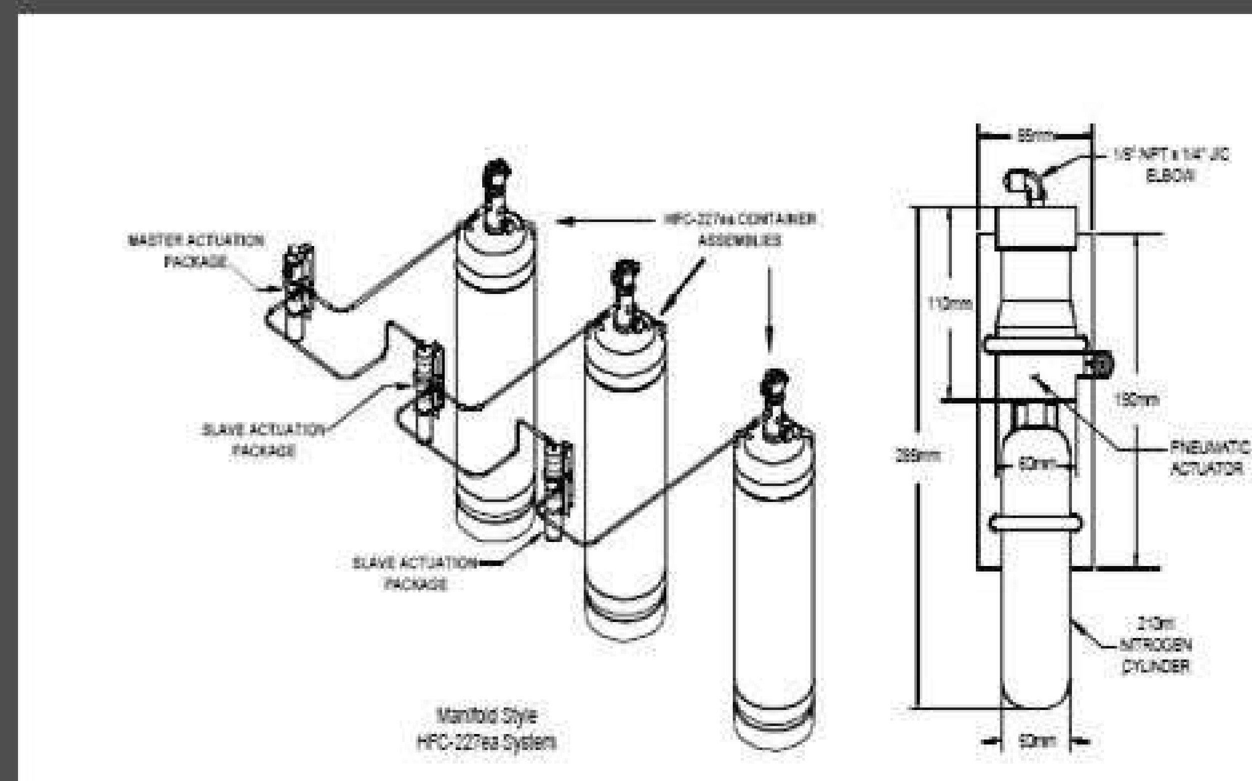
FM 200 System

Actuation:

Master Cylinder







Slave Cylinder

FM 200 System

Other Components

FM200 System Design

FM 200 System

1- DETERMINE HAZARD TYPE

The three Hazard Types are:

- Class “A” (wood, paper, cloth – anything that leaves an ash residue after combustion)
- Class “B” (flammable liquids)
- Class “C” (electrical)

2- DETERMINE CONCENTRATION PERCENTAGE

The following is a guideline to be used in determining the proper agent concentration percentage for the hazard(s) being protected.

For combinations of fuels (hazard types) the design value for the fuel requiring the greatest concentration MUST be used.

FM 200 System

2- DETERMINE CONCENTRATION PERCENTAGE

CLASS A OR C HAZARDS

Systems protecting hazards containing Class A or C flammable materials can generally be designed for a 7.7% concentration.

Fuel	Minimum design concentration (%)
Heptane	8,6
Surface class A hazards [a]	7,5
NOTE 1: Extinguishing concentrations were derived in accordance with ISO 14520-1:2000, annex B, using the VdS cup burner. NOTE 2: Verified by the full-scale ULI cup burner method.	
[a] See 7.5.1.3 of ISO 14520-1:2000	

FM 200 System

2- DETERMINE CONCENTRATION PERCENTAGE

CLASS B FLAMMABLE LIQUIDS

Systems protecting hazards containing Class B Flammable Liquids MUST be designed for the highest concentration required of the specific fuels listed. Therefore, the designer must perform an audit of the hazard space to identify the flammable liquids involved and their associated design concentrations. The fuel that requires the highest concentration shall be the one that determines the design concentration for the hazard.

Fuel	Minimum design concentration (%)
Acetone	8,5
Ethanol	9,9
Ethylene glycol	10,1
Methanol	12,9
Tolulene	6,6

NOTE 1: Derived by the VdS cup burner method.

FM 200 System

3- DETERMINE THE HAZARD VOLUME :

The volume is calculated by multiplying the length x width x height of the space.

CALCULATE AGENT QUANTITY

The next step in designing the HFC-227ea system is to determine the base quantity of agent required to provide the desired concentration within the hazard(s) being protected. This calculation must be based upon two important criteria:

1- The lowest expected ambient temperature,

2- The design concentration

To determine the agent quantity needed to produce the design concentration level, the Hazard Volume is multiplied by the concentration volume factor.

HFC 227ea total flooding quantity (Ref: ISO 14520-9 and NFPA 2001)

Temp. T (°C)	Specific Vapor Volume S (m^3/kg)	HFC 227ea mass requirements per unit volume of protected space, m/V (kg/m^3) Design concentration (by volume)									
		6%	7%	8%	9%	10%	11%	12%	13%	14%	15%
-10	0.1215	0.5254	0.6196	0.7158	0.8142	0.9147	1.0174	1.1225	1.2301	1.3401	1.4527
-5	0.1241	0.5142	0.6064	0.7005	0.7967	0.8951	0.9957	1.0985	1.2038	1.3114	1.4216
0	0.1268	0.5034	0.5936	0.6858	0.7800	0.8763	0.9748	1.0755	1.1785	1.2839	1.3918
5	0.1294	0.4932	0.5816	0.6719	0.7642	0.8586	0.9550	1.0537	1.1546	1.2579	1.3636
10	0.1320	0.4834	0.5700	0.6585	0.7490	0.8414	0.9360	1.0327	1.1316	1.2328	1.3364
15	0.1347	0.4740	0.5589	0.6457	0.7344	0.8251	0.9178	1.0126	1.1096	1.2089	1.3105
20	0.1373	0.4650	0.5483	0.6335	0.7205	0.8094	0.9004	0.9934	1.0886	1.1859	1.2856
25	0.1399	0.4564	0.5382	0.6217	0.7071	0.7944	0.8837	0.9750	1.0684	1.1640	1.2618
30	0.1425	0.4481	0.5284	0.6104	0.6943	0.7800	0.8676	0.9573	1.0490	1.1428	1.2388
35	0.1450	0.4401	0.5190	0.5996	0.6819	0.7661	0.8522	0.9402	1.0303	1.1224	1.2168
40	0.1476	0.4324	0.5099	0.5891	0.6701	0.7528	0.8374	0.9239	1.0124	1.1029	1.1956
45	0.1502	0.4250	0.5012	0.5790	0.6586	0.7399	0.8230	0.9080	0.9950	1.0840	1.1751
50	0.1527	0.4180	0.4929	0.5694	0.6476	0.7276	0.8093	0.8929	0.9784	1.0660	1.1555
55	0.1553	0.4111	0.4847	0.5600	0.6369	0.7156	0.7960	0.8782	0.9623	1.0484	1.1365
60	0.1578	0.4045	0.4770	0.5510	0.6267	0.7041	0.7832	0.8641	0.9469	1.0316	1.1183
65	0.1604	0.3980	0.4694	0.5423	0.6167	0.6929	0.7707	0.8504	0.9318	1.0152	1.1005
70	0.1629	0.3919	0.4621	0.5338	0.6072	0.6821	0.7588	0.8371	0.9173	0.9994	1.0834
75	0.1654	0.3859	0.4550	0.5257	0.5979	0.6717	0.7471	0.8243	0.9033	0.9841	1.0668
80	0.1679	0.3801	0.4482	0.5178	0.5890	0.6617	0.7360	0.8120	0.8898	0.9694	1.0509
85	0.1704	0.3745	0.4416	0.5102	0.5803	0.6519	0.7251	0.8000	0.8767	0.9551	1.0354
90	0.1730	0.3690	0.4351	0.5027	0.5717	0.6423	0.7145	0.7883	0.8638	0.9411	1.0202
95	0.1755	0.3638	0.4290	0.4956	0.5636	0.6332	0.7044	0.7771	0.8516	0.9277	1.0057
100	0.1780	0.3587	0.4229	0.4886	0.5557	0.6243	0.6945	0.7662	0.8396	0.9147	0.9916

FM 200 System

4- NOZZLE SELECTION:

The selection of nozzles is generally determined by the amount of HFC-227ea required (flow rate) vs. the flow rate capabilities of the nozzle(s). All HFC-227ea Systems are required to discharge the agent into the protected space within ten (10) seconds

Each nozzle size is capable of delivering a certain range of flow rates. To determine the number and size of nozzles required for each area, use the flow rate table below.

Note – this information is provided for estimation purposes only. The final system design MUST be verified using the HFC-227ea Flow Calculation Program

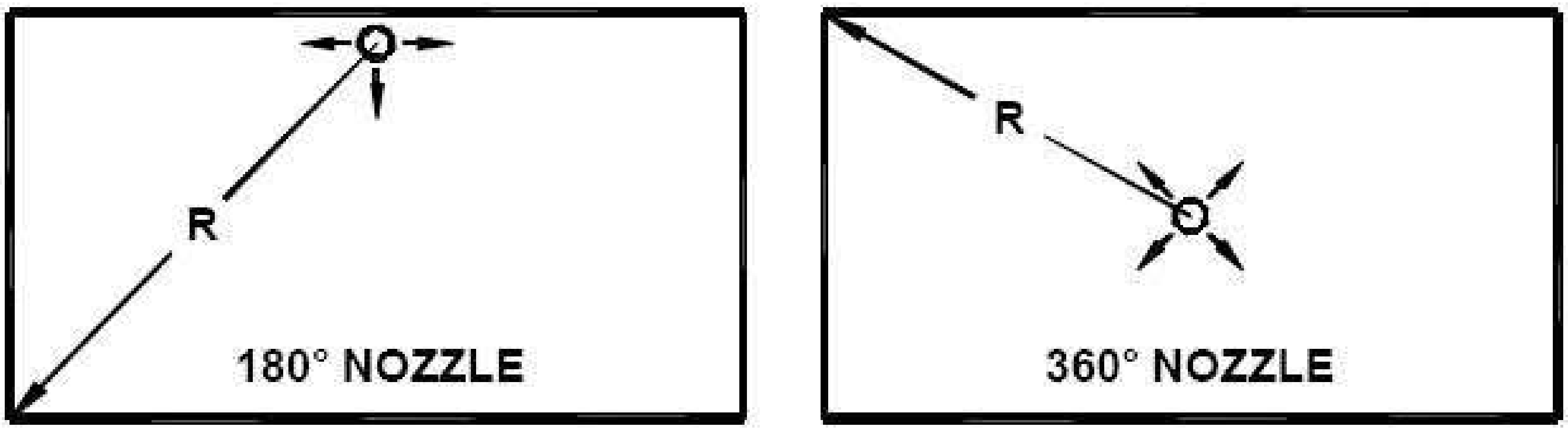
FM 200 System

4- NOZZLE SELECTION:

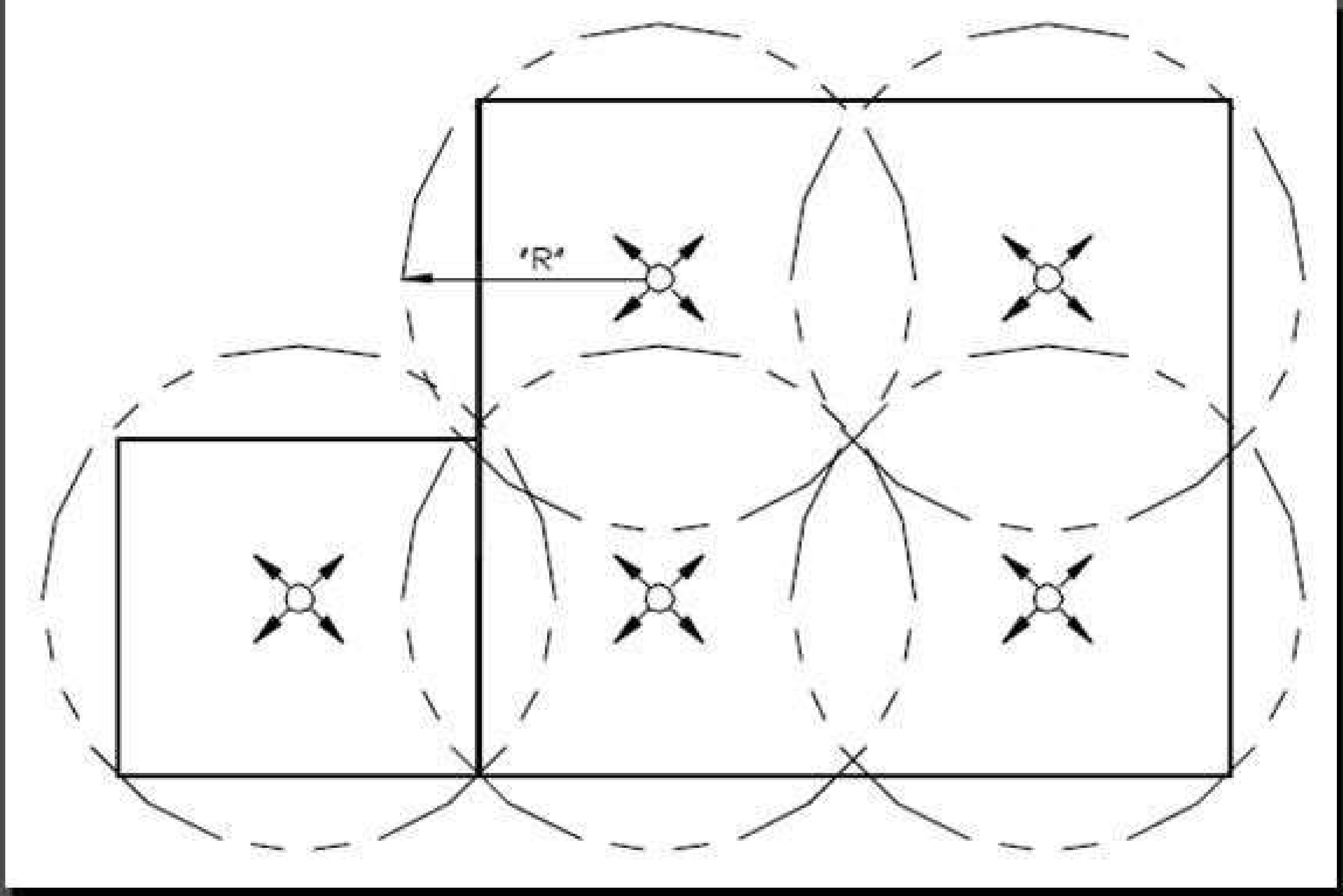
NOZZLE FLOW RATES (METRIC)		
NOMINAL PIPE SIZE	MINIMUM DESIGN FLOW RATE (System Limitation)	MAXIMUM DESIGN FLOW RATE (Estimate only)
10mm	0.3kg/sec.	0.9kg/sec.
15mm	0.5kg/sec.	1.5kg/sec.
20mm	0.9kg/sec.	2.7kg/sec.
25mm	1.5kg/sec.	3.9kg/sec.
32mm	2.6kg/sec.	5.9kg/sec.
40mm	3.8kg/sec.	8.9kg/sec.
50mm	5.9kg/sec.	15.0kg/sec.

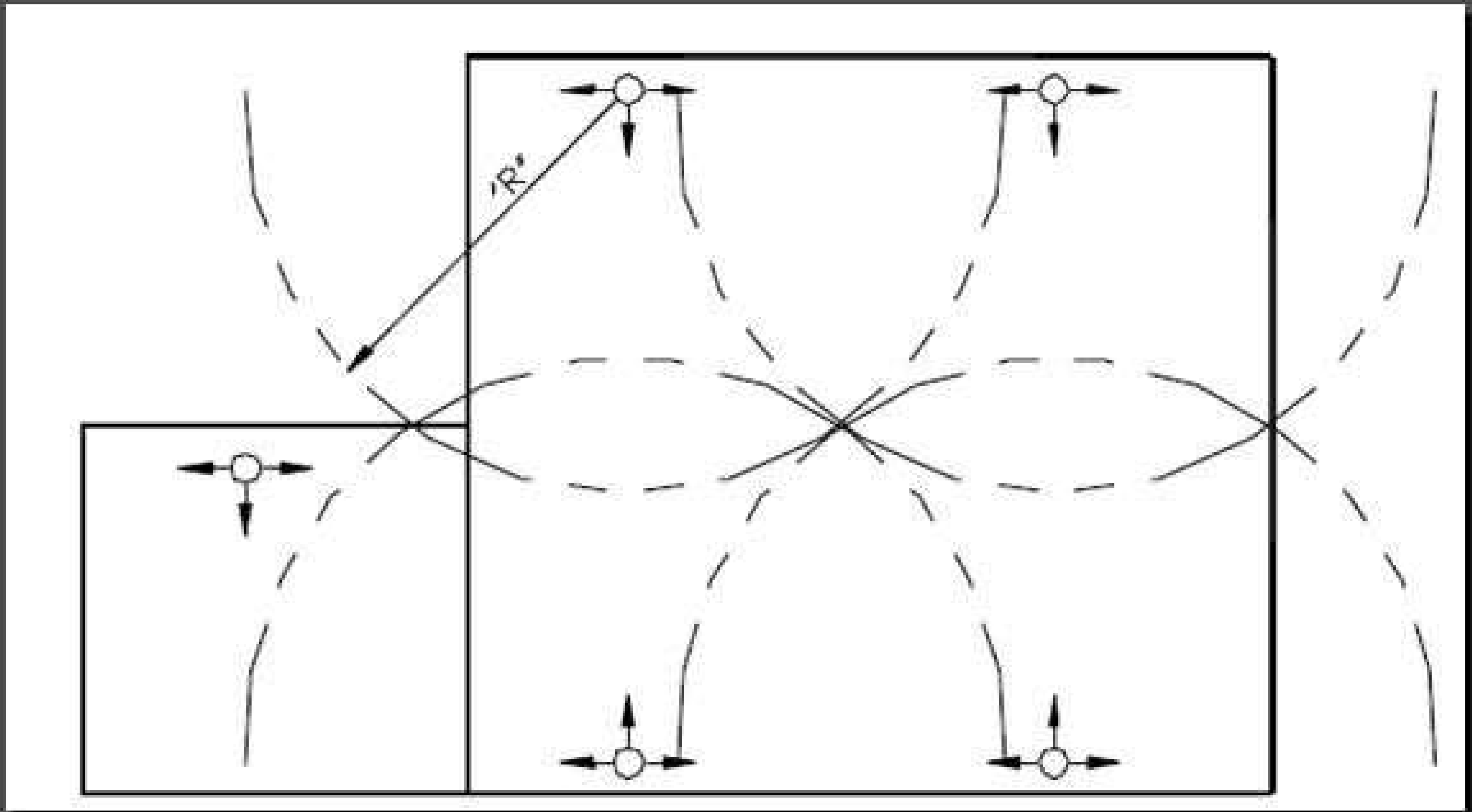
Example: A system supplying 590kg has a system flow rate requirement of 59kg/sec. (590kg ¸ 10sec. = 59 kg/sec.). Refer to the Nozzle Flow Rate Table. The highest possible flow rate for any nozzle size is 15kg/sec.
Therefore, a minimum of four (4) 50mm nozzles will be required.

NOZZLE AREA COVERAGE :

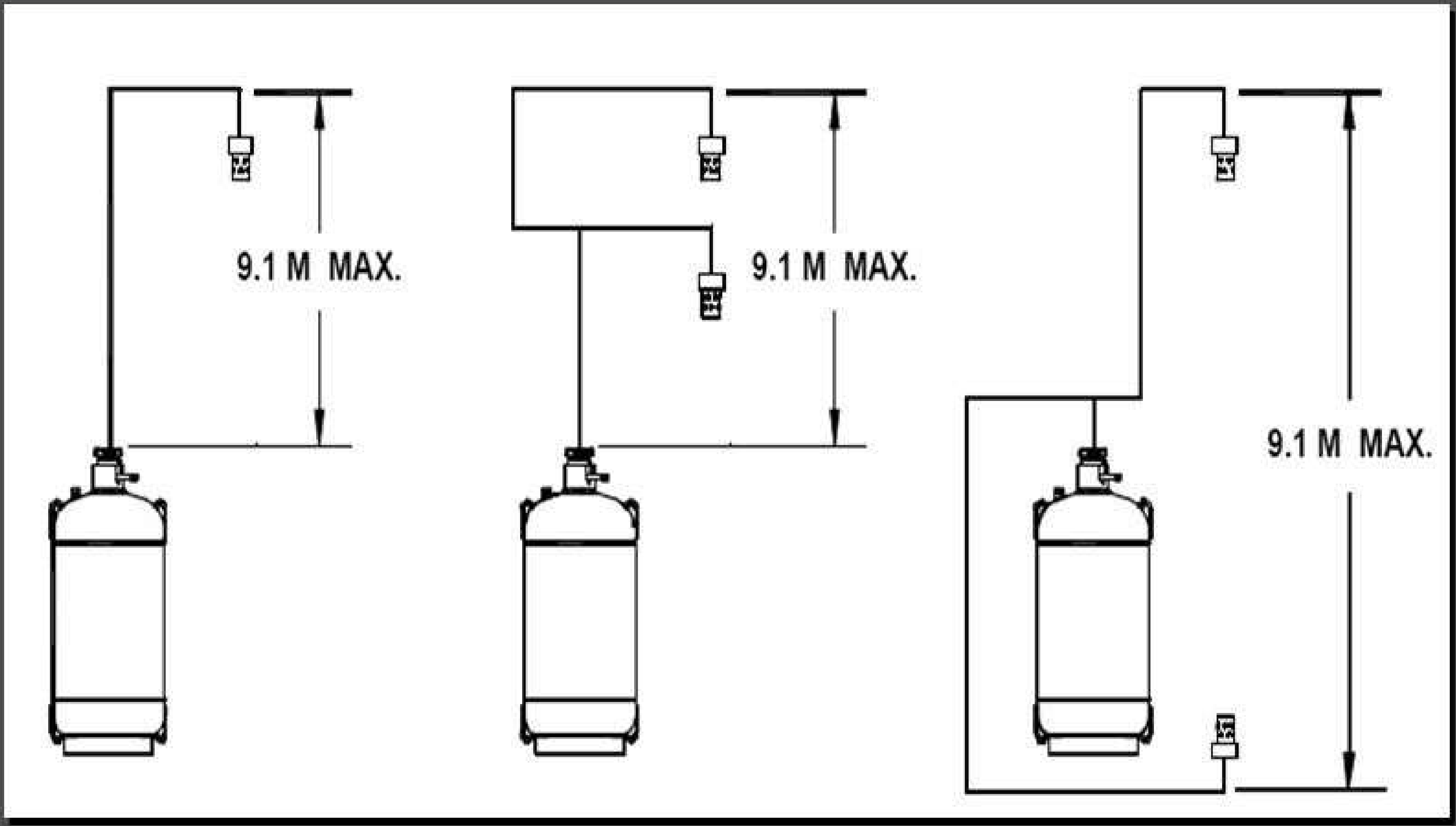


NOZZLE AREA COVERAGE		
Nozzle Type	Radius (R) Dimension	Ceiling Height Range
180°	14.0m	0.3 to 4.9m
360°	9.0m	0.3 to 4.9m


'R'


'R'

MAXIMUM ELEVATION DIFFERENCES IN PIPE RUNS



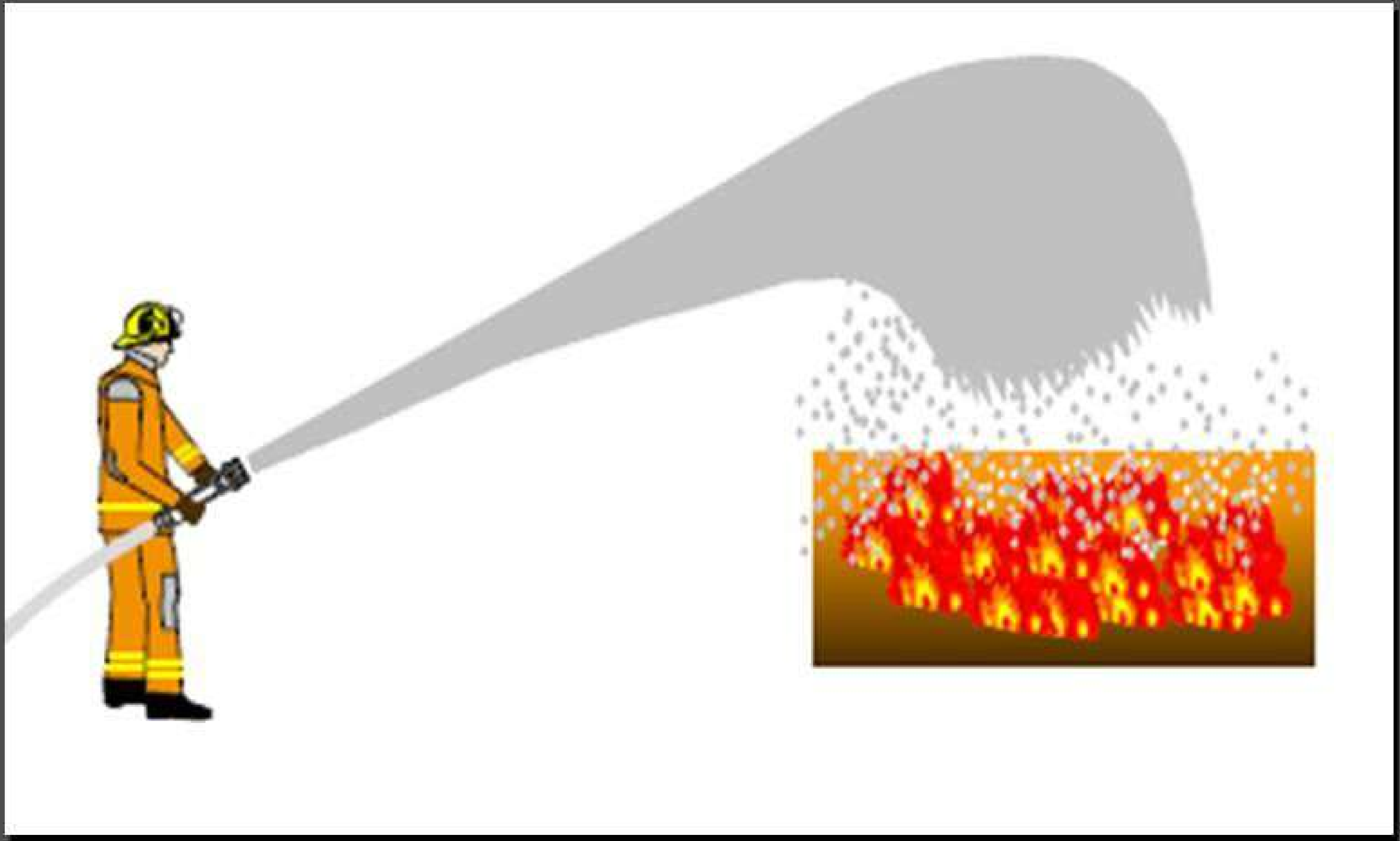
ESTIMATING PIPE SIZE :

PIPE SIZE ESTIMATING TABLE		
Metric Pipe		
Pipe Size Metric	Min. Design Flow Rate (Limitation)	Max. Design Flow Rate (Estimate)
10mm	0.3kg/sec.	0.9kg/sec.
15mm	0.5kg/sec.	1.5kg/sec.
20mm	0.9kg/sec.	2.7kg/sec.
25mm	1.5kg/sec.	3.9kg/sec.
32mm	2.6kg/sec.	5.9kg/sec.
40mm	3.8kg/sec.	8.9kg/sec.
50mm	5.9kg/sec.	15.0kg/sec.
65mm	8.9kg/sec.	26.3kg/sec.
80mm	15.0kg/sec.	43.1kg/sec.
100mm	26.3kg/sec.	57.6kg/sec.
125mm	43.1kg/sec.	100.7kg/sec.
150mm	57.6kg/sec.	144.2kg/sec.

WARNING: DO NOT install the pipe system based on estimates from this chart. The pipe system design MUST be verified by the HFC-227ea Flow Calculation Program prior to installing the system.


THE END

Foam System



Foam System

Introduction

Fire fighting foams are the primary agent for the control and extinguishment of flammable liquid fires such as :

* Non-water miscible liquids ----- hydrocarbons (non polar liquids) such as Crude oil , gasoline, hexane naphtha , diesel oil-----etc.

* water-soluble flammable chemicals ----- polar flammable liquids are mostly organic solvents such as alcohols, ethers, amines, and ketones .

Foam System

What is the foam?

As defined in National Fire Protection Association (NFPA) 11, foam is:
"an aggregate of air-filled bubbles formed from aqueous solutions which is lower in density than flammable liquids.
It is used principally to form cohesive floating blanket on flammable and combustible liquids, and prevents or extinguishes fire by excluding air and cooling the fuel.
It also prevents reigniting by suppressing formation of flammable vapors. It has the property of adhering to surfaces, which provides a degree of exposure protection from adjacent fires."

Foam System

Foam characteristics:

1- Knockdown :

Knockdown is the speed at which foam spreads across the surface of fuel. Extremely quick knockdown sacrifices good post-fire security, which is required for a stable, long-lasting foam blanket.

2- Heat Resistance :

Heat resistance is the ability of a foam bubble to withstand direct flame impingement or contact with elevated temperature surfaces, with little or no destruction to the foam bubble.

The heat resistance of a foam blanket is often called "burn back resistance."

Foam System

Foam characteristics:

3- Fuel Tolerance :

Fuel tolerance is the ability of the foam to enter the fuel and resurface with little or no pick up of fuel within the structure of the bubble.

A foam bubble which picks up fuel while submerged would simply carry the fuel to the surface and feed the fire.

4- Vapor Suppression:

Vapor suppression is the ability of the foam blanket to suppress flammable vapors and prevent their release. Vapor suppression is necessary to extinguish fires involving flammable liquids and to prevent ignition of un ignited flammable liquid spills.

Foam System

Foam characteristics:

5- Alcohol Tolerance :

Alcohol tolerance is the ability of the foam blanket to create a polymeric barrier between the fuel and the foam, thus preventing the absorption of the water from the foam bubbles. This absorption would result in the destruction of the foam blanket.

Foam System

Types of Foam:

The following foam concentrates are the most commonly used today by firefighters:

- Protein Foam Concentrates.
- Fluor-protein Foam Concentrates.
- Film Forming Fluor-protein Foam Concentrates (FFFP).
- Aqueous Film Forming Foam Concentrates (AFFF)
- Alcohol-Resistant Foam Concentrates (AR-AFFF and AR-FFFP)

Foam System

Protein Foam:

- Regular Protein foams (RP) are intended for use on hydrocarbon fuels only.
- They produce a homogeneous, stable foam blanket that has excellent heat resistance, burn back, and drainage characteristics.
- Regular Protein foams have slow knockdown characteristics; however, they provide superior post fire security at very economical cost.
- Regular protein foams may be used with fresh or sea water.
- They must be properly aspirated and should not be used with non aspirating structural fog nozzles.
- These foams are produced by the hydrolysis of granulized keratin protein (protein hydrolysate) such as hoof and horn meal, chicken feathers, etc. In addition, stabilizing additives and inhibitors are included to prevent corrosion, resist bacterial decomposition and to control viscosity.

Foam System

Fluor-Protein foam (FP) :

Fluor-protein foams have fluorochemical surfactants which greatly :

•Enhance performance with fast knockdown, improved resistance to fuel pick-up.

•They are intended for use on Hydrocarbon fuels.

• As with Protein, they have excellent heat resistance, burn back, and post fire security.

•Fluor- protein foams may be used with fresh or sea water.

•They must be properly aspirated and should not be used with non-aspirating structural fog nozzles.

•Fluor-protein Foams are made by the addition of special fluorochemical surfactants to protein foam, This enhances the properties of protein foam by increasing foam fluidity and improves the properties of regular protein foam by providing faster knockdown and excellent fuel tolerance.

Foam System

Film Forming Fluoroprotein Foam (FFFP) :

- FFFP's are a combination of fluorochemical surfactants with protein foam.
- They are designed to combine the fuel tolerance and burn back resistance of a fluoroprotein foam with an increased knockdown power.
- FFFP foams release an aqueous film on the surface of the hydrocarbon fuel.

Foam System

Aqueous Film Forming Foam (AFFF):-------- synthetic foaming agents.

- AFFF family of foams is designed to provide the fastest possible knockdown on hydrocarbon fuels.
- Their fluidity allows them to quickly flow around obstacles, wreckage and debris.
- Different percentages may be selected depending on the users proportioning hardware.
- Standard AFFFs can be used with either fresh or sea water.
- AFFFs may be used through nonaspirating devices.
- AFFFs are a combination of fluorochemical surfactants and synthetic foaming agents.
- AFFFs extinguish fire by forming an aqueous film. This film is a thin layer of foam solution that spreads rapidly across the surface of a hydrocarbon fuel causing dramatic fire knockdown.

Foam System

Alcohol resistant aqueous film forming foam (AR AFFF) :

- Alcohol resistant-AFFF foams are produced from a combination of synthetic detergents, fluorochemicals and polysaccharide polymer.
- Polar solvents (or water miscible) fuel such as alcohols are destructive to nonalcoholic resistant type foams.
- Alcohol resistant-AFFF foams act as a conventional AFFF on hydrocarbon fuels, forming an aqueous film on the surface of the hydrocarbon fuel.
- When used on polar solvents ,the polymer forms a tough membrane which separates the foam from the fuel and prevents the destruction of the foam blanket.
- While some concentrates are designed for use on hydrocarbon fuels at 3% and polar solvents at 6%, today's newer formulations are designed to be used at 3% on both fuel groups. These newer formulations provide more cost effective protection of alcohol type fuels, using half the amount of 6%

Foam System

Alcohol resistant Film Forming Fluoroprotein Foam (AR-FFFP):

- Alcohol resistant-FFFP foams are produced from a combination of protein foam, fluorochemical surfactants and polysaccharide polymer.
- Alcohol resistant- FFFP foams act as conventional FFFP's on hydrocarbon fuels forming an aqueous film on the surface of the hydrocarbon fuel. When used on polar solvents ,the polymer forms a tough membrane which separates the foam from the fuel and prevents the destruction of the foam blanket.
- AR-FFFP foams are available as 3% / 6% concentrates which are designed for use on hydrocarbon fuels at 3% and polar solvents at 6%.
- These formulations are also available for use at 3% on both hydrocarbons and polar solvent fuels.
- Class A foams may be used as a firefighting agent or as a fire barrier. When used as a wetting agent, the concentrate lowers the surface tension of the water, allowing better penetration into deep seated fires.

Foam System

Table 5.1: Various Types of Foam Rated by Their Properties

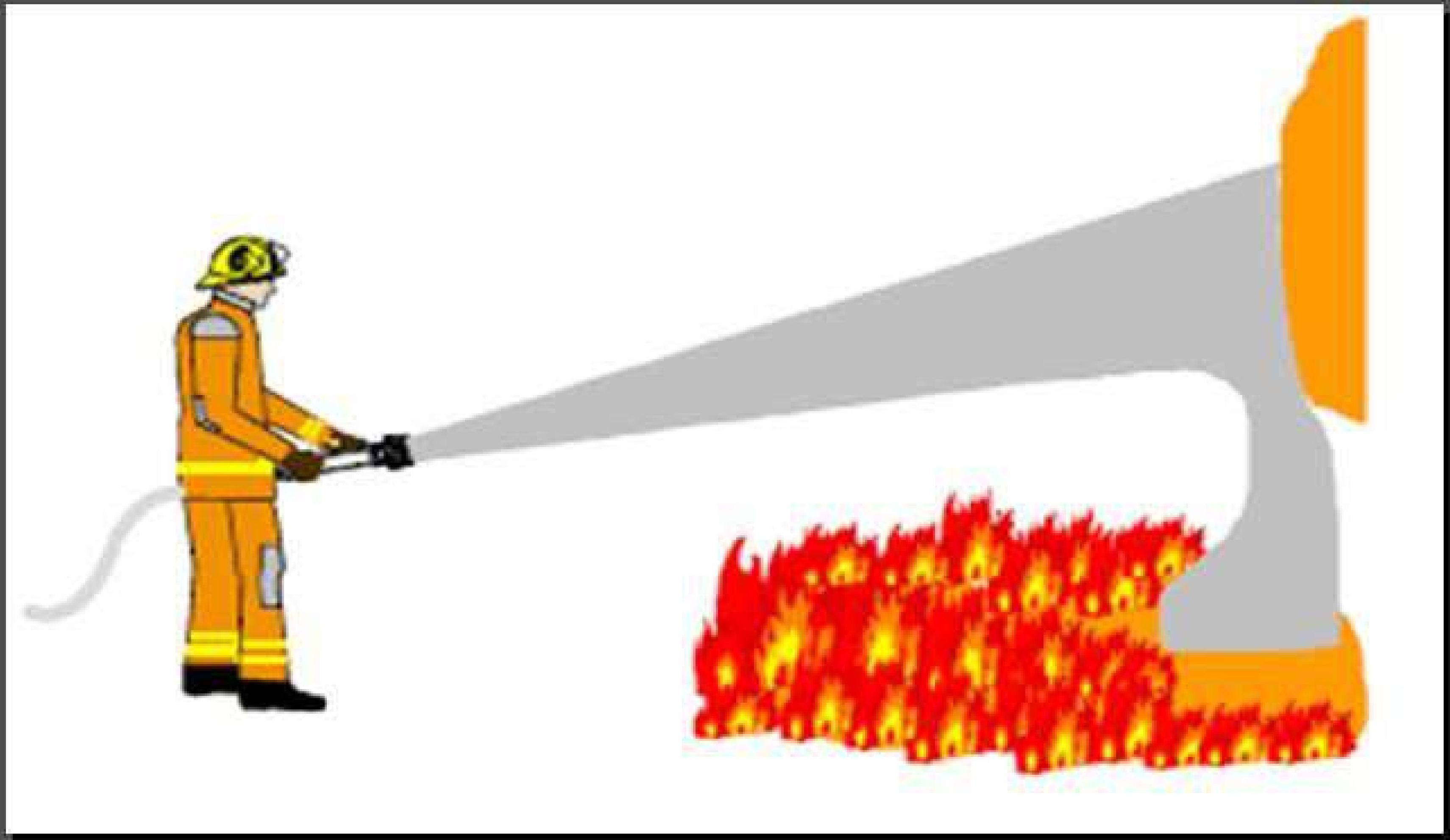
Property	Protein	Fluoroprotein	AFFF	FFFP	AR-AFFF
Knockdown	Fair	Good	Excellent	Good	Excellent
Heat Resistance	Excellent	Excellent	Fair	Good	Good
Fuel Tolerance	Fair	Excellent	Moderate	Good	Good
Vapor Suppression	Excellent	Excellent	Good	Good	Good
Alcohol Tolerance	**None**	**None**	**None**	**None**	**Excellent**
Source: National Foam					

Foam System

Foam application techniques:

1- Bounce off technique

When foam nozzles are used, particular care should be taken to apply the foam as gently as possible. For straight stream use, the foam should be banked off of a wall or other obstruction when available.

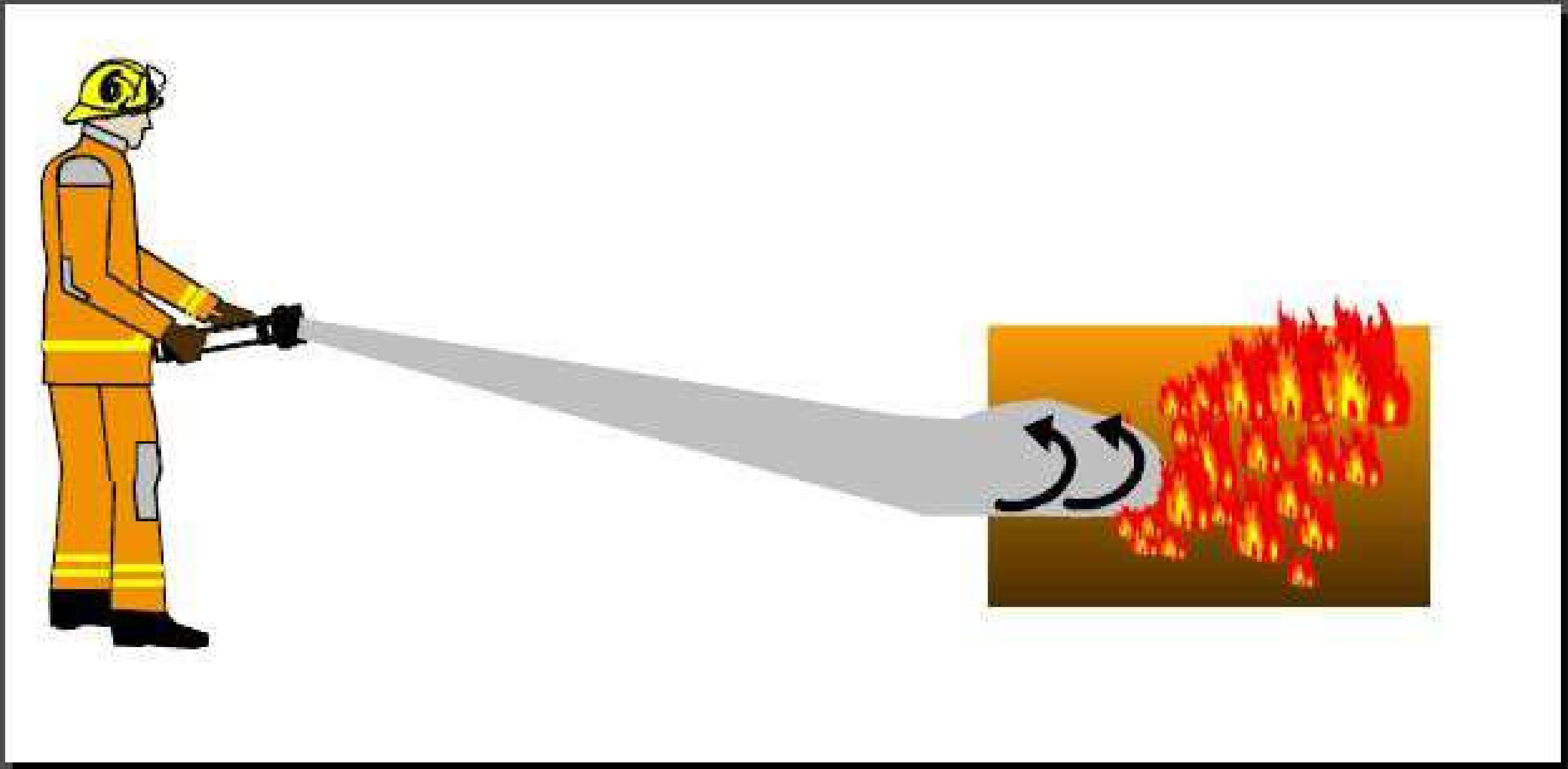


Foam System

Foam application techniques:

2- Bank-in technique

Foam can also be rolled onto the fuel surface by hitting the ground in front of the spill, and allowing the foam to "pile up" in front of the spill. The velocity of the stream will roll the foam onto the fuel.

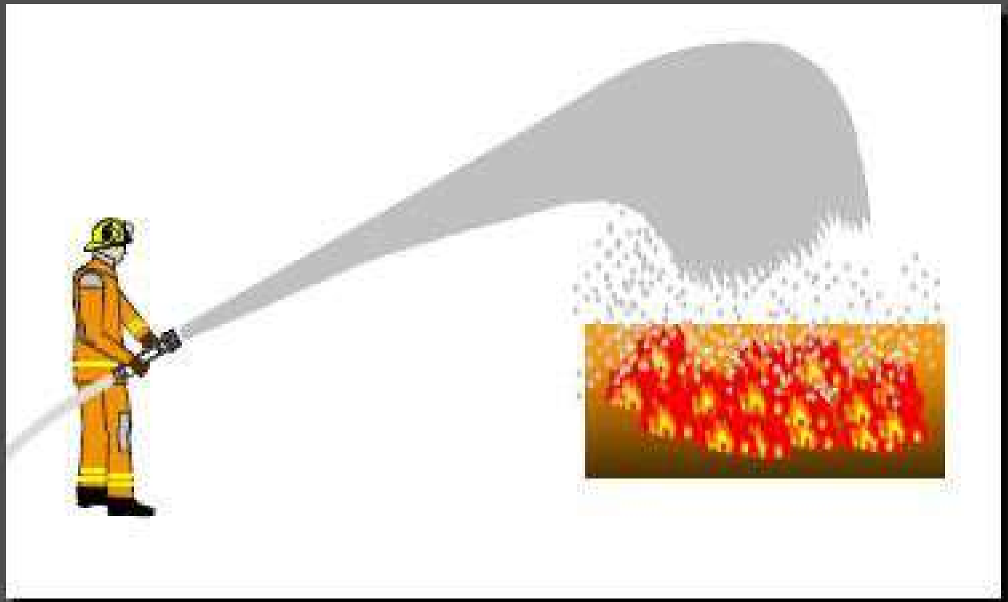


Foam System

Foam application techniques:

3-Raindown technique

- The foam nozzle is directed almost straight up and the foam stream is allowed to reach its maximum height and break into small droplets.
- The nozzle operator must adjust the altitude of the nozzle so the fallout pattern matches that of the spill area.
- This technique can provide a very fast and effective knockdown. How-ever, if the fuel has had a significant preburn and a thermal column has developed, or if the weather is severe (high winds), the Raindown method may not be practical or effective.



Foam System

Foam application techniques:

Never plunge Plunging the stream directly into the fire can splash the fuel causing the fire to spread. If a foam blanket exists, plunging can break the existing blanket allowing vapors to escape. This usually results in spreading the fire, reignition, or flare ups.

Foam System

Foam System Components:

All foam systems regardless of its size consists of :

- Foam Concentrates Supply.
- Foam Proportional Device.
- Water Supply.
- Foam Maker (s).

Foam System

Foam System Components:

Foam Proportional Device :

Proportioner : is a device to properly mix foam concentrate and water at a desired percentage rate of foam concentrate injection.

If proportioning is too "lean" (less than the design percentage of foam concentrate to water), the overall foam quality decreases, The drainage time decreases and the bubbles break faster resulting in less resistance to heat. Therefore, lean foam may or may not put out the fire.

On the other hand,

if proportioning is too "rich" (greater than the design percentage of foam concentrate to water), the foam shows stiffness and non-fluidity or reluctance to flow around obstructions. In addition, the foam concentrate supply is depleted more rapidly and hence may not adequately meet minimum operation time requirements.

Foam System

Foam System Components:

PROPORTIONING METHODS

1. Premix Foam Solution
2. Venturi (Vacuum Inducing)
3. Pressure Proportioner
4. Bladder Tank Proportioning
5. Balanced Pressure Proportioning
6. In-Line Balanced Pressure Proportioning
7. Around the Pump Proportioning
8. Pick-Up Nozzles
9. Jet Pump Proportioning.

Foam System

Foam System Components:

1- Premix Foam Solution

The simplest method of proportioning foam concentrate is the premix method This is accomplished by mixing pre-measured amounts of water and foam concentrate in a common container.

Typically the storage container is a pressure rated tank using inert gas to pressurize the system.

However, the premix can be stored in an atmospheric tank and a pump used to supply the premix solution under pressure to the discharge devices.

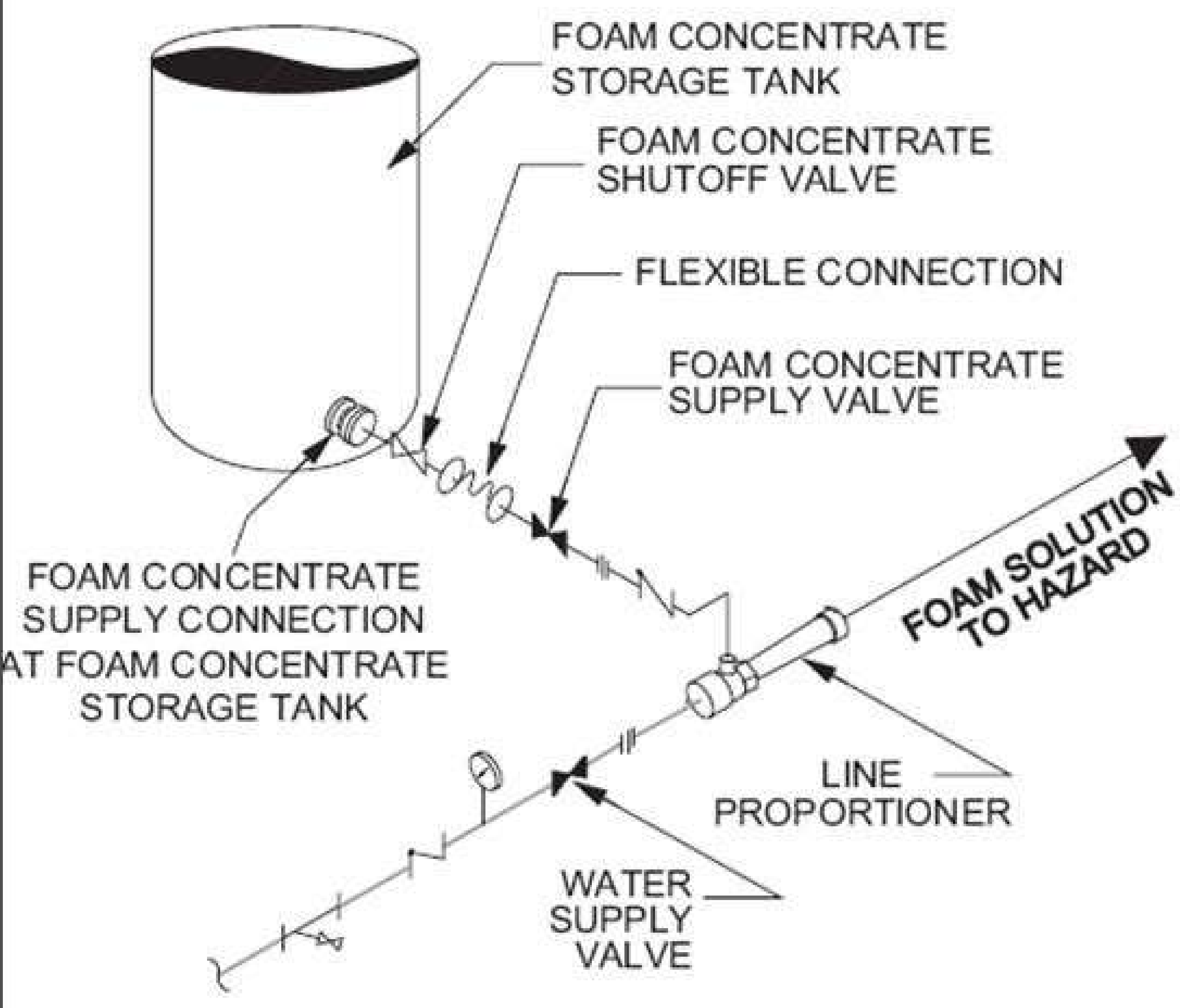
This type of proportioning :

- Is usually limited to small systems.
- Not all foam concentrates can be pre-mixed And storage life of premix solutions is unknown.

Foam System

Foam System Components:

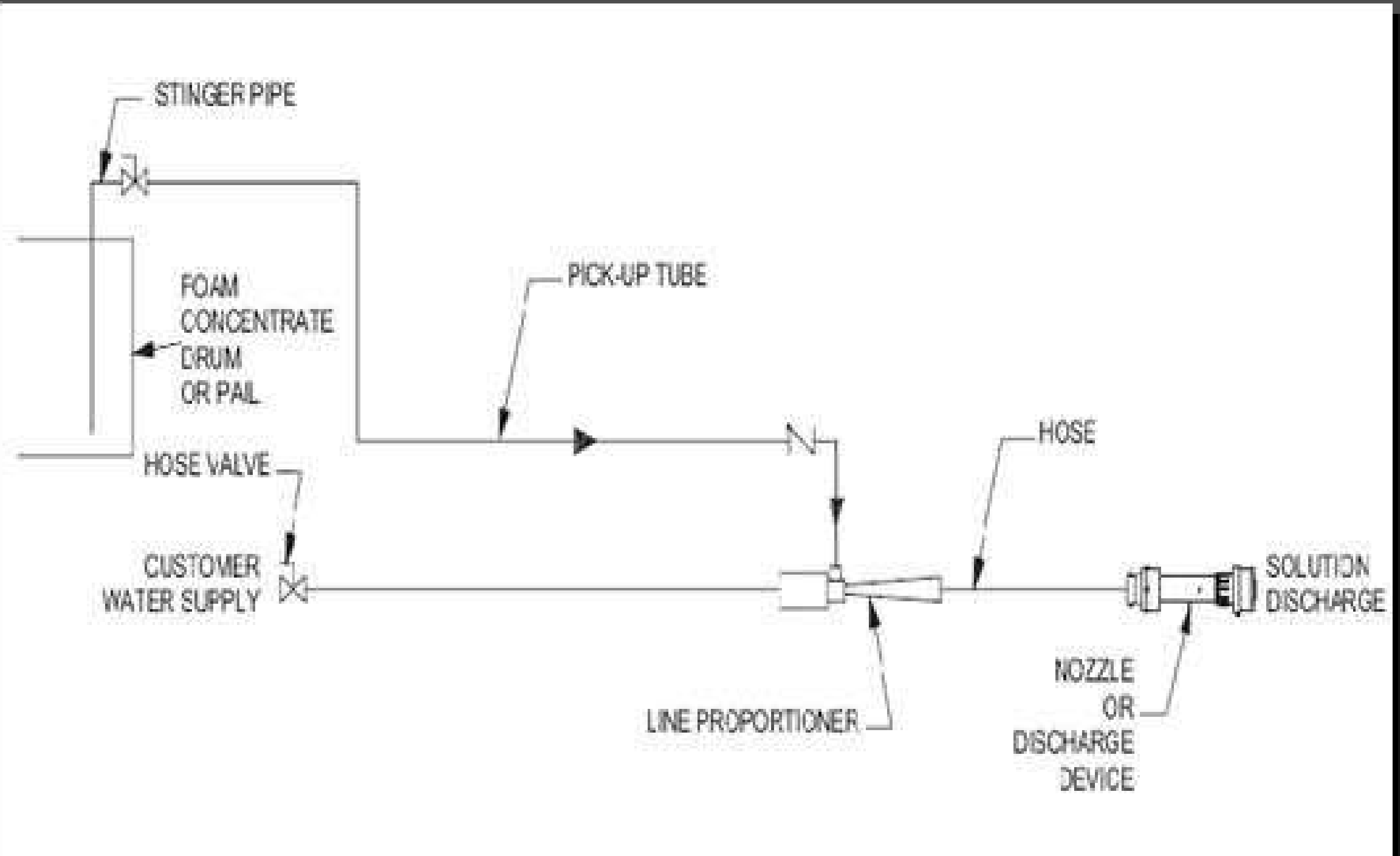
2- Venturi (Vacuum Inducing) :



Line Proportioning - Fixed Installation

Foam System Components:

2- Venturi (Vacuum Inducing) :



Portable Line Proportioning

Foam System

Foam System Components:

3- Pressure Proportioner:

THE END

THE END