

SECTION 6- FIRE SUPPRESSION & DETECTION

UNIT 4 - EXTINGUISHING SYSTEMS

UNIT GOAL

To introduce the student to the basic theories and concepts regarding extinguishing systems and types of systems and their operation.

UNIT OBJECTIVES

The student by the end of the semester shall:

- List four [4] ways that foam extinguishes a fire
- List the four [4] components that are required to produce firefighting foam
- List at least three [3] types of foam concentrate
- Identify what classes of fire carbon dioxide extinguishing systems are most useful on
- List two [2] modern types of halon extinguishing agents
- Describe the term Montreal Protocol of 1987
- List three [3] types of dry chemical powders
- List two [2] types of extinguishing agents used on cladd “d” fires
- List the geometric shape used to identify each of the classed of fire
- List three [3] types of fire extinguishers
- List the NFPA standards for the following extinguishing agents
 - Foam
 - Halon
 - Dry chemicals
 - Fire extinguishers

KEY TERMS

Foam concentrate	NFPA 12, <i>Standard on Carbon Dioxide Extinguishing Systems</i>
Foam solution	NFPA 11 - <i>Standard for Low Expansion Foam & Combined Agent Systems</i>
Proportioner	NFPA 11a - <i>Standard for Medium and High Expansion Foam Systems</i>
Finished foam	NFPA Standard 2001 - <i>Clean Agent Fire Extinguishing Systems</i>
Protein foam	NFPA Standard 12b, <i>Halon 1211 Fire Extinguishing Systems</i>
Fluoroprotein foam	Halon 1301 - Bromotrifluoromethane
Aqueous Film Forming Foam	Halon 1211 - Dibromodifluoromethane
AFFF Alcohol Resistant Foam	NFPA 17 - <i>Standard for Dry Chemical Extinguishing Systems</i>
Film Forming Fluoroprotein	NFPA 10, <i>Standard for Portable Fire Extinguishers</i>
Fluoroprotein alcohol resistant foam	Montreal Protocol of 1987
Medium & high expansion foams	Sodium Bicarbonate (Baking Soda)
NA-X	Purple K (Potassium Bicarbonate)
MET-L-X	Monammonium Phosphate
LITH-X	Clean Agents
Stored Pressure Extinguisher	Cartridge Operated Extinguisher

INTRODUCTION

Water is considered as the extinguishing agent of choice for the majority of fires, but there are fires where water can do more harm than good. It is in these cases that alternative methods must be used. As discussed in previous units, water has several disadvantages as an extinguishing agent. Because of this, other agents are used for various types of fuels.

In this unit we will discuss the following extinguishing agents and the fuels that they are used on: Foam, CO₂, Dry Chemical, Halon, Clean agents, Dry Powder, and Portable Fire Extinguishers

FOAM SYSTEMS

Foam is A fluid aggregate of air-filled bubbles, formed by chemical means, that will float on the surface of flammable liquids, flow over solid surfaces, and cling to vertical and horizontal surfaces. [See **Figure 1**] It is made up of three ingredients: water, foam concentrate, and air. When mixed, the ingredients form a stable, homogenous foam blanket that excludes air, seals liquids, and prevents volatile flammable vapors from being emitted. The foam blanket functions to extinguish fires or prevent the ignition of the material. The need for firefighting foams occurs on surfaces on which the cooling effect of water is needed and wherever a continuous foam blanket can provide the benefits of vapor suppression, insulation, delayed wetting, or reflection. Foams resist disruption due to wind and drafts, heat, and flame attack. It is also capable of resealing if an opening is made in the foam blanket. Foam products are commercially available for Class A fuel fires and Class B fuel fires (commonly referred to as Class A foam and Class B foam, respectively). [See **Figure 2**]

It is used in areas of flammable liquids, processing & storage, aircraft hangars, rolled paper storage & fabric storage. Foam works by smothering, separating, cooling, and suppressing. As mentioned before foam consists of foam concentrate (liquid) which when mixed with water forms a foam solution (water & foam liquid) that is mixed by a proportioner. Air is added at the nozzle via mechanical agitation creating finished foam (foam solution & air).

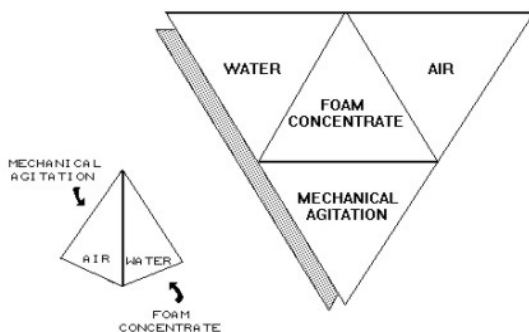


Figure 1 - Foam Tetrahedron

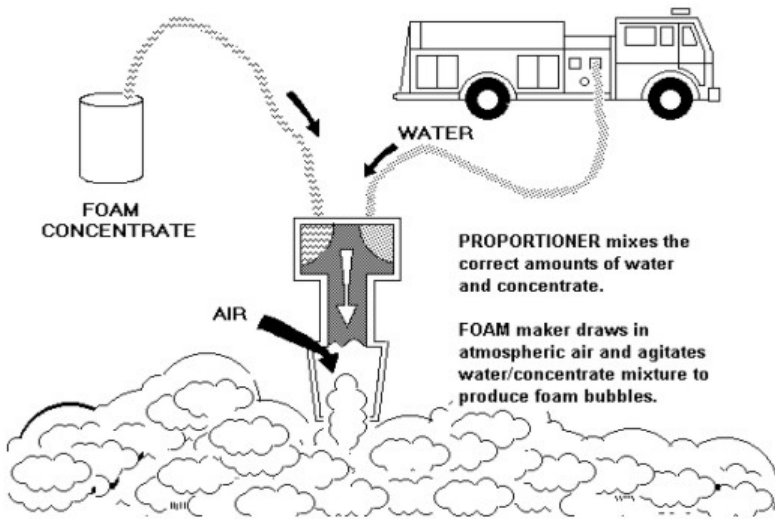


Figure 2 - How Foam is Made

Foam Proportioning Rates

Foam is about 94% to 99.5% water and 1/2% to 6% foam concentrate. The percentage of concentrate depends on what foam is used for. 1/2% to 2% used on class “A” material, while 3% to 6% usually used on flammable liquids. Foam ratings determined by testing from Underwriter Labs, Inc. These percentages also determine expansion rates of foam. There are three types of expansion rates.

- High Expansion
 - 1/2% to 2% concentrate percentage
 - 200:1 to 1000:1 expansion
- Medium Expansion
 - 1/2% to 2% concentrate percentage
 - 20:1 to 200:1 expansion ratio
- Low Expansion
 - 3% to 6% concentrate percentage
 - 7:1 to 20:1 expansion ratio

This information is found in the following standards **NFPA Standard 11 - *Standard for Low Expansion Foam & Combined Agent Systems*** and **NFPA Standard 11a - *Standard for Medium and High Expansion Foam Systems***.

For foam to work the three products must be properly mixed. The water & foam must be mixed at the **Proportioner** to create the foam solution. The foam concentrate and **proportioner** must be matched by percentage of concentration. The **foam nozzle** and the **foam proportioner** must be matched in g.p.m.. [See Figure 3]

Aspirating and non-aspirating nozzles can be used for AFFF or FFFP application. A nonaspirated nozzle typically provides a longer reach and quicker control and extinguishment. However, expansion rates and foam drainage times are generally less when AFFF or FFFP is applied with non-aspirating nozzles. It also should be understood that the foam blanket might be less stable and have a lower resistance to burnback than that formed using aspirating nozzles. [See Figure 2]

Foam Concentrate Eductor A device to draw foam concentrate out of a storage location through the principle of a venturi vacuum in the proper percentage for use in firefighting systems. It generally consists of a flexible hose connected to the throat of a venturi fitted with an orifice that is sized to the amount of proportioning specified for the foam concentrate. [See Figure 3]

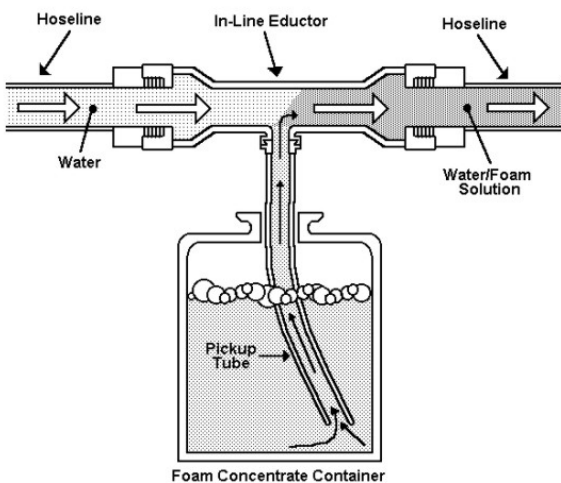


Figure 3 - Foam Eductor

Foam Application

For foam to work properly it must be applied properly. The following are some basic guidelines.

- Should be applied gently to liquid
- Make sure proper foam is being used for the spilled or burning liquid
- Do not plunge foam into burning liquid
- Need to continuously apply foam to replenish foam blanket
- Do not walk through foam blanket, creates openings that will allow ignitable vapors to be released and find ignition source

Type of Foam

Protein foam

Protein foam is a hydrolysate base of hoof and horn, fish scales, etc. combined with stabilizers. Protein foam (also called regular foam) was the first of the mechanical foams to be developed. It became

commercially available in the United States in the early 1940s. The concentrate consists of a protein source (commonly hoof and horn meal or feather meal) which has undergone an alkaline hydrolysis. This protein hydrolysate is then stabilized with metal salts, and has corrosion and bacterial growth inhibitors added. It may also contain freezing point depressants. The concentrate is normally available for 3 or 6 percent proportioning. The foam generated from these concentrates is very thick and viscous and exhibits poor fuel tolerance. Therefore, it spreads slowly over fuel surfaces, resulting in a slow knockdown. Its use has been declining in recent years with its primary use being control and extinguishment of in-depth fuel fires.

Fluoroprotein (FP)

Fluoroprotein (FP) foam is a protein hydrolysate base combined with fluorochemical surfactants. Fluoroprotein foam is an offshoot of the technology developed for AFFF. Chemically, the only difference between fluoroprotein foam and regular protein foam is the addition of a small amount of fluorochemical surfactant. There is generally not enough of this surfactant to allow the formation of an aqueous film as in the AFFFs. The properties of the foam lie in between those of AFFF and protein foam and are dependent upon the ratio of protein to fluorosurfactant. The concentrates available are 3 and 6 percent. Fluoroprotein foam is used on spill fires and in-depth fuel fires. It is also considered by many to be the choice for subsurface injection since it shows good tolerance to fuel contamination and great burnback resistance.

Film Forming Fluoroprotein (FFFP)

Film Forming Fluoroprotein (FFFP) foam is a combination of fluoroprotein surfactants and synthetic foaming agents. Film forming fluoroproteins (FFFP) are the results of attempts made in the past to combine the burnback resistance of a fluoroprotein foam with the knockdown of an AFFF. The first work on film-forming foams was carried out using protein-based concentrates. However, the result has to be a compromise to some extent, and those foams that are presently on the market usually suffer from poorer burnback resistance than a standard fluoroprotein type. The protein base can also lead to some storage problems due to sedimentation, particularly in hot climates.

Aqueous Film Forming Foam (AFFF)

Aqueous film forming foam (AFFF) is a combination of fluorocarbon surfactants and synthetic foam agents. They produce a foam that slides across the surface of hydrocarbon fuels. This is accomplished by the formation of a film that spreads ahead of the foam bubbles. AFFF represents the next generation in mechanical foam development. The development of AFFF came about as a result of advances in fluorine surfactant technology. The research and development program was conducted by the Naval Research Labs in the early 1960s principally by Tuve and Peterson, and was referred to as "light water." The objective of the research was to develop an improved foam product that could materially reduce the fire control and extinguishment times for complex Class B fires (aircraft fires), while at the same time being compatible with the dry chemical fire extinguishing agent Purple K. AFFF consists of fluorochemical surfactants, hydrocarbon surfactants, solvents, and foam stabilizers. The concentrate is available for 1, 3, and 6 percent proportioning. A lower percent allows less concentrate to be used, achieving cost and weight or storage space savings. A 1 percent proportioning system may be more susceptible to failure if contamination or particulates are large enough to cause blockages at the proportioner. The foam generated from these concentrates is watery and has a low viscosity. It can be regarded as super a detergent, which in solution has a low surface tension. Because of this, it spreads very quickly over fuel surfaces and around obstructions. A unique feature of AFFFs is that because of

fluorosurfactants, they are able to rapidly form a thin water film of the foam solution that actually floats on top of the less dense hydrocarbon fuel below. This very high-speed control of fire is the property that gives AFFF such a great advantage over older protein foam. The effectiveness and durability of the aqueous film is directly influenced by the surface tension of the hydrocarbon. AFFFs are more effective on fuels with higher surface tension coefficients, such as kerosene, diesel fuel, and jet fuels, than they are on fuels with low surface tension coefficients, such as hexane and high octane gasolines. In the United States, AFFFs are almost the only foams used for crash fire-rescue operations. They are also used for in-depth fuel fires, subsurface injection, and in non-aspirating sprinkler systems. AFFF is considered the most versatile of the mechanical foams.

Alcohol Resistant/Aqueous Film Forming Foam (AR-AFFF)

Alcohol resistant/ Aqueous Film Forming Foam (AR-AFFF) is a foam concentrate suitable for both hydrocarbon and polar solvent exposures and fuels. The concentrate is a combination of synthetic stabilizers, foamers, fluorocarbons, plus proprietary additives. Alcohol-resistant foams are suitable for fires on water soluble and certain flammable or combustible liquids and in solvents that are destructive to regular foams, such as alcohols (greater than 15 percent of volume in hydrocarbon, such as gasohol), ketones, etc. This foam has an insoluble barrier in the bubble structure that resists breakdown at the interface between the fuel and the foam blanket.

CARBON DIOXIDE SYSTEMS [See Figure 4]

Carbon Dioxide (CO₂) is a naturally occurring gas used for fire protection applications. Carbon dioxide is a noncombustible gas that can penetrate and spread to all parts of a fire, diluting the available oxygen concentration so that it will not support combustion. It also reduces the gasified fuel in the fire environment and cools the fire zone to aid in fire control and extinguishment. A CO₂ system extinguishes fires in practically all combustibles except those that have their own oxygen supply or contain certain metals that cause decomposition of the carbon dioxide. Carbon dioxide is primarily employed when water cannot be used and a fire must be controlled or suppressed by suffocation. Carbon dioxide does not conduct electricity and therefore it can be used on electrical equipment that is energized. It will not freeze or deteriorate with age. Carbon dioxide is a dangerous gas to human life since it displaces oxygen. CO₂ concentrations above 9 percent are considered hazardous, though 30 percent or more is needed to effect fire extinguishment. *NFPA 12, Carbon Dioxide Extinguishing Systems*, provides a table specifying the exact concentration requirements by volume for specific hazards. As a guide, 1 lb. (0.45 kg) of CO₂ liquid may produce 8 cu. ft. (0.23 m³) of free gas at atmospheric pressure. Carbon dioxide extinguishes a fire almost entirely by smothering. It does have a limited cooling effect of about 100 Btu per pound. Where rotating equipment such as turbines or compressors is involved, a primary and supplemental discharge is used. The supplemental discharge is used to account for leakages during “run-down” of the equipment. Concentrations are to be achieved within one minute and are to be maintained for 20 minutes within the protected enclosure. Carbon dioxide systems may be ineffective if used outdoors, since wind may dissipate the vapors rapidly. Therefore where required for outside applications, larger storage cylinders are used. It has a vapor density of 1.5 and will settle to the lower portions of an enclosure where ventilation effects do not occur. Carbon dioxide is the most commonly utilized liquefied gas fire extinguisher. Carbon dioxide for fire extinguishment is applied through portable fire extinguishers, local application systems, or total flooding systems.

Carbon Dioxide (CO₂) Fire Suppression System

Carbon Dioxide (CO₂) Fire Suppression System A fire suppression system that consists of carbon dioxide contained in a liquid condition in a pressurized storage container, a valve for releasing the material, a distribution system, discharge devices for applying carbon dioxide onto a fire, and a means for actuating the systems (automatic detection or manual release devices). Systems are usually specified as either high pressure (individual cylinders) or low pressure (bulk storage), depending on the pressure of the storage container of carbon dioxide. Low pressure systems are used where large quantities

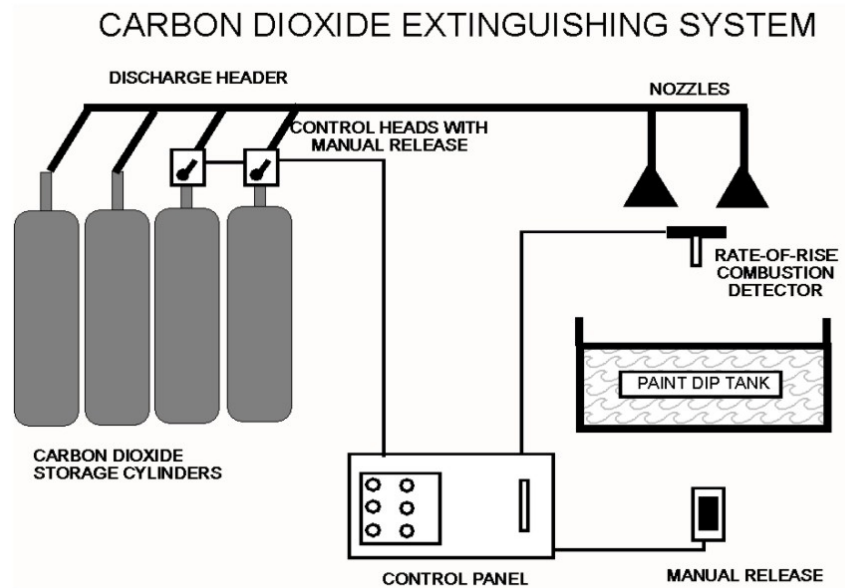


Figure 4 - CO₂ Extinguishing System

of carbon dioxide are needed for extinguishment, usually above 2,000 lbs. High pressure systems contain CO₂ in upright steel cylinders, which are at ambient temperatures of 32°F to 120°F, at about 850 psi. Low-pressure systems contain CO₂ in a storage container that is kept in a large, insulated, refrigerated tank at 0°F and approximately 300 psi. Fixed CO₂ fire suppression systems were first available in the 1920s. Guidance for the design and operation of fixed CO₂ systems is provided in *NFPA 12, Standard for Carbon Dioxide Extinguishing Systems*. NFPA began work on its standard for carbon dioxide extinguishing systems in 1928 and adopted it as an official standard in 1929.

System Activation

The system can be activated by three methods:

- Automatic - product of combustion detector, give warning signal to evacuate area
- Manual - person manually operating the control valve
- Emergency manual - used when other activation modes fail, cause system to discharge immediately and without warning

HALON SYSTEMS

An extinguishing agent contain chemicals from Halon Series (Bromine, Chlorine, Fluorine, Iodine). **Halogenated Agents** are chemical compounds (halogenated hydrocarbons) that consist of a carbon atom plus one or more elements from the halogen series of elements (fluorine, chlorine, bromine, iodine, and astatine group). Halon 1201 and 1301 are common halogenated agents that have been used for fire suppression applications..

Halon Extinguishing Systems

The NFPA standard affecting halon extinguishing systems is **NFPA Standard 12a, Halon 1301 Fire**

Extinguishing Systems. Halon was developed in the early part of the 20th century. An early type of halon was *Carbon Tetrachloride (Halon 104)*. **Carbon Tetrachloride (CCl₄)** is one of the earliest chemicals to be used as a firefighting agent for portable fire extinguishers (circa 1907), is now considered obsolete. It is a colorless, nonflammable, toxic liquid having an odor resembling chloroform. When carbon tetrachloride liquid is discharged on a fire, its thermal decomposition causes the formation of gaseous phosgene. Phosgene has a density about three and one-half times that of air. This causes the fire to extinguish by oxygen exclusion or smothering by the phosgene gas. Carbon tetrachloride is now considered an obsolete fire extinguishing agent due to the noxious and toxic decomposition products associated with CCl₄ when it is applied to a fire (inhalation of phosgene causes severe lung injury, the full effects appearing several hours after exposure). In the 1930s a number of deaths and injuries were attributed to the agent or its breakdown products and it was generally outlawed in the 1950s for fire protection applications. It is no longer referred to by NFPA for such applications. It is currently used as a solvent and as a refrigerant. Another halon was Chlorobromomethane (1011). This was developed around 1939 - 1940 and was used as an extinguishing agent in aircraft during World War II. It was similar to Carbon Tetrachloride and had the same safety concerns.

Modern halon is a contraction of halogenated hydrocarbons, commonly bromo-trifluoromethane (Halon 1301, CBRF3) and bromo-chlorodifluoro-methane (Halon 1211, CBrCLF2). A Halon may be any of a group of halogenated aliphatic hydrocarbons, most of which are derived from methane or ethane by replacing some or all of the hydrogen atoms by atoms of the halogen series (fluorine, bromine, chlorine, or iodine). The effectiveness of Halons in extinguishing fires arises from their action in interrupting chain reactions that propagate the combustion process. Halon 1301 is considered three to ten times more effective than carbon dioxide (CO₂) as a fire extinguishant. Halogenated hydrocarbons take the form of liquefied gas or vaporizing liquids at room temperature. Halons are nonconductors of electricity and can be used in fighting fires in flammable liquids and most solid combustible materials, including those in electrical equipment. They are ineffective on fuels containing their own oxidizing agent or highly reactive metals, such as sodium or potassium. Halon 1301 (bromotrifluoromethane, CBRF3) is especially favored for extinguishing fires involving electronic equipment because it leaves no residue and does not cause electrical short circuits or damaging corrosion of the equipment.

Because Halon is a compound considered destructive of the Earth's ozone shield, environmentalists have urged restriction of its use. In 1987 various scientists and government officials from many of the globe's industrialized nations met in Montreal, Canada to discuss the problem that halons and other fluorinated hydrocarbons were having on the atmosphere and ozone layer. In what is called the Montreal Protocol of 1987, it was decided to outlaw the manufacturing of halons and fluorinated hydrocarbons. It is generally considered obsolete for fire protection purposes and has been eliminated, phased out, or replaced with agents that are nondestructive to the ozone layer. The elimination of Halon in the United States took effect January 1, 1995.

The numbering system used to designate the products is based on number of atoms in the chemical formula. For example

- Halon 1301 - CF₃BR (1 Carbon Atom, 3 Fluorine Atoms, 0 Chlorine Atoms, 1 Bromine Atom)
- Halon 1211 - CF₂BRCL (1 Carbon Atom, 2 Fluorine Atoms, 1 Bromine Atom, 1 Chlorine Atom)

The reason that halon has been such an excellent extinguishing agent is that its characteristics lend to a rapid control of the fire. Some of these characteristics are as follows.

- Interrupts chemical chain reaction
- Works with low % in air (10% or less)
- Does not leave residue
- Works well on class “B” & “C” fires
- Interrupts flaming part of combustion

Toxicity & Hazards of Halons

Studies have been performed on the toxicity of the different halons and based on these the following applies. NFPA 12a allows up to 10% concentration in areas that are normally occupied & 15% for areas unoccupied. While high temperatures will cause halons to breakdown, creating toxic chemicals (Hydrogen Bromide, Chlorine, Hydrogen Chloride). Most fires are usually extinguished quick enough so high temperatures do not develop.

Halon Extinguishing Systems

Modern systems are typically total flooding systems. These systems can be pre-engineered or engineered in design. The storage container sizes range from 5 pound to 600 pounds. These systems have automatic activation based on products of combustion detection with an early warning alarm for personnel to activate area. Most systems designed so more than one detector has to detect fire before system will activate. The system also has a manual activation release system. Most systems have an abort control to prevent accidental dumping of agent. The nozzles for system can be located in ceiling or in floor depending on the hazard. Most of the fire codes require that the system should be inspected twice a year. [See Figure 5]

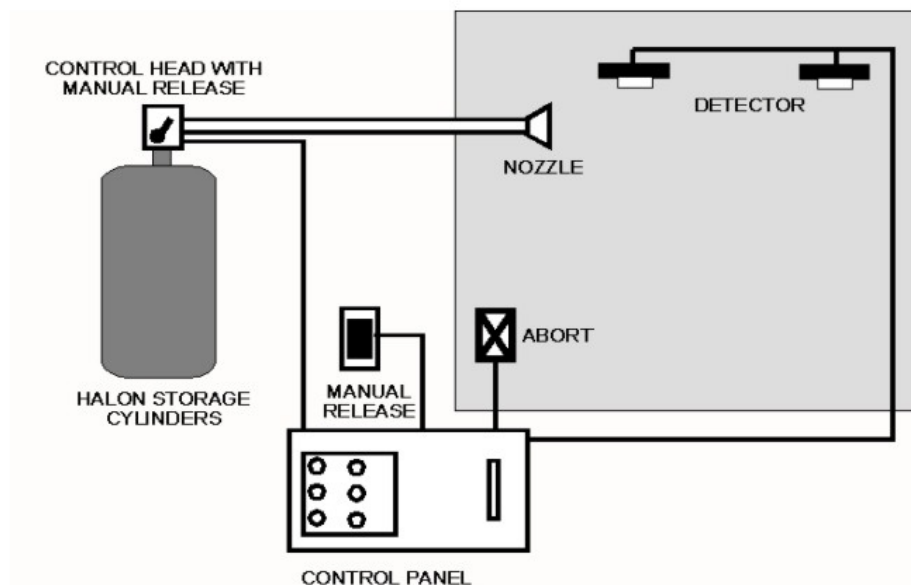


Figure 5 - Halon Extinguishing System

CLEAN AGENTS [See Figure 6]

Because of the Montreal Protocol of 1987 the fire protection has been required to develop new extinguishing agents to replace Halogenated extinguishing agents. These new agent are called “clean agents”. **A Clean Agent** is defined as a volatile or gaseous fire extinguishing agent that is not electrically conductive and does not leave any residue during or after its application following evaporation. Common clean agents include carbon dioxide, Halon, Inergen, and FM-200. Although Halon is considered a clean agent, it may contribute to the Earth’s ozone depletion and therefore is considered environmentally harmful. Some of the more common “clean agent” extinguishing agents are

- HCFC-124 Chlorotetrafluoroethane CHClFCF_3
- HFC-125 Pentafluoroethane CHF_2CF_3
- HFC-227ea Heptafluoropropane $\text{CF}_3\text{CHFCF}_3$
- HFC-23 Trifluoromethane CHF_3
- HFC-236fa Hexafluoropropane $\text{CF}_3\text{CH}_2\text{CF}_3$
- FIC-131I Trifluiodomethane CF_3I

These systems are primarily designed for use on class “B” and “C” fires, but have found to be useful on class “A” fires and in explosion suppression systems. The systems may be engineered or pre-engineered. System components are as follows

- Extinguishing agent [HCFC-124, HFC-125, HFC-23]
- Storage Container
- Piping
- Discharge Nozzle
- Detection Device
- Activation Device
- Control System

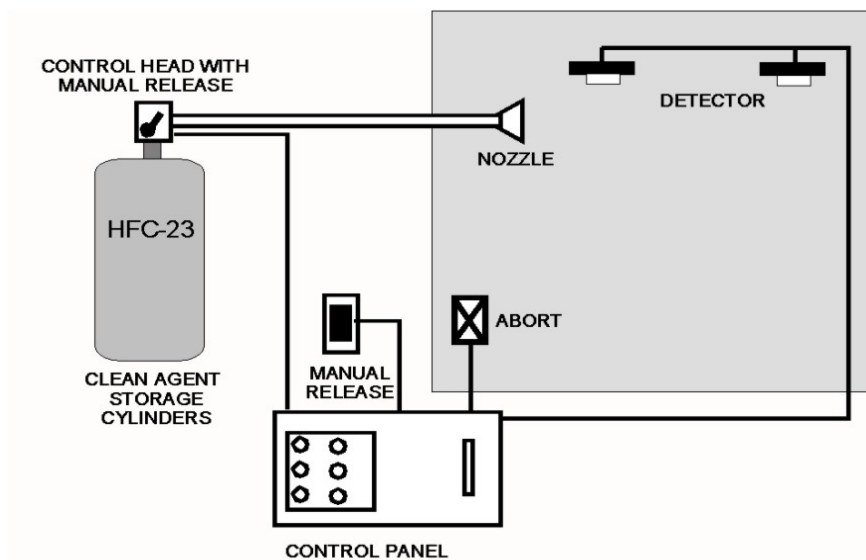


Figure 6 - Clean Agent System

DRY CHEMICAL SYSTEMS

Dry Chemical—A fire extinguishing agent principally of either sodium bicarbonate, potassium bicarbonate, or ammonium phosphate (multipurpose). Other ingredients are added to improve fluidity, non-caking ability, and water repellent effects. Dry chemical agents contain particles from 10 microns to 75 microns in size. A chemical agent extinguishes a fire by interrupting the chain reaction wherein the chemicals prevent the union of the free radical particles in the combustion process. Combustion does not continue when the flame front is completely covered with agent. Flame cooling by the surface area of the powder and the inerting effect of carbon dioxide produced by the thermal breakdown of the bicarbonate are thought to have a secondary effect on the combustion reaction. Dry chemicals are commonly used to extinguish Class B (burning liquids) or Class C (electrical) fires whereas dry powder is used to put out Class D fires (burning metals) such as magnesium and phosphorus. The two types of agents are not the same and cannot be used interchangeably. Multipurpose dry chemical may extinguish Class A fires (ordinary combustibles), however the fire may re-ignite since these fires may be deep-seated in the material and the agent may not reach these areas. Dry chemical agents are applied through fixed piping systems, through pipes to a hose station, or through portable handheld or wheeled fire extinguishers. Dry chemicals are non-toxic, but in large percentages can cause breathing problems. Its extinguishing properties are:

- Smothers - usually with ABC powder
- Cooling action - very minor
- Radiation shielding - can reflect some heat away via powder
- Chemical chain reaction - interrupts flame stage of fire
- Dry chemical is very good on class “B” fires to knock flame part of fire, but fire can reignite if vapors find an ignition source

Types of Dry Chemical

Sodium Bicarbonate is a dry chemical fire suppression agent. It was the first dry chemical agent to be formulated and is effective on Class B and C fires. It has about 50 percent greater effectiveness than water when applied to the same fire. It is usually compounded with other particular materials to render the mixture water repellent and therefore capable of flowing from a pressurized container (portable fire extinguisher).

Potassium Bicarbonate is a dry chemical agent used for rapid fire suppression. It was developed at the US Naval Research Laboratories (circa 1959) to apply simultaneously with aqueous film forming foams (AFFF) for aircraft crash fires. It is commonly referred to as Purple-K, a trademarked name by Wormald, U.S., Inc. It is generally about twice as effective as sodium bicarbonate. It is compatible with aqueous film forming foam and is sometimes combined in a twin nozzle arrangement to simultaneously apply foam and dry chemical for rapid fire knockdown, and vapor suppression for liquid fuel fires for protection of aircraft operations. Purple-K powder is dyed purple to differentiate it from other dry chemical agents; the K is the chemical symbol for potassium. It was originally named Purple K for the purple flame spectrum it exhibits when it encounters flame temperatures.

Multipurpose Dry Chemical, also known as mon-ammonium phosphate is dry chemical fire suppression agent that is effective on Class A, B, and C fires. It is based on a mixture ammonium phosphate or ammonium phosphates and sulfates. Multipurpose dry chemical agents suppress a fire by interfering with the chemical chain reaction of the fire and also coating Class A combustible surfaces with glassy coating during the reaction of the chemical during application, which excludes oxygen from the combustion process. A Class A fire extinguished by a multipurpose dry chemical application may re-ignite since these fires may be deep-seated in the material and the chemical agent may not reach these

areas. Multipurpose dry chemical extinguishers are the most widely used due to their versatility.

Dry Chemical Fire Extinguishing System [See Figure 7]

Dry Chemical Fire Extinguishing System is a fixed fire suppression system that uses stored dry chemical powder that is distributed to the fire hazard through a system of pipes and application nozzles or manually directed hoses with application nozzles. It is activated by manual or automatic fire detection. The system is usually activated by a storage bank of pressurized inert gas (such as nitrogen) high-pressure cylinders at the time of use. It is normally designated for use at locations where combustible liquids may be present, such as restaurant deep fat fryers, paint dip tanks, hydraulic systems, etc. The requirements are found in *NFPA Standard 17 - Standard for Dry Chemical Extinguishing Systems*. Some common areas where they are found are

- Dip tanks
- Flammable liquid storage
- Cooking areas
- Auto-body paint spray booths

They are not recommended for delicate electrical systems due to corrosive nature of the powder. There are two types of systems

- Engineered - calculated for a specific hazard in a specific area
- Pre-engineered - packaged system for any location

The components of the system are as follows

- Tanks that can be from 30 pounds to 100 pounds of powder and compressed gas (air)
- Piping specially designed to flow a certain amount of powder
- Nozzles vary with manufacturer, but usually one position or two position
 - One position - straight stream
 - Two position - fan shaped stream
- Activating device typically is a fusible link, similar to that of an automatic sprinkler system. They can have an audible alarm so personnel can evacuate area. They are also required to have a manual activation control

The systems are also required to have a dry-chemical portable extinguisher available that has the same dry chemical as the system. Kitchen system, which are the most typical, are usually required to be inspected twice a year by most of the model codes.

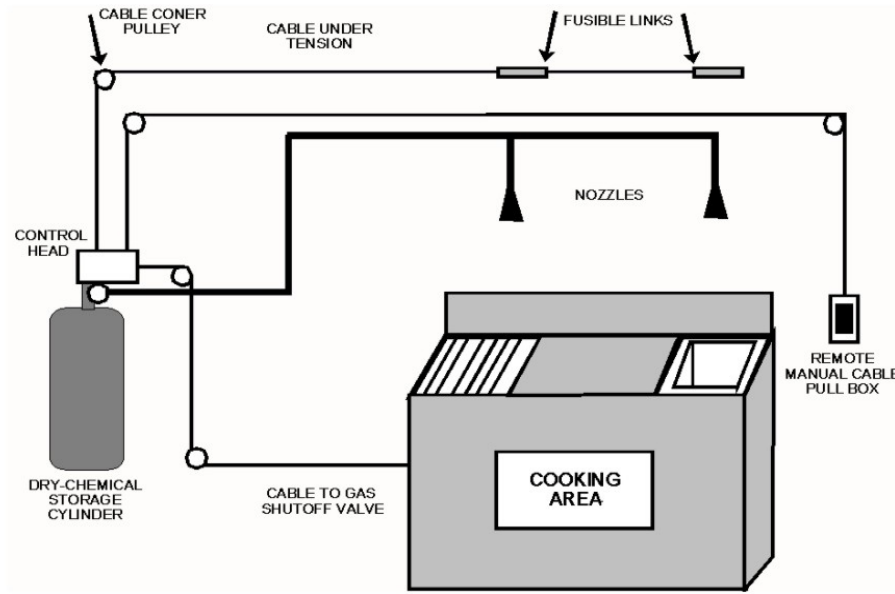


Figure 7 - Dry Chemical Extinguishing System for Cooking Application

COMBUSTIBLE METALS

Combustible Metals are defined as “metals that will burn in a finely divided form, or when exposed to moisture or react with other materials”. There are numerous agents developed to extinguish class “D” fires, but no one powder will work on all materials. Some of the extinguishing agents, properties and application techniques are:

NA-X

- Used on potassium, sodium
- Not suitable for magnesium
- Extinguishing action creates a caking or crust on burning material causing a smothering effect
- Can be applied from extinguishers or scooped from a pail

MET-L-X

- Sodium chloride based agent
- Use on magnesium, sodium and potassium
- Extinguishes similar to NA-X
- Applied from extinguisher or bucket

LITH-X

- Used on Lithium, Magnesium, Zirconium, Sodium
- Extinguishes by conducting heat away from fuel after a layer has been applied

Most agents are recommended to be applied at a 5:1 ratio of powder to burning metal and should covering layer should be at least 2 inches thick

Portable Fire Extinguisher

Historical Background

Early fire extinguishers in the 1730s were just glass balls of water or saline solution that were thrown on fires. They were invented by a German physician, M. Fuches, in 1734. Although they were widely advertised and sold, in general they were not really used (primarily because they were too small to be effective). In 1816, George Manby, an English army captain, invented the first practical extinguisher similar to modern models. It used compressed air to force water (pressurized water) out of a cylinder through a control valve. It delivered 3 gallons (11.4 liters) of water from a cylinder that was pressurized with compressed air and was three-quarters full of water. A more efficient portable extinguisher was invented by Francois Carier, a French doctor, in about 1866. He mixed sodium bicarbonate with water and fixed a glass bottle of sulfuric acid inside the extinguisher near the neck. The bottle was broken by striking a pin and the chemical mixed. This produced carbon dioxide (CO₂) gas, which forced out the water. In 1909, Edward Davidson of New York patented the use of carbon tetrachloride (CCl₄). It was ejected out of the extinguisher by pressurized carbon dioxide. It vaporized immediately to form a heavy, noncombustible gas that smothered the fire. Four years before this, foam extinguishers had been invented in St. Petersburg, Russia, by Professor Alexander Laurent. He mixed a solution of aluminum sulfate and sodium bicarbonate with a stabilizing agent. The foam bubbles that were formed contained carbon dioxide gas. They were able to float on burning oil, paint, or petrol and smother a fire. NFPA's standard on portable fire extinguishers was developed in 1921. In addition to fire class, fire extinguishers are grouped by the means of expelling the agent.

Portable Fire Extinguisher is defined as “a portable or movable apparatus used to put out a small fire by directing onto it a substance that cools the burning material, deprives the flame of oxygen, or interferes with the chemical reactions occurring in the flame. They are intended as the first line of defense against fires of limited size.” Portable extinguishers can be water-based, gaseous, or dry chemical types. Most portable fire extinguishers are small tanks provided with an expelling gas that has been compressed (compressed air or carbon dioxide) to propel the extinguishing agent through a nozzle and onto the fire. This method supersedes the previous method used in the soda-acid fire extinguisher whereby carbon dioxide (CO₂) was generated by mixing sulfuric acid with a solution of sodium bicarbonate. [See Figure 8]

The type of portable fire extinguisher depends primarily on the nature of the burning materials. Secondary considerations include cost, stability, toxicity, ease of cleanup, and the presence of electrical hazard. Small fires are classified according to the nature of the burning material. Class A fires involve wood, paper, and similar cellulosic materials. Class B fires involve flammable liquids, such as cooking fats and paint thinners. Class C fires are those in electrical equipment and Class D fires involve highly reactive metals, such as sodium and magnesium. Water is suitable for putting out fires of only one of these classes (A), though water is the most commonly used because it can cool and protect exposures as well. Water converts to steam when it absorbs heat and the steam displaces the air from the vicinity of the flame. The water may contain a wetting agent to make it more effective against fires in upholstery, an additive to produce stable foam that acts as a barrier against oxygen, or antifreeze to prevent freezing in cold ambient temperatures. Fires of classes A, B, and C can be controlled by carbon dioxide (CO₂), halogenated hydrocarbons such as environmentally friendly Halon substitutes, or dry chemicals such as sodium bicarbonate or ammonium dihydrogen phosphate. Class D fires are ordinarily fought with dry chemicals. The CO₂ extinguisher is a steel cylinder filled with liquid carbon

dioxide, which, when released, expands suddenly and causes so great a lowering of temperature that it solidifies into a powdery “snow.” This snow volatilizes (vaporizes) on contact with the burning substance, producing a blanket of gas that cools and smothers the flame.

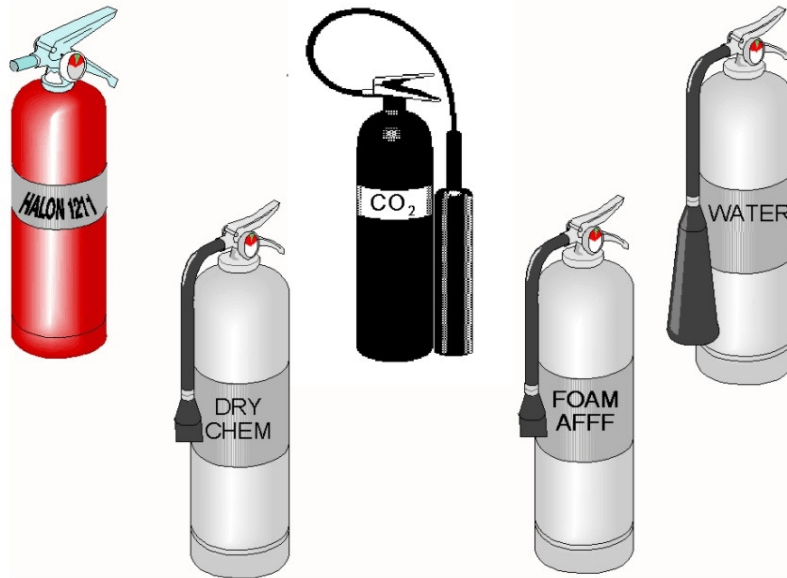


Figure 8 - Types of Fire Extinguishers

Five methods are commonly employed. These include self-expelling, gas cartridge or cylinder, stored pressure, mechanically pumped, and hand propelled or applied. **[Figure 9]**

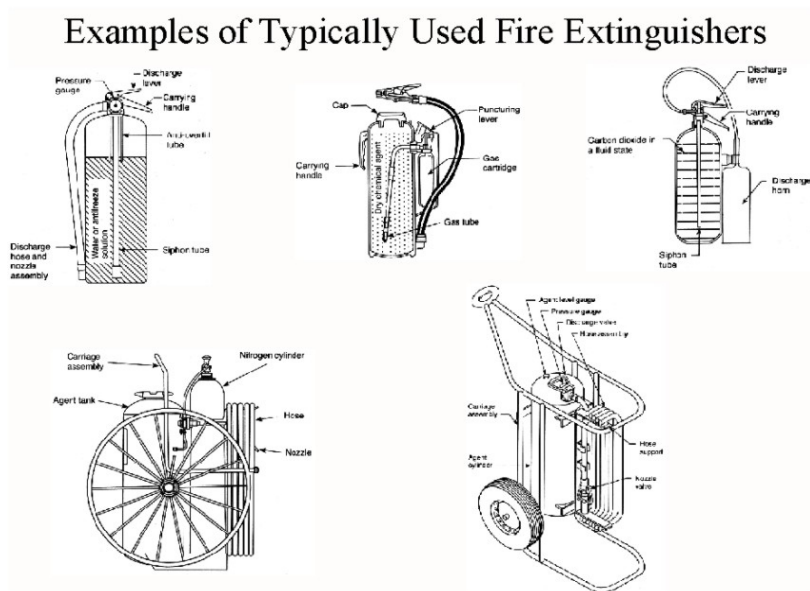


Figure 9

Extinguisher Symbols

NFPA Standard 10, *Standard for Portable Fire Extinguishers* provides most of the information you will need for portable fire extinguishers. There are two recognition systems used to identify what type of fire an extinguisher is used on. The first is Letter Symbols. Each class of fire that extinguisher will work on is indicated by a letter (A, B, C, D) and a geometric shape and color.

- **Class A - Green Triangle**
- **Class B - Red Square**
- **Class C - Blue Circle**
- **Class D - Yellow Star**

Pictorial Symbols are symbols that indicate what type of fire the extinguisher can be used on (Only A,B,C; Not D). It will also indicate what type of fire the extinguisher should not be used on. Will be indicated by symbol with a red or black slash through the symbol. [See Figure 10]

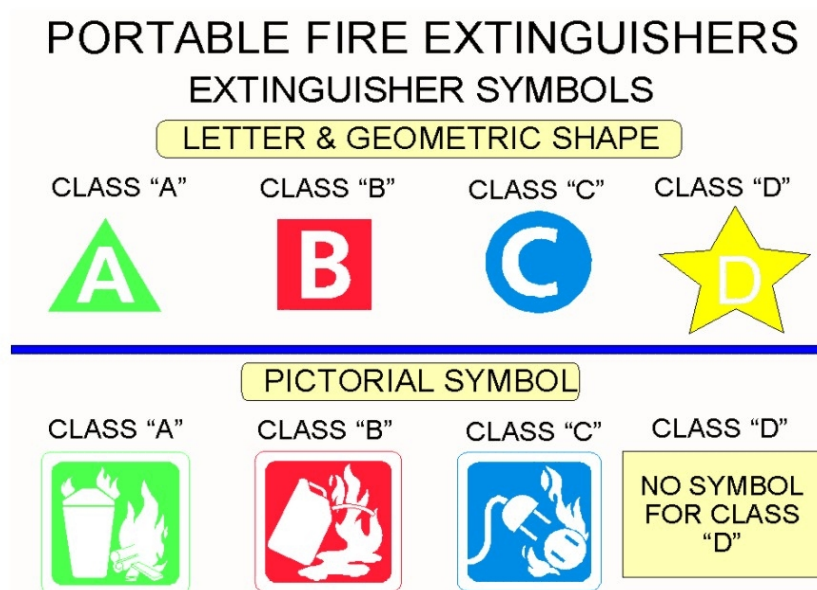


Figure 10

Rating of Extinguishers [See Figure 11]

Fire extinguishers are rated according to their intended use and firefighting capability. This is based on the type of agent and amount in the extinguisher. Rating tests are done on Class "A" & "B", Class "C" rating is only a letter, there is no rating for class "D" except for letter designation. Class "A" & "B" receive a letter and a numerical designation. Possible number & letter combinations are:

- A: B
- A: B: C
- B: C
- Class "D" Has No Multiple Rating

Rating Test for Class “A” Extinguishers

There are three tests for class “A” extinguishers. These are:

- Wood crib
- Wood panel
- Excelsior

Extinguishers are given an “A” letter rating and a numerical rating of 1 through 6 for all 3 tests and a 10-a for just the wood panel test. Rating tells that the extinguisher is good on class “A” material and is that many times more effective than a 1-A extinguisher

Rating Test for Class “B” Extinguishers

These extinguishers are given a letter designation of “B” and a numerical designation that is based on the approximate area (square foot) of fire involving a 2 inch layer of a flammable liquid (n-heptane) that can be extinguished by a novice. Example - a designation of 60-B will be given to an extinguisher where a novice has extinguished a flammable liquid fire of 60 square feet. An expert is expected to extinguish 2 ½ times that of a novice or in this case 150 square feet. A 1 square foot of burning liquid corresponds to a 1-B rating. Items are evaluated on time of extinguisher application, time at which fire was extinguished, time the agent discharge ended

Rating of Class “C” Extinguishers

For this class no number assigned. Rating signifies that the agent is non-conductive. The test determines how much conductivity the agent. [Note - discharge horn on the extinguisher must also be non-conductive]

Example of Class “A” & “B”

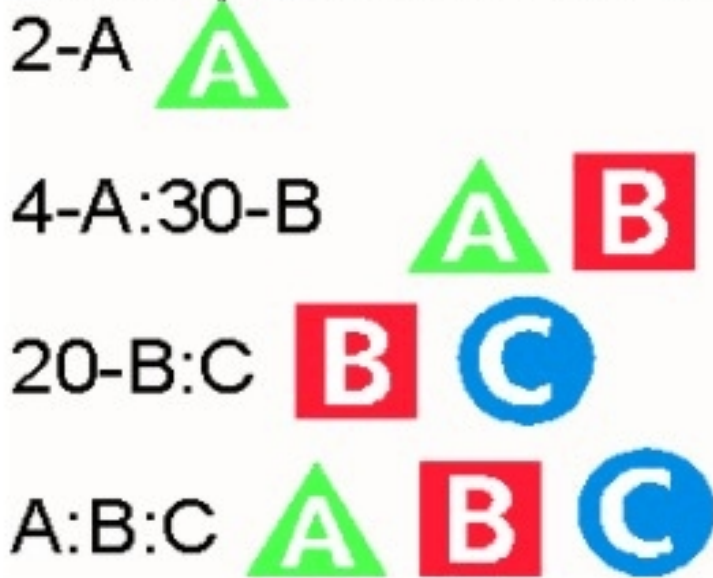


Figure 11 - Example of Extinguisher Ratings

Types of Extinguishers [See Figure 9]

Stored Pressure Extinguisher is a portable fire extinguisher in which the firefighting agent and expelling medium are stored in the same container. A pressurized multipurpose dry chemical portable fire extinguisher is an example of a stored pressure extinguisher

Gas Cartridge or Cylinder Extinguisher is a portable fire extinguisher in which the firefighting agent and expelling medium are stored together but in separate pressure vessels until required, at which time the agent container is pressurized by the expelling medium. The cartridge is a small replaceable cylinder normally filled with carbon dioxide (CO₂). Nitrogen-filled cartridges are used where low temperatures may be encountered. The fire extinguisher is operated by a lever that punctures a sealed orifice in the cartridge, which then pressurizes the large container of fire extinguishing agent from the cartridge. A separate nozzle valve is provided on the discharge hose attached to the large container to release and control agent flow onto the fire. A cartridge operated multipurpose dry chemical portable fire extinguisher is an example of a gas cartridge extinguisher.

Mechanically Pumped Extinguisher is a portable fire extinguisher in which the firefighting agent is mechanically pumped from its storage container and the container itself does not become pressurized. A hand water pump is an example of a mechanically pumped extinguisher.

Obsolete Extinguishers [See Figure 12]

there are several types of extinguishers that are no longer approved for use by NFPA standards or OSHA. These are Soda Acid extinguishers which was made obsolete in 1969. This an inverting type, which means that it must be turned upside down to operate. Inverting extinguishers (soda acid, foam) cannot be turned off once they are activated, the agent is more corrosive than the water, they are costly to maintain. They were subject to gas build-up in chamber that would cause seam to rupture and explode They were removed from service by OSHA as of January 1, 1982 . The other types was a Vaporizing Liquid. This also became obsolete in 1960's. it contained carbon tetrachloride or chlorobromomethane..

Examples of Obsolete Extinguishers

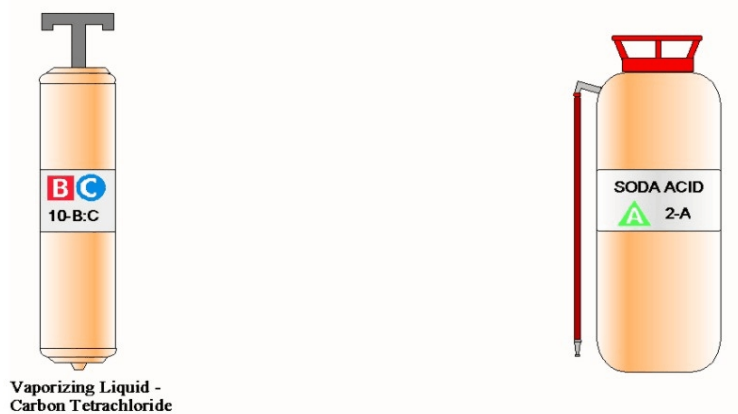


Figure 12

Distribution of Extinguishers

The distribution of extinguishers is based on information found in NFPA Standard 10. Distribution is based on travel distance, building arrangement, and occupancy hazard. NFPA 10 recommends a travel distance between extinguishers not to exceed 75 feet. Travel distance is not merely a simple circle radius matter, but is the actual distance the user of the fire extinguisher will need to walk. Consequently, travel distance will be affected by partitions, location of doorways, aisles, piles of stored materials, machinery, etc.

Arrangement in a Building.

- The actual placement of fire extinguishers can best be accomplished through a physical survey of the area to be protected. In general, locations should be selected that will:
 - Provide uniform distribution,
 - Provide easy accessibility,
 - Be relatively free from blocking by storage and equipment, or both,
 - Be near normal paths of travel,
 - Be near entrance and exit doors,
 - Be free from the potential of physical damage,
 - Be readily visible, and
 - Be installed on a floor-by-floor basis.

Consideration for type of hazard and size of extinguisher when placing

General method of placing - by hazard occupancy type. Classification of occupancy by hazards are the following.

- Light - church, classroom, ballroom
- Ordinary hazard - stores, light manufacturing
- Extra hazard - automotive repair, flammable liquid storage, high pile storage

General method of placement - extinguisher size [See Extinguisher Spacing Table]

Class “A”

- Yields minimum # of extinguishers to be provided

Class “B”

- Normal Class B fire hazards fall into two quite different general categories regarding requirements for fire extinguishers. One condition is where the fire does not involve flammable liquids in appreciable depth, such as spilled fuel on an open surface, a fire involving vapors issuing from a container or piping system, or a running fire from a broken container.
- The other condition is where the fire involves flammable liquids in appreciable depth [defined as a depth of liquid greater than 1/4 in.], such as fires involving open tanks of flammable liquids commonly found in industrial plants (dip tanks used for coating, finishing, treating, or similar processes).
- The reason the basic maximum travel distance to Class B fire extinguishers is 50 ft as opposed to 75 ft for Class A fire extinguishers is that flammable liquid fires reach their maximum intensity almost immediately. It is imperative that the fire extinguisher be brought to the fire in a much shorter period of time than allowed for a slower developing Class A fire.

Class “C”

- The capacity of the fire extinguishers supplied for each major Class C hazard situation must be individually judged according to:
 - The size of the electrical equipment,

- The configuration of the electrical equipment (particularly the enclosures of units) that influences agent distribution,
 - The effective range of the fire extinguisher stream,
 - The amount of Class A and B material involved.
- Each of these factors influences the amount and type of agent needed, the desired rate of agent discharge, the associated duration of application, and the potential wastage factors.
 - For large installations of electrical apparatus where the power continuity is critical, fixed fire protection is desirable. At locations where such fixed systems are installed, it is practical to also provide Class C portable fire extinguisher units to handle quickly discovered fires: obviously, the number and size of these units can be reduced under such conditions.

Class “D”

- For Class D hazards, the availability of special portable fire extinguishers (or equivalent equipment to contain or extinguish any fire developing in a combustible metal) is particularly important. Extinguishing equipment for such fires should be located no more than 75 ft from the hazard.
- Use of the wrong fire extinguisher can instantly increase or spread the fire. Quantitatively, the amount of agent needed is normally measured by the surface area of combustible metals that might become involved, plus the potential severity of the fire as influenced by the shape and form of the metal. Because fires in magnesium fines are more difficult to extinguish than fires involving magnesium scrap, the amount of agent needed to handle fires in magnesium fines is correspondingly greater. Fire extinguishers labeled for Class D fires are not necessarily equally effective on all combustible metal fires. Often, fire extinguishers so labeled might be hazardous when used on some metal fires. Unless the effect of the extinguishing agent is known for the metal being considered, tests should be made with representative material.

Installation & placement

- Normal path of travel
- Must not be blocked by equipment or storage
- Near points of egress
- Must be visible

Extinguisher Spacing Table			
Maximum Area To Be Protected per Extinguisher, Sq Ft			
Class A Rating Shown on Extinguisher	Light (Low) Hazard Occupancy	Ordinary (Moderate) Hazard Occupancy	Extra (High) Hazard Occupancy
1A	—	—	—
2A	6,000	3,000	—
3A	9,000	4,500	—
4A	11,250	6,000	4,000
6A	11,250	9,000	6,000
10A	11,250	11,250	10,000
20A	11,250	11,250	11,250
30A	11,250	11,250	11,250
40A	11,250	11,250	11,250
Note: 11,250 is considered a practical limit.			