FIRE PROTECTION SYSTEMS

TERMINAL OBJECTIVES

The students will be able to:

1. *Identify fire protection systems and devices and describe procedures to validate their operational readiness.*

2. *Determine the components of water distribution systems.*

ENABLING OBJECTIVES

The students will:

1. *Define fire alarm systems.*

2. *Define suppression systems, including automatic sprinkler systems and other automatic extinguishing systems.*

3. *Define portable fire extinguishers.*

4. *Identify the various types of water storage devices.*

5. *Identify the various types of piping materials used in water supply systems.*

6. *Identify the different types of valves in water supply systems.*

7. *Describe a water distribution system.*

8. *Contrast private and public water supply systems.*

9. *Explain the function of pumps, pipes, and valves used in water distribution systems.*

INTRODUCTION

Under the rather broad heading of fire protection systems, this module will examine the main components of alerting, suppression, and containment features and systems. Consideration of these systems is a natural adjunct to a discussion of hazards and building construction features.

The primary components we will examine are fire alarm systems, fire detection and notification systems, suppression agents and systems, water distribution systems, automatic sprinkler systems, standpipe and hose systems, and portable fire extinguishers. This module will cover a lot of basic material meant to provide the novice inspector a solid foundation on which to build. As was said in the earlier modules, it is only a beginning.

FIRE ALARM SYSTEMS

Purpose of Fire Alarm Systems

A properly designed, installed, operated, and maintained fire alarm system can reduce the losses associated with an unwanted fire in any building. These losses include property and, more importantly, human life. The primary motivation for fire alarm system requirements in building and fire codes is to provide early notification to building occupants so they can exit the building, and to notify the fire service so it can respond to the fire. In settings such as hospitals the fire alarm system provides notification to staff so they can respond to the fire emergency (as opposed to evacuating the building). This module will explain the basic features of fire alarm systems and the inspection of these systems. It should be noted that fire alarm systems also are called "protective signaling systems," especially in NFPA documents and in other codes and standards.

Basic Components of a Fire Alarm System

Fire alarm systems generally have the following components.

Alarm Initiating Device Circuits

These are the circuits which connect initiating devices such as smoke detectors, heat detectors, manual pull stations, and water flow alarms. Additionally, many system monitor devices important to the overall fire safety of the building also tie in to initiating circuits. These devices indicate an "abnormal" condition, not a fire or "alarm" condition. They are referred to as "supervisory devices." One example would be the valve supervisory switch or tamper switch of a valve controlling the automatic sprinkler system. These types of devices also may be connected to supervisory type circuits.

Alarm Indicating Appliance Circuits

Audible and visible alarm indicating appliances tie in to these circuits to provide warning to the building occupants. Devices which send a signal off premises also can be connected to these circuits.

Fire Alarm Control Panel

The fire alarm control panel contains the electronics that supervise and monitor the fire alarm system. The initiating and indicating circuits are connected directly into this panel.

Primary Power Supply

The primary electrical supply powers the entire fire alarm system. Primary power for fire alarm systems typically is provided by connecting into the local commercial power service.

Secondary Power Supply

A separate power supply that will operate automatically when the primary power fails and is capable of operating the entire system is considered a secondary power supply.

Initiating Devices

Initiating devices fall into one of two main categories: either those that indicate an alarm condition, or those that indicate an abnormal condition of a monitored device. A brief description of the common types of devices follows.

Fire detection can occur by using any device that responds to conditions caused by fire. The most common byproducts of fire are heat, smoke, flames, and fire gases.

In addition, people can detect a fire and initiate an alarm by activating a manual pull station. Also, when a sprinkler system activates and causes an alarm, it is a result of the sprinkler system detecting heat produced by the fire (if the sprinklers have fusible links). We will now look briefly at heat detectors, smoke detectors, flame detectors, gas sensors, manual fire alarm boxes, automatic suppression systems, and indicating appliances.

Heat Detectors

Heat detectors commonly are used to detect fires. They are not as prone to false alarms and are less expensive than smoke detectors. However, the response of heat detectors may not be adequate in many instances, which limits their usefulness. Heat detectors are slower to respond to fires than are smoke detectors because heat detectors cannot respond to smoke. Heat detectors typically are best suited for detecting fast-growing fires in small spaces. Heat detectors are also a means of fire detection in locations that smoke detectors cannot protect due to such environmental effects as mist, normally occurring smoke, and high humidity. Heat detectors have several different operating mechanisms.

Fusible-element type mechanisms use a eutectic alloy that melts rapidly at a predetermined fixed temperature. When this temperature is reached and the fusible alloy melts, an electrical contact occurs and causes an alarm. Fusible alloys also are commonly used in sprinkler heads. These mechanisms must be replaced after each operation.

Bimetallic type mechanisms combine two metals with different thermal expansion coefficients. As the mechanism heats, one metal expands more than the other, causing a deflection in the shape of the element. This deflection causes an electrical contact, thus initiating an alarm. These types of mechanisms are self-resetting as the element cools.

Rate-compensated heat detectors respond to a given temperature of the surrounding air regardless of the rate at which the temperature rises. This, in effect, compensates for thermal lag, which standard thermal detectors do not do. This can be compared to the rate-of-rise detectors discussed immediately below.

Some heat detectors operate on what is commonly referred to as the "**rate of rise**" principle. Regardless of the ambient temperature, if the detector senses a rise in temperature exceeding a set amount, an alarm occurs. One method of accomplishing this is using a container that has a small vent hole. As air is heated it expands; this can cause a set of contacts to close and send an alarm. If the expanding air can leak out of a vent hole, the resulting pressure will be reduced. However, if the air expands at a rate faster than the vent hole can compensate for, the contacts will close and an alarm will be sent.

Combination heat detectors can combine the two operating principles of reaching a fixed temperature and reaching a set rate of rise. Smoke and heat detectors also can be combined into a single unit. It should be noted that some combination smoke/heat detectors activate when either condition is reached, while others require both the smoke and heat mechanisms to operate. In most cases, little benefit, if any, results from the combination detector which requires both heat and smoke to cause an alarm.

Other types of heat detectors include heat-sensitive cables and liquid expansion detectors.

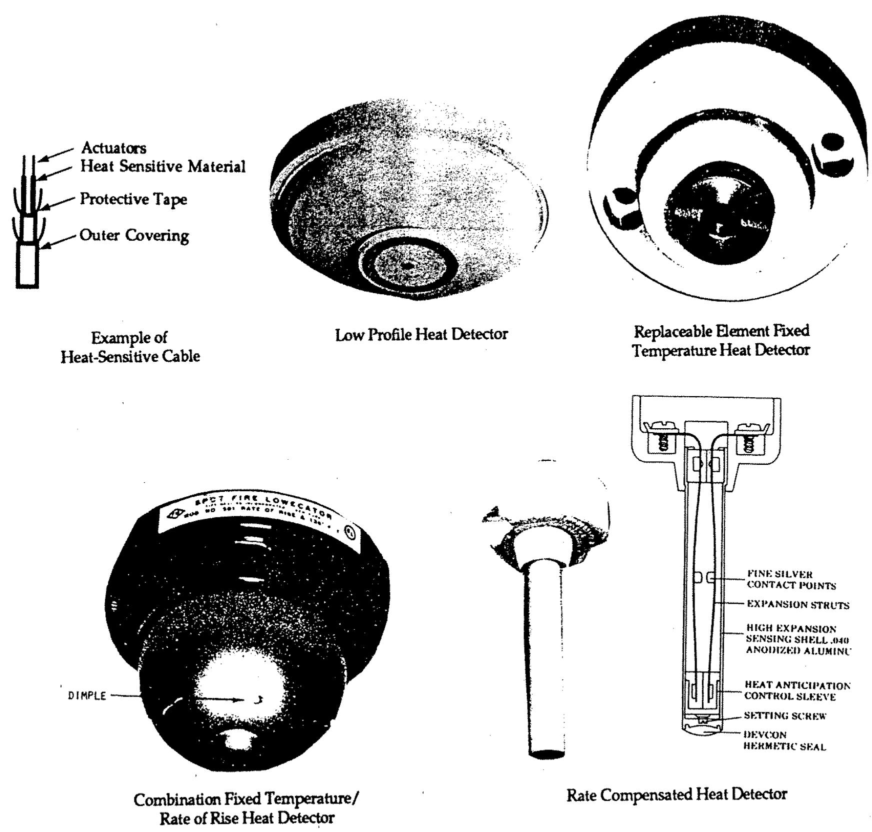


Figure 1
Heat Detectors

Smoke Detectors

One cannot overemphasize the benefits of smoke detectors. However, smoke detectors are not usable in all environments and their effectiveness varies depending on the fire scenario and occupant capability. The two basic operating mechanisms currently used in smoke detectors are photoelectric and ionization.

Ionization smoke detectors have a small amount of a radioactive material located within the detector that "ionizes" the air entering the detection chamber. Once ionized, the air particles become conductive, allowing a current to flow through the detector circuitry. Smoke entering the ionization chamber causes a reduction in the current flowing through the detector's circuitry. At a certain reduced level of current flow, the detector signals an alarm.

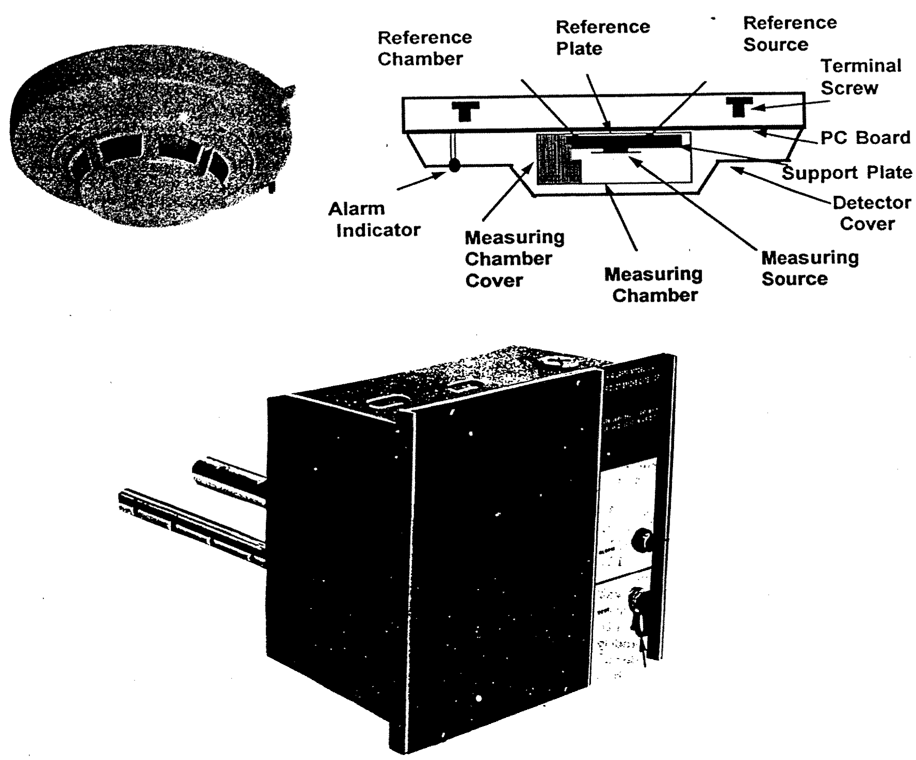


Figure 2
Example of Ionization Smoke Detector with Air Sampling Tubes for Installation in Duct Work for Air Handling System

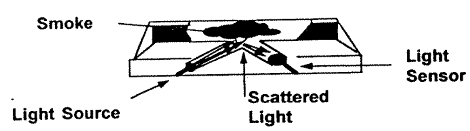
Photoelectric smoke detectors use one of two methods to detect smoke; however, both use a light-emitting source and a receiver. Photoelectric smoke detectors that operate on the "light obscuration" principle work as follows. A light source is directed at a receiver which is accustomed to receiving a certain intensity of light. When smoke particles enter the detection chamber they partially block the light traveling from the emitter to the receiver. When the light is reduced or obscured by a certain amount, the detector's built-in circuitry sounds an alarm.

The second operating principle used in photoelectric detectors is that of "light scattering." It is more common and operates as follows. The receiver in the detection chamber is located so that the light emitted is normally not "seen" by the receiver. That is, the light emitter and receiver are not aligned as with the light obscuration method. When smoke enters the detection chamber, light from the emitter strikes it. A fraction of the light striking the smoke particles is scattered or "reflected" away from the smoke particle. Some of this scattered light lands on, or strikes, the photo receiver. When a preset amount of light lands on the receiver, the detector signals an alarm.

Detectors that operate on the photoelectric principle are generally appropriate in locations where slow-growing, smoldering fires are expected. These fires typically generate large size particles (0.3-10 microns). They also respond better to light gray smoke as opposed to very dark smoke. Ionization-type detectors respond better to fast-flowing, flaming fires that produce smaller particles (0.01-3.0 microns). Ionization detectors respond better to dark smoke than to light smoke. Photoelectric detectors are better suited than ionization detectors for locations with high humidity. Air velocity also may affect smoke detector operation.

A special type of photoelectric smoke detector is the **projected-beam detector**. Here the operating principle is the same as a light-obscuration-based detector but the light emitter and the receiver are physically separated across large areas (e.g., the length of a room). Smoke at any location between the two components can result in an alarm. These detectors also can be used in conjunction with mirror systems so that the projected beam is directed in several directions before ultimately striking the receiver.

Another special type of smoke detector is the **cloud chamber** smoke detector. This detection system uses a pump to sample the air from a given room. The air is pumped into a high humidity chamber and the pressure in the chamber then is reduced slightly. If smoke particles are present, as the pressure is lowered, moisture will condense on the smoke particles. This creates a "cloud" within the chamber. The photoelectric principle discussed above is then used to detect the presence of the "cloud" and, hence, smoke.



Light Scattering Principle

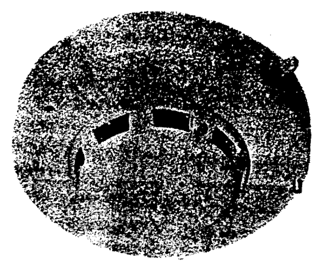
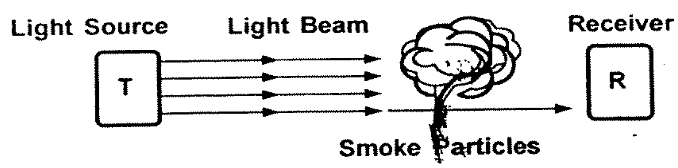


Figure 3
Examples of Photoelectric Smoke Detectors



Light Obscuration Principle

Figure 4
Example of Beam Smoke Detector

Recent data indicate that health care facilities, for example, are experiencing an average of approximately 15 unwanted alarms for every real alarm. One problem resulting from these high averages is that people may ignore the fire alarm's warnings during fire drills and actual emergencies, believing it to be "just another false alarm." Quite obviously this could lead to a tragedy. Many of the unwanted alarms are attributed to "field" problems such as insects in the detector and other maintenance deficiencies.

Some modifications in detector design are helping to reduce the unwanted alarm problem. Alarm verification recently was approved by U/L. This allows the fire alarm panel to "wait" for a specified time period to see whether the signal from the detector is just from a brief exposure to smoke or from electrical "noise." Device manufacturers are modifying their products continually to reduce the unwanted alarm rate. System maintenance can have a profound effect on the false alarms at facilities.

There are other ways to deal with the unwanted alarm situation: proper system design, installation, and acceptance test procedures. For example, the specification could specify a certain sensitivity rating such as 2.5 percent or 3 percent which would eliminate detectors that are too sensitive. During the acceptance test one should verify the sensitivity of the detectors. Also, proper location of smoke detectors with respect to air diffusers will assist in reducing unwanted alarms. As a general rule of thumb, a detector should have a three-foot separation from a supply air diffuser.

Flame Detectors

Another method of fire detection is detectors that are sensitive to the light waves emitted by fires. These typically operate by detecting **ultraviolet** (UV) or **infrared** (IR) energy. These detectors are extremely quick to operate and typically are used only in high hazard areas such as industrial process facilities, fuel-loading areas, and areas where explosions may occur. Explosion suppression systems protect them. One problem with IR detectors is that they will respond to sunlight, creating an unwanted alarm problem. Besides, both types of flame detectors must "see" the flame to detect it so they usually have to be pointed toward the locations where fires are likely to originate.

Figure 5
Infrared Flame Detectors

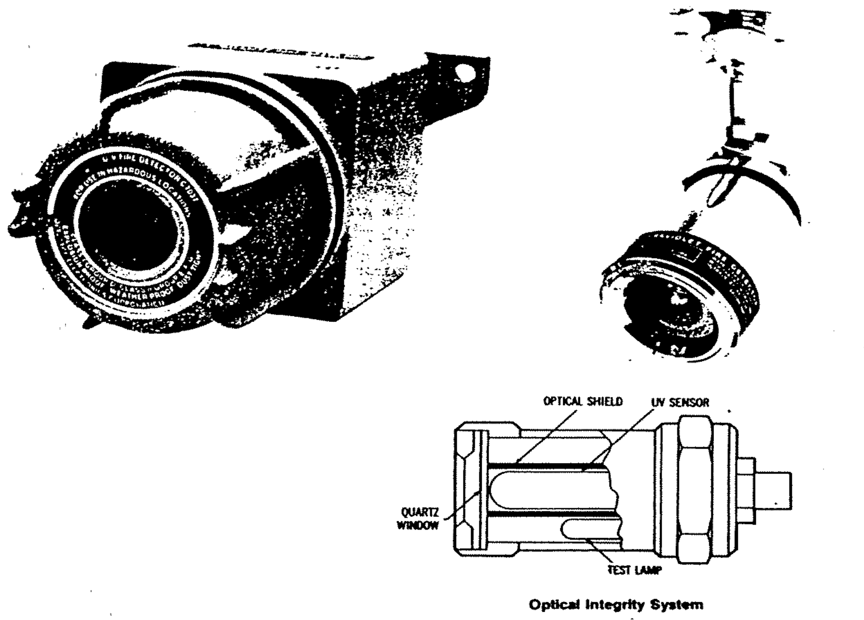


Figure 6
Ultraviolet Flame Detectors

Gas Sensing and Other Phenomena Detectors

Gas sensing detectors and "other phenomena" detectors are not common. Special gas detectors sense specific gases given off by a fire; these gases indicate a fire. For example, there are carbon dioxide and carbon monoxide detectors. The use of carbon monoxide gas detectors in the home is becoming very popular as a way of warning residents of gases produced by malfunctioning heating equipment.

Basically, any method of fire detection not already mentioned is considered under the "other phenomena" category. One example is pressure. If a fire burns in a sealed room (the Apollo capsule, for example), excessive pressures develop quickly and can be detected. Some explosion detection devices operate this way.

Manual Fire Alarm Boxes (Pull Stations)

Very common initiating devices, the manual fire alarm boxes usually are referred to as manual pull stations. These are simple devices which operate manually, i.e., they require that a person operate the mechanism. These are found throughout building hallways, near exits, and at other strategic locations such as a nurse's station or security center.

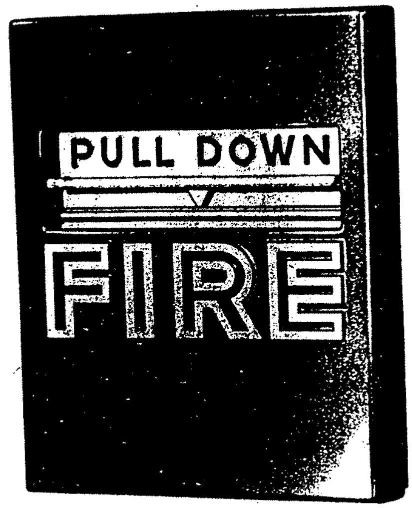


Figure 7
Manual Pull Box

The manual fire alarm devices provide a means of manually activating the fire alarm system and are used in all types of fire alarm systems. They may be the only initiating devices provided, or they may be used with automatic initiating devices, such as heat or smoke detectors.

Manual fire stations generally are located near main exits from a building or from a floor of a multistory building and in certain work areas containing unusual fire hazards, valuable equipment, or records subject to fire damage. Paint shops, aircraft repair areas, computer rooms, and telephone equipment rooms are examples of such work areas.

Automatic Suppression Systems

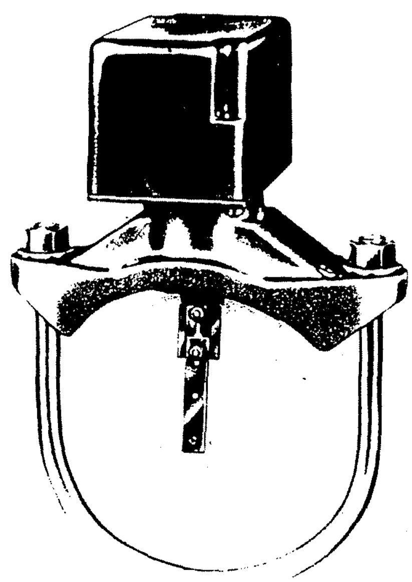
Fire suppression systems can connect into a fire alarm panel so that activation of the system causes the panel to signal an alarm. Wet pipe automatic sprinkler systems commonly have water flow detectors. As water starts to flow in the sprinkler piping, it causes a vane to swing into an alarm position; this sends an alarm to the fire alarm panel. Dry pipe sprinkler systems may have pressure sensors for the same reason.

All other fire suppression systems also can be connected to the fire alarm panel. As mentioned above, not all devices signal an alarm condition.

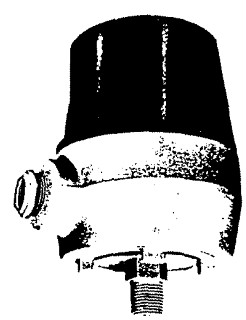
Many devices tie into the fire alarm system so that they will alert for abnormal conditions. Perhaps the most common example is that of a valve supervisory switch or "tamper switch" on a sprinkler system. To assure valves that control a sprinkler system are in the proper position, they can have a tamper switch that will operate if the valve position changes. If the valve moves, a signal will appear at the fire alarm panel indicating the valve should be inspected. This is important since someone could inadvertently, or purposely, close a valve on the sprinkler system, rendering the system inoperable.

Many other indicating devices can connect into the fire alarm panel for supervision. The following is a partial list.

- water level and temperature in a gravity tank;
- water level and air pressure in storage tank;
- status of fire pump;
- air pressure on dry pipe system; and
- temperature in the sprinkler control valve room.



Vane type water flow detector for wet type systems only. Vane is inserted into the pipe through a drilled hole.



Pressure increase type water flow detector for either wet or dry type systems

Figure 8
Examples of Water Flow Detectors

Indicating Appliances

<u>Signal Circuit Appliances</u>

When a fire alarm system goes into an alarm condition because of the operation of an initiating device, several activities can occur. NFPA 101 and the building codes may require that a signal be sent to the fire department. Activation of the fire alarm panel may cause other events to happen. In most cases the fire alarm system also provides audible and visual indications that an alarm condition has occurred. This latter function is the most important when considering an occupied building.

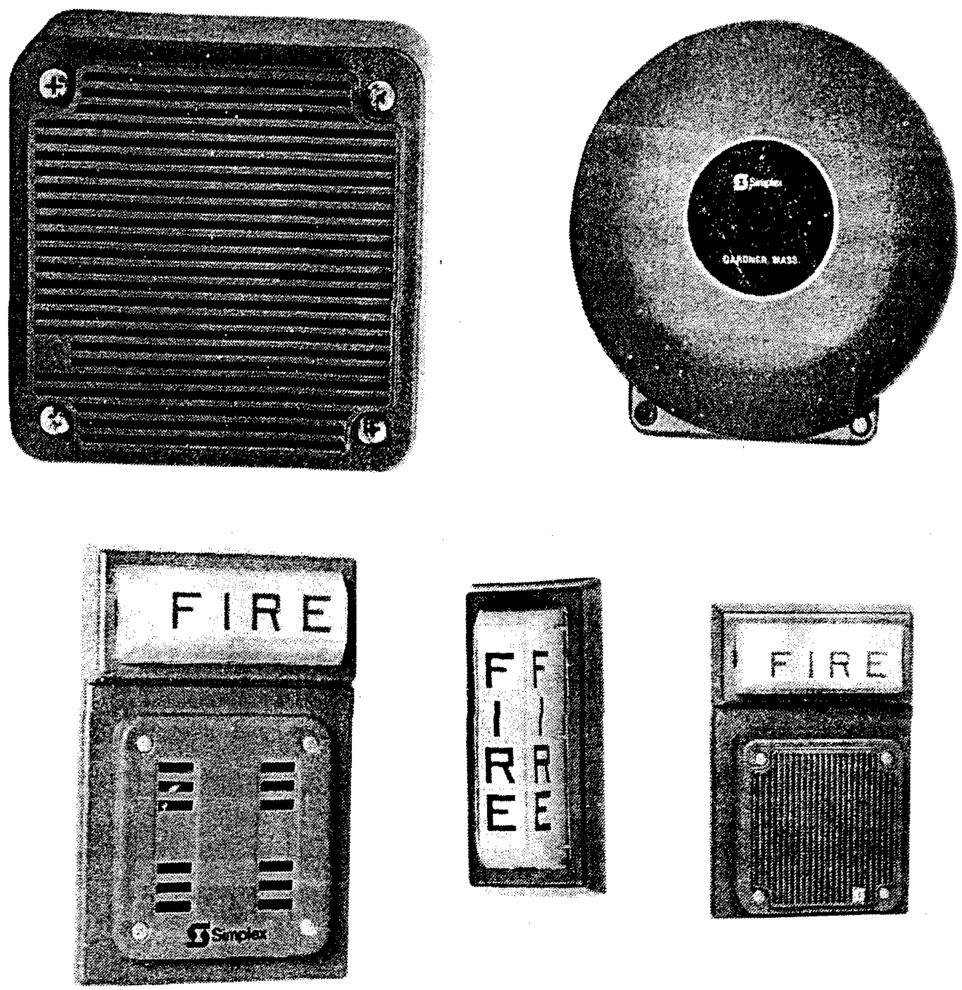


Figure 9
Audible and Visual Alarm Appliances on Indicating Circuits

A fire alarm panel also can perform functions as needed or required. Examples of these would be to control a remote annunciator or to operate relays that capture and recall elevators. These and other functions will be discussed further in following sections.

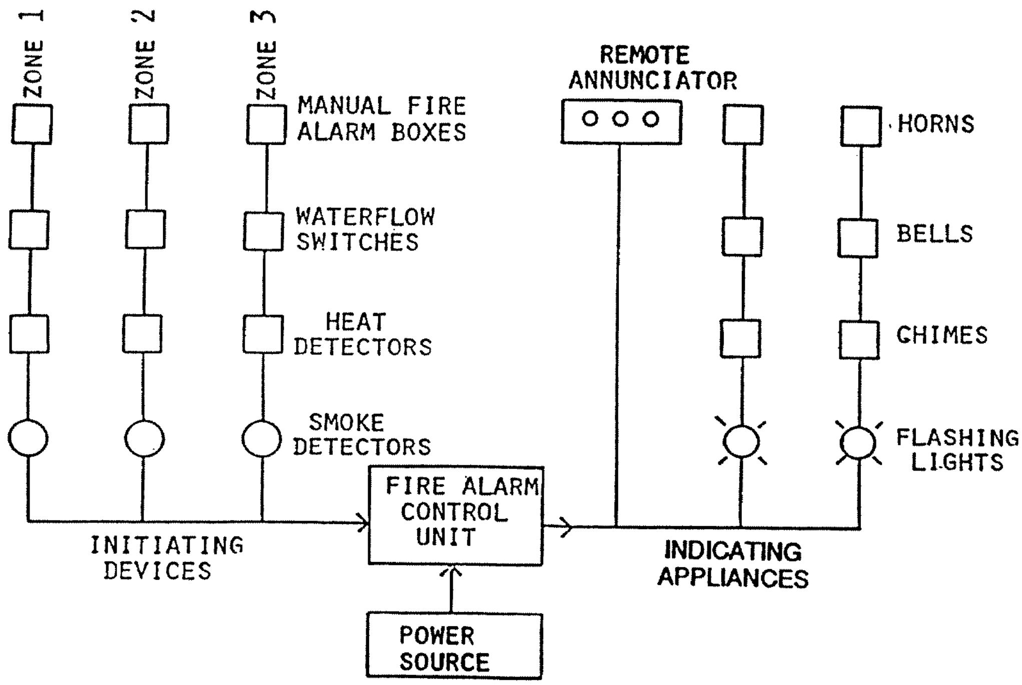


Figure 10
Local Fire Alarm System Diagram

Secondary Power Supply

The secondary, or backup, power supply is required so that fire alarm operations can continue if failure of the main power supply occurs. The secondary power supply should activate automatically within 30 seconds of the primary power failure to maintain its normal operating voltage. Secondary power supplies should be capable of powering the system at maximum loading for at least a 24-hour period and then be capable of operating all alarm appliances for another 5 minutes. The time period requirements for secondary power operation capabilities vary and can be found in NFPA 72, *National Fire Alarm Code.* Batteries with chargers are a common form of secondary power supply and engine-driven generators also are acceptable.

Trouble Signal

An important feature of any fire alarm system is the trouble signal. Upon the detection of an abnormal condition within the fire alarm system, the trouble alarm signal activates to attract attention to the system so that the condition can be repaired. NFPA 72 requires as a minimum that all systems provide an abnormal condition trouble signal for a signal open or ground fault of the system's initiating, indicating circuits, and loss of primary and secondary power supply to the system.

All components of fire alarm systems should be listed for fire alarm system use by an acceptable testing agency such as Underwriters Laboratories (U/L). Additionally, all components must be used only for the specific function for which they have been designed and tested.

Types of Fire Alarm Systems

In 1993 the National Fire Protection Association incorporated all of the existing 72 series standards into one standard that also included NFPA 71. This new standard is titled NFPA 72, *National Fire Alarm Code.*

Fire alarm systems can be designed and configured to meet the requirements of local fire codes. In addition to the basic features or components common to most fire alarm systems, there are several "types" of fire alarm systems. These are described here (with a reference to the standard prior to being incorporated into NFPA 72).

Local Protective Signaling System

This type of fire alarm is contained entirely within the building which it services. The main purpose of this type of system is to provide an evacuation alarm for occupants of that building. The system need not be connected by any means to the fire service. Therefore, notification of the fire service can occur only if someone hearing the evacuation alarm calls and reports the fire alarm. This is the most common type of fire alarm and was covered previously in NFPA 72A, now part of NFPA 72.

Auxiliary Protective Signaling System

This type of system is connected to a municipal coded fire alarm box dedicated to that building. Upon activation of the fire alarm within the building, the municipal box is tripped and sends a signal to the fire service. It uses the same line as the street fire alarm boxes available to the public. This type of system, covered previously in NFPA 72B, is now part of NFPA 72.

Remote Station Protective Signaling System

This type of system uses leased telephone lines to connect the fire alarm system of a given building to a remote receiving station such as the local fire or police station. This type of system, covered previously in NFPA 72C, is now part of NFPA 72.

Central Station Protective Signaling System

In this type of system the fire alarm system is connected to a privately owned central station. The central station monitors the fire alarm system and takes the necessary action when an alarm is received, such as to call the local fire department to report an activated fire alarm. This type of system, covered previously in NFPA 71, is now part of NFPA 72.

Proprietary Protective Signaling System

This type of system is similar to the central station system discussed above, except that the central station is owned by the same concern as the building being monitored. The building(s) being protected may or may not be on the same property as the central station. Many large facilities use this type of system with the security center serving as the central station. This type of system, covered previously in NFPA 72D, is now part of NFPA 72.

Voice-Alarm Communication System

Systems can include an emergency voice/alarm communication system. Inclusion of this equipment within the fire alarm system provides for the transmission of information to occupants of the building. The fire department also can use this equipment while operating within the building. This type of equipment, covered previously in NFPA 72F, is now part of NFPA 72.

Audible and Visual Alarm Indicators

To make occupants of a building aware of a possible fire emergency, they must be notified in some manner. Fire alarm systems typically accomplish this through audible and visual indicating devices. So that occupants don't mistake the signals' purpose, and because the building may be occupied by handicapped persons, there is a need for both types of signals. For example, a deaf person will not hear a fire alarm bell and a blind person cannot see a fire alarm strobe light. Bells, chimes, horns, buzzers, and speakers as well as strobe lights, rotating beacons, and flashing lights are common examples of these devices. Many times the audible devices will ring in what is referred to as "march time." This means the ringing is not constant but in an on-off manner. The flashing of lights or strobes acts better to alert occupants than a steadily illuminated light. It is common practice, but not always desirable, to locate the audible and visual devices in one unit.

In addition to march-time signals, there are "coded signals." Coded signals, as the name implies, have a pattern (code) that provides information regarding the initiation of the alarm. The code may indicate a location such as a floor or wing where the alarm started. It also could alert the occupants about the required action. The extent and meaning of any coded fire alarm signal must suit the needs of a particular facility. In hospitals, for example, where loudspeaker warnings are common, either coded or direct, such warnings and any fire alarm warnings need coordination so that the two do not interfere with one another. All signaling systems should be engineered and tested to ensure they are capable of alerting all occupants. This requires a knowledge of the anticipated background noises. For example, a mechanical room that has equipment operating that produces high noise levels may require special attention.

Other Functions Controlled By Fire Alarm Systems

As mentioned above, fire alarm systems can do more than receive an indication of an emergency and send an alarm. This section will identify some of the common functions controlled by fire alarm systems. The list is not intended to be all-inclusive.

The fire alarm panel can send a signal to the fire department or other desired facility via one of the methods described at the beginning of this section. Elevator capture and recall is a common function that fire alarm panels can perform easily. Upon receiving an alarm, the fire alarm panel can operate one or more relays that control the actions of the elevator. The heating, ventilating, and air conditioning system (HVAC) or a smoke control system also can be controlled through fire alarm panels.

Fire alarm systems frequently include remote annunciators. Briefly, a remote annunciator "displays" the condition of the fire alarm panel at a remote location, usually through lights (LEDs) on graphic or tabular displays. Remote annunciators also can have switches that control the main fire alarm panel. The fire alarm panel may be in a secured area out of the public way. However, it must be remembered that those investigating an alarm need to inspect the indicators on a fire alarm or annunciator panel to determine the cause of the alarm and the location of the initiating device. Remote annunciators can be at locations such as the main lobby of a building, or at a security desk, so that the needed information on the condition of the fire alarm panel is readily available.

Earlier we said that fire suppression systems can tie into fire alarm panels so that their activation is monitored. Another important function that a fire alarm panel can control is the activation of fire suppression systems. In this function, the fire alarm panel identifies a fire through its initiating circuits, and activates a fire suppression system such as a halon or CO_2 system, through a control circuit. This means that fire alarm systems can both alert when a fire suppression system is activated, and serve as a control mechanism when suppression systems are activated. Other types of fire suppression systems that fire alarm panels can control are preaction and deluge sprinkler systems. We will talk more about these later.

FIRE SUPPRESSION AGENTS AND SYSTEMS

Basic Fire Suppression

Fire suppression and extinguishment involve two essential variables: the extinguishing agent and the system or procedure for applying the agent. The primary methods of achieving fire suppression can be explained through the use of the fire tetrahedron which evolved from the familiar fire triangle. The fire triangle is a graphic representation of the three components that must be present for combustion to occur: 1) fuel, 2) heat, and 3) oxygen. If some of these components are removed or sufficiently reduced, combustion ceases. Fire suppression involves the removal or reduction of one or more components of the fire triangle. Or so it was thought until fairly recently.

With the advent of halon and a re-evaluation of the dry chemical extinguishing agents, came a necessity to modify the fire triangle. In addition to the removal of one of the three components just described, fire can be put out by interfering with the complex chemical reactions that are constantly occurring during the combustion process. This "uninhibited chain reaction" now adds a fourth side to the fire triangle, and the fire triangle becomes the fire tetrahedron.

Water

Water is the most common fire extinguishing agent used because it has several features that make it a desirable extinguishing agent. It also has some limitations. Water can extinguish fire by cooling the fuel below the temperature at which the fuel can produce flammable vapors. Water also can extinguish by smothering, dilution, and emulsification.

Water has a very high specific heat; it needs a great deal of heat before it can change from the liquid to the gaseous phase. Therefore, water applied to a fire will absorb a large portion of the heat released by the fire. If there is enough water to absorb the heat, the fire will go out since the fuel cools below the temperature required to liberate additional flammable vapors. Once water is converted to steam, it is still an effective fire extinguishing agent, since the steam can continue to absorb a great deal of heat. It is best to introduce water into the fire area in the form of a spray as opposed to a stream. A spray will allow for the quicker absorption of heat. For this reason, sprinklers discharge water in a spray pattern.

When water transforms into steam, its volume increases approximately 1,600 times. This acts to displace the oxygen from the fire area. This will result in the smothering, or oxygen depletion, of the fire. Without adequate oxygen, the fire soon will die. Thus, water transferring to steam acts as a suppression agent in two ways: heat absorption and oxygen displacement.

Extinguishment by dilution means the introduction of water into a burning liquid. The dilution acts to cool the liquid and reduces the vapor production at the fuel surface, since the flammable liquid is diluted.

Emulsification is another method of fire extinguishment using water. Basically, an emulsion is formed when immiscible liquids are mixed and one of the liquids becomes dispersed in the other. The emulsion that forms at the surface will retard the liberation of flammable vapors and the fire will die. Dilution and emulsification have several limitations and generally are not a good way to extinguish a fire. Spills and boilovers may occur in some tanks, causing the fire to spread and possibly causing injuries.

Perhaps the main benefit of water as a suppression agent is that it is relatively cheap and readily available in most areas, especially if there is a municipal water supply. The major limitations of water are that it is extremely heavy, it conducts electricity, it can damage property, and it can freeze. However, there are design methods, including the selection of other agents, that can minimize the negative aspects of water as a suppression agent.

Water With Modifiers

Occasionally the water used for fire suppression has modifiers added to change some of its characteristics. Foam is perhaps the most common example. Low- to high-expansion foam concentrates frequently are added to water to form a foam solution for fighting certain types of fire, such as flammable liquid spills. Additives also include surface tension reducing agents frequently called wetting agents. These increase the ability of water to penetrate combustibles; in turn this allows the water to attack deep-seated fire. Antifreeze is used to reduce the freezing point of water when temperatures at or below freezing threaten the proper use of water-based fire suppression systems. NFPA's *Fire Protection Handbook* discusses other water additives used with less frequency.

Carbon Dioxide (CO_2)

CO_2 is a substance with many commercial uses. Perhaps the most familiar is the carbonation in soda pop and other carbonated beverages. CO_2 also has a number of properties which make it a good fire extinguishing agent. One of the most common uses of CO_2 systems is to protect kitchen cooking equipment. The hood, ducts, and enclosed broilers may be protected with a total flooding application. Deep fryers require local application protection.

At room temperature and pressure, CO_2 can exist as a vapor or a solid. Eventually the solid form (dry ice) will transfer to the gaseous form. For fire extinguishing purposes CO_2 cannot exist at pressures below 75.1 psi absolute (about 60 psi). At this pressure, the liquid, vapor, and solid phases of CO_2 can all exist simultaneously. This point is of importance when designing piping systems to carry liquid CO_2. Pressure in the pipeline must not drop below this point or the attendant formation of dry ice will block the pipe and stop the flow.

In any fire, heat results from the rapid oxidation of the fuel. Some of the heat generated brings the unburned portion of the fuel to its ignition temperature, while a large portion of the heat and combustion escapes by radiation and convection to the surroundings. If the atmosphere that supplies oxygen to the fire is diluted by adding carbon dioxide, the rate of heat generated by oxidation is reduced. When the rate of heat generation is less than the rate of heat loss, the fire will die. Complete extinguishment will occur when all of the fuels involved cool below their ignition temperatures.

When the liquid is discharged to atmospheric pressure, it "flashes" over to vapor and dry ice. The percentage of dry ice and vapor produced depends primarily on the storage condition of the liquid. The superheated CO_2 vapor is about 50 percent more dense than air. The dry ice has a temperature of about -110°F at atmospheric pressure. In spite of the low temperature of the dry ice particles, the heat capacity of the CO_2 is rather low compared to other fire extinguishing agents such as water. Thus the cooling effect, though present, is not as significant on a pound-for-pound basis as the cooling produced by water. Most of the dry ice from a typical total flooding discharge is sublimated by the air in the enclosure.

The evaporation of the dry ice in the fire zone removes heat from surroundings at a rate between 60 and 110 Btus per pound of liquid CO_2 discharged. While this cooling is small compared with the cooling obtained with other agents (water provides ten times the cooling effect per pound), it does contribute to extinguishing effectiveness.

The relative high density of CO_2 vapor makes it useful for blanketing the surface of a fuel. The oxygen in the surrounding air physically separates from the surface of a fuel. This effect is noticeable particularly with local application.

Halon

Halon is a fire extinguishing agent commonly used to protect electronic and electrical equipment, surface burning solids such as some plastics, flammable liquids, and gases. Halon generally is not successful in protecting reactive metals (e.g., magnesium, sodium, etc.) and in extinguishing many fires that can become deep seated. For these fires, high concentrations and a long soak time would be required. Fuels that contain their own oxidizing agent will burn freely in halon, making it ineffective. Halons also are quite expensive, a concern when determining the type of agent and system to use for fire protection.

Halon extinguishes fire by entering into, and disrupting, the chemical combustion chain reaction; the exact mechanism still is not understood completely. This is unique for a fire extinguishing agent in that it affects the chemical chain reaction as opposed to quenching (removal of heat by water) or smothering (by CO_2).

The breaking of the chain reaction allows halon to suppress fires quickly. In addition, halon is considered a "clean" agent, in that it leaves no residue after discharge. It is almost completely electrically nonconductive; hence its wide use in electronics. Halon is also noncorrosive to many materials. Since Halon 1301 is a gas when discharged, it has good volume filling capabilities. However, Halon 1211, another fairly common agent, does not vaporize as readily as Halon 1301. The concentrations required typically are low, on the order of five percent by volume. This results in smaller storage containers. Halon is approximately 2-1/2 times more effective than CO_2 on a weight basis. Finally, halon is colorless, which allows people caught in a discharge to see through it.

Halon systems often protect data processing centers and other areas which contain sensitive electrical equipment. Such systems also exist in electric and telephone switchgear rooms. In addition to the type of hazard protected, another critical criterion for using halon is the need to provide a tight enclosure. Since halon is a gas, it can leak through improperly sealed openings and, as a result, the required design density is not maintained.

Lately, there has been great concern over the effects halon has on the environment, and in particular its depletion effect on the ozone layer. This has resulted in a re-evaluation of the use of halon as a fire suppression agent. In addition, the use of halon in acceptance testing has been subject to study, and options such as using different test gases (e.g., sulfur hexafluoride, SF_6) are now being evaluated. Several new products are now under development to replace the halon agent in existing fire suppression systems.

Dry Chemical

Dry chemical extinguishing agents can extinguish extremely fast if introduced directly into the flaming area. Smothering and cooling result from the application of dry chemical agents, but the primary extinguishing capabilities result from the combustion-chain-reaction-breaking abilities of the dry chemical agent. This is the same principal extinguishing feature of halons.

Dry chemical fire suppression systems use a dry chemical powder mixture as an extinguishing agent. Common dry chemical agents include sodium bicarbonate, potassium bicarbonate, urea-potassium bicarbonate, and monoammonium phosphate. Additives in the base compound reduce caking, promote water repellence, and increase flow and storage characteristics. Examples of common additives include metallic stearates, tricalcium phosphates, and silicones. Multipurpose dry chemical usually refers to the monoammonium agent which can be used to suppress fires involving ordinary combustibles, and energized electrical equipment as well as flammable liquids.

Regular dry chemical is not considered a good agent for ordinary combustibles, since water also must be applied to attack any subsurface burning which the regular dry chemical cannot reach. The multipurpose agent does have penetrating abilities, thus its multipurpose listing. Agents should never be mixed unless specifically listed for mixing, as some agents will generate CO_2. This may cause containers to explode and the agent to cake.

Dry chemical agents can be applied via portable fire extinguishers, hand hoselines, or fixed systems. Portable extinguishers and fixed systems are covered later in this section.

Here are some examples of hazards for which dry chemical agents are effective.

- Flammable and combustible liquids and combustible gases.
- Combustible solids that melt when involved in fire (such as naphthalene and pitch).
- Those fuels released from transfer facilities, including transfer piping leaks.
- Electrical hazards similar to transformers and oil circuit breakers.
- Multipurpose, ordinary combustibles and some plastics, if all involved surfaces can be covered by the agent.
- Kitchen hoods and ducts as well as surface cooking units and deep fat fryers (a very common application).

Here are examples of hazards for which dry chemical agents are **not** considered satisfactory.

- Chemicals containing their own oxygen supply, such as cellulose nitrate.
- Combustible metals, unless the agent is specifically listed for such use.
- Deep-seated fires in ordinary combustibles when multipurpose dry chemical agents cannot cover all involved surfaces.
- In addition, it is not wise to use a dry chemical to prevent reignition if a heat source is present.

Dry chemical agents are likely to leave sticky residues, may adhere to electrical components, are slightly corrosive, and may affect occupant breathing and reduce vision. If the agent does become moist, it may not flow properly through the systems and will not discharge properly. Dry chemical agents, however, are considered nontoxic.

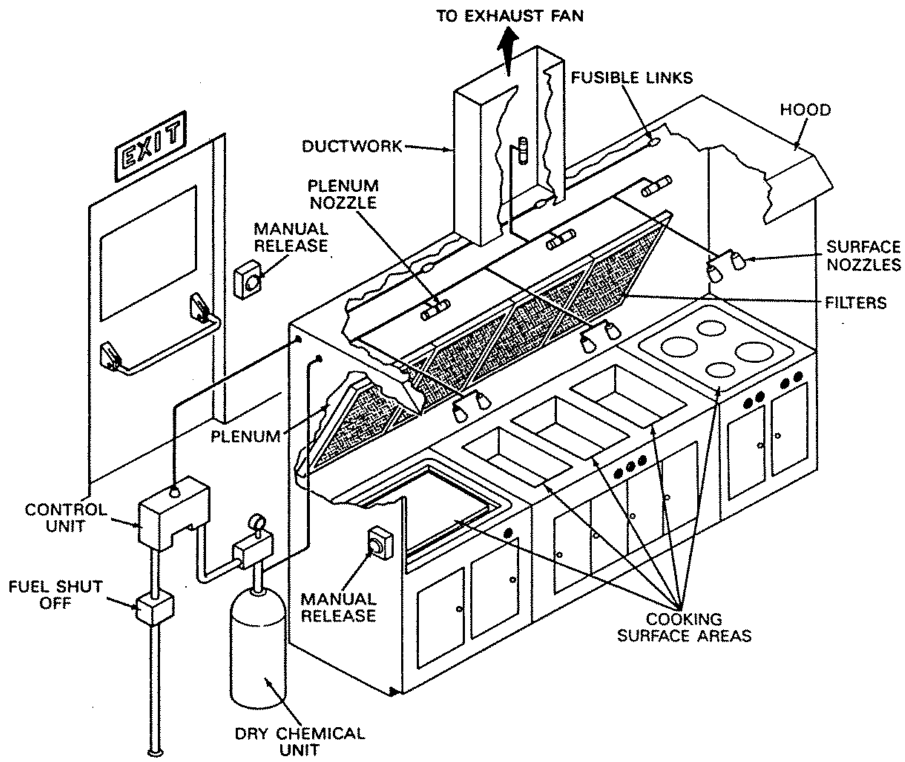


Figure 11
Local Application Dry Chemical System Installation

Wet Chemical

Wet chemical suppression agents are a relatively new means of suppressing fires involving cooking equipment. Leading manufacturers of wet chemical suppression systems introduced these systems in the early 1980s. Wet chemical suppression systems currently are accepted only for the protection of restaurant, commercial, and institutional hoods, plenums, ducts, and associated cooking appliances. Only pre-engineered systems are used.

Wet chemical extinguishing agents typically are potassium carbonate-based, potassium acetate-based, or a combination of these, mixed with water. These solutions are alkaline-based and discharge through system piping by an expellent gas. The primary extinguishing capability of the wet agent is its characteristic of mixing with cooking grease to form a foam barrier over the burning fuel. This blanket effect prevents the flammable volatiles from mixing with the oxygen needed for combustion. It also acts to cool the fuel surface; this aids in fire suppression.

The wet chemical agents generally are harmless to humans. Any effects that may occur usually disappear once contact with the agent ends. The agents may have corrosive effects on some metals; the manufacturer's literature should be consulted for such information. Manufacturers' warnings to use the right agent in the right system are very important. In part, this is due to the testing of specific systems with specific wet chemical agents. Using nonapproved agents, or agents from other manufacturers may make a system inoperative.

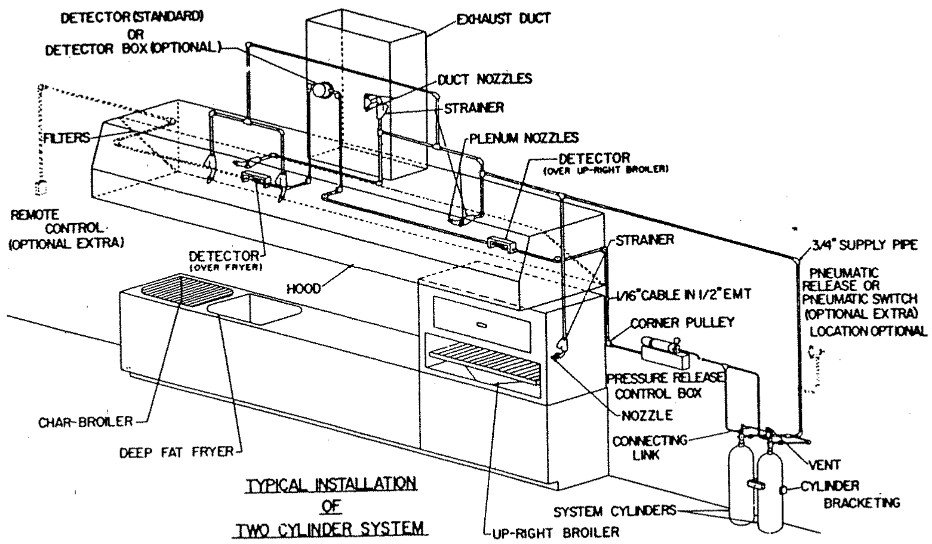


Figure 12
Restaurant Range Hood Wet Chemical System

TYPES OF WATER DISTRIBUTION SYSTEMS

The two basic types of systems are public systems and private systems.

Public Water Systems

Public water systems usually fall under a unit of local government or an "authority" with legal responsibility. The water utility department and the fire department need to develop and maintain a good working relationship. They should support each other and work together to plan, design, and maintain the system for the benefit of the community. If a public water system and the fire department are both units of the local government, it is easier to work together.

This becomes even more critical when the water authority is separate from local government.

Private Water Systems

Private water systems usually are owned by land development or manufacturing companies. They may supply water utility service to a particular site or in some instances to a community. When serving a single site, the water usually is used for manufacturing, processing, and fire protection. Generally, the system has its own water storage and, in some cases, its own water processing equipment.

The water distribution system (pipes and valves) is only for use on the site and generally is not connected to a public system. The system may have standard water distribution hardware, or hardware manufactured for the private system owner. If nonstandard hardware is used, sometimes the hydrants and hose connection are not compatible with the local fire department's apparatus. If you have any private systems within your jurisdiction, preplan the site and make arrangements with the private system operators for appropriate hardware so that the fire department's equipment and the equipment at the site system are compatible or are adaptable for compatibility.

WATER SUPPLY SYSTEM COMPONENTS

All water supply systems, either private or public, have the same basic functional components: a water source, water storage, water distribution systems (pipes and valves), and hydrants or other end-user devices (sprinkler systems, etc.).

Water Sources

The source of a utility's water varies around the country, and perhaps even within smaller geographic areas. The two sources for water supply systems are ground water and surface water. Although most water systems have only one source, there are instances of both.

Ground Water Sources

Ground-water-source users receive the water from wells, where the water is pumped up from the ground; ground-level springs; or subterranean springs from which the water is either drained off or pumped out of the springs. Once brought to the surface it is either stored or sent through the distribution system. Ground-water-source users may or may not treat the water prior to distribution.

Surface Water Sources

Surface water sources include lakes, rivers, ponds, coastal waters, and natural or artificial reservoirs.

Surface water users usually will treat the water, since water from this source tends to be exposed to contaminants more than ground water. In some coastal areas the local water utility may operate a desalination plant to convert salt water to fresh water.

Two Systems

There is a trend today, in parts of the country, to have two separate systems in the community. One system provides potable water and the other system supplies nonpotable water. Potable water is used for human consumption and for food preparation or processing. The nonpotable water generally is used for industrial processes, irrigation of crops or landscapes, and fire suppression systems.

This nonpotable water is referred to as "gray water." It is processed water residue from sewage treatment plants; all solids have been removed, but the water is not purified enough to be potable. These systems use water normally discharged into lakes or rivers, or pumped underground into wells. By using this "gray water" the community is able to conserve the potable supply and get good use out of water that it otherwise would discard.

Water Storage

Storage of water prior to delivery in water systems normally occurs in elevated tanks; ground-level tanks or underground storage; or a combination of elevated and ground-level tanks.

Elevated Storage

Elevated storage tanks or reservoirs are common because they do not require pumping water into the distribution system; gravity supplies pressure to the distribution system. Generally a pumping system increases water main pressure in the event of a larger demand for water. The use of the system for firefighting could put a larger-than-normal demand on the system, and the utility company could supply larger pressures and volumes with pumps.

In some systems elevated tanks are used solely for storage of water for fire protection. For these tanks to be reliable, they must be properly located, have an adequate capacity, and be of sufficient height to develop the required pressures.

Ground-Level and Underground Storage

Ground-level storage tanks, which lack the gravitational pressure of elevated tanks, usually cannot supply the minimum pressure demands for normal use. Therefore, pumps maintain a minimum pressure and can increase the pressure should there be a demand.

Combination Storage Systems

Some systems use a combination of elevated and ground-level tanks for storage.

Pumps

The main components of water distribution systems are pumps, pipes (mains), valves, hydrants, and fire protection connections.

Pumps provide proper pressure and volume in the water distribution system. Normal system pressure may have to be increased in the event an increased demand is placed on the system or part of the system. Such a demand may result from a main break, flushing of the system, or a large fire or multiple fires occurring at the same time.

Pipes (Mains)

Water mains form the foundation of a good water supply. Size, location, tie-ins, and materials, along with proper maintenance, all affect the quality and quantity of water service delivered. For this reason, communities and water departments must consider the quality, capability, and reliability of new system installations and retrofits. The fire department should be consulted any time that modifications are made to a system to assure that fire department requirements are met, and that the system will supply enough pressure and quantity of water for fire protection purposes.

The first fire mains in the Colonies were hollowed-out logs. Water mains today generally are constructed out of cast iron, ductile iron, steel, cement asbestos, polyvinyl chloride (PVC), or a combination of these materials.

Water mains usually have the larger diameter pipe closer to the water source. From that point to the end user, the size gradually decreases.

Valves

Valves control the flow of water through the water distribution system. Valves are broadly divided into two categories: indicating and nonindicating.

Indicating valves visually show the position of the gate or valve seat to indicate whether it is closed, partially closed, or open. The primary types of indicating valves used for connections to fire suppression systems are OS&Y (Outside Screw and Yoke), YPIV (Yard Post Indicating Valve), and indicating Butterfly Valves.

Valves supplying water for fire protection and suppression systems should be chained and locked in the open position at all times. If not chained and locked, the valve should have a valve tamper alarm, which activates a trouble signal on an alarm system if the valve is not in the full open position.

Nonindicating valves do not have any visible means to show their position. Except for a few valves in plants and pumping stations, valves in water supply systems are of the nonindicating type. Valves in water distribution systems usually are buried or installed in manholes.

When properly installed, a buried valve is operable from above ground through a valve box. A long-handled wrench, known as a "T" wrench, is inserted in the valve box to operate the valve. It is very important that valves are in the full open position, as a partially closed valve will not deliver the amount of water needed for the system and can hamper or even cripple firefighting operations.

Valves should be tested at least once a year to assure their proper operation. Valves should be spaced so that only a short length of pipe will be out of service at one time should a break occur.

Hydrants

Early methods of obtaining water for firefighting purposes were crude. Water systems used hollowed-out logs for water mains. Pits were dug at specified intervals to expose the mains. A hole was made in the main and a wooden plug was inserted. These plugs were known as "fire plugs," and this term is still sometimes used to identify hydrants. When a fire occurred, the wooden plug was removed from the main, water filled the pit, and fire apparatus drafted from the pit. However, the flow of water was so meager that the system was seldom effective.

Cast iron pipe permitted the system pressure to be increased, and this led to the development of the post-type fire hydrant. An opening at the upper end of the standpipe provided a place for the fire pumpers to receive their supply.

Two basic types of fire hydrants used today are dry barrel and wet barrel.

Hydrant Installations

For hydrants to be immediately useful, they must be kept clear of obstructions such as fences, walls, landscaping, and snow. The center of the large opening should be a minimum of 18 inches above grade. The hydrant must be far enough from any adjacent object to allow the hydrant wrench to turn in a continuous movement and to allow for hose connection.

The caps on the openings and the threads need to be inspected on a periodic basis to assure that they operate freely and that the hose couplings can be connected. Any hydrants found to be nonfunctional should be reported to the utility authority and a followup inspection made to be sure the hydrant was repaired and placed in service.

One of the most common problems with out-of-service hydrants is that someone failed to turn on the control valve for the hydrant after installation or maintenance. Usually each hydrant on a system will have its dedicated valve so that only one hydrant will have to be out of service for repair or replacement.

Hydrants come in many styles. Utility companies usually will have one type of hydrant on their system; however, some communities may have more than one design of hydrant on the system. Some large developments have hydrants designed to add to the aesthetics of the development.

Dry Barrel Hydrants

Dry barrel hydrants operate with a valve at the bottom of the hydrant that opens at the water main and, when closed, permits the water remaining in the barrel to drain out. These hydrants are common in areas subject to freezing weather conditions and are by far the most common hydrants today.

Current dry-barrel hydrant designs incorporate a traffic safety flange and operating rod installed just above grade. With this type of design, if a vehicle hits the hydrant, it will shear the hydrant and operating rod and allow the main valve to remain closed. The safety flange allows a new hydrant to be installed without digging down to the water main; this provides for less expensive repair and decreases time out of service.

Wet Barrel Hydrants

Wet barrel hydrants may have a valve at each outlet or they may have only one valve that controls the flow to all outlets.

In general, hydrant bonnets (tops), barrels, and foot pieces are made of cast iron. The important working parts usually are made of bronze, but the valve facings may be made of rubber, leather, or composition material. A standard hydrant is equipped with one large opening (4 inch or 4-1/2 inch) and two outlets for 2-1/2-inch hose couplings.

Hydrant outlet threads must conform to the threads which the local fire department uses. National Standard hose coupling threads are best suited for mutual-aid operations. Adapters may be necessary when using hydrants in other response areas or those on private systems.

AUTOMATIC SPRINKLER FIRE SUPPRESSION SYSTEMS

Many codes do not require a specific type of automatic suppression system, but generally it is expected that an automatic sprinkler system will exist unless the hazard is not compatible with water. Automatic sprinkler systems are the most common automatic fire suppression systems. They consist of automatic sprinklers that operate at a predetermined temperature and automatically distribute water upon a fire in sufficient quantity at least to contain, and possibly to extinguish, the fire. The water reaches the sprinklers through a system of overhead piping. Some reliable public or private water source supplies the overhead piping.

Sprinklers Have Two Main Purposes

Sprinkler systems have two main purposes: 1) to extinguish unwanted fires, and 2) to control the size of a fire until trained fire suppression crews arrive to extinguish the fire. Either of these activities results in increased property protection and life safety. When connected to an approved fire alarm system, sprinkler systems provide the added benefit of acting as initiating devices to activate the fire alarm system.

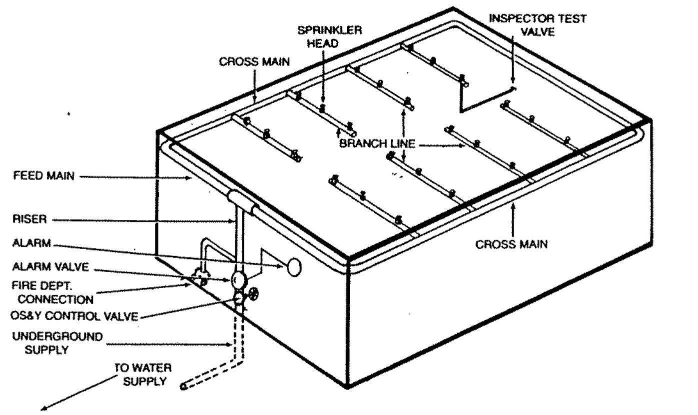


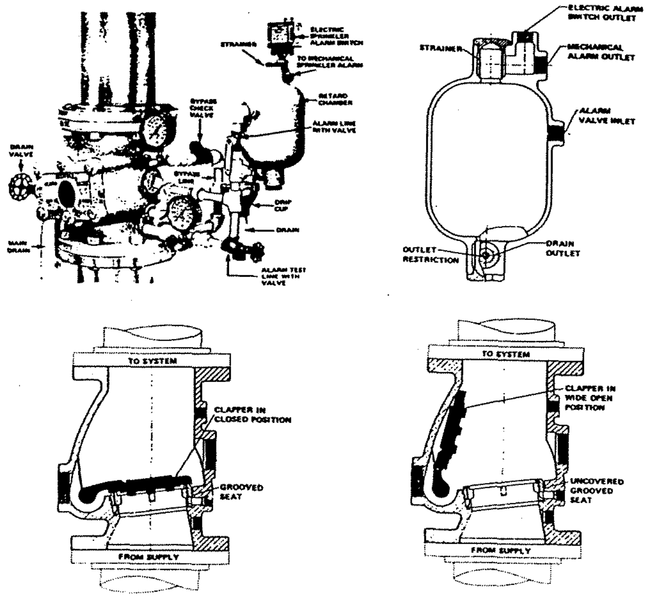
Figure 13
Major Sprinkler System Components

Classifications of Automatic Sprinkler Systems

NFPA 13, *Standard for the Installation of Sprinkler Systems*, defines the six major automatic sprinkler systems.

Wet Pipe Systems

Wet pipe systems use closed automatic sprinklers attached to a piping system containing water under pressure at all times. The wet pipe system is the most common type of sprinkler system in use unless there is danger of the water in the pipes freezing or when other special conditions require one of the other types of systems.



Example of Alarm Retard Chamber

Figure 14
Examples of Alarm Check Valves

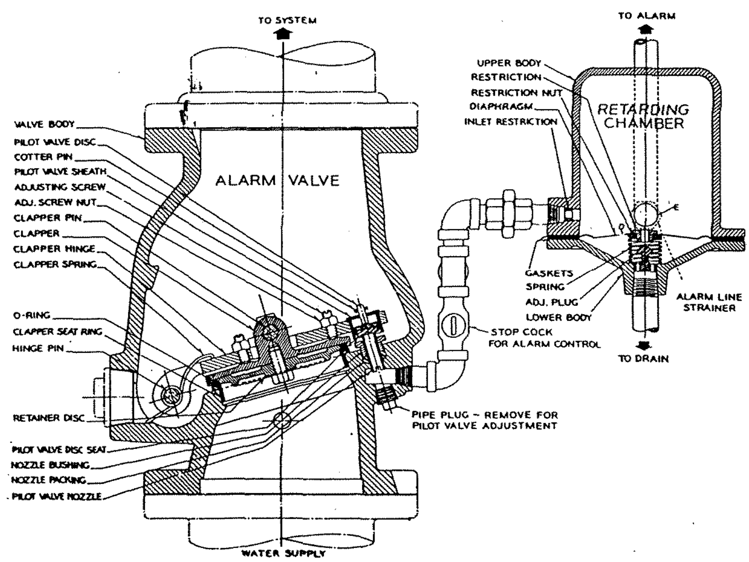


Figure 15
Alarm Check Valve (Section)

<u>Dry Pipe Systems</u>

Dry pipe systems employ closed automatic sprinklers attached to a piping system which contains air or nitrogen under pressure. When a fire occurs and an automatic sprinkler activates, the air or nitrogen escapes. This reduces the pressure in the system to a point at which the pressure on the water supply side causes the valve to operate, allowing water to flow through the system piping. Dry pipe systems usually exist only in locations that cannot be heated properly.

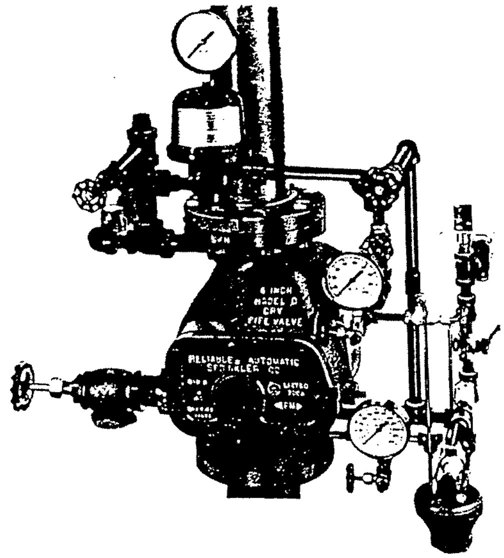


Figure 16
Dry Pipe Valve

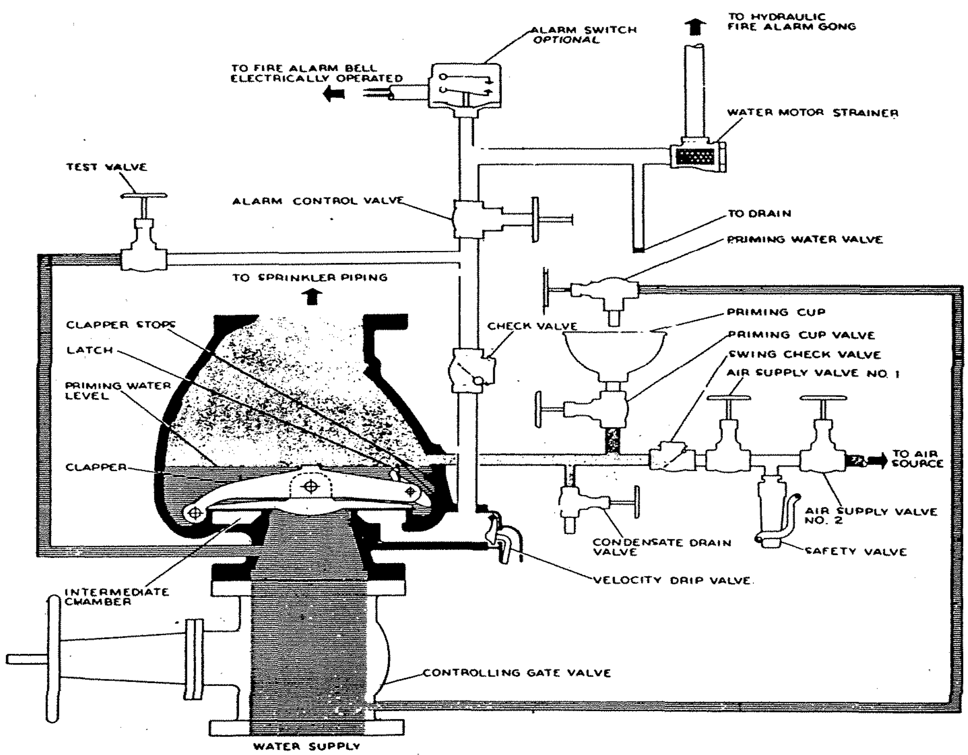


Figure 17
Differential Dry Pipe Valve

Preaction Systems

Preaction systems employ closed automatic sprinklers attached to a piping system which contains air, which may or may not be under pressure. When a fire occurs, a fire detecting device, such as a smoke or heat detector, activates and causes the water control valve to open and water to flow into the pipe system. Thereafter, when an automatic sprinkler activates, water is available to flow through the sprinkler immediately. Preaction systems commonly exist in areas where there is danger of serious water damage as a result of a damaged automatic sprinkler or broken piping. Electrical equipment rooms, computer rooms, and operating rooms are locations which use preaction sprinkler systems.

Deluge Systems

Deluge sprinkler systems employ automatic sprinklers which are open at all times. When a fire occurs, a fire detecting device, usually a heat detector, activates and causes the deluge valve to open. Water then will flow into the piping and discharge through all the open sprinklers. Deluge sprinkler systems offer effective protection from severe hazards, such as flammable liquids, where there is a possibility that the fire could flash ahead of the operation of closed automatic sprinklers.

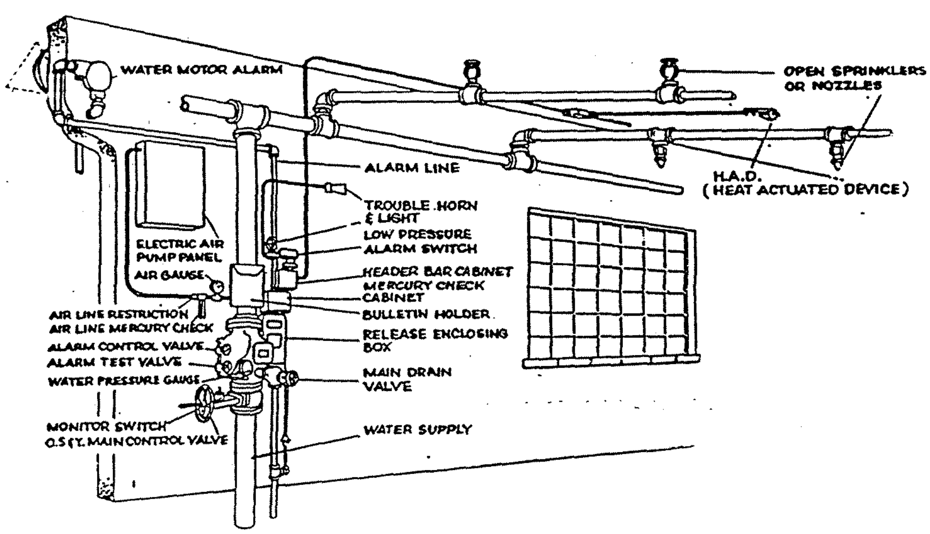


Figure 18
Deluge System

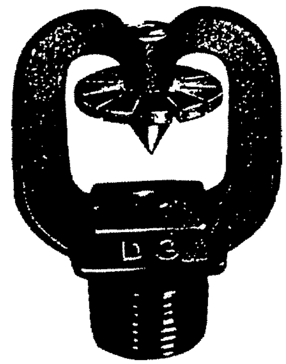


Figure 19
Open Sprinkler Head

Combined Dry Pipe and Preaction Systems

These systems combine the essential features of each system and can operate as either system. Typically the dry pipe feature serves as a supplemental operation in case of failure of the preaction system. Such systems are effective in areas that are too large for a single dry pipe system.

Antifreeze Systems

These types of systems are used to protect small, unheated areas. The system's piping is filled with a special antifreeze solution to prevent freezing in the piping that protects the area.

Types of Automatic Sprinklers

There are various types of sprinklers. We will briefly examine the most commonly found ones.

Standard

Automatic sprinklers are heat-sensitive devices designed to react at predetermined temperatures to release a stream of water automatically, and to distribute it in a specified pattern and quantity over designated areas. Under normal conditions, the discharge of water from a closed automatic sprinkler is restrained by a cap or valve held tightly against the orifice by the releasing mechanism. The standard automatic sprinkler orifice is one-half inch in diameter. The most commonly used release mechanisms include fusible links, glass bulbs, and chemical pellets.

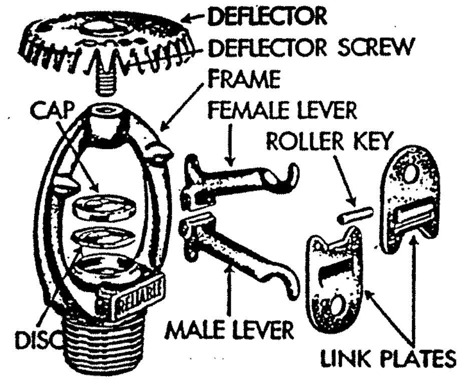


Figure 20
Fusible Link Automatic Sprinkler

Water flowing through the orifice strikes a deflector designed to create the specified discharge pattern. Sprinklers are made for installation in an upright (SSU), pendent (SSP), or sidewall position. While the shape of the deflector usually indicates the proper position of the sprinkler, the letters "SSU" or "SSP" are stamped on the deflector's surface for easy identification. For upright and pendent sprinklers, the water spray flows downward in a hemispherical pattern from the deflector. For sidewall sprinklers, which are mounted in a horizontal or vertical position depending on design, the flow projects horizontally away from the wall-mounted sprinkler. A small amount of water also hits the wall directly behind the sidewall sprinkler.

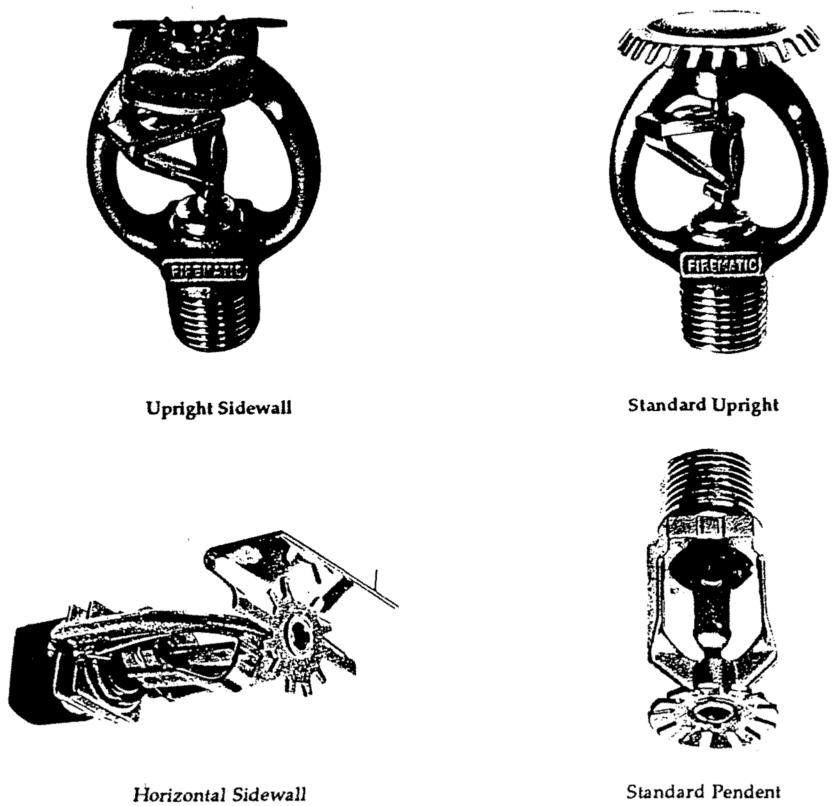


Figure 21
Sprinkler Deflector Styles

<u>Special Heads</u>

Extended Coverage

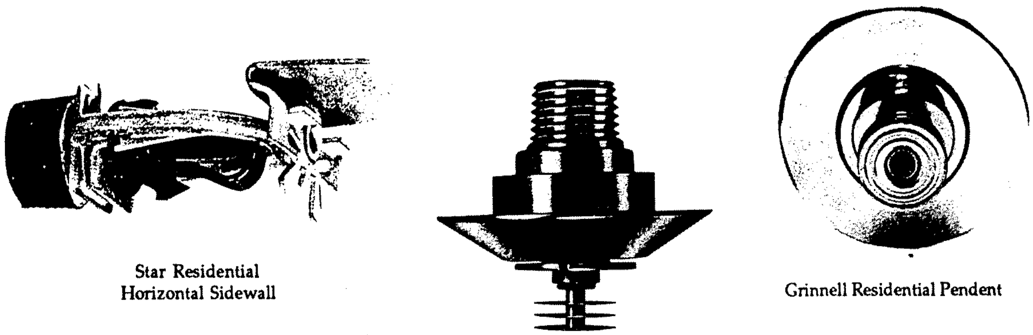
NFPA 13 defines extended coverage sprinklers as "sprinklers with special extended, directional discharge patterns." These are specially designed sprinklers and must be installed according to their listings and the appropriate sections of NFPA 13.

Fast Response Sprinklers

Fast-response sprinklers, as the name implies, are specially designed to react more quickly than standard sprinklers when subjected to the effects of fire. This group of sprinklers includes three types of fast-acting sprinklers: 1) quick response sprinklers, 2) residential sprinklers, and 3) early suppression fast response (ESFR) sprinklers. A quick response early suppression (QRES) is also under development.

Residential

These are sprinklers intended for use in residential applications only and which have been listed according to U/L Standard 1626 and installed in accordance with the requirements of NFPA 13, NFPA 13D, and NFPA 13R. These sprinklers typically use less pressure and flow, and the design requirements stem from fires and conditions found in residential settings. Because of this, they must not be used outside their listed uses and applications.



Star Residential Horizontal Sidewall

Central Residential Pendent

Grinnell Residential Pendent

Figure 22
Residential Sprinklers

Quick Response

Recent technology has introduced "quick-response sprinklers." The sole criterion for this special designation is performance on the Underwriters Laboratories' (U/L) plunge test, presently a 14-second maximum operating time. The faster operating time holds promise of improved life safety and property protection. The quicker response time results from an actuation element that has a higher ratio of surface-area-to-mass than normal sprinklers. The higher surface area allows for quicker transfer of heat into the element and the lower mass requires less heating. Therefore, a shorter time is needed to reach the element's activation temperature. A sprinkler that responds more quickly is more likely to attack a fire before it can develop high velocity plumes, which are more difficult for water spray drops to penetrate. Also, there is the probability that more sprinklers may activate, thus prewetting areas the fire has yet to reach. This can help prevent the spread of the fire. Clearly, the sooner sprinklers activate, the sooner they mitigate hazardous conditions.

Early Suppression Fast Response (ESFR)

These sprinklers, intended for special fire-threat applications, were developed as a result of the quick-response residential sprinkler research coupled with the high pressures and water flows associated with existing large drop sprinklers. The result is basically a large drop sprinkler with a quick response actuation element. These sprinklers attack a fire rapidly with large amounts of water so that the activation of a small number of ESFR sprinkler heads minimizes or prevents the spread of the fire.

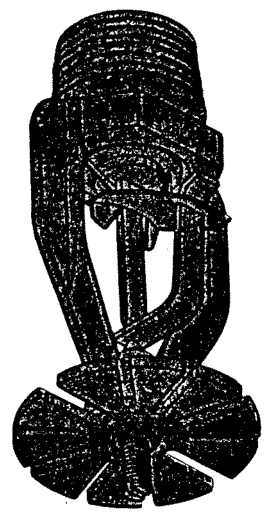


Figure 23
Grinnell ESFR Head

Dry

In some instances it is desirable to use dry sprinklers attached to wet pipe sprinkler systems. One common example is the protection of a freezer in an otherwise heated area. Dry sprinklers have mechanisms that keep a tight seal in place, which prevents water from the wet pipe system flowing into the dry sprinklers. The dry sprinklers typically have extended pipe lengths that are dry (without water) and which extend into the unheated area. When the sprinkler fuses, the seal linkage drops out, allowing water to flow into the previously dry sprinkler.

Ornamental, Flush, Recessed, and Concealed

In some cases it is desirable to change the appearance from that normally associated with standard sprinkler installations. Aesthetics is one reason people do not use sprinklers. Standard sprinkler heads are considered unsightly. Manufacturers have responded by painting or finishing sprinklers heads or by giving them a low profile so they do not project from the ceiling as much (flush, recessed, and concealed). In some cases, this also can be used to limit damage to the sprinklers and prevent tampering. Prisons are one setting where low profile sprinklers are desirable, as inmates cannot hang themselves from the sprinkler heads.

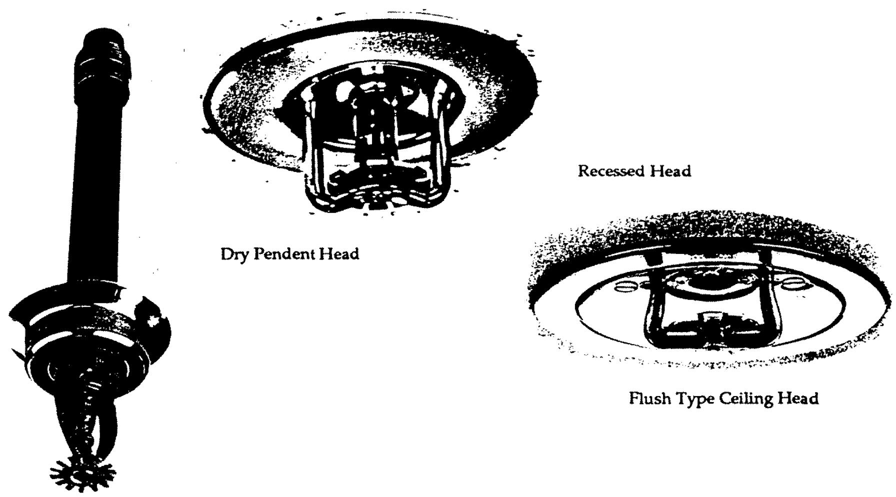


Figure 24

Large Drop

These sprinklers are designed to provide a water spray of large drops (as compared to other sprinklers). These larger drops have an increased ability to travel through high-heat and high-velocity fire plumes, thereby reaching the seat of the fire. Water drops from standard design sprinklers may be dispersed by high-velocity fire plumes, significantly reducing the sprinkler's ability to control and extinguish the fire.

Open

These sprinklers do not employ an actuating element. Therefore, when water flows into the piping all sprinklers will flow immediately.

Nozzles

Nozzles are sprinklers used in applications which require special discharge patterns and spray characteristics.

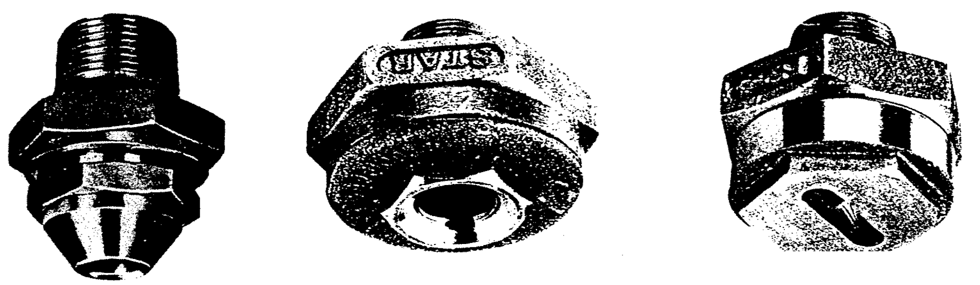


Figure 25
Water Spray Nozzles

Automatic On-Off

On-off sprinklers refers to any sprinkler head that has an integral water-flow control mechanism which can allow or prevent the flow of water through the sprinkler. One common use of these sprinklers is in the protection of computer facilities where limited water flow is desirable. A common design uses a simple heat-driven valve which will allow flow if heated, and will close if the sprinkler cools (i.e., if it appears the fire has been controlled).

Intermittent Level

These sprinklers include a shield located directly above the sprinkler which is designed to prevent water from other sprinklers located at higher levels from cooling the sprinkler's operating elements. Without this protection, sprinklers would respond more slowly, or not at all, to fire conditions.

Corrosion Resistant

Sprinklers used in environments that are hostile to unprotected sprinklers may include corrosion protection. This generally is some form of protective coating applied to the special sprinkler.

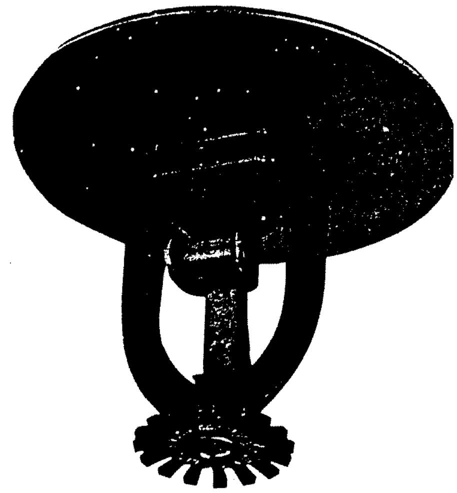
System Readiness

Sprinklers are one part of the fire suppression system the inspector can more easily examine and inspect. It is not realistic to expect the beginning inspector to be able to determine the status of the jurisdiction's water system. But if a structure is sprinklered, the inspector can at least check this part.

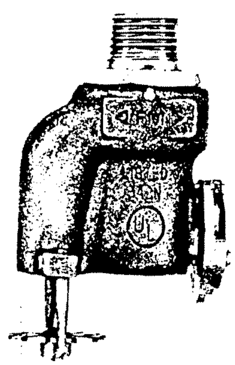
Without getting into design and testing issues, the inspector needs to make sure at a minimum that none of the sprinkler heads is blocked, painted over, missing, or damaged. If one suspects there are problems with the system, it would be wise to report this to one's superiors. Obviously, it is not the inspector's job to test the sprinklers. This could be disastrous.

The next parts of the suppression system we need to examine are the standpipes and hose systems.

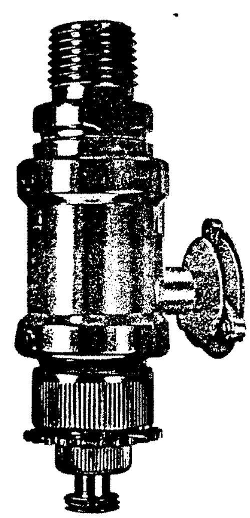
Intermittent Level Head
in Upright Position



Intermittent Level Head
in Pendent Position

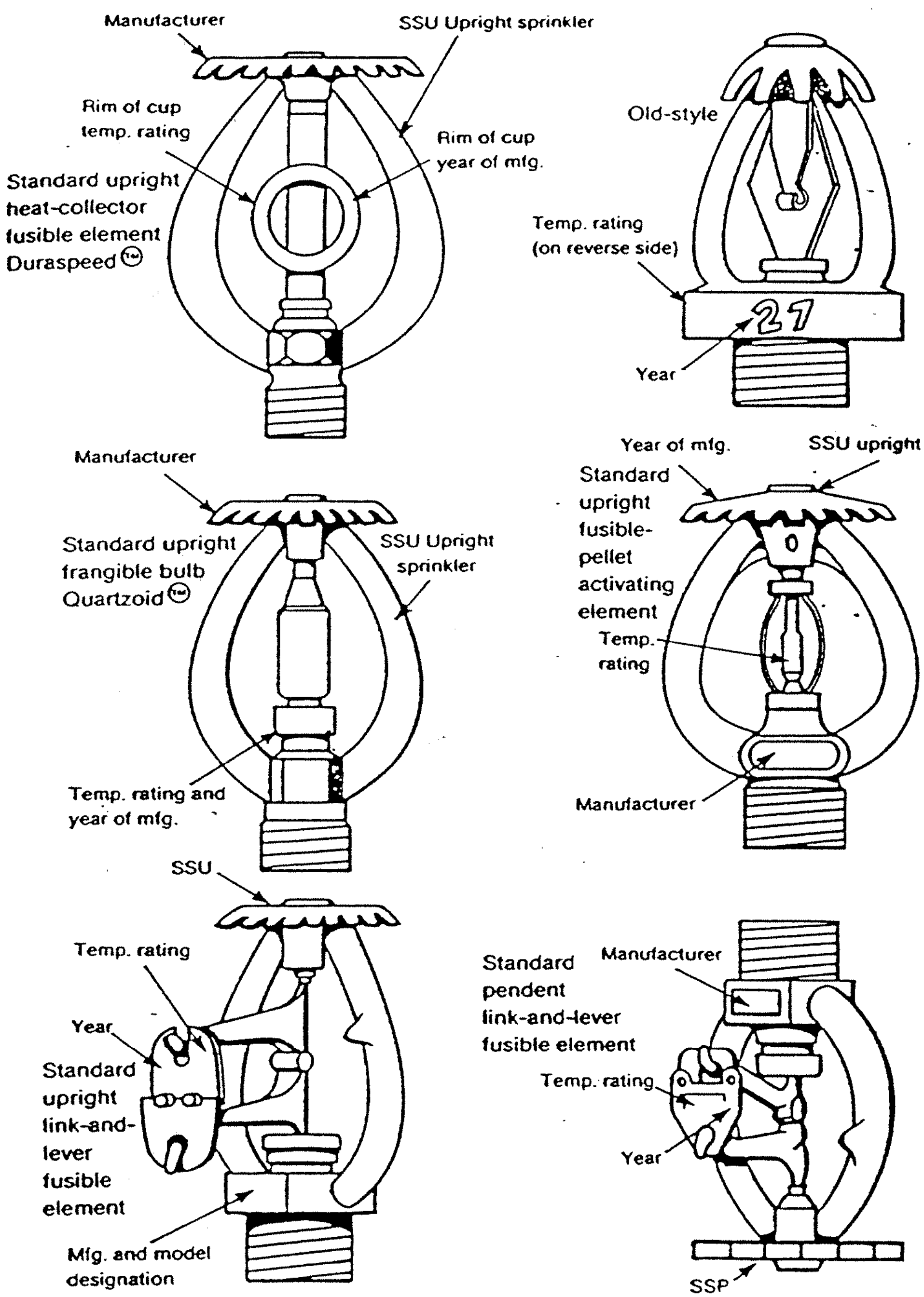


Grinnell Automatic
On and Off Head



Central Automatic
On and Off Head

Figure 26
Examples of Intermittent and Automatic On/Off Sprinkler Heads



Sprinkler styles and types with location of identification information on the sprinkler. (ISO Commercial Risk Services, Inc.)

Figure 27
Examples of Automatic Sprinkler Head Components

STANDPIPE AND HOSE SYSTEMS

Purpose

Standpipe and hose systems in buildings allow the occupants or fire service personnel to suppress a fire without further help. Standpipe systems are an arrangement of piping, valves, hose connections, and related equipment installed in a building in a fixed manner. The systems may or may not have hoses permanently attached. Water supplies may or may not be continually provided to standpipe systems. These features of a standpipe system are dictated by the class and type of system. Fire department personnel trained in manual fire suppression methods are the ones who primarily use standpipe systems. Many standpipe systems no longer have occupant hoselines (small diameter 1-1/2 inch). The fixed piping of a standpipe system in a building allows the fire service to connect its hoselines into a pressurized water source near the fire floor. Consequently, the fire service is relieved of the burden of extending hoses into the building from grade level to the location (floor) of the fire. In mid- to highrise buildings, standpipe systems are extremely important for the prompt manual extinguishment of fires.

Classes of Standpipe and Hose Systems

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, defines three classes of standpipe systems.

Class I

Class I systems have 2-1/2-inch hose connections on the system piping. This size hose produces a heavy fire stream primarily for the fire service which supplies its own hoses for fighting the fire.

Class II

Class II systems have 1-1/2-inch hose connections. This hose is primarily for occupant control of a fire until the fire department arrives. A hose and nozzle connect to the system piping.

Class III

Class III systems provide both 2-1/2-inch and 1-1/2-inch hose connections for use by either the fire service or the building occupants. Typically, the two sizes of hose tie in by a 2-1/2-inch connection to the system piping and a 1-1/2-inch reducer connection on the 2-1/2-inch connection. The fire service can easily remove the reducer. This gives the fire service the 2-1/2-inch connection it requires for manual suppression. A small hose (1-1/2 inch) and nozzle must be provided for occupant use.

Types of Standpipe and Hose Systems

There are four types of systems available.

- Wet systems with supply valves open and the system continually under pressure.
- Dry systems with a supply valve that automatically opens when a hose valve is opened.
- Dry systems with a supply valve that is opened by a remote control device located at each hose station.
- Dry systems with no permanent water supply connection. This type requires that a system be connected to a pressurized water supply, such as a fire department pumper. Such systems may be filled with water for supervision purposes.

Standpipe and Hose System Standards

Where required, standpipe systems typically comply with the requirements of NFPA 14. If the system is a combined sprinkler-standpipe system, the requirements of NFPA 13 also play a role.

As with sprinkler systems, the Uniform Building Code has its own standpipe standard, *Uniform Building Code Standard No. 38-2*. This standard is very similar to NFPA 14.

PORTABLE FIRE EXTINGUISHERS

Purpose of Fire Extinguishers

A portable fire extinguisher enables an individual with minimal training and orientation to extinguish an incipient fire without risk after calling the fire department. There have been many disastrous fires resulting from a delayed notification of the fire department while someone attempted extinguishment with portable fire extinguishers. One was the Beverly Hills Supper Club fire which claimed over 160 lives.

Extinguisher Use Based on Fire Classification

Fire extinguishers fall into four classes based on the type of fire(s) they are effective at extinguishing.

Class A: Fires in ordinary combustibles such as wood, cloth, paper, rubber, and many plastics. They can be extinguished by cooling, smothering, and insulation, or by inhibiting the combustion chain reaction.

Class B: Fires involving flammable or combustible liquids and gases, including greases and similar fuels. They can be extinguished by oxygen exclusion, smothering, and insulation, and by inhibiting the combustion chain reaction.

Class C: Fires involving energized electrical equipment which requires the use of a nonconductive agent for protection of the extinguisher operator. If electrical power is eliminated, these fires become Class A or Class B, and may be extinguished accordingly.

Class D: Fires in combustible metals such as magnesium, potassium, sodium, titanium, and zirconium. They require the use of an agent that absorbs heat and does not react with the burning metal.

Class A and Class B fire extinguishers also have a numerical rating according to the size of the fire they potentially can extinguish. Although somewhat subjective, a 2-A extinguisher is roughly equivalent to a 2-1/2-gallon water extinguisher; a 4-A extinguisher has about as much extinguishing power as 5 gallons of water.

Class B extinguishers are given a numerical rating based on the area of flammable liquid they potentially can extinguish. As an estimate, it can be assumed that for each unit of "B," one square foot of burning liquid can be extinguished. For example, a 10-B extinguisher can be used to extinguish a ten-square-foot liquid fire. It must be emphasized that the numerical rating is for estimating only, as the actual effectiveness will depend on such factors as user qualifications and skill.

The classifications, including the numerical rating, can be compounded to provide multipurpose extinguishers. For example, a fire extinguisher listed as 4-A:20-B:C has the capacity of two 2-A extinguishers, 20 times the capacity of a single 1-B extinguisher, and it can be used on electrical (C) fires.

To assist potential users, the NFPA has developed a color-graphic identification system for rapid identification of fires related to a particular extinguisher. This system is described in NFPA 10, *Standard for Portable Fire Extinguishers*.

Types of Portable Fire Extinguisher Agents

There are six common agents used in portable extinguishers.

Water Based

For the most part, extinguishers that use water are for use on Class A fires. An exception is Aqueous Film Forming Foam (AFFF) extinguishers, which will be discussed below. The remaining water-based extinguisher types include antifreeze additives, loaded streams, and wetting agents. Other foams may be used, but generally are obsolete. Until 1969, there were three methods of water-based extinguisher operation: 1) stored pressure, 2) pump tank, and 3) inverting type. The last type was discontinued in 1960; this made soda-acid extinguishers obsolete.

Carbon Dioxide (CO_2)

Compressed CO_2 provides both an agent and a discharge method, as the gas is under pressure while in the storage container. CO_2 extinguishes fire primarily by excluding oxygen from the combustion region, although there is some cooling effect. In fact, the operator of a CO_2 extinguisher must be careful not to touch the horn of the extinguisher due to risk of freezer burn injury. CO_2 is for fighting Class B and Class C fires, but can be used on Class A if needed. One advantage of CO_2 is that it leaves no residue. A drawback of CO_2 is that it is a gas and, as such, may be carried away from the intended area by drafts and wind. Also, users must avoid asphyxiation if the extinguisher is used in a confined place.

Dry Chemical

Dry chemical agents are either ordinary or multipurpose agents. Ordinary dry chemical agents include sodium bicarbonate, potassium bicarbonate, urea-potassium bicarbonate, and potassium chloride. They are effective on Class B and Class C fires.

Multipurpose dry chemical is based on ammonium phosphate and can be used for Class A, Class B, and Class C fires; hence, its "multipurpose" listing. Dry chemical agents extinguish fires by inhibiting the chemical chain reaction of the combustion process; they also may have a blanketing effect. Dry chemical extinguishers need either stored or cartridge-operated pressure to force the dry chemical agent from the extinguisher. Typically, CO_2 or nitrogen is used for this purpose.

Halon

Halon 1211 can be used in portable fire extinguishers because it is not as volatile as Halon 1301 which instantly becomes gaseous when discharged. The low relative volatility of Halon 1211 allows the extinguisher user to direct the liquid flow toward the intended strike zone of the fire. As with the larger halon systems, Halon 1211 extinguishes fires by inhibiting the combustion chemical chain reaction. Like CO_2, halon is a clean agent which leaves no residue. Halon is for Class B and Class C fires as well as for Class A if needed.

Dry Powder

Dry powder agents are for fighting Class D (metal) fires and typically are sodium chloride based. This type of agent extinguishes fire by reacting with the heat of the fire to form a blanket over the fuel. This prevents the fuel and oxygen from meeting.

Aqueous Film Forming Foam (AFFF)

AFFF is a special type of water-based fire extinguishing agent. It differs from other water-based agents in that it can be used successfully for combating Class B fires, where it extinguishes via oxygen exclusion, as well as on Class A fires, where it acts by cooling and penetrating.

Some Obsolete Extinguishers

A note on some obsolete extinguishers to identify and remove from circulation. In addition to operating difficulties, these older extinguishers had an unacceptably high test failure rate. **Soda-Acid** extinguishers were quite popular years ago but are no longer acceptable because they may explode when inverted to activate the extinguisher. **Cartridge-Operated Water** extinguishers are similar to soda-acid extinguishers in operation and have the same problems. **Foam** extinguishers look like the soda-acid extinguishers; these should be replaced by newer AFFF extinguishers. **Vaporizing-Liquid** extinguishers have been banned from service due to problems with toxicity of both the agent and products generated during fire extinguishment. The most common type of this agent is carbon tetrachloride--CCl_4.

Distribution of Portable Fire Extinguishers

The first step in addressing extinguisher distribution requirements is determining the hazard classification according to NFPA 10.

Light (Low) Hazard

These are areas where the total amount of Class A type combustibles is small. Examples include offices, classrooms, churches, and assembly halls. Small amounts of Class B fuels may exist but should be negligible, e.g., duplicating fluid or solvents in art rooms.

Ordinary (Moderate) Hazard

These are areas where the total amount of Class A and Class B fuels is greater than that of Light Hazard areas. Examples include offices, classrooms, mercantile shops and storage, light manufacturing, research operations, auto showrooms, parking garages, and workshops.

Extra (High) Hazard

These are areas where the total amount of Class A and Class B fuels is greater than that of Moderate Hazard areas. Examples include woodworking shops, vehicle repair shops, aircraft and boat service areas, product display areas, storage, and manufacturing processes such as painting, dipping, and coating which use flammable liquids.

The next step is figuring the total area of each hazard. From here one simply consults the tables in NFPA 10 which specify the fire extinguishers needed, based on the hazard class and area to be protected. In addition, there are maximum travel distances allowed. For Class A extinguishers it is 75 feet; for Class B it is either 30 feet or 50 feet, depending on extinguisher size.

For each location with Class C fire threats, there must be a Class C rated extinguisher. Similarly, for each location with Class D fire threats, there needs to be a Class D extinguisher.

Basis for Code Requirements

Not all buildings require portable fire extinguishers, nor do all locations within a building need extinguishers for a particular hazard. In general, portable fire extinguishers are a **must** in occupancies that have people familiar with the building and the fire extinguishers. Hospitals, factories, and mercantile occupancies are examples of buildings that may require portable fire extinguishers. In some cases, the code may require portable fire extinguishers to provide protection from a given hazard. A magnesium milling machine shop and a flammable liquid process area are examples of locations which may need special portable fire extinguishers. Locations where untrained people are normally the only ones present are generally exempt from portable fire extinguisher requirements.

Installation, Inspection, Testing, and Maintenance of Portable Fire Extinguishers

NFPA 10 places the responsibility for inspection, maintenance, and recharging on the property owner. The local authority having jurisdiction (AHJ) may wish to verify that the owners or their representatives are taking their responsibilities seriously.

Before being placed into service, fire extinguishers need to be inspected. Thereafter, fire extinguishers should be inspected every 30 days unless circumstances dictate more frequent inspections. NFPA 10 recommends the following items be checked during the inspection:

- location in designated place;
- access or visibility not obstructed;
- operating instructions on nameplate are legible and facing outward;
- seals and tamper indicators are not broken or missing;
- determination of fullness by weighing or "hefting";
- examination for obvious physical damage, corrosion, leakage, or clogged nozzle; and
- pressure gauge reading or indicator is in the operable range or position.

In addition, one needs to confirm the presence of the recordkeeping tag and review its contents. One should remedy all deficiencies at once and replace all extinguishers removed for servicing.

Extinguishers require maintenance at least once a year. It should cover three main areas: mechanical parts; extinguishing agent; and expellent means.

In addition maintenance needs to cover these steps.

- Discharge stored pressure extinguishers before service.

- Perform a conductivity test of the hose assembly on carbon dioxide extinguishers. If found conductive, the assembly should be replaced.

- Every 6 years, empty stored pressure extinguishers that require a 12-year hydrostatic test and subject them to the applicable maintenance procedures.

- Place a recordkeeping tag on the extinguisher and indicate the month and year the service was completed and by whom. This tag also should indicate if recharging was performed.

NFPA 10 contains requirements for charging (regardless of use) and hydrostatic testing. Hydrostatic testing is required on either a 5-year or 12-year schedule. These requirements vary by agent and extinguisher type, and NFPA 10 should be consulted for the correct service and interval required.

The following standards apply to extinguisher testing.

- U/L 711, Rating and Fire Testing of Fire Extinguishers.
- U/L 154, Carbon Dioxide Fire Extinguishers.
- U/L 299, Dry Chemical Fire Extinguishers.
- U/L 626, 2-1/2 gallon stored pressure, water-type fire extinguishers.
- U/L 715, 2-1/2 gallon cartridge operated, water-type fire extinguishers.

SUMMARY

An understanding of the different types of fire protection systems, equipment, and water distribution in your protection area is of the utmost importance. Your fire department depends on these systems for the basic needs of fire protection and fighting fire. Your ability to identify the various components of these systems and to inspect them for operational readiness may mean the difference between life and death should the systems be needed.

Activity 1

Types of Fire Detection and Suppression Systems

Purpose

To identify components of fire alarm systems, describe methods of fire detection, and identify fire suppression agents.

Directions

Each group should write its responses to assigned work on an easel pad and be ready to report to the remainder of the class.

Group 1:

From the information provided, identify the various components of fire alarm systems.

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Group 2:

From the information provided, identify methods of fire detection and notification.

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Group 3:

From the information provided, identify fire suppression agents.

Activity 2

Impairments to Sprinklers

Purpose

To identify situations that affect operational readiness of sprinkler systems.

Directions

Note below the impairments shown on the slides. Be prepared to discuss your answers.

1.

2.

3.

4.

5.

6.

7.

8.

9.

10.

11.

Job Aid

Inspecting Fire Extinguishers

	Yes	No	N/A
Located in designated place.			
Access or visibility not obstructed.			
Operating instructions on nameplate legible and facing outward.			
Seals and tamper indicators not broken or missing.			
Determine fullness by weighing or "hefting."			
Examine for obvious physical damage, corrosion, leakage, or clogged nozzle.			
Pressure gauge reading or indicator in the operable range or position.			