SMA Fire Training Manual

March 2010

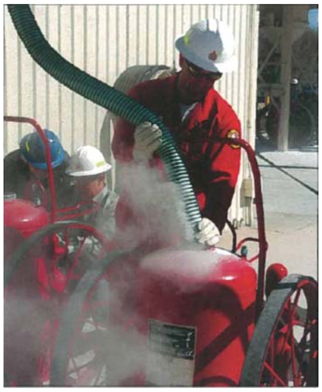
There are four basic principles which must be understood by a fire fighting trainee before he can be expected to use fire extinguishing equipment successfully.

1. **Extinguisher Capabilities and Limitations** - When faced with a fire situation, an operator must make a split second decision whether to attempt extinguishment or seek safety. He can either make this decision emotionally or he can make it based on some degree of sound judgment. One of the primary objectives of any fire training program is to provide the operator with a base of experience on which he can evaluate the probability of extinguishing a fire with the equipment at hand without endangering his physical well-being. Classroom work, film demonstrations and most importantly, actual hands-on training substantially increase the operator's willingness to attempt extinguishment and will significantly reduce his reaction time.

2. **Extinguisher Operation** - Even a willing operator cannot successfully extinguish a fire unless he knows how to actuate the available extinguishing equipment. Classroom work and repetitive "hands-on" training under the critical eye of a trained instructor help to reduce the operator's reaction time. Two or three seconds saved in an actual fire situation can mean the difference between a small or large fire, extinguishment or disaster. An important objective of any fire training program should be to help create this added margin of safety.

3. **Applications Technique -** The most important element of any fire training program is development of proper applications technique - teaching the trainee how to apply the extinguishing agent correctly. Here there is no substitute for handling extinguishing equipment under actual fire conditions. Trainees must learn how to direct the stream of extinguishing agent and how to safely approach the fire. They learn how individual fires behave and how to avoid flashback. They are trained to take advantage of the prevailing wind and how to cope with the heat of the fire and visibility restrictions caused by both fire and extinguishing agent. They gain confidence and learn the capabilities and limitations of extinguishing equipment.

4. **Recharge and Maintenance -** History has proven that nearly every fire extinguishing equipment failure can be traced back to human negligence. Even the best piece of equipment will not operate if it is not recharged and maintained properly. Although the individual trainee may not be responsible for the recharge and maintenance, he should be made aware of the consequences of improperly serviced extinguishers. He must understand the critical nature of reporting the use of an extinguisher so that it can be immediately recharged. That is why students at the ANSUL Fire Training Program "pack their own parachutes." They recharge and maintain the equipment they use.



BASIC ELEMENTS OF FIRE

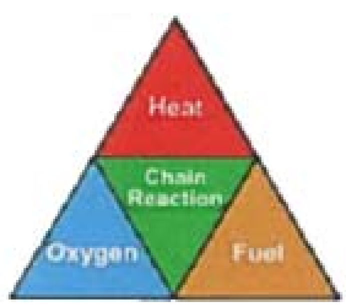
For many years, we thought that fire consisted of three components: heat, fuel, and an oxidizing agent (usually air). These three components were represented by the three sides of the fire triangle. As our knowledge of fire increased, we recognized that fire also involves a series of interconnecting chemical reactions which are commonly referred to as a chemical chain reaction.

This process of combustion (fire) can be represented by the following general equation:

FUEL		PRODUCTS OF COMBUSTION
+	=	+
OXIDIZING AGENT		ENERGY

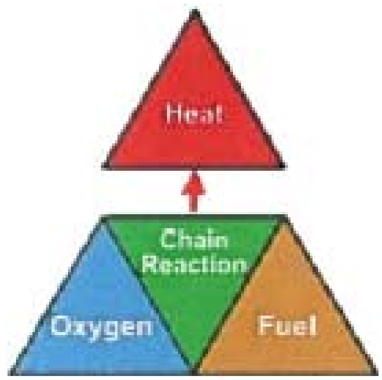
The equation shows that as fuel and an oxidizing agent are brought together, and the fuel is raised above its ignition temperature, a combustion process will result. The combustion process is represented by a series of chemical reactions that convert the fuel and oxidizing agent into products of combustion and energy. The energy is released in the form of heat and light — what we recognize as fire.

Because we now recognize the chemical chain reaction as a fourth fire element, the representative fire triangle has been changed to the fire tetrahedron. The four legs of the tetrahedron represent the four components of fire: heat, fuel, oxidizing agent, and chemical chain reaction. If any one of these legs is absent, a fire cannot occur. Therefore, there are four methods of extinguishment that generally represent removal of one of the four fire components.



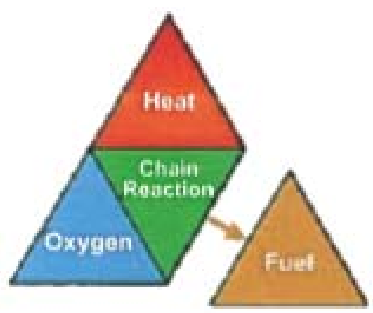
Remove Heat

The removal of heat from fire cools the fuel below its ignition temperature resulting in extinguishment of the fire. There are a number of materials that can effectively remove heat from fire; water being the most common. (Water extinguishment details are covered in the Agents Section of this manual.)



Remove Fuel

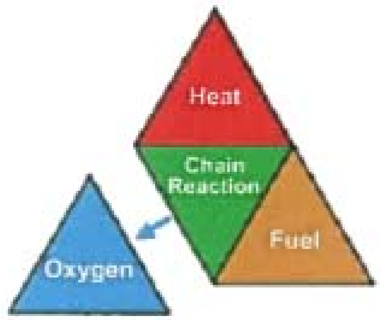
Often taking the fuel away from a fire is difficult but there are exceptions. Valves can sometimes be used to isolate or control the flow. Keep in mind your safety when attempting to reach the valve. If fuel cannot be removed, we can separate the fuel from oxidizing agents. There are, again, a number of materials that have this property, with foam agents being the most common. (Foam agents are covered in more detail in the Agents Section of this manual.)



Remove Oxygen

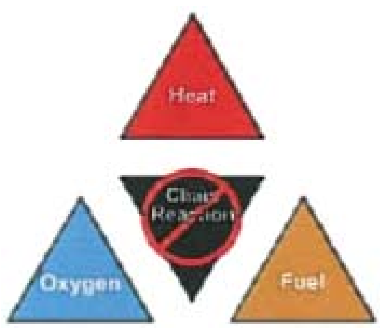
Again, oxygen is not actually removed from the fire, but is separated or diluted to below 14% from the fuel. Foam agents provide this type of extinguishment as do foam blankets and dirt.

It is also important to note that liquids and solids do not burn. What burns are the vapors produced when the fuel is heated above its ignition temperature. Gaseous agents, such as nitrogen and carbon dioxide, change the composition in the vapor phase (where the fire occurs) thereby separating the oxidizing agent from the fuel. (This type of extinguishment is detailed in the Agents Section of this manual.)



Stop the Chemical Chain Reaction

Since the chemical chain reaction is the mechanism by which the fuel and oxidizing agent produce fire, the fourth extinguishing method must stop this reaction sequence. There is one class of extinguishing agent that terminates the chemical chain reaction sequence: dry chemical agents. (For details, see the Agents Section of this manual.)



Summary

Because fire is considered to have four components instead of three, the four-component tetrahedron now represents the combustion process. If we can remove any one of the four components necessary for fire (heat, fuel, oxidizing agent, or chemical chain reaction) the fire will be extinguished.

More detailed explanations of the process of fire and the methods of extinguishment are available in the literature published by the National Fire Protection Association (NFPA). An excellent source of information is the NFPA Fire Protection Handbook.

CLASSIFICATION OF FIRES

Class "A" Fires

Class "A" fires occur in ordinary combustible materials such as wood, cloth and paper. The most commonly used extinguishing agent is water which cools the fuel substrate below its auto-ignition temperature. A secondary mechanism of extinguishment is the fact that water is converted to steam and undergoes a 1700 fold increase in volume which is sometimes referred to as "steam smothering" of the fuel. Fires in these materials are also extinguished by special dry chemical extinguishing agents for use on Class A, B, and C fires. These provide a rapid knockdown of flame and form a fire retardant coating which prevents re-ignition.

Class "A" fuels are the only fuels showing two modes of combustion. In the early stage right after ignition, distillation of the volatile components of the fuel results in what is referred to as "flaming combustion." After distillation of the volatile fuel components, the type of combustion that occurs within the fuel bed of the Class "A" fuel is referred to as "glowing combustion" or "deep-seated" combustion. Flaming combustion is controlled by diffusion of fuel vapor to the source of oxygen which is usually air. Deep-seated combustion is controlled by the diffusion of the oxygen in air into the fuel mass.

Class "B" Fires

Class "B" fires occur in the vapor-air mixture over the surface of flammable liquids such as greases, gasoline and lubricating oils. A smothering or combustion inhibiting effect is necessary to extinguish Class "B" fires. Dry chemical, foam, carbon dioxide and water fog can be used as extinguishing agents depending on the circumstances of the fire.

Characteristics of Flammable Liquids

Flammable liquids are always covered with a layer of vapors. When mixed with air and contacted by an ignition source, it is the vapor, not the liquid, which burns. A flammable liquid is usually more dangerous when temperatures are high because more vapors are generated. Four terms are commonly used with flammable liquids:

FLASH POINT: The lowest temperature at which a liquid gives off enough vapors to form a flammable mixture with air.

FIRE POINT: The lowest temperature at which the vapor-air mixture will continue to burn after it is ignited. This is generally a few degrees above the flash point.

IGNITION TEMPERATURE: The temperature at which a mixture of flammable vapor and air will ignite without a spark or flame. This term is also applied to the temperature of a hot surface which will ignite flammable vapors. The temperature varies with the type of fuel.

FLAMMABLE OR EXPLOSIVE RANGE: The range between the smallest and largest amounts of vapor in a given quantity of air which will explode or burn when ignited. The amount is usually expressed in percentages. For instance, carbon disulfide has an explosive range of 1% to 50%. If air contains more than 1% or less than 50% of carbon disulfide vapor, the mixture can explode or burn.

Gasoline as a Fire Hazard

Class "B" fuels can be subdivided into combustible liquids and gases, flammable liquids and gases and greases. Combustible liquids and gases have a flashpoint at or above 100 °F (37 °C).

Flammable liquids and gases have flashpoints below 100 °F (37 °C) and have a vapor pressure less than 40 psi (2.6 bar) at 100 °F (37 °C).

Gasoline is one of the most commonly known flammable liquids. It has a flashpoint of about -50 °F (-46 °C) and an ignition temperature of about 495 °F (257 °C).

Burning gasoline has an equilibrium flame temperature of 1500 °F (816 °C).

Therefore it can heat objects in the fire area above its ignition temperature. To prevent reignition after extinguishment, allow sufficient time for hot objects in the fire area to cool below the ignition temperature of the gasoline. Watch for re-flash; more dry chemical may be needed.

With carbon dioxide or steam, the amount of oxygen in a given atmosphere is reduced from its normal 21% to 14% by delusion. Most petroleum products cannot burn. As a result, a gasoline fire can be suffocated by diluting the atmosphere with gases such as carbon dioxide or steam.

Class "B" fuels can also be divided into two categories based on composition and water solubility. The categories are "hydrocarbon fuels" and "polar solvents." Hydrocarbon fuels as the name implies are those fuels consisting mostly of carbon and hydrogen, i.e., gasoline, methane gas, kerosene, toluene, liquefied petroleum gas (LPG), etc. The polar solvent fuels have in addition to carbon and hydrogen either oxygen or nitrogen and all have some solubility in water. Polar solvents can be divided into the following categories:

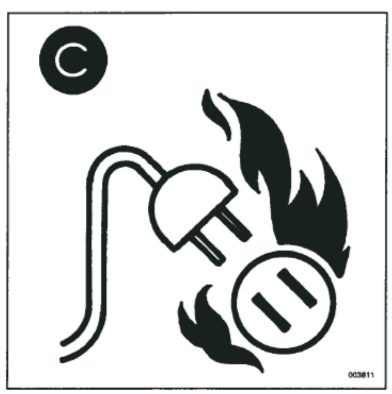
- Alcohols - fuels such as methanol, ethanol, isopropyl alcohol (IPA), and tertiary butyl alcohol (TBA).
- Ketones - fuels such as acetone, methyl ethyl ketone, methyl isobutyl ketone (MIBK).
- Ethers - fuels such as diethyl ether and diisopropyl ether.
- Acids - fuels such as acetic acid and formic acid.
- Aldehydes - fuels such as acide aldehyde, formaldehyde, and butyraldehyde.

The distinction between hydrocarbon fuels and polar solvents is most important when dealing with foam extinguishing agents because aqueous foam solutions derived from proportioning or premixing foam concentrates with water and mechanically mixing with air can be dissolved by the polar solvents. These types of fuels which act in this way are referred to as “foam destructive”. It is necessary to use an alcohol resistant concentrate (ARC) when attempting to extinguish such fuels. A general rule of thumb is that if the fuel has more than 12-15% water solubility, special alcohol resistant concentrates (ARCs) are required to be used on this type of fuel substrate.

Class "C" Fires

Class "C” fires occur in energized electrical equipment where non-conducting extinguishing agents must be used. Dry chemical, carbon dioxide, and vaporizing liquids are suitable. Because foam, water (except as a spray), and water-type extinguishing agents conduct electricity, they should not be used on Class "C" fires except by specially trained personnel. Their use can result in injury or death of the person operating the extinguisher, and cause severe damage to electrical equipment. It should be noted that the Class "C” designation refers to the source of ignition and not to the fuel, as is the case with the other three classes of fires. There is no Class "C" only fires, when examined in terms of the fuel, they include Class "A," Class "B" or Class "D."

Note: An attempt should be made to de-energize equipment before fighting fire.



Class "D" Fires

Class "D" fires occur in combustible metals such as magnesium, titanium, zirconium, sodium, lithium, and aluminum. Specialized techniques, extinguishing agents, and extinguishing equipment have been developed to control and extinguish fires of this type. Normal extinguishing agents should not be used on metal fires as there is a danger in most cases of increasing the intensity of a fire because of a chemical reaction between the extinguishing agents and burning metal. This is particularly true of water and foam, both of which can react explosively with reactive metals due to the formation of hydrogen because of a chemical reaction between water and fuel. In certain extreme cases, and then only with personnel trained and properly equipped, should water be used on reactive metals. This is also true of the halons, carbon dioxide, and dry chemical extinguishing agents which should be used on metal fires. It is worthwhile to note that the approval agencies only recognize sodium, potassium, an alloy of sodium and potassium (NaK), and magnesium as combustible metals. In actuality, there are a number of other combustible metals that have been identified such as titanium, zirconium, lithium, and aluminum on which certain Class "D" metal extinguishing powders can be used. The recommendation of the manufacturer of the powder with regard to its applicability and effectiveness on any of the metals not listed by approval agencies should be used as the basis for the use of a particular agent and under what conditions of application that agent may be applied.

INTRODUCTION

As previously presented, the fire tetrahedron explains there are four basic requirements for any fire. These are:

1. Heat
2. Fuel
3. Oxidizing Agent
4. Chemical Chain Reaction

Any method for inhibiting the combustion process will involve one, or a combination, of the following:

1. Remove the heat at a faster rate than it is released.
2. Separate the fuel and oxidizing agent.
3. Dilute the fuel/oxidizing agent mixture below the flammability limit for that fuel.
4. Stop or interrupt the chemical chain reaction.

It is possible to examine the effectiveness of fire extinguishing agents by the method of extinguishment. Agents that inhibit the chemical chain reaction (Number 4 above) will exhibit superior “flame knock down”. In contrast, agents that extinguish by attaching the physical portions of combustion (Numbers 1, 2, and 3 above) will take comparatively longer to extinguish a fire.

DRY CHEMICAL FIRE EXTINGUISHING AGENTS

Dry Chemicals are compounds consisting of finely ground particles treated to resist packing and moisture absorbtion while maintaining proper flow characteristics.

The currently accepted theory explaining dry chemical's effectiveness indicates that interrupting the chemical chain reaction is the primary method of extinguishment. As a fuel burns (oxidizes), key components for the continuous chemical reaction (called free radicals) are released. The free radicals are attracted to — and combine with — the fine dry chemical particles. This process interrupts the chemical reaction and the fire is extinguished. The smaller the particle of dry chemical the more effective the agent. This is because the total surface area able to react with the free radicals is increased. More reactive elements contained in some dry chemical also augments the agent's ability to scavenge free radicals (consequently, the most effective agents combine "reactive" elements and will be ground as fine as possible).

Because dry chemicals exhibit rapid flame knock down and fire extinguishment, they are generally used in portable extinguishers which can be used quickly and effectively to bring a fire under control.

Sodium Bicarbonate Based Dry Chemical ($NaHCO_3$)

ANSUL PLUS-FIFTY® B dry chemical is class "B" and "C" rated. It differs from other dry chemicals because it still employs Magnesium Stearate as a water repellent. PLUS-FIFTY B is used primarily in systems because it flows better (through long piping and hose runs) than silicone-treated dry chemical.

ANSUL PLUS-FIFTY C Foam Compatible Dry Chemical is silicone-treated to be water repellent. It is slightly more effective than PLUS-FIFTY B. PLUS-FIFTY C is rated for class "B" and "C" situations. The agent is primarily used in hand portable, wheeled, and hoseline extinguishers.

Both PLUS-FIFTY B and C are color-coded pale blue to distinguish ANSUL's Sodium Bicarbonate-based agents from other types.

Potassium Bicarbonate Based Dry Chemical ($KHCO_3$)

In the early 1950s, Potassium-Barcarbonate-based agents were evaluated. However, even when treated with Magnesium Stearate (the only water repellent available) the agent still absorbed moisture readily. It wasn't until the silicone water repellent process was perfected that the dry chemical became viable. In 1960, the Naval Research Lab (NRL) published a paper on the viability of a silicone-treated potassium bicarbonate based agent that they called Purple K. The first Purple K listed extinguisher appeared on the market in 1961.

Potassium Bicarbonate-based Dry Chemicals are ground more finely than other agents. They contain materials that make them free-flowing and water repellent (silicone).

Purple K is approximately twice as effective as sodium bicarbonate-based dry chemicals on class "B" fires. The Purple K is also rated in class "C" situations.

Purple K is used quite extensively in military applications and in civilian areas where maximum fire suppression is desired. The agent can be found in hand portable, wheeled, and hose-line systems. It can also be used in large fixed-nozzle systems.

ANSUL Purple K Dry Chemical is rated for class "B" and "C" situations. It is color-coded pale violet for rapid identification and differentiation from other types of dry chemicals. ANSUL Purple K is among the most effective of the dry chemicals currently in use.

Monoammonium Phosphate Based Dry Chemical ($NH_4H_2PO_4$)

During the 1950s, there was increasing interest in a Multi-Purpose Dry Chemical. IN 1956 in Germany, a dry chemical based on ammonium carbonate (with questionable effectiveness on class “A” fires) was introduced. However, in 1960, ULI listed a multi-purpose agent based on Monoammonium Phosphate (MAP).

Monoammonium Phosphate based dry chemicals are generally used in area where there are mixed class “A”, “B”, and “B” hazards and only one extinguisher is desired, or where the temperatures are below freezing a good portion of the year, which may preclude the used of water-based agents.

Earlier in the chapter the method of extinguishment of dry chemical on class “B” fuels was explained. Multi-purposed dry chemicals suppress class “A” fires by a different mechanism. The difficulty of extinguishing class “A” fuels is the deep-seated ember typically produced as these fuels burn. Monoammonium Phosphate melts at approximately 300°F (149°C) and leaves a sticky residue on heated surfaces (embers). This residual layer coats the ember and suppresses the oxygen to extinguish the fire.

Monoammonium Phosphate-based agents are silicone treated for water repellency and contain flow enhancing additives to improve discharge characteristics.

All Monoammonium Phosphate-based dry chemicals are color-coded yellow, regardless of the manufacturer. Because this agent is the only multi-purpose dry chemical, it is vitally important the agent is used in the proper extinguisher. A second concern is mixing of dry chemicals. Monoammonium Phosphate is slightly acidic, while the bicarbonate agents are mildly alkaline. When the agents are combined a chemical reaction takes place which releases CO2 gas and produces water. As was shown, water and dry chemical cake which could cause failure of the extinguisher.

Prompt cleanup is recommended with Monoammonium Phosphate-based dry chemicals. In post-fire situations, moisture may combine with the agent to produce mild corrosion.

ANSUL FORAY Multi-Purpose Dry Chemical is rated for class “A”, “B”, and “C” situations. On class “B” fires, FORAY is approximately 1 ½ times as effective as sodium bicarbonate-based agents. Foray is also color-coded yellow to distinguish it as a multi-purpose agent and differentiate it from other dry chemicals.

Applications

Dry chemical fire extinguishing agents are most generally used where significant fire extinguishment capability is required from a relatively small quantity of material. This is the reason that dry chemical fire extinguishing agents are mostly used in portable and wheeled extinguishers having capacities of up to 350 lb (158.8 kg). There are also special applications involving stationary equipment up to a 3000 lb (1360.8 kg) capacity.

GASEOUS EXTINGUISHING AGENTS

Inerting

The primary mechanism of extinguishment associated with gaseous extinguishing agents of the inerting type is to alter the vapor phase concentration of the fuel oxidizing agent mixture so that it is either below the lower flammability limit or above the upper flammability limit. Carbon dioxide is only one commonly used extinguishing agent of this type. Carbon dioxide can be used in both a local application mode or a total flooding mode. The former refers to the application of the extinguishing agent to the fuel area from a set of fixed nozzles. The latter refers to the application of the agent to develop a volumetric concentration where a 3-dimensional enclosure exists around the hazard. It is important to note that because of the asphyxiating properties of carbon dioxide, it can only be used in a total flooding mode where people are not normally present. Proper safeguards must be taken in local application to prevent people from being exposed to concentrations of carbon dioxide in excess of 9% for more than 10 minutes.

DRY POWDERS

Dry powders are those formulations developed specifically for use on Class "D" combustibles. Class "D" combustibles represent reactive and combustible metals such as sodium, potassium, magnesium and aluminum, which represent the lower melting point metals; and titanium, zirconium and zinc which represent the higher melting point metals.

Underwriters Laboratories in ANSI/UL 711 recognizes only sodium, potassium, sodium potassium alloy and magnesium as test fuels for combustible metal rating purposes. Of these, only magnesium is recognized in more than one form. Magnesium is recognized in the form of powder or dust; chips, either dry or wet with mineral oil; and also in the form of castings, dry only. The first dry chemical powder that was developed to satisfy the Underwriters Laboratories requirements was MET-L-X® agent. MET-L-X agent is a composition based upon common salt (sodium chloride) with the addition of a thermo-setting resin. The thermo-setting resin aids the salt in bridging the surface of these metals which tend to become liquid or molten (depending on the metal) at relatively low temperatures. The mechanism of extinguishment, therefore, is primarily the separation of the fuel from the source of oxygen with a secondary mechanism associated with cooling of the fuel. MET-L-X agent is not only effective on these metals, but also has been demonstrated to be effective on aluminum and aluminum alloy in the various forms that they are found in industry. MET-L-X agent is not, however, effective on metals which have melting points in excess of 1832 °F (1000 °C). The principle reason for this is that like common salt, MET-L-X agent melts at about 1562 °F (850 °C).

Because MET-L-X agent consists principally of common salt, it has a high chloride content and its use around certain types of stainless steel is undesirable due to a phenomenon known as chloride stress corrosion. This is a type of corrosion which is not accompanied by visible tarnishing or pitting, but simply a structural failure of the stainless steel metal component.

LITH-X® agent is a product that consists primarily of graphite for use on high melting point metals such as zinc, titanium, zirconium, etc. It is also effective on lithium, not because of the high melting point of lithium, but because of the very low density of lithium compared to the other liquid metals such as sodium and potassium. MET-L-X agent or NA-X® agent are not capable of extinguishing a lithium fire because they dissolve in the molten lithium. LITH-X agent, on the other hand, because of the low density graphite, is an effective agent on lithium fires in addition to being effective on the other metals mentioned.

MET-L-X and NA-X agents are listed by Underwriters Laboratories for application either with a scoop or from a portable or wheeled extinguisher up to 350 lb (159 kg) capacity. Since Underwriters Laboratories does not recognize lithium or some of the high melting point metals, LITH-X agent is not a listed product, but can be applied in the same manner as MET-L-X and NA-X agent.

One other special metal powder formulation, MET-L-KYL® agent, was developed specifically for phyrophoric fuels of the metal alkyl variety. It is based on a combination of sodium bicarbonate and silica gel. Metal alkyls are organometal compounds such as triethylaluminum and diethyaluminum that are pyrophoric in nature (will spontaneously ignite when exposed to air). Since metal alkyls are used extensively in the chemical industry as intermediates, a need for an extinguishing agent to handle small spills and subsequent fires associated with metal alkyls was recognized. No Underwriters Laboratories listing is available for this category of fuel; however, MET-L-KYL agent is available for use in hand portable and wheeled equipment up to 350 lb (159 kg) capacity.

WATER

Water is certainly the oldest and the most common fire extinguishing agent. The reasons for this are cost, availability, ability to be projected, and effectiveness on Class "A" combustibles which, until the 20th century, were the most common types of combustibles encountered.

The primary mechanism of extinguishment by water is its ability to cool the fuel/oxidizing agent mixture below the ignition temperature of the fuel. Water has outstanding thermodynamic properties in that converting 1 lb (0.5 kg) of water as a liquid at 32°F (0°C) to steam at 212°F (100°C) absorbs 1150 BTUs of thermal energy. In the process, the volume of water present as a liquid is expanded by a factor of 1700 times in converting it to steam. This represents the secondary mechanism of extinguishment associated with water which is to alter the vapor phase concentration of the fuel/oxidizing agent mixture so that it is either below the lower flammability limit or above the upper flammability limit.

The amount of water required for extinguishment will depend on the amount of heat that must be absorbed and, therefore, the quantity of fuel that has to be extinguished. The speed of extinguishment will depend on the rate of application of the water to the burning fuel-air mixture. The speed of extinguishment also will be affected by the degree of coverage possible in the manner in which water is applied. If water is dispersed mechanically or chemically in small droplets, the heat transfer process is much more efficient, but this must be balanced against the need to project water where it is needed in suitable volumes. Water can be effective on flammable liquids whose flash points are above 150°F (66°C) when applied as a spray. Because most natural water contains dissolved salts, it must be used with extreme caution around energized electrical equipment since the water is electrically conductive.

There are also other drawbacks to the use of water as an extinguishing media. One of the obvious drawbacks is a relatively high freezing point of 32°F (0°C). When water is applied to a fuel such as gasoline, the water will tend, because of its higher density, to sink below the fuel surface allowing the fuel to be spread over greater areas. When water is applied to class “A” combustibles such as wood, there is a high degree of “run off” because the water does not wet the wood particularly well. This drawback results in a very marked decrease in effectiveness of water on these fuels when compared to some of the other extinguishing agents.

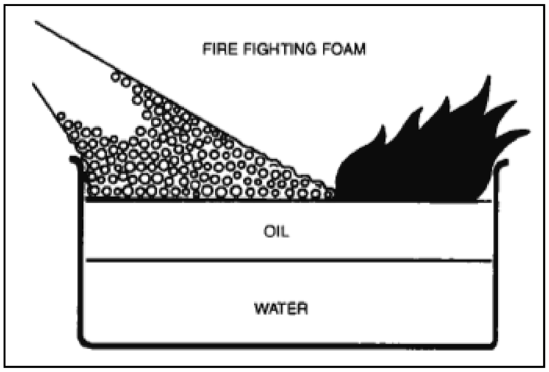
There are ways to overcome some of these drawbacks, but they generally result in undesirable side effects. For example, calcium chloride can be added as a freezing point depressant, but it will increase the conductivity of water requiring even more caution around energized electrical equipment. When dissolved, calcium chloride can cause corrosion problems and can also result in sedimentation if the temperature is lowered to the point where the calcium chloride becomes insoluble.

In summary, water is the most commonly used fire extinguishing agent because of its availability, cost, and ability to be projected with simple mechanical equipment. Water, where it can be applied, has outstanding thermodynamic properties which result in cooling of the fuel below its ignition temperature or alteration of the fuel-oxidizing agent mixture so that it is either below the lower flammability limit or above the upper flammability limit. There are some disadvantages to the use of water which must be understood before this agent is applied.

FOAM EXTINGUISHING AGENTS

Foam extinguishing agents can be divided into three categories: chemical foams, mechanical foams and wetting agents. The latter category is somewhat of a misnomer in that wetting agents generally do not result in the generation of foam.

Foam is the result of adding certain materials to water which improve its ability to wet certain fuel surfaces. By definition, it is a stable mass of small bubbles (lighter than oil or water) separated by films of solution. Generated foams result from the presence of chemicals known as surfactants in the watery films that make up the bubbles. These surfactants are common to all foam extinguishing agents and wetting agents.



Chemical Foams

Chemical foams are produced by a chemical reaction between substances such as sodium bicarbonate and aluminum sulfate. In this chemical reaction, carbon dioxide is released and is the blowing agent which results in the formation of a mass of foam bubbles. Chemical foams are mostly obsolete in North America.

Mechanical Foams

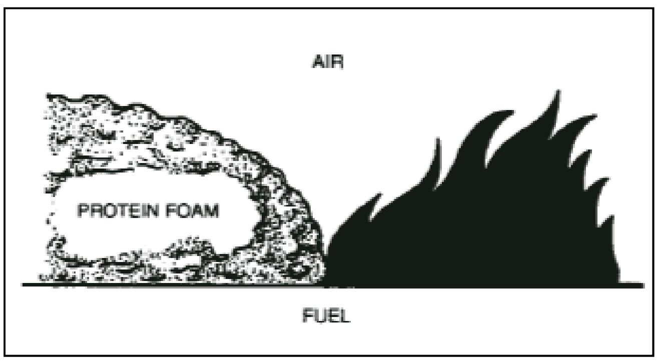
Mechanical foams are produced by mechanically mixing air with a proportioned foam solution. The solution is a mixture of water and foam concentrate at an appropriate dilution, the two most common dilutions being 6% and 3%, (i.e., 6 parts foam concentrate to 94 parts water or 3 parts foam concentrate to 97 parts water). All mechanical foam concentrates consist of mixtures of chemical surfactants (surface active) that alter the surface activity of the water with which they are mixed.

Foam agents are most often employed in fighting fires involving Class "B" flammable and combustible liquids. The primary mechanism of extinguishment with mechanical foam agents is to place a barrier, or effective separation, between the fuel and the oxidizing agent (usually air). A secondary mechanism of extinguishment is associated with the boiling off of water to produce a cooling effect. All of the foam extinguishing agents can be used on Class "A" combustibles. The most commonly used foams for Class "A" combustibles are based on synthetic type concentrates using hydrocarbon surfactants (detergents). Medium and low expansion foams should be considered electrical conductors in their expanded forms.

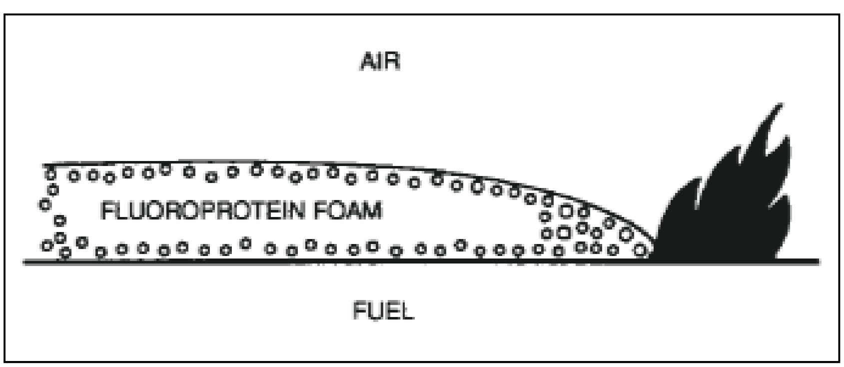
Current mechanical foam concentrates are as follows:

1. Protein Foam
2. Fluoroprotein Foam
3. Aqueous Film-Forming Foam (AFFF)
4. Alcohol Type Foam
5. Synthetic Foam

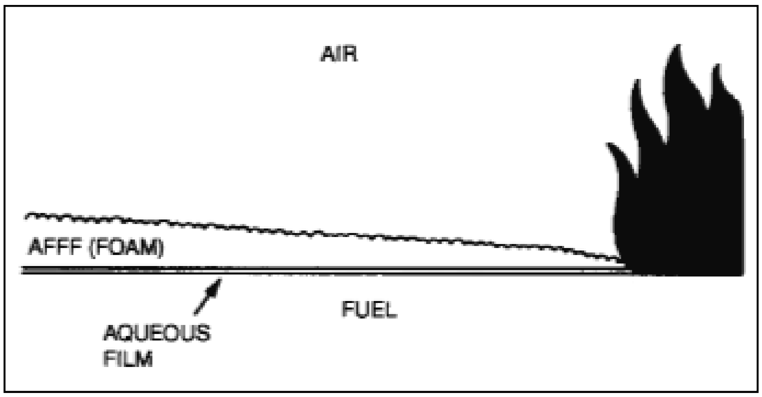
Protein Foam is derived from naturally occurring chemicals found in the hoofs and horns of animals. This particular protein is chemically treated or hydrolyzed and certain chemicals are added to the hydrolized protein to protect it from freezing, from being decomposed by natural microorganisms, and to make it less corrosive. Protein foams result in a thick mass of foam bubbles that have excellent burnback resistance, but are not particularly mobile on a fuel surface. Protein foams also have a tendency to pick up the fuel to which it is being applied.



Fluoroprotein Foam was successfully developed to overcome two of the drawbacks of protein foams: the first being the ease with which the foam blanket spreads across a fuel surface; and the second being a reduction in the amount of fuel picked up by the foam blanket. Fluoroprotein foam differs from protein foam in that a fluorocarbon surfactant is added at relatively low concentrations to provide better extinguishment speed and burnback resistance. Fluoroprotein foams are commonly used in both top-side and subsurface application for the protection of flammable and combustible liquid storage tanks.



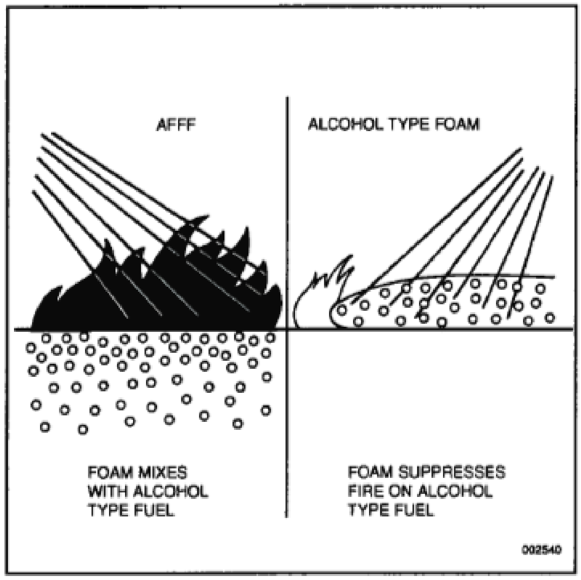
Aqueous Film Forming Foam (AFFF) was developed at the U.S. Naval Research Laboratory primarily to provide very rapid fire extinguishment, or knockdown capabilities, for use in aircraft crash rescue fire fighting efforts aboard ship and on land. It consists of fluorocarbon and hydrocarbon surfactants that can be used in both aspirating and non-aspirating mechanical foam hardware. Aspirating nozzles are specifically designed to entrain air in certain proportions into the diluted foam-water solution to produce a fully aspirated foam extinguishing agent. Non-aspirating type foam hardware is designed primarily for the application of water in either spray or straight-stream patterns.



Alcohol-Resistant Concentrates (ARC) have been specially formulated for extinguishment of fires involving water-soluble fuels.

All of the foam agents discussed up to this point are effective on non-water soluble fuels such as gasoline, diesel fuel, crude oil, kerosene, toluene, etc. If any of these foam agents is used on a water soluble fuel, such as methyl alcohol or acetone, the foam will simply dissolve because of the high solubility of the fuel in water. In order to overcome this problem, the first protein foam concentrates were modified by the addition of metal soaps to make them effective on these types of fuels. This practice, however, is mostly obsolete.

Most of the currently used alcohol-resistant concentrates (ARC) are based on formulating AFFF in such a way as to allow it to be used on a water soluble fuel. This is accomplished by adding a chemical which forms an insoluble membrane (similar to an egg white) between the fuel and the foam blanket. In this way, alcohol-resistant concentrates, based on AFFF, have been successfully formulated and are now widely used.



Synthetic Foam Concentrates consist of mixtures of only hydrocarbon surfactants. They are divided into three categories based on expansion ratio. (It should be noted that protein, fluoroprotein and AFFF foams are in a category defined as low expansion foams, that is, those having expansion ratios of 20:1 or less.) Synthetic foams may be used as low expansion foams, although this is not a common practice. A more common practice is to use them as medium expansion foams having expansion ratios about 20:1 but less than 200:1, or as high expansion foams with ratios greater than 200:1. High expansion foam has been used to totally flood a 3-dimensional volume such as a room or mine shaft. High expansion foam has also been used to act as a vapor dispersion agent on cryogenic fuels such as LNG. Special equipment is required to generate both medium expansion and high expansion foams.

WETTING AGENTS

Wetting agents are purely hydrocarbon surfactant mixtures that are proportioned at extremely low concentrations (i.e., 1-2%) to improve the wetability of the water being applied. Wetting agents are used primarily where a high degree of penetration of water is required for a 3-dimensional burning mass such as a coal pile or a forest fire. The use of these agents as expanded foams used in forest fire fighting applications is just beginning to evolve in the United States.

Time is critical in any first-aid fire situation, especially when you're dealing with highly volatile fuels. Two or three seconds saved in an actual fire situation can mean the difference between a small or large fire, extinguishment or disaster. That's why you can't afford to waste time figuring out how to operate available equipment or wondering whether it contains the proper agent necessary to safely extinguish the fire.

In this section of your ANSUL Fire Training Manual, we'll examine and explain the operation of the most common types of first-aid fire extinguishing equipment. Step by step sequential drawings should provide you with a useful guide to the actuation and operation of this equipment.

EXTINGUISHER TYPES

Dry chemical hand portable fire extinguishers are available with extinguishing contents ranging from 1 to 30 lb (0.45 to 14 kg). "Hand portable" may be defined as a unit which does not exceed 55 lb (25 kg) in total charged weight. This in turn dictates the maximum weight of extinguishing contents which may be tolerated in order to remain in the hand portable category. Wheeled units with 350 lb capacity may also be considered hand portable.

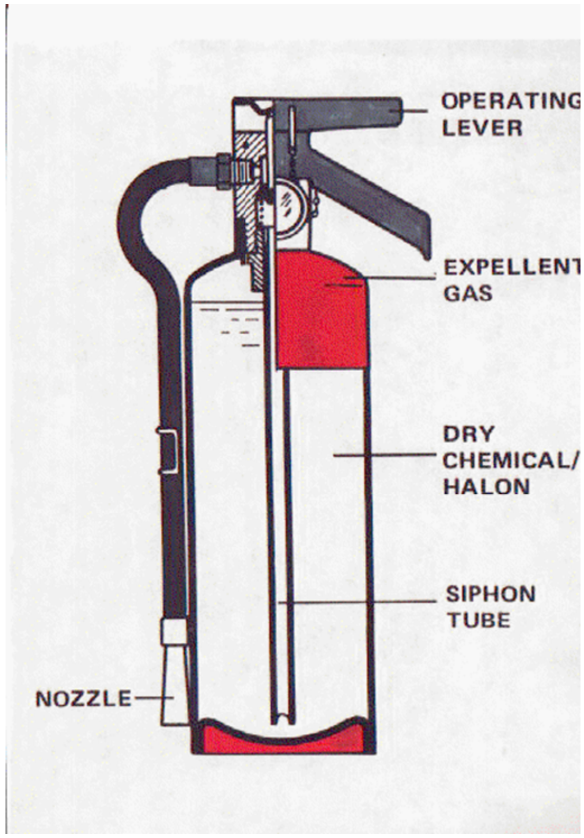
The fire equipment manufacturers refer to three basic types of hand portable fire extinguishers:

1. Stored Pressure
2. Cartridge Operated
3. Sealed Pressure

The difference lies mainly in the sealing method and the means by which the container is pressurized.

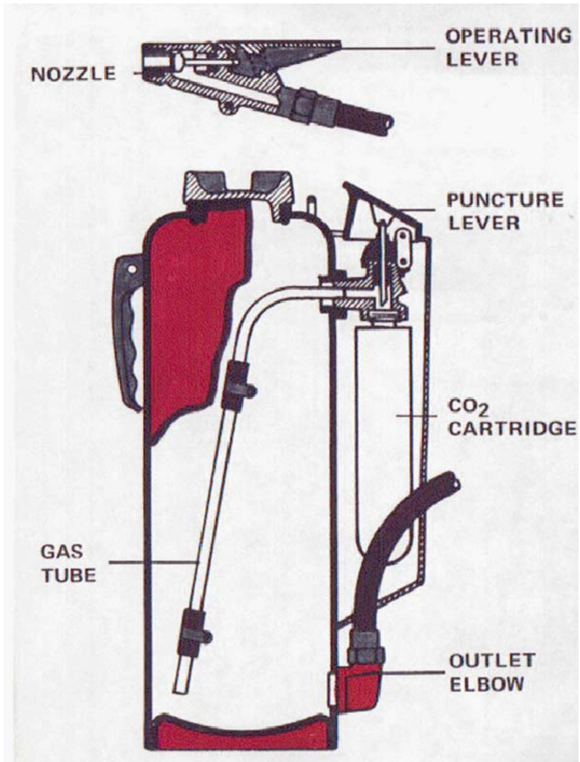
Stored Pressure

In stored pressure models the expellent gas and extinguishing agent are stored in a single chamber and discharge is directly controlled by the valve. These units have the advantage of being easily inspected since most are equipped with a pressure gauge indicating that the unit is ready for use. Once used, however, this unit requires special recharging equipment and is normally returned to the distributor for recharge. These units are generally found in areas where high use factors are not encountered, such as schools, retail outlets, offices, light industry, etc.



Cartridge Operated

With cartridge operated fire extinguishers, the expellent gas is stored in a separate cartridge located within or adjacent to the shell containing the extinguishing agent. The extinguishers are actuated by releasing the expellent gas which in turn expels the extinguishing agent. The discharge is then controlled by a valve which is generally located at the end of a discharge hose. Since these units are not under expellent gas pressure until actuated, a pressure gauge is of little use and inspection must be accomplished by weighing the gas cartridge and checking the condition of the dry chemical agent. Once used, however, recharge is accomplished by simply refilling the container with extinguishing agent and replacing the gas cartridge. Return cartridge to the distributor. These units are normally found in heavy industry where frequent use is common.



Sealed Pressure

Sealed pressure fire extinguishers are much the same as stored pressure units and are often referred to as disposable non-refillable types. The expellent gas and extinguishing agent are both stored in a single chamber, but differ from stored pressure units in that sealing is accomplished by means of a frangible metal disc as opposed to a valve. In this manner, recharge is accomplished by simply removing the pressure vessel after expending its contents and assembling the valve to a fresh container. The expended shell is then discarded, hence the term "disposable non-refillable" type. Economics become an important factor in the larger capacity units; consequently, few sealed pressure extinguishers are available in capacities exceeding 5 lb (2.7 kg). These units are designed for "personal" use. Some of the more common areas in which these extinguishers are utilized are home, boats, trailers, garages, etc.

The following information is used for ratings only; refer to Application Techniques for fire fighting.

To determine the relative extinguishing effectiveness of hand portable fire extinguishers, a system has been devised which incorporates an alpha-numeric designation based on extinguishing pre-planned fires of determined size. The end-user needs only to consult the rating located on the Underwriters Laboratories manifest on the extinguisher label in order to determine the extinguishing capability of the unit. The end-user, however, must understand the system utilized to establish a rating in order to attach any significance to the alpha-numeric designation. For example, a rating of 4-A:40-B:C indicates that a non-expert operator can expect to extinguish a class A fire 14 ft x 14 ft (4.3 m x 4.3 m); a class B fire 40 ft^2 (3.7 m^2) in area; and can also use the extinguisher to extinguish energized electrical equipment, class C.

Class A Ratings

The number designating an Underwriters Laboratories Class A rating reflects the relative quantity of water, soda acid or foam which can extinguish that size fire. One and one-fourth gallons (4.7 L) are required for the 1A fires, 2 1/2 gal (9.5 L) for the 2A fire, etc. Therefore, a dry chemical hand portable fire extinguisher with a 6A rating is equivalent to three 2 1/2 gal (9.5 L) water extinguishers. Application and operator technique is not as important in Class A fires as with Class B. Consequently, even though these fires are conducted with an expert operator, there is no correlation between what size fire the expert operator extinguishes and what size fire the non-expert operator should extinguish.

There are three types of Class A fires which must be extinguished for a 1A through 6A rating — namely a wood panel, a wood crib, and an excelsior fire. Classifications 10A and higher are rated on the basis of an appropriate wood crib test fire only. The size of each fire increases as the rating increases. Because of the greater area which must be covered for extinguishment, the panel is the most difficult to extinguish of the three. Tables I, II, and III are schematics of the three types and information on the actual dimensions which show the relationship between rating and size is included.

The panel consists of 3/4 in. (1.9 cm) fir strips laid over spruce or fir solid backing. Strips of 3/4 in. (1.9 cm) fir are first laid vertically approximately 2 ft (0.61 m) apart on this backing. Horizontal strips of 3/4 in. (1.9 cm) fir spaced 3/4 in. (1.9 cm) apart are then laid over this. A second layer of vertical and horizontal strips is then applied and the panel is then positioned upright.

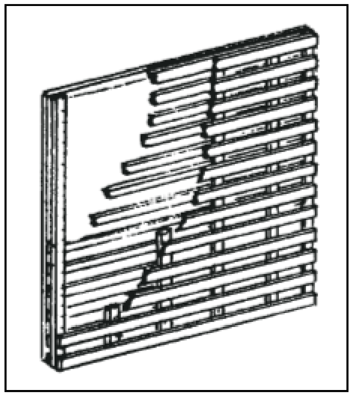


Table I
Types of Class A Fires (Panel)

Classification and Rating	Test Panel Size (ft)	Gallons Fuel Oil Applied	Total Pounds Excelsior For Windrows
1A	8 x 8	1	10
2A	10 x 10	2	20
3A	12 x 12	3	30
4A	14 x 14	4	40
6A	17 x 17	6	60

The entire panel is sprayed with fuel oil and the fire is started by igniting a N-Heptane fuse laid along a windrow of excelsior at the base of the panel. Further kindling of the panel is accomplished by pushing a windrow of excelsior up to the base of the panel at predetermined intervals. The panel is attacked when there is break-away of the horizontal fir strips across the entire face of the panel or near the bottom. The average preburn period is five minutes. Intermittent discharge is not allowed. After opening the nozzle, the unit must be exhausted before closing the nozzle.

The crib is made up of alternate layers of nominal 2 ft x 2 ft (0.6 x 0.6 m) spruce or fir placed at right angles to one another. The crib is supported 16 in. (41 cm) from the floor through use of cement blocks and angle irons. The fire is started by igniting stove and lamp naphtha in a pan immediately below the crib. Preburn time is 9 - 10 minutes, up to and including a 4A crib, 7 - 8 minutes for larger cribs. Agent can only be applied on the three crib sides, top and bottom of the crib. Application cannot be made at the side of the crib facing the wall. Again, the unit must be exhausted before closing the nozzle.

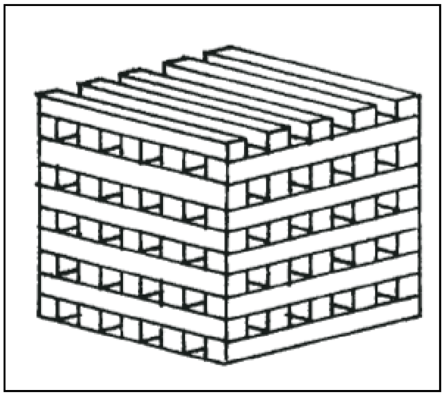


Table II
Types of Class A Fires (Crib)

Classification and Rating	Number of Members	Nominal Size and Length of Members (in.)	Arrangement of Wood Members
1A	50	2 x 2 x 20	10 layers of 5
2A	70	2 x 2 x 25 5/8	13 layers of 6
3A	98	2 x 2 x 303/4	14 layers of 7
4A	120	2 x 2 x 33 3/8	15 layers of 8
6A	153	2 x 2 x 38 3/8	17 layers of 9
10A	209	2x 2 x 471/2	19 layers of 11
20A	160	2 x 4 x 62 1/4	10 layers of 15 on edge 1 top layer of 10 flat
30A	192	2 x 4 x 74 5/8	10 layers of 18 on edge 1 top layer of 12 flat
40A	224	2 x4 x 871/8	10 layers of 21 on edge 1 top layer of 14 flat

The excelsior fire consists of a bed of seasoned basswood, poplar, or aspen laid out on the floor in accordance with a certain area. A fuse of stove and lamp naphtha is laid along the long edge of the rectangular bed. Ignition is made at the center of the fuse. When the flames reach the centerline of the bed, attack is made. Again the unit must be exhausted before closing the nozzle.

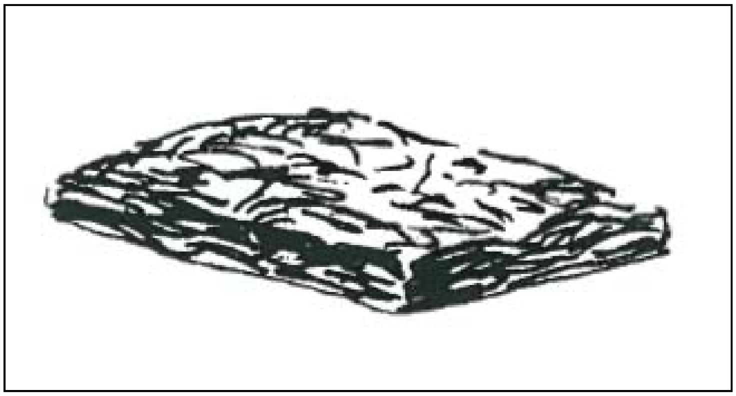


Table Ill
Types of Class A Fires (Excelsior)

Classification and Rating	Weight of Excelsior (lb)	Test Area (ft and in.)
1A	6	2 ft 10 in. x 5 ft 8 in.
2A	12	4 ft 0 in. x 8 ft 0 in.
3A	18	4 ft 11 in. x 9 ft 9 ½ in.
4A	24	6 ft 0 in. x 10 ft 8 in.
6A	36	6 ft 11 in. x 13 ft 11 in.

Class B Ratings
Class B fires are conducted with a square pan which contains 2 in. (5.1 cm) of heptane over enough water to permit a 6 in. (15.2 cm) freeboard. A 1-minute preburn period is allowed before attack is made. Table IV shows the relationship between classification, minimum effective duration of the unit, pan size, that must be extinguished by an expert operator, and quantity of heptane in the pan. The effective duration is the time required for the extinguisher to come to the "gas point." At this point in the discharge of the unit the concentration of dry chemical particles in the stream decreases rapidly and the ratio of gas to dry chemical is high. The number designating the rating represents the square feet of fire area that the non-expert operator can expect to extinguish. It is always 40 percent of the fire area that the expert operator at Underwriters Laboratories must extinguish consistently. For example, a 40-B:C rating requires extinguishment of 100 ft^2 (9.3 m2) pan by the expert operator. The non-expert can then expect to extinguish a 40 ft^2 (3.7 m^2) fire.

As the fire areas become larger and the ratings increase, the effective duration of the unit must also increase. This is necessary in order to provide the non-expert operator with the safety margin required to make adjustments in technique and to correct for errors. If this were not the case, his lack of experience in handling high velocity extinguishers would greatly reduce his chances for extinguishing the fire consequently, a unit with a 20-B:C rating requires an 8-second minimum effective discharge time, whereas a unit with an 80-B:C rating requires 20 seconds.

Table IV
Underwriters Laboratories Class B Rating System

Classification and Rating	Minimum Effective Discharge Time (Seconds)	Pan Size ft2 (Inside)	Approximate Gallons of Heptane Used
INDOOR FIRES			
1-B	8	2 1/2	3 1/4
2-B	8	5	6 1/4
5-B	8	12 1/2	15 1/2
10-B	8	25	31
20-B	8	50	65
OUTDOOR FIRES			
30-B	11	75	95
40-B	13	100	125
60-B	17	150	190
80-B	20	200	250
120-B	26	300	375
160-B	31	400	500
240-B	40	600	750
320-B	48	800	1000
480-B	63	1200	1500
640-B	75	1600	2000

Class C Ratings
To obtain a Class C rating, the extinguishing agent need only be a non-conductor of electricity. The Class C rating is then provided in conjunction with a rating previously established under the requirements for Class A and/or Class B fires. There are no fires conducted specifically for Class C ratings. The agent itself, however, is subjected to dielectric withstand tests conducted in accordance with ASTM Specification D 877-67 (ANSI C59. 19-1968). The Class C rating is applied in conjunction with the Class A and/or Class B components of the electrical hazard being protected, however, there is no numerical rating specifically applied to Class C ratings.

There is no single fire training program which can effectively satisfy the needs of industry in general. Each industry has particular fire risks and hazards associated with its operation which require special consideration. Nevertheless, there are several basic categories of fires which, for training purposes, effectively simulate the vast majority of fire situations encountered in industry. A basic understanding of these categories of fires is essential before beginning any training program.

In this section of you ANSUL Fire Training Manual, you'll find an outline of the simulated hazards you'll be facing on the training field. Trainees who develop proficiency in controlling these fires with the extinguishers and agents indicated, will be prepared to cope with a large percentage of the fires most commonly encountered in industrial environments.

Flammable Liquid Spill Fires

The uncontained flammable liquid spill fire is a common industrial situation for which dry chemical or twin-agent equipment is particularly well-suited. Carbon dioxide extinguishers, although not as effective, can also be used. If proper extinguishing equipment is used, this fire can be readily extinguished by one person.

The introduction of any obstacle into a flammable liquid spill fire creates an application problem. To extinguish this fire with dry chemical alone requires the addition of a second application point (operator). The single operator trying to extinguish this fire with dry chemical cannot reach behind the obstacles. The fire continues to burn behind the obstacles and when agent discharge is discontinued the entire spill reflashes. Two people, each working with an extinguisher can readily put out the fire.

A single operator can extinguish this fire using a securing agent such as AFFF, or AFFF in conjunction with the dry chemical application. This is the twin-agent concept.

Typical Liquid Spill Fires

Flammable Liquids under:
Vehicles Compressors
Turbines
Metalworking machines
Storage drums
Transformers

Accidental Spillage around:
Filling stations
Bulk storage areas Batch processing areas
Warehouses
Paint mixing areas

Equipment Used

Cartridge operated dry chemical hand portables Stored pressure dry chemical hand portables Dry chemical wheeled extinguishers
Large dry chemical hand hoseline systems
1 1/2 in. (3.8 cm) water hoseline, fog nozzles
AFFF/Foam handlines

Flammable Liquids in Depth

The flammable liquid in depth fire is another common industrial hazard. Although it is nothing more than a contained spill, tests have shown it to be far more difficult to extinguish than an uncontained spill. For practical purposes, operator efficiency is cut in half. The steel- sided pan interferes with the application of extinguishing agent, and the operator must be careful not to splash the flammable liquid over the sides of the pan.

Extinguishment can best be accomplished by using dry chemical or foam. Water fog and CO2 can also be used on small pan fires.

Correct application technique becomes more critical in fighting this fire.

The introduction of an obstacle creates an applications problem. Dry chemical in the hands of one operator is ineffective in extinguishing this fire. The fire on all sides of the obstacle can be extinguished only by a combined attack utilizing at least two operators. Water fog can aid the operator by providing a heat shield. Team work is an essential element in this application.

An alternate approach to this problem is the use of foam or the twin-agent concept. This alternate permits extinguishment by a single operator.

Typical Flammable Liquids in Depth
Dip tanks
Drainboards
Solvent cleaning tanks
Drip pans
Flow coaters
Quench tanks
Flammable liquid tank dikes

Equipment Used

Cartridge operated dry chemical hand portables
Stored pressure dry chemical hand portables
CO_2 hand portable
Dry chemical wheeled extinguishers
Large dry chemical hand hoseline systems
Twin-agent hand hoseline systems
1 1/2 in. (3.8 cm) water hoseline, fog nozzles
AFFF/Foam handlines

Three Dimensional Fires

The three dimensional, gravity flow fire represents a more complicated applications problem. The drawing indicates that there are actually two fires to contend with. First, the flammable liquid flowing from the tank. Second, a spill fire with the tank acting as an obstacle. Correct application technique is critical in this fire situation. The spill fire must be extinguished before the gravity flow portion of the fire is attempted.

The tank supports act as an obstacle and two point application is necessary for extinguishment when dry chemical is used alone.

Water fog may be used in conjunction with dry chemical to provide a heat shield for the operators and to cool the hazard.

A single operator can extinguish this fire using the twin-agent concept provided the gravity flow portion of the fire is completely accessible to the dry chemical stream.

Typical Three Dimensional Fires
Paint lockers
Ruptured barrels or tanks
Overflows in filling operations
Piping breaks or broken valves with fuel running down any object

Equipment Used
Cartridge operated dry chemical hand portables
Dry chemical wheeled extinguishers
Twin-Agent Units

Pressure Fires
Like the gravity flow fire, a flammable liquid fire under pressure will normally produce a spill fire, either "contained" or "in depth." Unlike the three dimensional fire, the escaping fuel must first be extinguished at the pressure source before the resulting spill is extinguished. Dry chemical used alone or in combination with AFFF is the best agent for extinguishing a pressure fire involving a flammable liquid. Water fog can provide increased exposure protection to operators applying dry chemical.

Typical Flammable Liquids Under Pressure
Seal or packing failures in pumps, compressors or turbines
Flange failures on piping systems
Gasket failure on pump parting surfaces
Valve stem packing failure

Equipment Used
Cartridge operated dry chemical hand portables
Dry chemical wheeled extinguishers
Large dry chemical hand hoseline systems
1 1/2 in. (3.8 cm) water hoselines, water fog

Flammable gas pressure fires represent another hazard commonly found in industry. A non-impinging gas fire is simply a burning stream of gas escaping to the atmosphere under pressure. This type of fire can be extinguished using dry chemical agents and an extinguisher that is capable of discharging at the required flow rate for effective extinguishment. The presence of an object in the path of the escaping gas results in an impinging fire. This fire is much more difficult to extinguish because the impinging object becomes heated and provides a continuing source of ignition.

Extinguishment should not be attempted unless fuel flow can be shut off. Otherwise, escaping fuel could possibly find another source of ignition and cause an explosion.

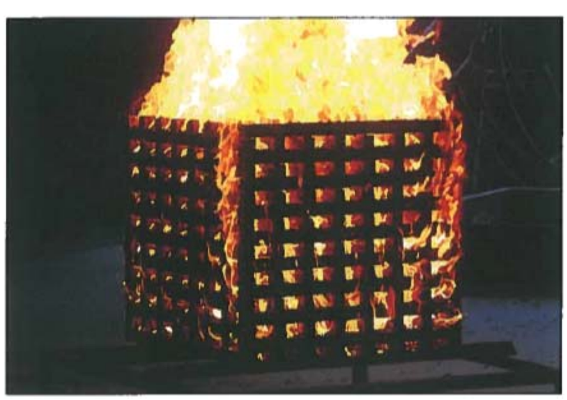
The addition of water fog provides a heat shield for the operator and aids in extinguishment by cooling the impinging object below the flash point of the fuel.

Water fog can be very valuable when it is desirable to stop the flow of fuel. Its cooling effect allows the operator to approach critical control equipment.

Typical Flammable Gas Under Pressure
Operation of safety relief valve
Failure of welded joints
Ruptured piping
Seal or packing failure on valves and compressors
Line ruptures on gas fired appliances

Equipment Used
Cartridge operated dry chemical hand portable
Dry chemical wheeled extinguishers
1 1/2 in. (3.8 cm) water hoselines, fog nozzles

Class A Fires
Class A materials are ordinary combustible materials such as wood, paper and cloth. Water and multi-purpose dry chemical are the agents used to extinguish these fires. Water can be used most effectively on deep-seated fires because of its ability to cool and penetrate Class A materials. Multi-purpose dry chemical should be used when flammable liquids or energizing electrical equipment area in the hazard area.



Typical Class A Fires

Tires
Dust collectors
Smoldering trash
Paint filters
Cardboard boxes
Wooden pallets
Laundry

Equipment Used

Hand portable water and foam extinguishers
Stored pressure ABC dry chemical hand portables
Cartridge operated ABC dry chemical hand portables
Wheeled ABC dry chemical extinguishers
1 1/2 in. (3.8 cm) water hoselines

The most important element of any fire training program is the development of proper applications technique — teaching the trainee how to apply the extinguishing agent correctly. This section will provide you with an excellent reference source once you complete your fire training course.

Flammable Liquid Spill Fire with Obstacle Using Dry Chemical

Approach the fire from the upwind side holding the nozzle at a 45° angle. Stop at a point approximately 8 to 10 ft (2.4 to 3.1 m) from the front edge of the fire area.

Direct both streams of dry chemical 6 in. (15.2 cm) ahead of the flame edge.

Advance slowly around each side of the pan. Each operator should cover two-thirds of the fire area using a side to side sweeping motion.

Extinguish the fire remaining behind the obstacle. If the obstacle itself contains burning liquid, the agent should then be directed into the container.

Flammable Liquid Fire in Depth Using Dry Chemical

Approach the fire from the upwind side holding the nozzle at a 45-60° angle. Stop at a point approximately 8 to 10 ft (2.4 to 3.1 m) from the front edge of the fire area.

Direct the dry chemical stream at the upwind corner of the fire, 6 in. (15.2 cm) ahead of the lip of the pan. Make a slow pass across the front edge of the pan, making sure to overlap each side by 6 in. (15.2 cm).

Direct the dry chemical stream using a rapid side to side sweeping motion. Each sweep of the dry chemical stream must be slightly wider than the pan.

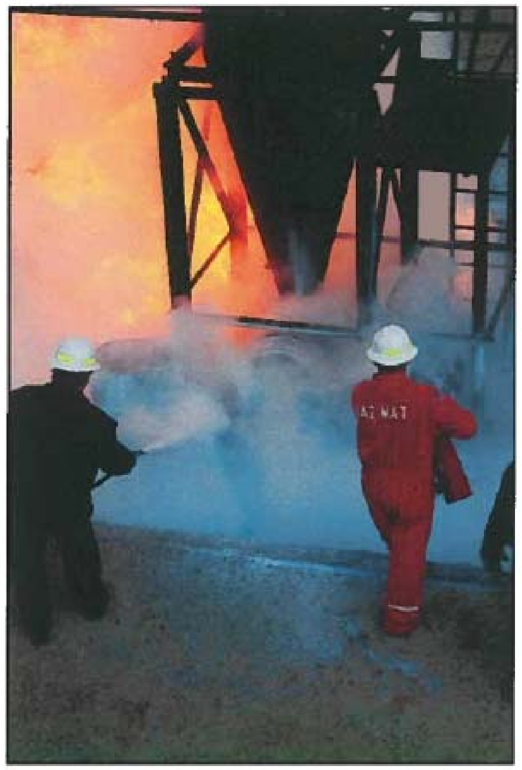
Raise the dry chemical stream slightly but continue to hold the nozzle at a 45-60° angle. This is accomplished by raising the arm. Work the flames to one corner of the pan and extinguish.

Flammable Liquid Fire in Depth with Obstacle Using Dry Chemical

Approach the fire from the upwind side holding nozzles at a 45-60° angle. Stop at a point approximately 8 to 10 ft (2.4 to 3.1 m) from the front edge of the fire area.

Direct both streams of dry chemical 6 in. (15.2 cm) ahead of the lip of the pan.

Advance slowly around each side of the fire. Shut extinguisher off once visible flame is extinguished.

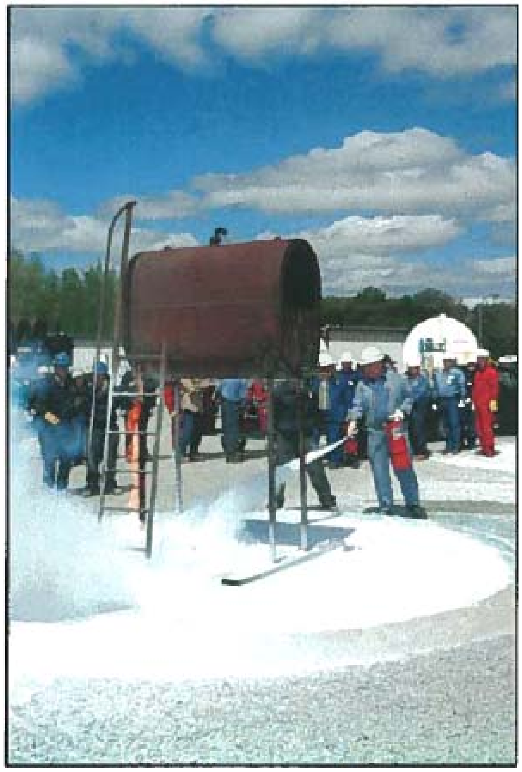


Begin overhaul, searching for hot spots. Overhaul hot spots with water or coat with ABC dry chemical.

Gravity-Fed Fire Using Dry Chemical

Approach the fire from the upwind side holding the nozzle at a 45-60° angle. Take a position at approximately 10 ft (3.1 m) from the front edge of the fire area

Extinguish flammable liquid spill fire first using a side to side sweeping motion.



Continue to raise dry chemical stream, extinguishing the fuel source last.

Three Dimensional Gravity Fed Fire Using Dry Chemical

Approach the fire holding the nozzle at a 45-60° angle. Stop at a point 8 to 10 ft (2.4 to 3.1 m) from the front edge of the spill fire area.

Make a VERY SLOW pass across the front edge of the flammable liquid spill. Be sure the spill is completely extinguished before moving on. DO NOT close extinguisher nozzle.

Raise the dry chemical stream to front lip of the dip tank. Extinguish the dip tank fire.

Direct the dry chemical stream up the tray pushing the fire towards the fuel source. Extinguish fuel source last.

Flammable Liquid Pressure Fire Using Dry Chemical

Approach the fire from the upwind side. Stop at a position approximately 15 ft (4.6 m) from the front edge of the spill fire area.

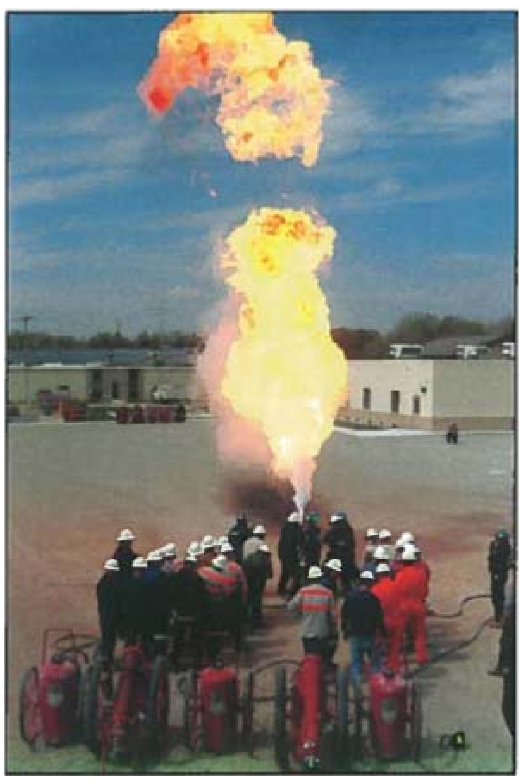
Direct the dry chemical stream at the fuel source.

Move the dry chemical down the stream of escaping fuel.

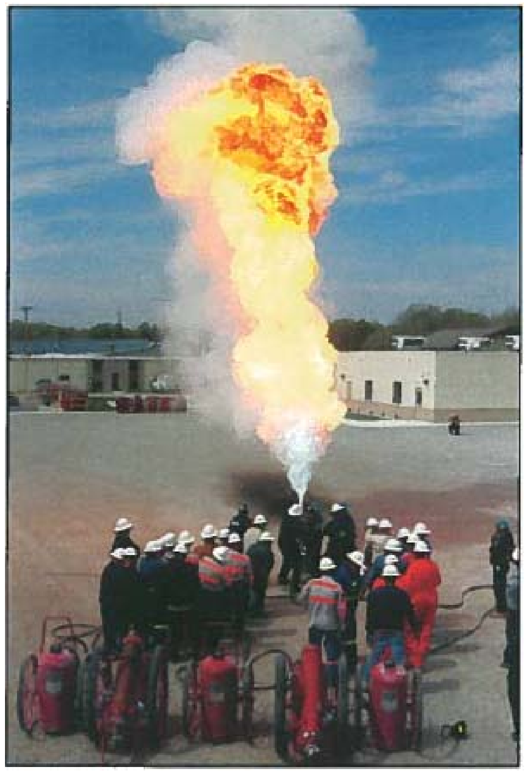
Extinguish remaining spill fire using a rapid side to side sweeping motion.

Note: In some cases it may not be desirable to extinguish this fire unless the fuel supply can be shut off.

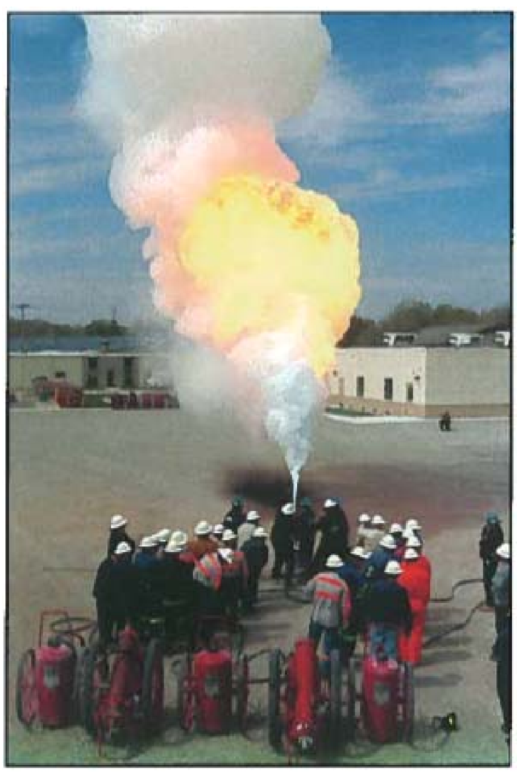
Flammable Gas Pressure Fire Using Dry Chemical
Approach the fire from the upwind side.



Direct the dry chemical stream at the fuel source.

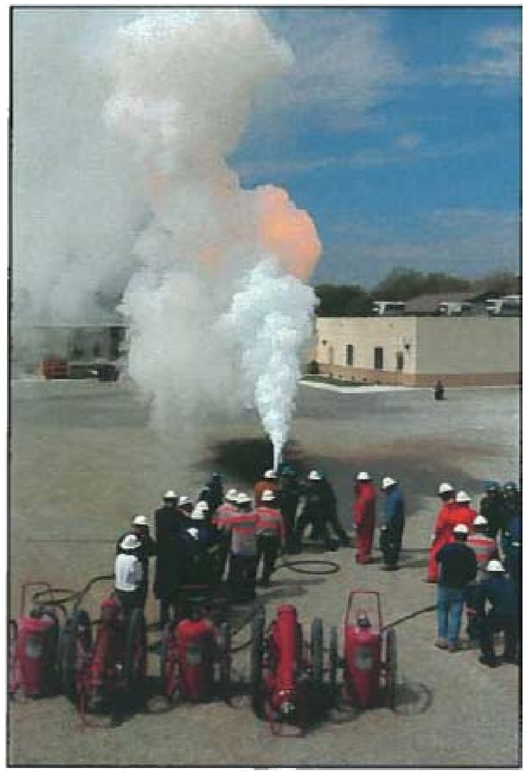


Move the dry chemical up the stream of escaping gas.



Continue moving the dry chemical stream upward until the fire ball is extinguished.

Note: In some cases it may not be desirable to extinguish this fire unless the fuel supply can be shut off.



Class A

Approach the fire from the upwind side holding nozzles at a 45-60° angle. Stop at a point approximately 8 to 10 ft (2.4 to 3.1 m) from the front edge of the fire area.

When using dry chemical on a Class A fire, you must use an ABC rated extinguisher. If a B,C extinguisher is the only extinguisher available, you must overhaul with water or an ABC fire extinguisher.

Direct nozzle at the fire covering the entire area.