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CHEMISTRY OF FIRE AND PREVENTION

DIGITAL EDITION

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CHEMISTRY OF FIRE AND PREVENTION

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Mariners Learning System™
Princeton, New Jersey

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Chemistry of Fire and Prevention

Introduction to Boat Fire Prevention and Susceptible Areas

Fire has the greatest single potential for disaster on a boat. The possibility of fire can never be completely eliminated and is always a threat.

Boat operators must be especially alert for fire, its possible causes, and areas on a boat that are susceptible to fire. There are some causes of fire more frequently encountered on boats. The skipper and crew should learn to be especially watchful for them.

Preventive Actions

In dealing with fire on a boat, the single most important consideration is prevention. During boat and equipment checks, all systems must be inspected including the fuel, oil system, and wiring. Crewmembers should check for abrasions, cracked wiring, loose connections, or pinholes in oil and fuel lines. Any discrepancy must be corrected at the time it is discovered.

The following are also good fire prevention measures for you to practice:

- Keep oil and grease out of bilges. Identify and correct any sources of fuel or oil leaks.
- Clean up any spilled fuel or lube oil immediately and properly dispose of it ashore.
- Stow cleaning materials off the boat.
- Keep all areas free of waste material.
- Use proper containers for flammable liquids.
- Be alert for suspicious odors and fumes, and vent all spaces thoroughly before starting engine(s).

Susceptible Areas

Spontaneous ignition (combustion) is often overlooked as a cause of fire aboard a boat. Many common materials are subject to this dangerous chemical reaction. Spontaneous ignition can easily occur aboard a boat when an oil or paint soaked rag is discarded in the corner of a compartment or engine room.

When an area is warm and there is no ventilation, oil on a rag begins to oxidize (to react chemically with the oxygen in the warm air around it). Oxidization is a natural process that produces heat. Heat produced by oxidization causes any remaining oil to oxidize even faster and produce still more heat.

Because the heat is not drawn away by ventilation, it builds up around a rag and causes it to get hot enough to burst into flames, after which it can ignite any nearby flammable substances and start a major fire. All of this occurs without any additional or outside source of heat. In this case, fire prevention is a matter of good housekeeping. Cleaning rags and waste should be stored in closed or sealed metal containers and discarded as soon as possible.

Engine Room Fires

Engine rooms are particularly vulnerable to electrical, fuel, and oil fires. There are several ways that engine room fires can readily start. Water spraying from ruptured seawater lines can cause severe short-circuiting and arcing in electric motors (alternators), electrical panels, and other exposed electrical equipment. This, in turn, can ignite insulation and nearby combustible materials. Even more serious than leaking seawater lines are ruptured fuel and oil lines near electrical equipment. All crewmembers must constantly monitor these lines for leaks.

Electrical System

The electrical system can short and cause a fire. These fires are typically small and easily controlled with either carbon dioxide (CO_2) or dry chemical (PKP) extinguishers.

Fuel Line

If fittings leak, fuel can drip onto a hot manifold and ignite. This situation could continue unnoticed for some time, allowing a major fire to develop when a manifold finally gets hot enough to ignite all leaked fuel.

Lube Oil Line

This line, if leaking or ruptured, will allow lube oil to spill onto a hot engine. As the burning lube oil collects on and around an engine, the engine's fuel supply line would probably be burned through. This would provide a fire with a continuous fuel supply, even after engines have been shut down. Fuel continuing to spill into the bilges, fires can spread and block access to the engine compartment, eventually leading to the development of a major fire.

Bilge Areas

Fire occurs in bilge areas because of fuel or oil accumulation. Most often, oil or gas leaks into bilges from an undetected break in a fuel or lube oil line. The oil vaporizes, and flammable vapors build up in and around bilge areas. Once these vapors are mixed with air in the right proportions, a spark can ignite them and cause a fire or explosion. Bilge fires can move very quickly around machinery and piping and are not easily controlled. They are more difficult to extinguish than most other types of engine room fires. Bilge areas should be watched closely. Oil in a bilge nearly always indicates a leak, and all fuel and lube oil lines should be checked until the leak is found.

An explosion is a common accident for boats when bilges are not properly ventilated before starting engines. A spark from "turning the key" can instantly ignite the trapped gas, creating a potentially deadly explosion.

Electrical Circuits and Equipment

With properly insulated and wired equipment, electricity is a safe and convenient source of power. However, when electrical equipment exceeds its useful life, is misused, or is improperly wired, it can convert electrical energy to heat. Equipment then becomes a source of ignition and a fire hazard. For this reason, electrical equipment must be installed, maintained, tested, and repaired in strict accordance with published regulations. Qualified personnel must complete all work on electrical equipment.

Replacement Parts and Equipment

Standard residential or industrial electrical equipment does not last very long at sea. The salt air causes corrosion, the boat's vibration breaks down the equipment, and a steel hull can cause erratic operation or a shorted circuit. As a result, equipment or its wiring may overheat or arc, causing a fire when flammable materials are located nearby. For this reason, only approved replacement parts and equipment should be installed aboard small boats. Given proper maintenance, these parts and equipment are designed to withstand the strenuous conditions encountered at sea.

When a fuse or circuit breaker in a particular circuit is too large, a circuit will not "break" when overloaded. Instead, increased current will continue, a circuit will overheat, and eventually insulation will burn and may ignite other combustible material in the vicinity.

Wiring and Fuses

Insulation on electrical wiring will not last forever. With age and use, it can become brittle and crack. It may be rubbed (chafed) through or broken by abuse or by the vibration of a boat. Once insulation is broken, bare wires may be exposed and are dangerous. A single exposed wire can arc to any metal object. If multiple wires are exposed, they can touch each other and cause a short circuit. Either condition could produce enough heat to ignite insulation on wiring or some other flammable material nearby. Replacing wires that have faulty or worn insulation can prevent this type of fire. Install only fuses and circuit breakers of the proper size for their circuits.

"Jury-rigging" of electrical panels to serve additional equipment is a dangerous practice. Wiring in every electrical circuit is designed to carry a specified maximum load. When circuit wiring is overloaded with too many pieces of operating equipment, in addition to possibly damaging the equipment, it can overheat and burn its insulation. Hot wiring can also ignite flammable materials in surrounding areas.

Electrical Motors

Faulty electric motors are major causes of fire. Problems may result when a motor is not properly maintained or when it exceeds its useful life. A motor requires regular inspection, testing, lubrication, and cleaning. Sparks and arcing can result if a winding becomes short-circuited or grounded or if the brushes do not operate smoothly. If a spark or an arc is strong enough, it can ignite nearby combustible material. Lack of lubrication may cause the motor bearings to overheat, with the same result.

Charging Batteries

When batteries are charging, they emit hydrogen, a highly flammable gas that is potentially explosive. Hydrogen is lighter than air and will rise as it is produced. If sufficient ventilation is not available at the highest point above where a battery is being charged, hydrogen will collect at the overhead. Then, any source of ignition will cause an explosion and fire.

Battery gases are highly explosive. Never smoke around a battery and never disconnect, change out, or perform maintenance on a battery until the surrounding space has been thoroughly ventilated.

Introduction to Fire Theory, Classifications, and Fuel Sources

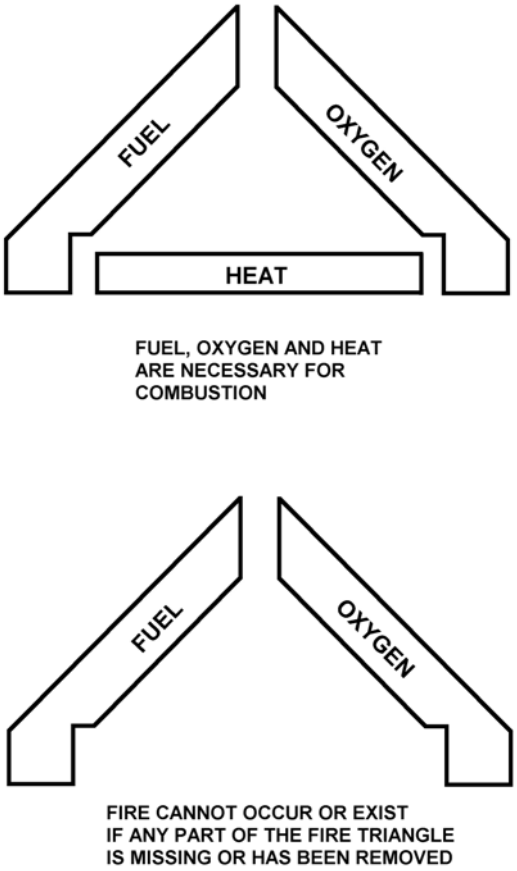
As a boat captain, it is important to understand the theory of fire, the different classifications of fire, and the types of fuel that perpetuate fires. This knowledge will enable you to identify the precautions, equipment, and extinguishing agents required to successfully fight fires.

Fire Theory

Fire is a chemical reaction known as combustion. It is defined as rapid oxidation of combustible material accompanied by a release of energy in the form of heat and light.

• Fire Triangle

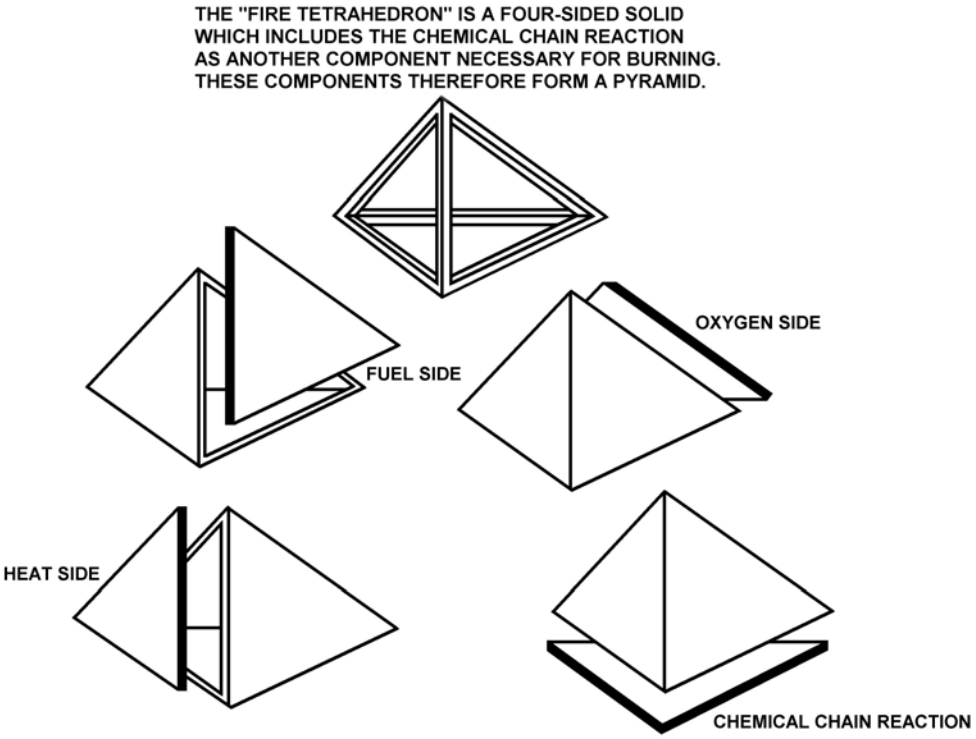
For years, a 3-sided figure called the fire triangle has been used to describe the combustion and extinguishing theory. This theory states that proper proportions of oxygen, heat, and fuel are required for a fire. If any one of the 3 elements is removed, a fire will cease to exist.



Fire triangle

• Fire Tetrahedron

A new theory has been developed to further explain fire combustion and extinguishment. This theory can be represented by a 4-sided geometric figure, a tetrahedron. The base of this figure represents a chemical reaction. The 3 standing sides of the figure represent heat, oxygen, and fuel. Removing one or more of the 4 sides will make a tetrahedron incomplete and cause a fire to be extinguished.



Fire tetrahedron

Heat Transmission

Fire spreads or extends to wider boundaries and to adjacent areas by one or more of the three physical phenomena that transmit heat: radiation, conduction, or convection.

• Radiation

Heat energy travels through space in direct heat rays, equally in all directions. There does not need to be direct physical contact between the fire and the decks, bulkheads, or other surfaces that are heated by radiation. The radiated heat is absorbed as it passes through these barriers. Radiation heat will ignite combustibles on the opposite side of exposed decks and bulkheads.

• Conduction

In conduction, heat is transmitted through solids, liquids, and gases. This is the process in which molecules of a substance are heated by molecules with a higher temperature than those they are in direct contact with.

• Convection

Portions of gases and liquids that are heated to a higher temperature than the rest of the mass become lighter in weight and move upwards into the cooler portions of the space above. Heated air and other heated gases rise over a fire by convection, are carried by the wind, and can ignite combustibles at some distance away. From a practical aspect, this process directly affects ventilation systems that can carry the heated gases to places far removed from the fire.

Classification of Fires and Fuel Sources

- ### Class A

  A Class A fire involves common combustible materials. Fuel sources in this class include wood and wood-based materials, cloth, paper, rubber, and certain plastics.

  Class A fires are best extinguished by quenching and cooling effects of large quantities of water, water fog, or solutions containing large amounts of water.

- ### Class B

  A Class B fire involves flammable or combustible liquids, flammable gases, greases, and similar products. Fuel sources within this class include petroleum products.

  In these fires, the blanketing or smothering effect of the extinguishing agent is of primary importance.

- ### Class C

  A Class C fire involves energized electrical equipment, conductors, or appliances.

  Here the extinguishing agents must not conduct electricity so that electrical shock does not become an unexpected factor in firefighting.

- ### Class D

  A Class D fire involves combustible metals. Fuel sources within this class include sodium, potassium, magnesium, and titanium.

  Use only the specifically recommended extinguishing agents to put out this type of fire.

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