MODULE – 3 PART I
WATER BASED FIRE PROTECTION SYSTEMS

This module will introduce the student to the following:

- Water as an extinguishing agent
- Building Occupancy Classification, Fire Loading, and Sprinkler Density requirements.
- Definition of a fire sprinkler system
- NFPA standards for sprinkler systems
- Sprinkler system types
- Sprinkler system components
- Description of a standpipe and various standpipe classes.

Following successful completion of this module, the student should be able to:

- List the characteristics of water as an extinguishing agent
- Describe the various occupancy fire hazard classifications as defined by NFPA and cite examples.
- Provide the basic definition of a sprinkler system.
- Cite at least two NFPA standards that apply to sprinkler systems
- Describe the five basic sprinkler system types, how they function, where they apply, and the differences between them.
- List basic sprinkler system components and identify the function of each.
- Describe and list the three standpipe classes, what type of personnel are intended to use them, and general water supply requirements.

WATER AS AN EXTINGUISHING AGENT

Water is the most commonly used fire extinguishing agent due to the fact that it is widely available, and inexpensive. Additionally, the fire extinguishing properties of water (mainly the high specific heat and latent heat of vaporization) make it a desirable medium. A single gallon of water can absorb 9,280 Btus of heat as it increases from 70° F to steam at 212° F.

It should be noted that water is not appropriate for all types of fires. In some cases water (as in the case of water reactive materials) can produce heat, flammable or toxic gases, and explosions. In the case of most hydrocarbon fuels, water is heavier that the fuel, immiscible (will not mix with the fuel), and will in some cases actually spread the fire. (Note that there are applications where water can be applied to flammable or combustible liquids fires. Such is the case with water mist systems that will be covered in Part II of this module). Therefore, it is critical that the designer of a fire protection system have a firm understanding of the material to be protected to avoid incompatibility between the extinguishing agent and the protected commodity. However, our discussion in both parts of this module will center on the appropriate application of water for fire protection systems.

BUILDING OCCUPANCY CLASSIFICATION, FIRE LOADING, AND SPRINKLER DENSITY REQUIREMENTS

NFPA 13 discusses the minimum requirements concerning the amount of water needed for proper sprinkler operation based upon the traditional design method of occupancy fire hazard control. Simply put, sprinkler water supply rates are determined based upon occupancy classifications that have been established based upon the expected quantity of combustibles, expected rates of heat release, potential total energy heat release, height of combustibles, and the expected presence of flammable and combustible liquids.

NFPA has established the following occupancy classifications:

- Light Hazard
- Ordinary Hazard (Groups I and II)
- Extra Hazard (Groups I and II)
- Special Occupancy Hazards

Light hazard occupancies represent the least severe type fire, and usually have a relatively low fuel load and are typically characterized by churches, schools, offices, theaters, museums, and hospitals.

Ordinary hazard (Group I) occupancies are typically characterized by occupancies similar to automobile parking showrooms, bakeries, electronic plants, laundries, and restaurant service areas.

Ordinary hazard (Group II) occupancies are typically characterized by horse stables, dry cleaners, cereal mills, large library stack rooms, repair garages, wood machining, and machine shops.

The extra hazard classification is assigned to occupancies where the expected quantity of combustibles is very high, may or may not contain combustible and flammable liquids, dust, lint, and other materials are present that provide the possibility of a fast developing fire with a high heat release rate. Generally, extra hazard group I occupancies contain little or no flammable or combustible liquids, whereas group II occupancies contain appreciable amounts of flammable or combustible liquids.

Extra hazard (Group I) occupancies are typically characterized by saw mills, plastics processing, plywood and particle board manufacturing, printing with low flash point inks. (Note that for this classification to be valid, little or no flammable or combustible liquids would be expected.)

Extra hazard (Group II) occupancies would be characterized by the same type of occupancies as Group I, however appreciable amounts of flammable and combustible liquids would be expected to be found.

Special Hazard occupancies are characterized as occupancies or potions of occupancies that fall outside the realm of other NFPA standards.

NFPA 13 provides “area density curves” that define the minimum amount of recommended water discharge over a specific area of operation (designated in gallons per minute per square foot, gpm/sq.ft.). As the area of sprinkler operation increases, the density of water discharge (gpm/sq.ft.) decreases. The hydraulic characteristics of sprinkler systems will be covered under part II of this module.

Sprinkler system

The maximum floor area on any one floor to be protected by any one sprinkler system riser or combined riser is limited to the following areas as contained within NFPA 13:

♦ Light Hazard Occupancy	52,000 sq. ft.
♦ Ordinary Hazard Occupancy	52,000 sq. ft.
♦ Extra Hazard Occupancy	40,000 sq. ft.
♦ Storage- High Piled Storage	40,000 sq. ft.

It should be pointed out that the above section is the most critical design element in the design of a sprinkler system since this sequence determines the amount of water to be delivered to a potential fire. Due to the critical nature and the potential impact on property and life safety, the application of this information from NFPA 13 should only be applied by individuals that possess sufficient engineering credentials, experience and judgment.

DESCRIPTION OF A TYPICAL FIRE SPRINKLER SYSTEM

Generally, when we speak of a fire sprinkler system, we are referring to a network of piping, valves, and sprinkler heads configured in such a manner as to automatically activate in the event of a fire. The objective of the sprinkler system is to automatically discharge water in a quantity and pattern sufficient to either extinguish the fire or suppress the fire until the fire department can respond. The successful operation of a sprinkler system aids in life safety by limiting the spread of fire, and alerting the occupants (through alarm features), that a fire is present in the building, thus affording evacuation time from the building.

NFPA STANDARDS RELATED TO FIRE SPRINKLER AND STANDPIPE SYSTEMS

The generally accepted standards for sprinkler systems are:

- NFPA 13- Standard for the Installation of Sprinkler Systems®
- NFPA 13D- Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes®
- NFPA 13R- Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height.®
- NFPA 14- Standard for Installation of Standpipe, Private Hydrants, and Hose Systems®

SPRINKLER SYSTEM TYPES

There are five major classifications of sprinkler systems as follows:

1. <u>Wet Pipe Systems</u>- Fire sprinkler systems that employ automatic sprinklers attached to the piping system which contains water under pressure at all times. Generally, the wet pipe type system is employed where there is no danger of freezing. (NFPA requires that wet systems be maintained within environments 40º F or above). Generally, wet pipe systems are the most reliable, and least cost type of system to install in a building.

2. <u>Dry Pipe Systems</u>- Fire sprinkler systems that employ automatic sprinklers attached to the piping system which contains pressurized air or nitrogen. When a sprinkler head is activated, pressurized air or nitrogen is expelled from the piping system which permits water to enter the piping and discharge from opened sprinklers. Generally dry pipe systems are employed where there is a danger of freezing (unheated attics, freezers, exterior canopies, loading docks, etc.). Generally dry systems are less reliable than wet systems due to additional components (air compressors, and alarms to maintain a suitable air pressure within the piping system), and cost more because of these additional components. Additionally, due to the delay in water delivery to the fire (due to the time to expel the air in the piping system) more sprinkler heads are activated by the fire which imposes a greater hydraulic demand on the system.

3. Preaction System- Fire sprinkler systems which contain air that may or may not be under pressure. When a fire occurs, a fire detection device (heat detector, smoke detector, etc.) sends a signal to open the main sprinkler water valve (usually controlled electrically) to admit water to the piping system. Water is contained within the piping system until a sprinkler head opens. (Usually, the fire detection device will respond to a fire condition earlier than the sprinkler head). This type of system is normally employed where the risk of damage to property from an accidental sprinkler discharge is unacceptable. Note that if a sprinkler head should open without activation of the main water valve from the fire detection circuit, water will not be admitted to the system.

4. Deluge Systems- Fire sprinkler systems that employ open sprinkler heads (i.e. no fusible link mechanism). When a fire occurs, a fire detection device (as described above) transmits a signal to open the main sprinkler water valve to admit water to the piping system. Once water is admitted to the system, water discharges from all sprinkler heads. This type of system is normally used where there is the likelihood of a fast spreading fire such as the storage of flammable liquids and in aircraft hangars where unusually high ceilings and drafts from hangar doors may delay heat activation of conventional sprinkler heads.

5. Combined Dry Pipe and Preaction System- This type of system incorporates the essential features of both a dry pipe and preaction system. The piping system contains air under pressure. When a fire occurs, a heat detector opens the main water control valve and air is exhausted from the system. At this point, the system fills with water and operates as a wet pipe system. If for some reason the heat detection system fails, the system will operate as a dry pipe system. The intended purpose of a combined dry pipe/preaction system is to provide an acceptable means of supplying water through two dry pipe valves connected in parallel to a sprinkler system of larger size than is permitted for a single dry pipe system by NFPA. These systems were originally developed for the protection of piers and where long lines of supply piping could have the potential of freezing when supplying a number of individual dry pipe valves. Due to complication of operation of this type of system and the delay in water delivery, this

type of system is used only in situations where there is difficulty in freeze protection of long runs of supply piping.

SPRINKLER SYSTEM COMPONENTS

Generally, most types sprinkler systems have the following components in common:

- A main valve (wet pipe, dry pipe, deluge, or preaction) that permits water to flow into the sprinkler system piping. These valves also prevent water flow out of the system (as in the case of the fire department pumping water into the system during a fire). The main valves also contain gauges and test valves to permit a visual inspection of the system status and to permit routine maintenance.

- A “Siamese” fire department connection. Normally, the Siamese fire department connection is located near the main sprinkler valve and/or standpipe system on the exterior of the building. This connection usually consists of (2) threaded inlets (usually 2-1/2” diameter inlets with a 4” common pipe), with protective caps that permit the fire department to make a direct hose connection between the pumper truck and sprinkler/standpipe system during firefighting operations.

- A means of providing an alarm signal to alert occupants to the presence of sprinkler system operation. This can be in the form of an alarm bell mounted on the exterior of the building, and usually includes a signal sent to the building fire alarm system to provide an audible alarm to occupants within the building.

- In the case of deluge or preaction valves, a battery back up power supply to provide power to operate the main valve in the event of a power outage.

- In the case of dry type systems, a means to automatically supply and maintain pressurized air into the piping system. This is normally accomplished through the use of air compressors specially listed for use on fire protection systems.

- In the case of dry pipe systems, a means to expel air or nitrogen from the system as quickly as possible. A device known as an accelerator. This device operates by sensing the pressure in the dry pipe system. A sudden drop in system air pressure (indicative of sprinkler head operation) activates the device to open and greatly increase the speed with which air is expelled from the system.

- Inspector's test connection. The inspector's test connection generally consists of a piping connection, and a valve connected to the most remote location of the system. The purpose of this component is to simulate the operation of a single sprinkler head on the system and to verify that all alarms properly function. On dry systems, this connection is also used to record the time for water delivery. Note that Inspector's test connections are not required on deluge sprinkler systems per NFPA.

- Main drain valve that permits draining of the sprinkler system for maintenance or in the case of a dry system, to permit the system to be reset.

- Sprinkler heads and/or fire detection devices. Sprinkler heads will be discussed in detail in part 2 of this module, and fire detection devices in Module-5

STANDPIPE DESCRIPTION AND CLASSES

Generally when we speak of a standpipe, we are describing a horizontal or vertical pipe designed to provide a means of the manual application of water to fires within a building. Standpipes are most often found in buildings of large area (e.g. warehouses), and in multi-story commercial buildings (e.g. high rises). Most model building codes require standpipes in commercial buildings over four stories in height. This requirement for standpipe systems is due to the height limitations of fire department aerial ladder equipment and the application of water to the upper stories of a building. Generally, the standpipe in a multi-story building is located within an exit stairwell to provide access to fire department personnel. However, standpipes must be located that all portions of the floor or section can be reached with a 30-foot water stream from a 100-foot hose.

Standpipe systems can be either wet or dry and are designated in one of three (3) classes under NFPA 14:

Class I standpipe systems are intended for use by trained personnel or the fire department, and are sized to provide heavy streams of water to combat the advanced stages of a fire. These standpipe systems utilize a 2-1/2" connection (usually an angle valve) that permits fire department personnel to connect 2-1/2" hose to fight the fire.

Class II standpipe systems are intended for use by building occupants and are sized to provide small streams of water to combat the incipient stages of a fire. These standpipe systems utilize a 1-1/2" connection with a hose rack and 100 ft of hose. The hose may be exposed or located within a cabinet.

Class III standpipe systems are intended for use by either building occupants or fire department personnel, and are sized to provide either small or large streams of water for fire fighting. These standpipe systems utilize a 2-1/2" outlet (usually an angle valve) with a 2-1/2" x 1-1/2" adapter, and 100 feet of 1-1/2" hose. The incipient stages of a fire can be fought by building occupants with the 1-1/2" hose. Once the fire department arrives, the 1-1/2" adapter and hose can be disconnected with fire fighting operations continuing with the 2-1/2" outlet as in the class I system.

Generally, a separate fire department connection (see sprinkler system components) is provided to enable the fire department to connect and control flow and pressure to the standpipe system.

In tall multi-story buildings, NFPA recommends that standpipe systems be divided into separate "pressure" zones, with no individual zone exceeding 275 feet in height. This recommendation is to prevent excessive pressure at each standpipe outlet.

Generally, water supplies should be capable of providing a minimum of 500 gallons per minute (gpm) for the first standpipe system and 250 gpm for each additional standpipe (not to exceed a total of 2,500 gpm) for class I and III systems. Water supplies may be reduced to a maximum of 1,500 gpm for light hazard occupancies and 2,000 gpm in ordinary occupancies in buildings that are completely sprinklered. Additionally, water supplies should be capable of maintaining a minimum residual pressure (water pressure measured with waterflow) of 100 pounds per square inch (psig), with the top (most remote) standpipe outlet flowing 500 gpm, and 250 gpm from all other standpipe outlets up to the maximum flow.