CHAPTER 13

CRASH RESCUE AND FIREFIGHTING

Firefighting is a highly technical profession. Firefighting in and around crashed aircraft is a highly specialized field of firefighting. An individual willing to become a firefighter must possess the following qualities: alertness, courage, dedication, agility, physical strength, and the ability to be an exacting team worker.

The primary duty of the firefighter is saving life. If there is a fire aboard an aircraft with ordnance on board, there is potential for loss of life. If an ordnance cookoff occurred, the top priority would be to cool off the ordnance, while simultaneously laying a personnel rescue path and extinguishing the fire.

During frequent drills and training sessions, it is important for you to actually use all equipment, extinguishing agents, and tools so you will learn their capabilities and limitations.

LEARNING OBJECTIVES

When you have completed this chapter, you will be able to do the following:

1. Identify the four elements necessary to produce fire and recognize the characteristics associated with the different classes of fires.
2. Describe the characteristics of the different extinguishing agents.
3. Explain the various systems and equipment used for aircraft firefighting on board ships and shore activities.
4. Recognize the types of firefighting and rescue vehicles.
5. Identify the different hazards associated with aircraft fires and recognize aircraft fluid line identification markings.
6. State the various firefighting techniques based upon the existing emergency conditions.

THE CHEMISTRY OF FIRE

Fire is the most common form of chemical reaction. The process of fire may be regarded as a chemical triangle (Figure 13-1). The three sides consist of fuel (combustible matter), heat, and oxygen. After extensive research, the presence of a fourth element has been identified. It is the chemical chain reaction (Figure 13-2) that takes place in a fire that allows the fire to both sustain itself and grow. This process of fire is now called the "fire tetrahedron." See Figure 13-3.

The most common method of controlling or extinguishing a fire is to eliminate one or more of the sides of the tetrahedron. This can be accomplished by the following methods.

- Smothering—removing the oxygen
- Cooling—removing the heat
- Starving—removing the fuel or combustible matter
Two terms you need to understand about fires are the fire point and the flash point.

The *fire point* of a substance is the lowest temperature at which its vapors can be ignited and will continue to burn. At this temperature, the vapor will ignite spontaneously in the air. Also, substances do not have to be heated to this ignition temperature throughout in order to ignite.

The *flash point* of a substance is the temperature at which the substance gives off enough vapors to form an ignitable mixture with the air near the substance’s surface. An ignitable mixture is a mixture within the explosive range. The mixture is capable of spreading a flame away from the source of ignition when ignited. For example, fuel will spontaneously ignite when a portion of it (or its vapors) is exposed to temperatures around 500 degrees Fahrenheit (°F) (ignition temperature). It is capable of being touched off by a match or spark at temperatures down to -5 °F (fire point). It will also flash across the surface at temperatures from -5 °F down to -45 °F (flash point).

From these examples, you can readily see that fuel has a low flash point and is easily ignited. Fuel is a constant fire hazard around aircraft. A spark, heat caused by friction, or an electrical discharge can supply enough heat to cause fuel to flash.

**Classes of Fire**

Different types of fires are combated by different means. It is important that you know how to identify the various types of fires and understand why each type must be combated in a specific way.

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**Figure 13-2 — Chain reaction.**

**Flaming Combustion**

- Oxygen
- Temperature
- Uninhibited Chain Reaction
  - Of Combustion Process
  - Diffusion & Continuous Reignition Automatically Obtained At Flame Temperature Levels
  - Fuel Is In Form Of Vapor & Gas

**Surface Glowing Combustion**

- Temperature
- Oxygen
- No Chain Reaction
  - Oxygen Is At Interface Of Glowing Fuel
  - Fuel Is In Form Of Incandescent Solid

**Figure 13-3 — Fire tetrahedron and triangle.**
Class A

Class A fires occur in combustible materials, such as bedding, mattresses, books, cloth, and any matter that produces an ash. All fires of this class leave embers, which are likely to rekindle if air comes in contact with them. Class A fires must not be considered extinguished until the entire mass has been cooled below its ignition temperature. Smothering (removing the oxygen) is not effective for class A fires because it does not lower the temperature of the smoldering embers below the surface. The extinguishing agents most effective for class A fires are solid water stream, both high- and low-velocity fog, carbon dioxide (CO$_2$), and water immersion.

Class B

Class B fires occur with flammable liquid substances, such as gasoline, jet fuels, paints, grease, and any petroleum-based product. These and other combustible substances do not leave embers or ashes. Class B fires are extinguished by providing a barrier between the burning substance and oxygen necessary for combustion. Chemical and mechanical foams produce such a barrier and are known as permanent smothering agents, but their effect is only temporary. The application must be renewed if there is any danger of reigniting. The extinguishing agents recommended for combating class B fires are CO$_2$, Purple-K-Powder (PKP), Halon 1211, and aqueous film-forming foam (AFFF).

Class C

Class C fires are energized electrical fires that are attacked at prescribed distances by using nonconductive agents such as CO$_2$ and Halon 1211. The most effective tactic is to de-energize the system and handle the fire as a class A fire. When fires are not deep seated, clean agents that pose no cleanup problem, such as Halon 1211 or CO$_2$, are the preferred extinguishing agents.

Class D

Class D fires occur with combustible metals, such as magnesium and titanium. Water in large quantities, such as high velocity fog, is the recommended extinguishing agent. When water is applied to burning class D materials, there may be small explosions. The firefighter should apply water from a safe distance or from behind shelter. Metal fires on board ships are commonly associated with aircraft wheel structures.

EXTINGUISHING AGENTS

Many materials may be used as firefighting agents. The primary agents discussed in the following paragraphs are the most extensively used aboard naval ships.

Water

Water is a cooling agent (Figure 13-4), and on board ship, the sea provides an inexhaustible supply. If the surface temperature of a fire can be lowered below the fuel's ignition temperature, the fire will
be extinguished. Water is most efficient when it absorbs enough heat to raise its temperature to 212 °F (100 degrees Celsius [°C]) or boiling point. At this temperature, the seawater will absorb still more heat until it changes to steam. The steam carries away the heat, which cools the surface temperature.

Water in the form of fog is very effective for firefighting purposes. Additionally, water fog can provide protection to firefighters from heat. However, the fog must be applied directly to the area to be cooled if its benefits are to be realized.

Water in the form of a straight stream (also called solid stream) is used to reach into smoke-filled spaces or areas at a distance from the firefighter. When a straight stream is needed as an extinguishing agent, it should be directed into the seat of the fire. For maximum cooling, the water must come in direct contact with the burning material. A straight stream is best used to break up and penetrate materials.

**Aqueous Film-Forming Foam (AFFF)**

AFFF is composed of synthetically produced materials similar to liquid detergents. These film-forming agents are capable of forming water solution films on the surface of flammable liquids (*Figure 13-5*). AFFF concentrate is nontoxic and biodegradable in diluted form. When proportioned with water, AFFF provides three fire-extinguishing advantages.

1. An aqueous film is formed on the surface of the fuel that prevents the escape of the fuel vapors.
2. The layer effectively excludes oxygen from the fuel surface.
3. The water content of the foam provides a cooling effect.

The primary use of AFFF is to extinguish burning flammable or combustible liquid spill fires (class B). AFFF has excellent penetrating characteristics and is superior to water in extinguishing class A fires.

**Carbon Dioxide (CO₂)**

CO₂ is an inert gas and extinguishes fires by smothering them (*Figure 13-6*). CO₂ is about
1.5 times heavier than air, which makes it a suitable extinguishing agent because it tends to settle and blanket the fire. CO₂ is a dry, noncorrosive gas, which is inert when in contact with most substances and will not leave a residue or damage machinery or electrical equipment. CO₂ is a nonconductor of electricity regardless of voltage and can be safely used in fighting fires that would present the hazard of electric shock.

CO₂ extinguishes the fire by diluting and displacing its oxygen supply. If gaseous CO₂ is directed into a fire so that sufficient oxygen to support combustion is no longer available, the flames will die out. CO₂ has limited cooling capabilities and may not cool the fuel below its ignition temperature. It is more likely than other extinguishing agents to allow reflash. Therefore, the firefighter must remember to stand by with additional backup extinguishers.

**NOTE**

CO₂ is not an effective extinguishing agent for fires in materials that produce their own oxygen supply, such as aircraft parachute flares, or fires involving reactive metals, such as magnesium and titanium.

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**Halon 1211**

Halon is a halogenated hydrocarbon (Figure 13-7). Halon 1211, known chemically as bromochlorodifluoromethane, is colorless and has a sweet smell. Halon attacks the fire by inhibiting the chemical chain reaction. Halon decomposes upon contact with flames or hot surfaces above 900 °F (482 °C).

Halon 1211 is used for twin agent (AFFF/Halon 1211) applications on board flight and hangar deck mobile firefighting equipment. For flight and hangar deck firefighting procedures, you should refer to NATOPS, U.S. Navy Aircraft Firefighting and Rescue Manual, NAVAIR 00-80R-14.

**Potassium Bicarbonate (Purple-K-Powder or PKP)**

Potassium bicarbonate (PKP) is a dry chemical principally used as a firefighting agent for flammable liquid fires (Figure 13-8). When PKP is applied to fire, the dry chemical extinguishes the flame by breaking the combustion chain. PKP does not have cooling capabilities on fire. PKP is highly effective in extinguishing flammable liquid (class B) fires. Although PKP can be used on electrical (class C) fires, it will leave a residue that may be hard to
clean. Also, when combined with moisture, it may corrode or stain the surfaces on which it settles.

PKP does not produce a lasting inert atmosphere above the surface of a flammable liquid. Therefore, its use will not result in permanent extinguishing if ignition sources, such as hot metal surfaces or persistent electrical arcing, are present. Reflash of the fire will most likely occur. The ingredients used in PKP are nontoxic. However, the discharge of large quantities may cause temporary breathing difficulty and, immediately after the discharge, may seriously interfere with visibility.

**FIREFIGHTING EQUIPMENT**

In assisting the crash firefighters, you will use very specialized equipment. A crash crew must bring its equipment into action with every pump nozzle delivering at its maximum capacity. Firefighting equipment is discussed in the following paragraphs.

**Firemain System**

You must get acquainted with the firemain system throughout your ship. You should know the location of the firemain and the riser piping that carries water to the upper decks. You must be able to identify the plugs where hoses can be attached to the mains. You must know the location of all pumps, valves, and controls in the vicinity of your duty and berthing stations.

Fireplugs have outlets either 1 1/2 or 2 1/2 inches in diameter. Some plugs are equipped with wye gates that provide two outlets, each 1 1/2 inches in size. In some cases, a reducing connection is used so that a 1 1/2-inch hose can be attached to a 2 1/2-inch outlet.

Connected to the fireplugs and stored in adjacent racks are two lengths of either 1 1/2- or 2 1/2-inch diameter hose. The 1 1/2-inch hose is used on smaller ships and below decks on larger ships. This hose is made up in 50-foot lengths, with the necessary end couplings. All threaded parts of firehose fittings and couplings have standard threads and are easy to connect. Hoses and fittings 1 1/2 inches and below have standard pipe threads. Those 2 1/2 inches and over have standard Navy hose threads.

Two people working together can quickly prepare a firehose. You can do the job alone if you place the hose on the deck and hold it down with your foot just behind the fitting. The pressure of your foot will cause the metal fitting on the end of the hose to point upward. In this position you can screw in the nozzle or other fitting.

Firehose is usually located on a bulkhead rack near a fireplug. Nozzles, extensions called applicators, and spanner wrenches are stowed on the bulkhead near the hose See Figure 13-9. When two lines are located separately on the bulkhead, one is connected to the firemain and the other is left unconnected.

![Figure 13-9 — Typical firehose station.](image)
High-Capacity AFFF Systems

An AFFF station consists of a 600-gallon AFFF concentrate tank, a single-speed injection pump or a two-speed AFFF pump, electrical controllers, valves, and necessary piping. Saltwater and AFFF flow is controlled by hydraulically operated valves, which are actuated by solenoid-operated pilot valves (SOPVs). The SOPVs are activated by electrical switches at user locations Primary Flight (Pri-Fly), Navigational Bridge (NAVBRIDGE), hose stations, and conflagration (CON-FLAG) stations.

The injection pump system supplies the flush eck nozzles on the flight deck, and the deck edge nozzles on Carrier Vessel Nuclear (CVNs). The two-speed pump operates at 27 or 65 gallons per minute (gpm), depending upon the demand. The low-rate output will supply handlines and small sprinkler systems. High-demand systems, such as hangar bay sprinklers, are served by the high-speed output. On selected CVs, the two-speed pump supplies the deck edge nozzles.

Hangar Deck AFFF Sprinkler System

The AFFF sprinkler systems are installed in the overhead of the hangar deck. The sprinkler system is divided into groups that can be individually actuated. Each group is supplied from two risers—one from a port AFFF injection station and one from a starboard AFFF injection station. Controls to start and stop flow to individual sprinkler groups are located in the CONFLAG stations and along each side of the hangar deck near the related sprinkler group.

Flight Deck AFFF Extinguishing System

Flight decks have an AFFF firefighting system that consists of flush-deck, flush-deck cannon-type, and deck-edge nozzles installed in combination with the saltwater washdown system. AFFF from the concentrate tank is injected into the saltwater (injection point is on the 03 level just downstream of the saltwater control valve) via a positive displacement pump, usually 60 gpm. This injection pump serves the flush-deck and cannon-type nozzles. Deck edge nozzles may be served by the AFFF two-speed pump system or single-speed injection pump system.

Controls for the flight deck fixed fire-extinguishing system are located in both Pri-Fly and on the NAVBRIDGE. The controls allow for selection of saltwater AFFF or system shutdown.

AFFF Hose Reel Station

Hangar bay AFFF hose outlets are located port and starboard near the AFFF injection stations from which they are supplied. A push-button control is located adjacent to each AFFF hose station. The station has a 1 1/2-inch hose reel and one 2 1/2-inch hose outlet (Figure 13-10).

Flight deck AFFF hose outlets are located in catwalks and near the island. The station has one reel of 1 1/2-inch hose and/or one 2 1/2-inch hose outlet or two 2 1/2-inch hose outlets with hose and nozzle preconnected to each outlet. A push-button control, X50J phone circuit box, and E call button are located next to each AFFF hose station. There is emergency lighting at each hose reel station. The controls are located in Pri-Fly and on the NAVBRIDGE.

Figure 13-10 —AFFF hose reel.
Portable Firefighting Equipment

As you become more familiar with aircraft firefighting tactics and equipment, you will become more familiar with the many different types of portable equipment that the firefighter uses to combat and contain aircraft fires. Some of the equipment you will use is discussed in this section.

Vari-Nozzles

Vari-nozzles are used on all AFFF and saltwater hose lines. Flow rates are 250 gpm for all 2 1/2-inch hose lines. Nozzles on 1 1/2-inch AFFF hoses on flight and hangar decks are the 125-gpm units. Nozzles on the 1 1/2-inch saltwater lines and those used with AFFF in-line inductors are 95-gpm models. All nozzle gpm flow rates are based on 100-pounds per square inch (psi) pressure at the nozzle inlet. See Figure 13-11.

Hoses

The standard Navy firehose is a double-jacketed, synthetic fiber with a rubber or similar elastomeric lining. The outer jacket is impregnated to increase wear resistance. The impregnating material contains an orange-colored pigmentation for easy identification. Navy firehose comes in 50-foot lengths and has a maximum operating pressure of 270 psi. Optimum hose handling occurs between 90 and 150 psi. Pressure above 150 psi is hazardous because excessive nozzle reaction force may result in loss of nozzle control.

Noncollapsible rubber hose for the AFFF hose reel system is available in 3/4-inch and 1 1/2-inch size. The length of these hoses varies in size depending upon application and location.

Tools

A firefighter’s toolkit should contain the following tools:

- Large claw tool; small claw tool
- Crowbar
- Parachute knife
- Pliers; screwdriver
- Wrench
- Hacksaw; metal saw
- Chisels
- Flashlight
- Carpenter’s hammer; maul
- Bolt cutters
- Notched ax

Naval Air Systems Command (NAVAIRSYSCOM) developed what is called an aircraft toolkit (Figure 13-12) for crash trucks. The station fire chief must ensure that one of these kits is carried on each of
the crash trucks assigned to the firefighting crew. The kit consists of a canvas tool roll with pockets or holders for specified tools. The crash kit contains tools for forced entry. Firefighters use these tools in rescuing occupants trapped in aircraft. The kit contains three tapered, hard-rubber plugs and three hardwood plugs. These plugs are used to stop fuel tank leaks.

**Protective Clothing**

Aircraft firefighting/rescue protective clothing is a prime safety consideration for personnel engaged in firefighting and rescue work. Aluminized protective clothing offers protection to fire fighters because of its high percentage of reflectivity to radiant heat. Aluminized proximity fabrics have been adopted for use in the Navy Mishap/Rescue Program. It is important to point out that these garments are not classified as entry suits, but are known as proximity clothing to be worn with firefighters' knee-length boots that have safety toes and soles.

**Care and Maintenance of Protective Clothing**

The heat-reflective ability of aluminized clothing is reduced when the clothing is stained or otherwise soiled. Therefore, you must give careful attention to the care and maintenance instructions for protective clothing. Some guidelines are as follows:

- Store clothing on hangers with suitable hanging space to prevent aluminized fabrics from creasing or cracking. If the garment is folded, the folds should be loose. Do not sit on a folded garment.
- Sponge off dirt and soot by using mild soap and water. Dry aluminum surfaces with a clean cloth. Rub gently to avoid removal of the aluminum.
- Remove grease stains by using dry-cleaning solvents. Remove AFFF by sponging the clothing clean with mild soap and water. Hang the garment to dry in the open or in a place with good circulation. During firefighting operations, it is not always possible to prevent firefighting agents from getting on protective clothing. However, aluminized protective clothing that has been covered or spotted with agents will have less heat-reflecting ability than the suit normally would provide.
- Corrosive chemicals will react with the aluminum surface and may etch the metal. Clean the clothing with water and wipe it dry. Allow it to hang in a ventilated location at room temperature.
- Replace garments when the aluminum wears off or when the fabric cracks or tears. Spraying worn clothing with aluminum serves no useful purpose and is a dangerous practice.

**Care of Facepiece**

The gold-coated facepiece is a heat-reflective shield. The facepiece is NOT a sun shield. This item should be kept in excellent condition to maintain the radiant-heat-reflective efficiency. When the gold surface of the facepiece becomes worn, scratched, or marred, 90 percent of the heat protection is lost, and you should immediately replace the facepiece. Other precautions you should take with facepieces are as follows:
- Keep the protective cover in place when you are carrying or storing the hood to minimize damage to the gold-coated surface. Remove it when using the hood.
- For adequate protection, replace a worn gold-coated facepiece. When wearing the facepiece, make sure the gold surface is on the outside as marked on the edge.
- Avoid touching or wiping the gold surface as much as possible.
- Clean the facepiece, without removing it from the hood, by using a clean, soft cloth with mild soapy water, and then rinse and pat dry.

AIRCRAFT FIREFIGHTING AND RESCUE VEHICLES

The Navy uses different types of trucks. The use depends on the base, type of aircraft assigned, and anticipated types of fires. Some of the trucks used by the Navy are the Oshkosh T-3000 firefighting/rescue vehicle, and the P-25 shipboard firefighting truck.

Oshkosh T-3000

The Oshkosh T-3000 (Figure 13-13) is a diesel-powered, six-wheel-drive truck with an automatic transmission. The operator controls consist of power-assisted steering, air or mechanical brakes, transmission range selector, and in-cab controls for operating the firefighting system. The water storage tank has a capacity of 3,000 gallons, the AFFF concentrate tank holds 420 gallons. The roof turret has a discharge rate of 600 to 1,200 gpm and an infinitely variable pattern from straight stream to fully dispersed. The bumper turret is electric joystick controlled with auto-oscillation. The discharge rate is 300 gpm, and it is also variable pattern. Two 15-feet, 1 3/4-inch preconnected handlines are provided, one per side. The handlines have a discharge rate of 95 gpm and have a pistol grip with variable pattern.

A/S32P-25 Shipboard Firefighting Vehicle

The P-25 shipboard firefighting vehicle (Figure 13-14) is a 4-wheel (2-wheel drive), 6-cylinder, turbocharged, liquid-cooled, 24-volt, diesel-powered vehicle, with a hydrostatic drive system that transmits power to the rear wheels. Steering is performed by a single hydraulic cylinder and tie rod assembly that controls the front wheels. Dynamic vehicle braking is provided by the hydrostatic drive system. When the accelerator is released, the brakes automatically engage. Separate tanks within the vehicle chassis carry 750 gallons of water and 55 gallons of AFFF. Three 20-pound fire extinguishers containing Halon 1211 are stored on the right side of the vehicle. One nursing line...
connection on each side of the vehicle provides AFFF mixture from the ship's system directly to the vehicle’s water pump.

The vehicle has seating for a crew of two. The driver compartment is located at the left forward end of the vehicle and contains the main control panel for activating the firefighting systems. AFFF can be sprayed from both the forward turret nozzle and handline hose reel nozzle. These nozzles operate independently and can be used simultaneously to make this vehicle ready for firefighting duty.

![Figure 13-14 — A/S32P-25 shipboard firefighting and rescue vehicle.](image)

**AIRCRAFT FIRE HAZARDS**

Not every crash results in fire. The responsibility of the crash firefighter does not end when fire fails to occur. Serious actual and potential fire hazards may have been created, which you must eliminate or minimize without delay.

The greater the damage to the aircraft is, the greater the possibility of fuel spillage. A spark or a hot engine part can ignite fuel vapors and set off a full-fledged fire. You should take every precaution to guard against accidental ignition. Personal laxity or unfamiliarity with ordinary preventive measures can allow a delayed fire to occur, which can endanger personnel.

**Flammable, Hazardous, and Fire-Accelerating Materials**

Accelerating materials carried on aircraft are of major concern to the aircraft rescue and firefighting crews. Aviation gasoline (AVGAS), jet fuels (JP-4, JP-5, and JP-8), engine oils, oxygen systems, and hydraulic fluids constitute problems in aircraft firefighting. Some of these fuels have restrictions as to where they can be used; for example, JP-4 is prohibited aboard ship due to its flash point.

![CAUTION](image)

Under aircraft crash impact conditions where fuel-air mixtures or mists are created, all fuels are easily ignited.

**Aviation Gasoline (AVGAS)**

The flash point (by closed cup method at sea level) of AVGAS is −50 °F (−46 °C). The rate of flame spread has also been calculated to be between 700 and 800 feet per minute.
**JP-4 Fuel**

JP-4 jet fuel is a blend of gasoline and kerosene and has a flash point of −10 °F (−23 °C). The rate of flame spread has also been calculated to be between 700 and 800 feet per minute.

**JP-5 Fuel**

JP-5 fuel is a kerosene grade with a flash point of 140 °F (60 °C). The rate of flame spread has been calculated to be approximately 100 feet per minute. The lowest flash point considered safe for use aboard naval vessels is 140 °F (60 °C).

**Fuel Tanks**

When an aircraft crashes, the impact usually ruptures the fuel lines and fuel tanks. Ordinarily, all the fuel is not liberated at once. There is a source of fuel that is supplying the fire either from the rupture in the tank or from the loosened and ruptured fuel lines in the accessory section of the engine.

The control of the fire around the fuselage section under these conditions presents a very complex problem. The top portion of the tank is more void of liquid than any other section of the tank. Because of the restraining cushion of the liquid itself, the explosive force will be directed upward instead of downward or on a horizontal plane.

Fuel loads can vary from 30 gallons in small aircraft to approximately 50,000 gallons in large jet aircraft. Fuel tanks are installed in a variety of places within the aircraft structural framework or as a built-in part of the wing. Fuel tanks are often carried under the floor area in the fuselage of helicopters. You should refer to *NATOPS, U.S. Navy Aircraft Emergency Rescue Information Manual, NAVAIR 00-80R-14-1*, for the exact location of fuel tanks on a particular aircraft. Upon severe impact these tanks generally rupture and result in fire. Many naval aircraft are provided with external auxiliary fuel tanks located under the wings and fuselages.

The aircraft manufacturers conducted a number of tests on external aircraft fuel tanks in which they were exposed to an enveloping fuel fire. These studies show that there were no deflagrations; however, the tanks did melt or rupture, releasing fuel onto the decks. The time to fuel tank failure (release of fuel) was dependent on the percent of fuel in the tank and ranged from 28 seconds for a 10-percent load to 3 1/2 minutes for a 100-percent load.

There is so little difference in the heat of combustion of the various aircraft hydrocarbon fuels that the severity after ignition would be of no significance from the “fire safety” point of view. The firefighting and control measures are the same for the entire group of aviation hydrocarbon fuels.

**Oxygen Systems**

Oxygen systems on aircraft can present hazardous conditions to firefighters during an emergency. Liquid oxygen is a light blue liquid that flows like water and is extremely cold. It boils into gaseous oxygen at −297 °F (−147 °C) and has an expansion rate of approximately 860 to 1. Liquid oxygen is a strong oxidizer, and although it is nonflammable, it vigorously supports combustion.

**General Hazards**

During aircraft firefighting operations, personnel are constantly in harm’s way, from the actual firefighting operations to the salvage and cleanup operations. All components and material in or on the aircraft are considered hazardous to personnel. The following paragraphs discuss a few of the hazards that personnel need to be familiar with.
Anti-Icing Fluids

Anti-icing fluids are usually a mixture of about 85-percent alcohol and 15-percent glycerin. While not as great as other aircraft hazards, you should remember that alcohol used in aircraft anti-icing systems burns with an almost invisible flame. The best method of control is by dilution with water.

Class A Combustibles

Class A combustibles in aircraft fires are best extinguished with AFFF. When aircraft cockpit and interior finish materials are burned or charred, they produce toxic gases. These gases include carbon monoxide, hydrogen chloride, and hydrogen cyanide. Therefore, it is necessary that firefighting and rescue personnel who enter an aircraft during a fire sequence be equipped with a self-contained breathing apparatus.

Ordnance

Naval aircraft carry a wide variety of ordnance in support of their assigned missions. For more information on the characteristics and cookoff times of ordnance, refer to Chapter 8 of this manual and NATOPS, U.S. Navy Aircraft Firefighting and Rescue Manual, NAVAIR 00-80R-14, Chapter 2.

Flare Dispensers

The SUU-44/SUU-25 flare dispensers carry eight Mk 45 or LUU-2 paraflares. When the flares are ejected from the dispenser and the tray separates, they must be considered fully armed. Once the tray separates from the flare, it ignites a fuse on the Mk 45 flare, which will fire within 5 to 30 seconds. The LUU-2 flare uses a simple mechanical timer instead of an explosive fuse. If ignited, the Mk 45 or LUU-2 candle should be extinguished by inserting a water applicator tip into the burning end of the candle, applying low-velocity fog. The flare will normally extinguish in less than 30 seconds. If a fog applicator is not readily available, an alternate method is to have a fully outfitted firefighter cut the shroud lines, pick up the flare by the cold end, and jettison it over the side or remove it to a clear area if ashore.

Batteries

Alkaline or nickel-cadmium batteries may get hot from internal shorting or thermal runaway. The overheated battery is hazardous to both aircraft and personnel. When an overheated battery is detected, the crash crew should open the battery compartment, check for the following conditions, and take the action indicated:

⚠️ **WARNING**

Halon 1211 or CO₂ is an acceptable fire-extinguishing agent once a fire has developed. CO₂ must not be directed into a battery compartment to effect cooling or to displace explosive gases. Static electricity generated by the discharge of the extinguisher could explode hydrogen or oxygen gases trapped in the battery compartment.

- When flame is present, use available extinguishing agent, such as Halon 1211 or CO₂.
- When the battery is emitting smoke, fumes, or electrolyte in the absence of flame or fire, make sure the battery switch in the cockpit is in the OFF position. Remove the quick disconnect from the battery and, if possible, move the battery clear of the aircraft. Use water fog to lower the battery temperature.
Composite Materials
The following paragraphs discuss the advantages and disadvantages of using composite materials in aircraft construction.

**Composite Materials Reinforced with Carbon/Graphite Fibers**
Composite materials that are reinforced with carbon/graphite fibers provide superior stiffness, a high strength-to-weight ratio, and ease of fabrication. As a result, this material is being used extensively in advanced aircraft, such as the F/A-18, to replace heavier metal components. Unfortunately, carbon or graphite fibers can be released into the atmosphere if their epoxy binder burns. Once free, these small, lightweight fibers can be transported up to several miles by air currents and, because of their high electrical conductivity, can damage unprotected electrical/electronic equipment.

Until such time as more information is known, aircraft crash and firefighting units must attempt to extinguish fires involving carbon-fiber-reinforced composites as quickly as possible and to provide maximum containment of the aircraft debris. The containment and cleanup function is extremely important and must be treated as a special hazard prevention measure. Accordingly, the practices for extinguishing, containment, and cleanup, as stated in the *NATOPS, U.S. Navy Aircraft Firefighting and Rescue Manual*, NAVAIR 00-80R-14, should be observed when an aircraft crash/fire incident occurs that involves any aircraft that contain carbon-graphite fiber composites. Any aircraft incident involving fire on these types of aircraft must be considered to have potential contamination hazards until positively identified to the contrary.

**Composite Materials Reinforced with Boron/Tungsten Fibers**
Composite materials reinforced with boron fibers also provide superior stiffness, a high strength-to-weight ratio, and ease of fabrication. This material is being used in advanced aircraft, such as the F/A-18 and F-35, to replace heavier metal components. Unfortunately, boron fibers can be released if their epoxy binder burns. Boron fibers pose less of a problem to unprotected electrical equipment than carbon or graphite fibers because boron fibers are much heavier and are less likely to become airborne. Also, boron fibers are much less electrically conductive. However, loose boron fibers are stiff and sharp and thus pose handling problems. The extinguishing, containment, and cleanup practices for boron fibers are the same as those previously outlined for carbon or graphite fibers.

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**WARNING**
When approaching a battery that is in a thermal runaway condition, aircraft rescue and firefighting personnel must work in teams of two and must be attired in full protective clothing, with extinguishing agent available for instant use.

**WARNING**
Inhalation of composite fibers resulting from aircraft fires and/or aircraft material damage may be harmful to personnel. Respiratory protection must be worn when personnel are exposed to these potential hazards.
Aircraft Fire and Personnel Hazards

Not every crash results in fire. The responsibility of the crash firefighter does not end when fire fails to occur. Serious actual and potential fire hazards may have been created, which must be eliminated or minimized without delay.

The greater the damage to the aircraft is, the greater the possibility of fuel spillage. A spark or a hot engine part can ignite fuel vapors and set off a full-fledged fire. You must take all precautions to prevent accidental ignition. Personal laxity or unfamiliarity with ordinary preventive measures can cause a delayed fire, which can endanger personnel who would otherwise survive a disaster.

Engine Accessory Section

The most common source of crash fires is the engine compartment, particularly the accessory section. Take steps to prevent ignition of fuel vapors by hot exhaust stacks and collector rings. CO₂ discharged through the cooling flaps, air scoop, or inspection doors is an effective precaution. CO₂ will cause no damage to the engine or its accessories.

Fuel Spills

Fuel spills can be caused by ruptured fuel lines. These spills should be swept clear of the aircraft. Use water streams and follow up with a layer of foam to halt vaporization. An aircraft should NEVER be dragged or moved unnecessarily. There is great danger that friction will ignite the fuel.

Selector Valve

You should know the location of the fuel selector valve on as many types of aircraft as possible. In single-engine aircraft, this valve is usually found on the lower left-hand side of the cockpit. In multi-engine aircraft, fuel selector valves for all engines are usually found on one panel. Turn the valve to OFF. It is the primary fuel cutoff valve. The valve is used to select various fuel tanks. In the OFF position, the valve completely separates the source of fuel from the engine.

Battery Switch

Turn the battery switch to OFF. This is the master electrical switch. It is the source of all power to the aircraft electrical system when the engine(s) are not running. Memorize the location of battery switches so you can turn the power off rapidly in emergencies. Disconnect the battery, if possible, as detonators and electrical recognition devices are connected ahead of the master switch. Turning the switch off will not stop the flow of current to these devices.

CAUTION

When fighting a fire on an aircraft known to have loaded guns aboard, stay out of the area forward of the guns. If rockets or bombs are in the aircraft, stay clear of them, keep low to the deck, and keep the bombs or rockets cool with water fog or fog foam until they are declared safe.

Armament

Turn gun switches to OFF so there is no chance of firing a gun accidentally. This is one of the first actions taken by firefighters to prevent fire at the crash scene.
Ejection Seat

The ejection seat is not normally a fire hazard if fire is not already present. The ejection seat should be disarmed or made safe by qualified personnel. The greatest danger from an ejection seat comes during rescue operations when fire is present.

Hydraulic System

The hydraulic system of a crashed aircraft should be considered a potential hazard. The loss of hydraulic fluid/pressure can cause an unexpected movement of the aircraft. The landing gear can collapse or brakes can release, causing injury to personnel.

Fluid Line Identification

Many different types of liquids and gases are required for the operation of aircraft. These liquids and gases are transmitted through many feet of tubing and flexible hose. Both liquids and gases are called fluids, and tubing and flexible hose are referred to as lines. The term "fluid lines" is used in the following discussion. Each fluid line in an aircraft is identified by bands of paint or strips of tape around the line near each fitting. These identifying markers are applied at least once in each compartment. Various other information is also applied to the lines.

In most instances, lines are marked by the use of tape or decals. On lines 4 inches and larger in diameter, steel tags may be used in place of tape or decals. On lines in engine compartments, where there is a possibility of tapes, decals, or tags being drawn into the engine intake, paint is usually used.

Identification tape codes indicate the function, contents, hazards, direction of flow, and pressure in the fluid line. These tapes are applied according to MIL-STD-1247. This military standard was issued to standardize fluid line identification throughout the Department of Defense. Figure 13-15 shows the application of these tapes as specified by this standard.

The function of a line is identified by the use of a tape. The tape, approximately 1-inch wide, has words, colors, and geometric symbols printed on it. Functional identification markings, as shown in MIL-STD-1247, are the subject of international standardization agreement. The function of the line is printed in English across the colored portion of the tape. Three-fourths of the total width on the left side of the tape has a code color. Non-English-speaking people can troubleshoot or maintain the aircraft if they know the color code. The right-hand quarter of the functional identification tape contains a geometric symbol that is different for every function. This symbol ensures that all technicians, whether colorblind or non-English-speaking will be able to identify the line function. Figure 13-16 is a listing of functions and their associated colors and identification markings as used on tapes.

Hazard tape shows the hazard associated with the contents of the line. Tapes used to show hazards are approximately 1/2-inch wide, with the abbreviation of the hazard associated with the fluid in the

Figure 13-15 — Fluid line identification application.
line printed across the tape. There are four general classes of hazards found in connection with fluid lines (Table 13-1).

**Flammable material (FLAM)**
The hazard marking FLAM is used to identify all materials known as flammables or combustibles.

**Toxic and poisonous materials (TOXIC)**
A line identified by the word TOXIC contains materials that are extremely hazardous to life or health.

**Anesthetics and harmful materials (AAHM)**
AAHM identifies all materials that produce anesthetic vapors and all liquid chemicals and compounds that are hazardous to life and property.

**Physically dangerous materials (PHDAN)**
PHDAN identifies a line that carries material that is asphyxiating in confined areas or is under a dangerous physical state of pressure or temperature. For example, the line shown in Figure 13-15 is marked PHDAN because the compressed air is under a pressure of 3,000 psi.
<table>
<thead>
<tr>
<th>Function</th>
<th>Color</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel</td>
<td>Red</td>
<td>⭐️</td>
</tr>
<tr>
<td>Rocket oxidizer</td>
<td>Green, Gray</td>
<td>⏰</td>
</tr>
<tr>
<td>Rocket fuel</td>
<td>Red, Gray</td>
<td>⭐️</td>
</tr>
<tr>
<td>Water injection</td>
<td>Red, Gray, Red</td>
<td>⬇️</td>
</tr>
<tr>
<td>Lubrication</td>
<td>Yellow</td>
<td>⦿ Johnston at ⦿</td>
</tr>
<tr>
<td>Hydraulic</td>
<td>Blue, Yellow</td>
<td>⚫️ Johnston at ⚫️</td>
</tr>
<tr>
<td>Solvent</td>
<td>Blue, Brown</td>
<td>☢️</td>
</tr>
<tr>
<td>Pneumatic</td>
<td>Orange, Blue</td>
<td>🍊</td>
</tr>
<tr>
<td>Instrument air</td>
<td>Orange, Gray</td>
<td>🎯</td>
</tr>
<tr>
<td>Coolant</td>
<td>Blue</td>
<td>⚪️ Johnston at ⚪️</td>
</tr>
<tr>
<td>Breathing oxygen</td>
<td>Green</td>
<td>⚪️ Johnston at ⚪️</td>
</tr>
<tr>
<td>Air conditioning</td>
<td>Brown, Gray</td>
<td>✨</td>
</tr>
<tr>
<td>Monopropellant</td>
<td>Yellow, Orange</td>
<td>🟢</td>
</tr>
<tr>
<td>Fire protection</td>
<td>Brown</td>
<td>🔥</td>
</tr>
<tr>
<td>De-icing</td>
<td>Gray</td>
<td>⬆️ Johnston at ⬆️</td>
</tr>
<tr>
<td>Rocket catalyst</td>
<td>Yellow, Green</td>
<td>🟢</td>
</tr>
<tr>
<td>Compressed gas</td>
<td>Orange</td>
<td>🔥</td>
</tr>
<tr>
<td>Electrical conduit</td>
<td>Brown, Orange</td>
<td>🔥</td>
</tr>
<tr>
<td>Inerting</td>
<td>Orange, Green</td>
<td>🟢</td>
</tr>
</tbody>
</table>

Figure 13-16 — Functional identification tape data.
AIRCRAFT FIREFIGHTING TACTICS

Aircraft firefighting, crash, and rescue techniques are well defined, but no two fire situations will be identical. Success will continue to depend on training, planning, leadership, and teamwork by both ship's company and air wing personnel. Supervisory personnel, fire parties, and squadron personnel should take advantage of every opportunity to drill and acquire knowledge of fixed and mobile firefighting equipment available to them. All personnel should become familiar with aircraft configuration, fuel load, weapons load, and firefighting techniques of assigned aircraft. The following paragraphs discuss procedures recommended for training purposes.

**Accessory Section, Compressor Compartment, or Engine Compartment of Jet Fixed-Wing and Rotary-Wing Aircraft**

Fires in the accessory section, compressor compartment, or engine compartment of jet aircraft result from fuel being introduced into the area between the engine and fuselage, or between the engine and nacelle on engines carried in pods that come into contact with the heat generated by the engine. You must be familiar with these areas to be able to properly apply extinguishing agents. (For more

<table>
<thead>
<tr>
<th>CONTENTS</th>
<th>HAZARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air (under pressure)</td>
<td>PHDAN</td>
</tr>
<tr>
<td>Alcohol</td>
<td>FLAM</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>PHDAN</td>
</tr>
<tr>
<td>Freon</td>
<td>PHDAN</td>
</tr>
<tr>
<td>Gaseous oxygen</td>
<td>PHDAN</td>
</tr>
<tr>
<td>Liquid nitrogen</td>
<td>PHDAN</td>
</tr>
<tr>
<td>Liquid oxygen</td>
<td>PHDAN</td>
</tr>
<tr>
<td>Liquid petroleum gas (LPG)</td>
<td>FLAM</td>
</tr>
<tr>
<td>Nitrogen gas</td>
<td>PHDAN</td>
</tr>
<tr>
<td>Oils and greases</td>
<td>FLAM</td>
</tr>
<tr>
<td>JP-4</td>
<td>FLAM</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>AAHM</td>
</tr>
</tbody>
</table>
information, refer to NATOPS, U.S. Navy Aircraft Emergency Rescue Information Manual, NAVAIR 00-80R-14-1.)

Halon 1211 or CO₂ is the extinguishing agent used on these fires. However, when a fire in an aircraft cannot be extinguished with Halon 1211 or CO₂, the use of AFFF to prevent further damage outweighs the disadvantages.

**Internal Engine Fires**

Internal engine fires usually result when residual fuel is dumped into the engine on shutdown. When starting equipment and qualified starting personnel are immediately available, these fires may be controlled by windmilling the engine. If this procedure fails or if the equipment and personnel are not available, an extinguishing agent must be directed into the engine. Halon 1211 or CO₂ is the primary agent for internal fires. Application of Halon 1211 or CO₂ must be accomplished at a distance so that the Halon 1211 or CO₂ enters the fire area in gaseous form.

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**Aircraft Engine Fires**

Use the following procedures for extinguishing fires in high bypass turbofan engines:

1. Engine accessory section fire.
   - Halon 1211 or CO₂ may be introduced into the engine accessory section area through the access doors located on the aircraft engine cowling.
   - When the fire is under control, one firefighter in full protective clothing (hot suit) will open the engine cowling. An AFFF handline should be used to provide fire protection to the firefighter.

---

**CAUTION**

When CO₂ or Halon 1211 is expelled directly into an engine, thermal shock may result, causing engine damage. High bypass turbofan engines require unique techniques to extinguish engine core fires.

---

**NOTE**

A screwdriver may be required to open the engine cowling due to the restrictions of proximity gloves.

2. Engine fire in compressor section engine core.
   - Halon 1211 or CO₂ may be introduced into the engine intake, exhaust, or accessory section.

---

**CAUTION**

The source of this fire will probably be burning titanium and can be identified by the sparking effect of this material when it is burning. This fire is potentially destructive and may possibly burn through the engine casing if immediate fire suppression measures are not taken.

---

**CAUTION**

When CO₂ or Halon 1211 is expelled directly into an engine, thermal shock may result, causing engine damage. High bypass turbofan engines require unique techniques to extinguish engine core fires.
• When the fire is under control, one firefighter in full protective clothing (hot suit) will open the engine cowling. An AFFF handline should be used to provide fire protection to the firefighter.
• When the engine cowling is open, apply AFFF to both sides of the engine casing to complete extinguishing and provide additional cooling.

**Electrical and Electronic Equipment Fires**

In combating electrical fires, you must secure the source of electrical power. For combating class C fires, Halon 1211 or CO\(_2\) is the primary agent and should have no adverse effect on electrical or electronic components.

---

**WARNING**

Halon 1211 may be used in a small electronics compartment to make the atmosphere inert, provided firefighters do not enter the compartment, or enter it with a self-contained breathing apparatus. Do NOT use CO\(_2\) to make the atmosphere in an electronics compartment inert, as it may produce a spark.

---

**Tailpipe Fires**

When a fire occurs in the tailpipe of an aircraft during shutdown, the aircraft engine should be started by authorized personnel in order to attempt extinguishing through exhaust pressures. If this operation does not extinguish the fire, the following should be performed by the crash crew.

1. Direct fire-extinguishing agents Halon 1211 or CO\(_2\) into the tailpipe.
2. If fire is not extinguished by the above method, direct the stream of extinguisher agent into the intake duct.

---

**WARNING**

Do NOT stand directly in front of the intake duct.

---

**Hot Brakes**

During a normal or an emergency landing, the landing gear is an item of considerable concern. With the added weight and landing speeds of modern aircraft, and because of the extreme braking required on shorter runways, overheated brakes and wheels are a common occurrence. You, as a firefighter, must have a thorough understanding of the hazards created by overheated brakes, as well as the techniques and equipment used with this type of emergency.

Overheated aircraft wheels and tires present a potential explosion hazard because of built-up air pressure in the tires, which is greatly increased when fire is present. To avoid endangering the crews needlessly, all nonessential personnel should evacuate the area. The recommended procedure for cooling overheated wheel, brake, and tire assemblies is to park the aircraft in an isolated area and allow the assemblies to cool in the surrounding air. Using cooling agents, such as water, is not recommended unless absolutely necessary due to increased hazards to personnel near the overheated assembly. Most aircraft operating manuals for propeller-driven aircraft recommend that flight crews keep the propeller turning fast enough to provide an ample cooling airflow. Most major jet, propeller-driven, and turboprop aircraft now have fusible plugs incorporated in the wheel rims. These
fusible plugs are designed to automatically deflate the tires. (Failure of fusible plugs to function properly has occurred.) Releasing the tire pressure reduces the pressure on the wheel, and thus eliminates the possibility of explosion.

When responding to a wheel fire or hot brakes as a member of the emergency crew, you should approach the wheel with extreme caution in a fore or aft direction, never from the side in line with the axle. Peak temperatures may not be reached until 15 to 20 minutes after the aircraft has come to a complete stop. See Figures 13-17 and 13-18.

Figure 13-17 — Danger zones and attack zones in combating wheel fires. (Attack the fire from fore and aft—do not attack from the side).
Wheel Assembly Fires

The following types of fires and hazards may occur around an aircraft wheel assembly:

1. The heating of aircraft wheels and tires presents a potential explosion hazard, which is greatly increased when fire is present. The combination of increased stress on the brake wheel assembly, additional tire pressure, and the deterioration of components by heat may cause an explosion. This explosion is likely to propel pieces of the tire and/or metal through the air at high speeds.

   **CAUTION**

   The use of CO$_2$ for rapid cooling of a hot brake or wheel assembly is extremely dangerous. Explosive fracture may result because of the rapid change in temperature.

2. Materials that may contribute to wheel assembly fires are grease, hydraulic fluid, bearing lubricants, and tire rubber.
   
   a. Grease and bearing lubricant fires. When ignited, wheel grease fires can be identified by long flames around the wheel brake/axle assembly. These fires are usually small and should be extinguished quickly with Halon 1211 or water fog.
b. Rubber tires. Rubber from the tires may ignite at temperatures from 500 °F (260 °C) to 600 °F (315 °C) and can develop into an extremely hot and destructive fire. Halon 1211 or water fog should be used as early as possible to extinguish the fire. Reigniting may occur if the rubber sustains its autoignition temperature or if the rubber is abraded and the fire is deep-seated.

c. A broken hydraulic line may result in the misting of petroleum-based fluids onto a damaged or hot wheel assembly. Upon ignition, misting fluid will accelerate a fire, resulting in rapid fire growth and excessive damage to the aircraft if it is not extinguished rapidly.

The following safety information pertains to all aspects of wheel assembly firefighting operations:

- Rapid cooling may cause an explosive failure of a wheel assembly.
- When water fog is used on a wheel assembly fire, an intermittent application of short bursts (5 to 10 seconds) every 30 seconds should be used.
- The effectiveness of Halon 1211 may be severely reduced under extremely windy conditions if the Halon cannot be maintained on the fire source.
- You must take protective measures to prevent hydraulic fluid from coming into contact with the eyes. Seek medical attention immediately should the fluid come in contact with the eyes.
- Positive-pressure, self-contained breathing apparatus must be worn in fighting fires associated with hydraulic systems.
- Although Halon 1211 may extinguish hydraulic fluid fires, reigniting may occur because this agent lacks an adequate cooling effect.
- Because heat is transferred from the brake to the wheel, agent application should be concentrated on the brake area. The primary objective is to prevent the fire from spreading upward into wheel wells, wing, and fuselage areas.

**WARNING**

A broken hydraulic line that causes misting of petroleum-based fluids around an overheated brake assembly can cause a potentially dangerous and destructive fire. Intermittent application of water fog should be used to extinguish this type of wheel assembly fire. Rapid cooling of a hot inflated aircraft tire/wheel assembly presents an explosion hazard. Therefore, firefighting personnel must exercise good judgment and care to prevent injuries. The vaporized products of hydraulic fluid decomposition will cause severe irritation to the eyes and respiratory tract.
Review Questions

13-1. What is considered the fourth element necessary to sustain a fire?
   A. Chemical chain reaction
   B. Fuel
   C. Heat
   D. Oxygen

13-2. What word is defined as the lowest temperature at which its vapors can be ignited and will continue to burn?
   A. Exhaust point
   B. Fire point
   C. Flash point
   D. Vapor point

13-3. At what temperature will fuel spontaneously ignite?
   A. 300 °F
   B. 500 °F
   C. 700 °F
   D. 900 °F

13-4. Removing the fuel or combustible matter is doing what to a fire?
   A. Cooling
   B. Feeding
   C. Smothering
   D. Starving

13-5. Water in what form is very effective for firefighting purposes?
   A. Foam
   B. Fog
   C. Solid stream
   D. Straight stream

13-6. What fire-extinguishing agent is an inert gas and extinguishes fires by smothering them?
   A. AFFF
   B. CO₂
   C. Halon 1211
   D. PKP
13-7. What fire-extinguishing agent is a dry chemical principally used as a firefighting agent for flammable liquid fires?

A. AFFF
B. CO₂
C. Halon 1211
D. PKP

13-8. What fire-extinguishing agent is known chemically as bromochlorodifluoromethane, is colorless, and has a sweet smell?

A. AFFF
B. CO₂
C. Halon 1211
D. PKP

13-9. What size, in inches, are fireplug outlets?

A. 1¼ or 2¼
B. 1½ or 2½
C. 2¼ or 3¼
D. 2½ or 3½

13-10. How many gallons does a high-capacity AFFF system tank hold?

A. 200
B. 400
C. 600
D. 800

13-11. How many gallons per minute (gpm) flow from a 2 ½ inch vari-nozzle?

A. 150
B. 200
C. 250
D. 300

13-12. What firefighting vehicle is a diesel-powered, six-wheel-drive truck with an automatic transmission?

A. A/S32P-25
B. A/S33P-26
C. T-1000
D. T-3000
13-13. What firefighting vehicle is a 4-wheel (2-wheel drive), 6-cylinder, turbocharged, liquid-cooled, 24-volt, diesel-powered vehicle, with a hydrostatic drive system that transmits power to the rear wheels?

A. A/S32P-25  
B. A/S33P-26  
C. T-1000  
D. T-3000

13-14. How many feet per minute (fpm) is the rate of flame spread of aviation gasoline (AVGAS)?

A. 700 to 800  
B. 800 to 900  
C. 900 to 1000  
D. 1,000 to 1,100

13-15. What is the flash point of JP-4?

A. −5 °F  
B. −5 °C  
C. −10 °F  
D. −10 °C

13-16. The time to fuel tank failure (release of fuel) is dependent on the percent of fuel in the tank and ranges from what amount of time?

A. 28 seconds for a 10-percent load to 3 1/2 minutes for a 100-percent load  
B. 38 seconds for a 10-percent load to 4 1/2 minutes for a 100-percent load  
C. 1 minute for a 10-percent load to 6 1/2 minutes for a 100-percent load  
D. 3 minutes for a 10-percent load to 8 minutes for a 100-percent load

13-17. At what temperature does liquid oxygen boil into gaseous oxygen?

A. −55 °F  
B. −155 °C  
C. −200 °F  
D. −147 °C

13-18. What are the primary agents used to extinguish internal engine fires?

A. AFFF or water  
B. Halon 1211 or CO₂  
C. Halon 1211 or PKP  
D. PKP or CO₂

13-19. What are the primary agents used to extinguish electrical and electronic equipment fires?

A. PKP or water  
B. Halon 1211 or CO₂  
C. Halon 1211 or PKP  
D. PKP or CO₂
13-20. What are the primary agents used to extinguish rubber tire fires?

A. PKP or water
B. Halon 1211 or CO$_2$
C. Halon 1211 or PKP
D. Halon 1211 or water fog
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