SECTION 6- FIRE SUPPRESSION & DETECTION
UNIT 3 - AUTOMATIC SPRINKLER SYSTEMS

UNIT GOAL
To introduce the student to the basic theories and concepts regarding automatic sprinkler systems and types of systems and their operation.

UNIT OBJECTIVES
The student by the end of the semester shall:
- Identify the success rate of automatic sprinklers in a percentage
- List at least three [3] reasons why automatic sprinklers fail
- List at least three [3] disadvantages of water as an extinguishing agent
- Define term automatic sprinklers
- List at least three [3] benefits of automatic sprinklers
- List at least two [2] types of automatic sprinklers
- List four types of indicating type control valves used in automatic sprinklers
- Identify the purpose of the fire department connection
- List the five [5] types of automatic sprinkler systems

KEY TERMS
NFPA 13 Standard for Installation of Sprinkler Systems
NFPA 13A Recommended Practices for the Inspection, Testing and Maintenance of Sprinkler Systems
NFPA 13D Standard for Installation of Sprinkler Systems in One and Two Family Dwellings
NFPA 13E Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems
NFPA 13R Standard for Installation of Sprinkler Systems in Residential Occupancies up to Four Stories in Height
Sprinkler Head - Upright
Sprinkler Head - Pendant
Wet-pipe Sprinkler System
Dry-pipe Sprinkler System
Pre-action Sprinkler System
Deluge Sprinkler System
Residential Sprinkler system
OS&Y Valve
Post Indicator Valve [PIV]
Butterfly Valve
Indicating Valve
Fire Department Connection [Sprinkler Siamese]

INTRODUCTION

Automatic sprinkler systems have had an unparalleled success in fire protection. For over 100 years they have provided fire protection for thousands of structures in the United States. While simple in design the protection has been invaluable. In this unit we will discuss the benefits of sprinkler systems, the major components, and the five different types.

AUTOMATIC SPRINKLER BASICS

Automatic Sprinklers have shown their usefulness over and over again. As mentioned in the Introduction they are simple in design. By definition they are a system of water pipes, discharge nozzles and control valves designed to discharge water to control a fire.

History of Sprinklers

The idea of providing an automatic suppression system, using water, has intrigued man for centuries. Some of the early attempts included a cask of water with a cask of gunpowder inside with a fuse that would be ignited by the fire and cause the gunpowder to explode and spray the water over the fire and extinguish it. Another attempt was to use perforated piping that water was flowed through after a fire was discovered. These attempts were somewhat successful but, they were not an **automatic** sprinkler system. The first successful automatic sprinkler system developed by Parmelee in 1878 in New England, by the 1880's it was being used in over 200 factories in New England. This system used discharge device that was capped by a fusible link device that would melt at a given temperature. When the fusible material melted the cap was released and water flowed out of the discharge device and on to the fire. Improvements on Parmelee's system were developed by the Grinnell Company. Many insurance companies liked the idea of an "automatic" suppression system and readily supported it. As sprinkler systems became more prevalent it became apparent that standardization was required. The insurance industry asked a relatively new organization, around the turn of the 20th century to develop standards for sprinkler systems. This organization was the National Fire Protection Association [NFPA]. The standard they developed still exists today in the form of NFPA Standard 13, Standard for Installation of Sprinkler Systems. Sprinkler design and effectiveness has changed over the past 120 years, but the basic principle designed by Parmelee in 1878 remains the same.

Sprinkler Performance

Automatic sprinkler systems have proven themselves over and over again. They are considered the most efficient, effective and cost-effective suppression in existence today. Statistics in the United States from 1896 to 1970 show that sprinklers have a success rate of 96%. Studies in New Zealand and Australia show a success rate of 99.7%. There has never been a major loss of life (5 deaths or more, as per NFPA) in any building that has been on fire that was fully protected by sprinklers, **does not include explosions that disabled the sprinkler system**. Most fires (70%) are controlled by less than 5 sprinkler heads activating.

Sprinklers are not a panacea, there are times when they have not worked. In the United States this is about 4% of the time. Some of the reasons for unsatisfactory performance are as follows.

- Sprinklers being shutoff
- Partial protection (Stouffer's Inn fire in 1980)
- Faulty building construction
- Inadequate water supply
- Hazard of occupancy

- Obstruction
- Inadequate maintenance
- Unknown reasons.

Benefits of Automatic Sprinklers

Sprinklers have shown themselves as an excellent means of fire protection. Some of benefits of having a structure protected by sprinklers are the following.

- Enhances life safety
- Can reduce business downtime
- Less water than fire department
- Gives an audible alarm
- Rarely malfunction

STANDARDS RELATED TO SPRINKLERS

Over the years the NFPA has developed various standards that relate to automatic sprinkler protection. The following standards are the most important to be aware of.

- NFPA 13 Standard for Installation of Sprinkler Systems
- NFPA 13A Recommended Practices for the Inspection, Testing and Maintenance of Sprinkler Systems
- NFPA 13D Standard for Installation of Sprinkler Systems in One and Two Family Dwellings
- NFPA 13E Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems
- NFPA 13R Standard for Installation of Sprinkler Systems in Residential Occupancies up to Four Stories in Height
- NFPA 25 Standard for Water-Based Fire protection Systems
- NFPA 231 Standard for General Storage
- NFPA 231C Standard for High-Rack Storage

COMPONENTS OF A SPRINKLER SYSTEM

As the definition of automatics sprinklers states: they are a system of water pipes, discharge nozzles and control valves designed to discharge water to control a fire. It is designed to be simple in nature and operation. The main parts consist of

- Water supply
- System distribution piping
- A discharge nozzle
- Control Valves
- Fire Department Connection
- An alarm notification device **[See Figure 16]**

Water Supply

A sprinkler system must have an adequate and reliable water supply. Some of the common supply sources are.

- Municipal - water comes from city water mains
- Elevated tanks - water tank on site provides both volume and pressure to the system

- Above ground reservoirs - water supply usually supplying a fire pump in an industrial facility
- Pressure tanks - large water tank under air pressure force water from the tank once the sprinkler head opens
- Natural water source - pond, lake, stream where water is drafted by means of a fire pump to the sprinkler system

Piping

This is the distribution system for the sprinklers. These pipes are made from three types of materials

- Ferrous metal (black pipe) most common
- Copper tubing
- Plastic piping (PVC)

The types of piping found in a sprinkler are the following. ***Water supply main*** that is used to connect a sprinkler system to the water supply. The next is a ***Riser*** that is a vertical pipe from the sprinkler valve to the first feed main. This is can be from 3" in diameter to 8" in diameter. Coming off of this is the Feed main, this large pipe connects to the ***Cross mains***, which in turn connect to the **Branch lines**. - the **Branch lines** come off cross mains, this is where the sprinkler heads are connected. **[See Figure 1]**

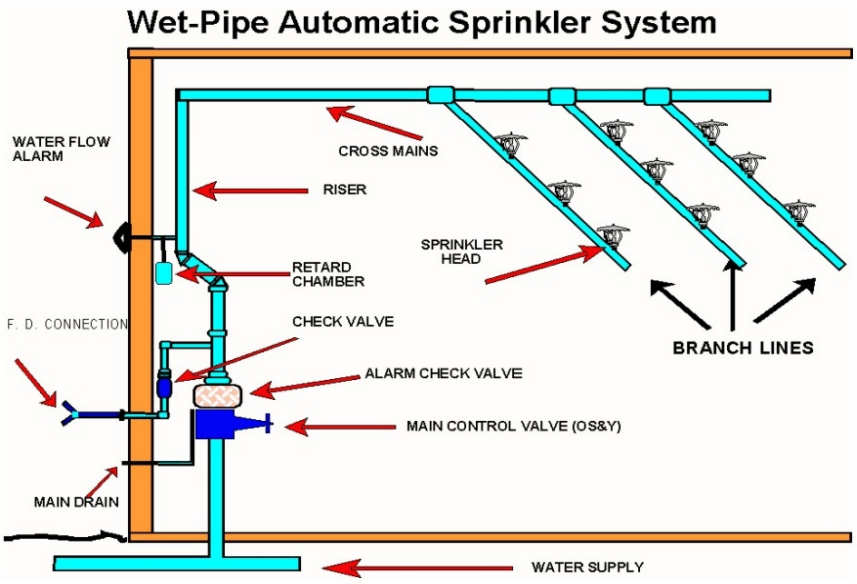

Figure 1 - Example of types of piping

Sprinkler Heads

A water spray device for the application of water onto a fire hazard in defined densities over a specific area. They are usually designed to activate individually by the provision of a heat-sensing element (fusible solder or glass bulb) that releases the contained water supply source to the sprinkler it supplies. A sprinkler may also be open without a heat - responsive element. Sprinklers are specified for amount of coverage, orifice size, type of configuration (upright, pendent, sidewall, etc.), and temperature rating. Standard sprinklers have an orifice of 0.5 in.

Types of sprinkler heads

- **Sprinkler, Upright** - A sprinkler designed for and placed in an upward position above the supply pipe, rather than installed in a downward fashion from the supply pipe. It directs 100 percent of its water toward the floor. A sprinkler designated for upright installation cannot be used in the downward position because the water will be directed to the ceiling instead of toward the fire incident and will not achieve its density pattern for fire control and extinguishment. **[See figure 2]**
- **Sprinkler, Pendent -** A sprinkler designed for and installed with the head in a downward fashion from the piping, rather than placed in an upward position above the supply pipe. They are primarily used where upright sprinklers cannot be used because of lack of space (headroom) or where concealment of sprinkler piping above a false ceiling is desired because of aesthetic reasons (office areas). **[See figure 3]**
- **Sprinkler, Sidewall -** Sprinkler designed to be installed on piping along the sides of a room instead of the normal sprinkler spacing requirements. The sprinkler is made with a special deflector that deflects most of the water away from the nearby walls in a pattern similar to a quarter of a sphere. A small portion of the water is directed at the wall behind the sprinkler. Sidewall sprinklers are generally used because of aesthetic concerns, building construction arrangements, or installation economy considerations.
- **Sprinkler, On-Off -** A cycling (on-off), self-actuating, snap-action, heat-actuated sprinkler. Water flow automatically shuts off from the sprinkler when the fire has been extinguished (no heat is available to activate the sprinkler head) and it is automatically reset for later operations. This type of sprinkler requires a water supply that is free of contaminants (potable) that could interfere with its operation. It does not have to be replaced after operation. It is provided to avoid water damage by eliminating the need to shut off the water supply after a fire has been extinguished. Typical applications include areas containing high-value inventories, materials, or equipment highly sensitive to water, areas subject to flash or repeat fires, and where the water supply is limited.
- **Sprinkler, Residential** - A type of fast-response sprinkler that is well known for its ability to enhance human survivability in the room of fire origin and is used in the protection of dwelling units as specified by listing or approval agencies. The first effective fast-response sprinkler for residential use was developed by the Factory Mutual Research Corporation (under contract to the United States Fire Administration) and was demonstrated in 1979..

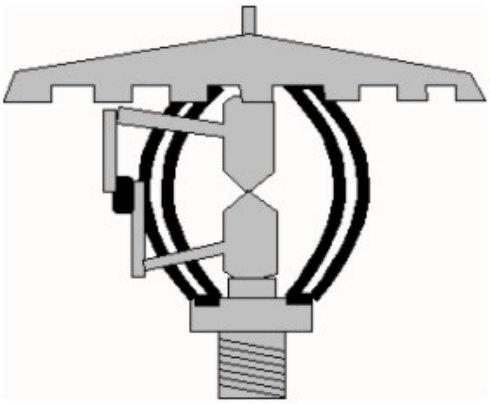

Figure 2 - Upright Sprinkler Head

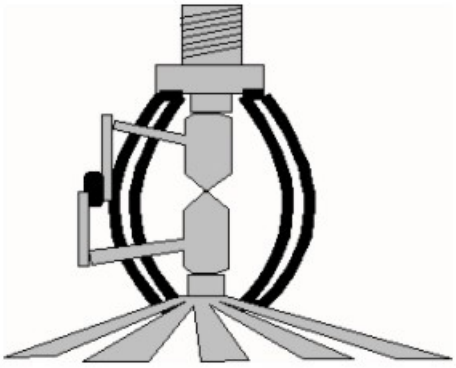

Figure 3 - Pendent Sprinkler Head

Special Type Heads

As mentioned the standard type head is ½ " in diameter. There are other types of head that are used and these will have varying diameters. The larger the diameter the greater the water flow from the head. Some of these are as follows

- Small (1/4" - 7/16" Orifice)
- Standard Head (½" Orifice)
- Large (17/32" Orifice)
- Extra Large (5/8" Orifice)
- Very Extra Large (3/4" Orifice)
- Large Drop (5/8" Orifice)
- Early Suppression Fast Response (ESFR) (5/8" Orifice)
- Extra Large Orifice (ELO) (3/4" Orifice)

Parts of the Sprinkler Head [See Figure 4]

Fusible device
Deflector
Arms
Cap
Discharge orifice
Heat sensitive device

Deflector - This device orms the discharge pattern of the water. There are three common types.

- Upright deflector - water is deflected downward in hemispherical pattern
- Pendent - breaks water into pattern of small water droplets
- Sidewall - used in corridors, offices and residential occupancies

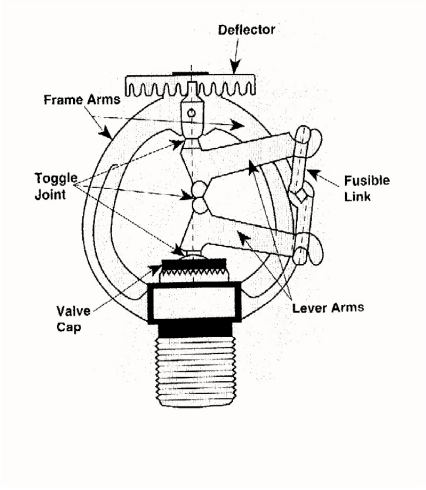

Figure 4 - Parts of a Sprinkler Head

How a Sprinkler Operates [See Figure 5]

A nozzle is under pressure and held in place by a fusible device. Typical types of fusible devices are Fusible Link; Frangible Bulb; Fusible Alloy Pellets; Chemical Pellets. Heat causes fusible device to fail at a certain temperature range, releasing pressure on the nozzle and causing the sprinkler head to activate.

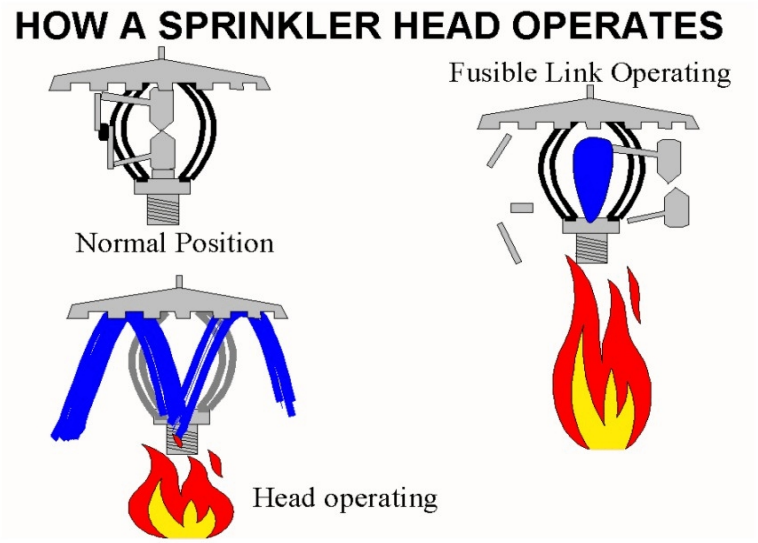

Figure 5 - How a Sprinkler Head Operates

Temperature Ratings of Heads

Fusible devices of the sprinkler head have operating temperatures from 135 deg. F. To 575 deg. F. Sprinkler heads are stamped with the temperature rating either on the deflector, frame arm, fusible link. A color coding is used to indicate temperature range.[**See Table 1**].

Sprinkler Response Time

There is a delay between the ignition of the fire and when the sprinkler activates. The temperature of the fusible device needs to be raised from room temperature to the operating temperature of the device

TABLE 1 - TEMPERATURE RATINGS OF SPRINKLER HEADS		
HEAD TYPE	**COLOR**	**TEMPERATURE RATING**
ORDINARY	BLACK COLOR	135 to 170 DEG. F
INTERMEDIATE	WHITE COLOR	175 to 225 DEG. F.
HIGH	BLUE COLOR	250 to 300 DEG. F.
EXTRA HIGH	RED COLOR	325 to 375 DEG. F.
VERY EXTRA HIGH	GREEN COLOR	400 to 475 DEG. F.
ULTRA HIGH	ORANGE COLOR	500 to 575 DEG. F.

Control Valves

All sprinkler and standpipe systems have control valves designed to shut off water from water source to

sprinkler system. Early closure of these valves has been a cause of many large loss fires. To ensure this does not happen, these valves are indicating valves - you can visually tell if they are open or shut. The common types are .

- Outside Screw & Yoke (OS&Y) **[See Figure 6]**
  - Valve has an outside yoke with a threaded stem
  - When stem is out the valve is open
  - When stem is in the valve is closed
- Post Indicator Valve (PIV) **[See Figure 7]**
  - Hollow metal post with a valve housing
  - On outside is a moveable target with the words "open" & "shut" to indicate if the valve is open or closed respectively **[See Figure 8]**
  - Similar to this is the wall post indicator valve (WPIV)
- Butterfly valve **[See Figure 9]**
  - A gate rotates 90 degrees in the waterway
  - Position of the valve is indicated by a pointing device that points to the word "open" or "closed"

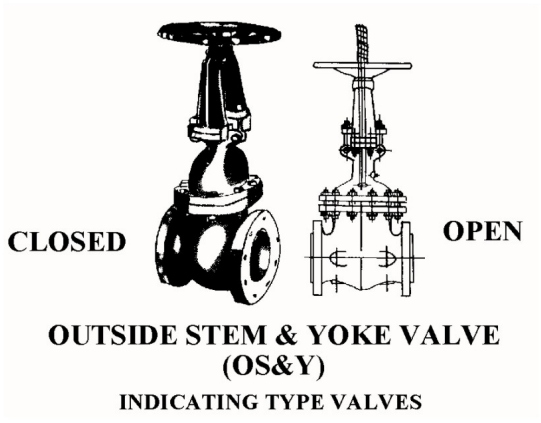

Figure 6

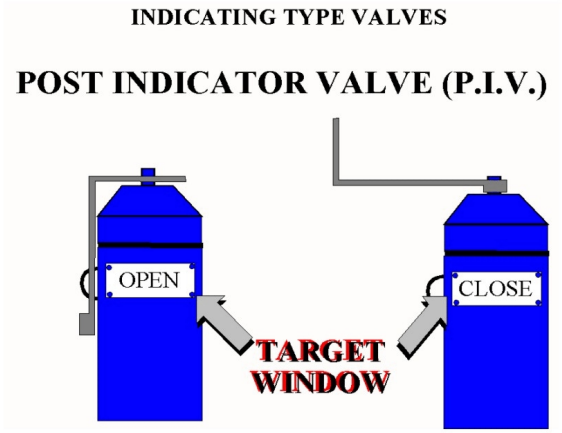

Figure 7

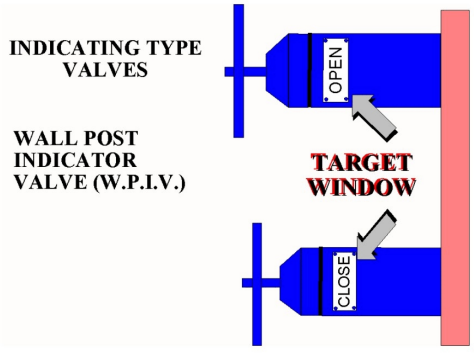

Figure 8

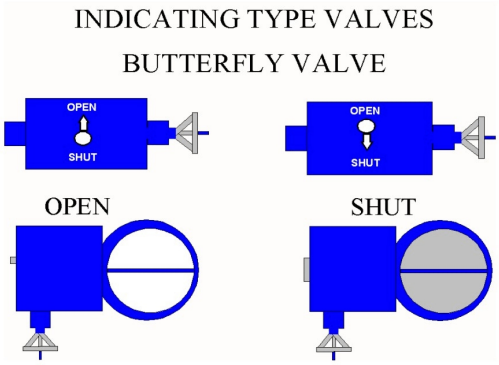

Figure 9

Fire Department Connection [FDC] (Sprinkler Siamese) [See Figure 10]
This device permits the fire department to connect a pumper to the sprinkler system by means of fire hose to boost up the pressure and volume in the sprinkler system. They commonly consist of a 4" pipe with a 2 ½" siamese fitting to allow connecting of fire hose. The connection has a check valve to prevent water from the system from entering the piping and leaking out. Types of connections are:

- Single riser system - connection is attached directly to the system side of the sprinkler system
- Multi-riser system - connection is on the supply side piping between the main supply valve and the individual riser valves

All FDC's must be properly indicated as to what they are used for. If it is used for a automatic sprinkler system it must be marked as such. The same goes for a FDC for a standpipe system. Some codes also require that a sign be attached near the FDC to indicate what part of the structure the FDC is supplying.

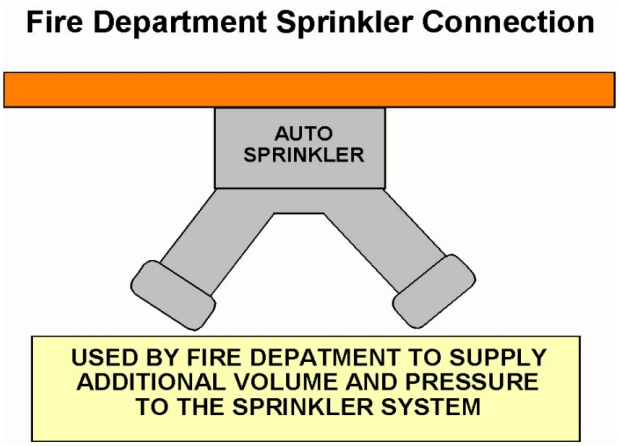

Figure 10

Figure 11 - Fire Department Connection

TYPES OF SYSTEMS
Wet Pipe System [See Figure 12]
A sprinkler system that uses automatic sprinklers installed in a piping system containing water and connected to a water supply. Individual sprinklers discharge immediately when they are affected by the heat of a fire. Sprinklers that are not affected by the heat remain closed. It is used where there is no danger of the pipes freezing and where no other conditions require the use of a special system.

Parts of sprinkler system

- Alarm check valve. A valve that is incorporated with an alarm function. When water flows the valve activates and sets off an alarm, a retard chamber is usually provided to prevent false alarms from surges in the system
- Water flow indicator. A vane that protrudes into the sprinkler piping and is attached to alarm switch so if there is a water flow the vane moves and activates the alarm

Operational sequence

- Heat from fire causes heat actuating device in sprinkler head to release arms
- Water in piping discharges from sprinkler head
- Water moves throughout the system causing alarm check valve in sprinkler riser to open and activate the alarm mechanism
- Alarm is transmitted to supervising agency or fire department
- If needed pressure or volume is required the fire department can connect to the fire department connection

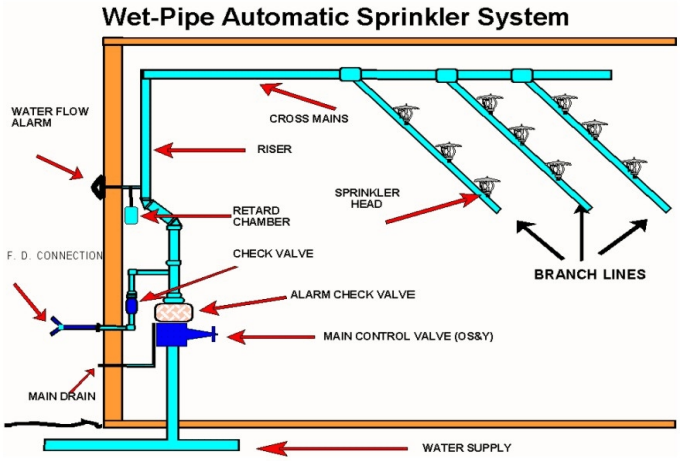

Figure 12

Dry Pipe System [See Figure 13]

A sprinkler system that uses automatic sprinklers installed in a piping system containing air or nitrogen under pressure. A release of pressure on the system (as from the opening of a sprinkler) permits the water pressure to open a valve known as a dry pipe valve. The water then flows into the piping system and out the opened sprinklers. Dry pipe systems operate more slowly than do wet pipe systems and are more expensive to install and maintain, therefore they are only used where there is an absolute necessity, such as freezing conditions.

Parts of the dry-pipe sprinkler system

- Dry-pipe valve. A valve designed so small amount of air pressure hold back water pressure of a greater amount.
- Quick opening devices. Devices designed to expel air from system in a short period of time. Two common types are an Accelerator and a Exhauster

Operational sequence for dry-pipe system

- Heat from fire causes fusible element to release on sprinkler head
- Pressurized air in piping begins to discharge through the open head
- After a slight drop in air pressure the quick opening device activates to speed up removal of the air in the system
- Once air is removed from the system dry-pipe valve opens and allows water into the piping

- Water flows through piping to open head and discharges on the fire

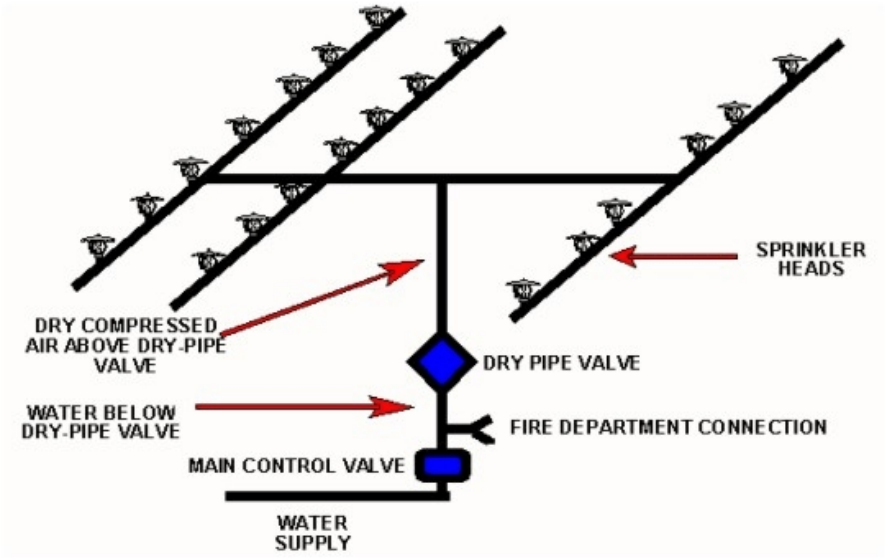

Figure 13 - Dry-Pipe Sprinkler System

Pre-Action System [See Figure 14]
A sprinkler system using automatic sprinklers installed in a piping system containing air that may or may not be under pressure, with a supplemental detection system installed in the same areas as the sprinklers. Actuation of a detection system opens a valve that permits water to flow into the sprinkler piping system and to be discharged from any sprinklers that have opened from the effects of a fire. Sprinklers that are not affected by heat from a fire remain closed. They are designed to counteract the operational delay of dry pipe and eliminate the damage from a broken or sprinkler head.

Operational sequence for preaction sprinkler system
- Product of combustion detector senses a fire
- Detection system sends signal to preaction valve causing valve to open
- Sensors in piping detect water flow and trigger fire alarm
- When level of heat fuses sprinkler head water flows from the head on to the fire

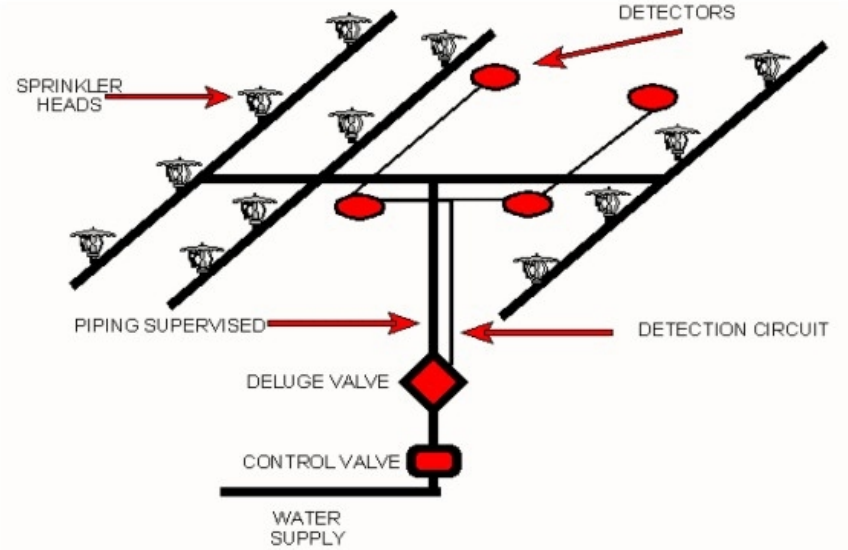

Figure 14 - Pre-Action Sprinkler System

Deluge System [See Figure 154]
A sprinkler system using open sprinklers installed in a piping system 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 the deluge valve opens, water flows into the system piping and discharges from all sprinklers. There are no closed sprinklers in a deluge system. Its objective is to deliver the most amount of water in the least amount of time. Deluge systems are specified for high hazard locations where a fire occurs quickly and reaches very high temperatures, such as from highly flammable fuels.

Operating sequence of deluge system

- Product of combustion detector senses a fire
- Detection device sends a signal to the deluge valve causing it to open or an individual discovers fire and manually trips the deluge valve
- Water enters the piping, activates the alarm
- Water flows through to all heads simultaneously

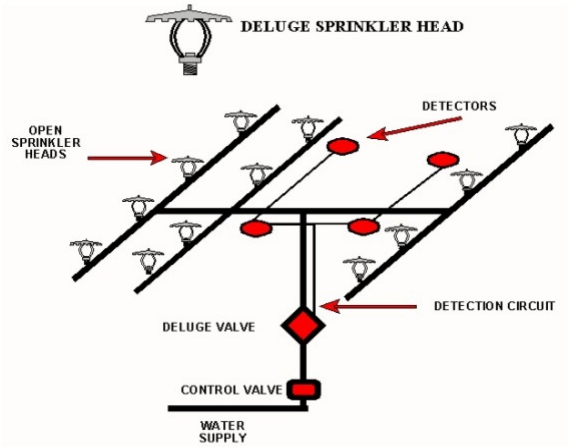

Figure 15 - Deluge Sprinkler System

Residential Sprinkler Systems

It is known that 80% of all fire deaths occur in residential occupancies. This type system was designed to create survivable conditions in the fire area. Residential sprinkler systems differ from standard sprinkler systems in the following areas:

- Less hardware
- Less expensive to install
- Designed with life safety in mind
- Reduced water supply requirements
- Faster response sprinkler head than standard system
- Area of coverage designed around residential fire loads
- Alarms designed for residential occupancies
- Piping can be steel, copper, plastic
- Minimum size is 3/4" pipe
- Water supply
- 18 g.p.m. for any one sprinkler head
- System needs to supply flow for only ten minutes
- Large residential buildings need to supply rate for up to 30 minutes

Figure 16 - Sprinkler Alarm Bell