Firefighting and Fire Prevention for Industrial Facilities

An Online Continuing Education Course for Engineers

Course Number: M-2071

Credit: 2 Hours / 2 PDH / 2 CPD

Firefighting and Fire Prevention for Industrial Facilities

Introduction

Operations and maintenance personnel working in industrial facilities are not presumed to be firefighters, but occasionally their duties may make it necessary for them to fight fires. This course provides basic information on fire prevention and firefighting methods for industrial facilities, including the selection, use, care, and testing of firefighting equipment.

The information in this course is intended as a companion and supplement to Subpart L, Fire Protection, part 1910 of Title 29 of the Code of Federal Regulations (Occupational Safety and Health Administration), which prescribes the requirements for fire brigades, and all portable and fixed fire suppression equipment, fire detection systems, and fire or employee alarm systems for all employments except for maritime, construction, and agriculture.

I. Chemistry of Fire

1.1. Mechanics of Combustion. From casual observation of a simple wood fire, it seems that the wood itself is burning. Actually, only the vapors given off by it supply the fuel that feeds the flames. Nearly all combustible materials, whether in a liquid or solid state, give off vapors when heated. Even paper, which is not ordinarily regarded as vapor producing, when heated gives off vapors which can be burned at some distance from the paper itself. Most solids must first be converted into a liquid state before vaporization takes place. Paraffin, for example, turns to a liquid before vaporization – as can be seen when a candle burns. The ignited wick melts the paraffin into a liquid, and the liquid flows into the wick and gives off vapor to feed the flame.

1.2. Flashpoint. Almost all oils must be heated until a vapor is given off before burning can take place. The temperature at which an oil begins to give off vapors that can be ignited is known as the flashpoint. Most lubricating oils must be heated to over 149℃ (300℉) before they will flash. However, more highly volatile liquids such as gasoline, alcohol, naphtha, etc., have flashpoints so low they can be ignited readily at room temperature. The fire hazards that these liquids present are due to the fact that even at low temperatures they are constantly giving off highly flammable vapors.

The flashpoint of gasoline is -43°C (-45°F), and while the ever-present vapors are not visible to the naked eye, they may be observed by means of a shadow image produced by a powerful light. The flashpoint of a liquid, however, should not be confused with the temperature necessary to ignite the vapors, for unless a source of heat considerably hotter than the flashpoint of the fuel comes into direct contact with the vapors, the fuel will merely continue to give off vapors without burning.

1.3. Oxygen Required for Combustion. The second essential factor in the process of combustion is oxygen. Without oxygen, even the most flammable vapors will not burn. Under normal conditions, a flame draws the amount of oxygen necessary to sustain combustion from the air. When the oxygen content of the air falls from the normal of 21% to below 15%, there is immediate extinguishment of practically all flames.

The part that oxygen plays in supporting combustion is illustrated in a cutting torch. When only the acetylene gas is used, there is no cutting effect on the metal, but when the oxygen valve is opened the torch readily cuts through the metal on which it is being used. Under normal conditions, the oxygen in the air combines with the combustible vapor in direct proportion to sustain combustion. With the regulated flow of vapor in an open space, the ready mixture of the two elements is evidenced. The greater the flow of vapor, the greater the mixture with oxygen and the larger the flame. This action is caused by the heat of the flame. The hot-air currents rising from the flame create a draft suction that draws a steady flow of oxygen into the flame area.

With fuel at its flashpoint and vapors combining readily with air, the mixture may be regarded as in a state of readiness. Combustion, however, cannot occur until further heat is applied. An electric spark in some cases, or the heat of an open flame in others may furnish this needed heat.

1.4. Ignition Temperature. There is a wide temperature difference between the flashpoint of a fuel and the ignition temperature; for example, the flashpoint (vapor given off) of gasoline is -43°C (-45°F), and the ignition temperature (heat necessary to ignite the mixture) is 257°C (495°F). A small flame can be thrown into lube oil which is at average room temperature and it will not burn, but with the addition of burning gasoline, vapors soon rise and burn to raise the temperature of the surrounding oil to the flashpoint. The rate of burning is governed by the surface area; i.e., only the fuel coming into contact with the air is consumed. The greater the surface area, the more readily oxygen reaches the vapors. The surface area of a material in proportion to its volume affects the readiness with which it will ignite. For example, if you cut two identical blocks of wood from the same piece of timber and reduce one of them to a pile of shavings, this greatly increases the surface area of the material; when a lighted match is placed against the solid block, it merely chars and absorbs the heat, while the same flame readily ignites the shavings.

1.5. Fire Triangle. The starting of a fire involves three elements: fuel, oxygen, and ignition temperatures. These elements may be compared to the three legs of a triangle (fig. 1), for fire cannot occur until all three are brought together.

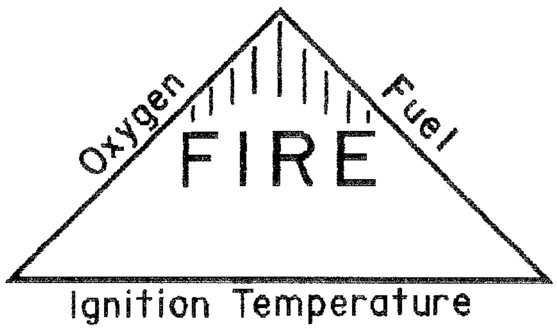


Figure 1. Fire triangle

The following is a common cause of fires in terms of the fire triangle. A cigarette is carelessly discarded and comes to rest on a scrap of paper. The heat of the glowing cigarette is sufficient to cause the fuel in this case, the paper (with a low ignition temperature) to give off vapor. Oxygen is present, and when the vapors are given off in sufficient quantity the mixture ignites - the cigarette being hot enough to supply the ignition temperature. Because of the relatively large surface area, the fire spreads rapidly and grows in intensity, building up higher temperatures, causing more and more vapors to be given off. The heat of the flame causes the hot air to rise, drawing in additional oxygen to combine with the vapors and feed the flames.

Referring to the fire triangle, to extinguish a fire, it is necessary to break up the triangle by taking away any one if its sides. This may be accomplished in various ways, as will be pointed out in the following sections.

II. Classification of Fires

2.1. Definition and Types. Classification of fires is the systematic arrangement in classes of the various substances that as fuels produce heat by combustion, as follows:

2.1.1. Class A: Ordinary combustible materials such as wood, cloth, paper, and some rubber and plastic materials.

2.1.2. Class B: Flammable liquids, gases, greases, and some rubber and plastic materials.

Flammable or inflammable (identical in meaning) liquids do not themselves burn or explode, but, as pointed out previously, the gases or vapors formed when they are heated and evaporated explode; that is, the change of state from liquid to gas must first occur. As long as they are in a liquid state with no vapors being given off, there is little or no hazard. For the more volatile liquids, such as gasoline, storage in a closed container is a necessity. In order for any vapor to explode, it must have the correct vapor-air ratio, just as in the carburetor of a car. When the engine is flooded with gas, the mixture is too rich and fails to ignite. The same holds true in gasoline storage. The danger is when the gasoline is being poured from one container to another, thus giving the vapors the change to mix with the correct amount of air to form an explosive mixture. The same circumstances hold true with all flammable oils when enough heat is present to release vapors from the liquid.

Keeping in mind that a flammable liquid is not hazardous as long as it is not hot enough to give off vapors which can mix with the oxygen in air and burn, two things can be done: (a) The liquid can be cooled down to the point where no vapors are given off; and (b) the supply of oxygen can be blanketed out. Some flammable liquids give off vapors at temperatures ordinarily considered cold. For example, gasoline vaporizes at -43°C (-45°F) or lower.

2.1.3. Class C: Live electrical equipment.

When equipment is deenergized, extinguishers for class A or B fires could be used safely; however, in fighting an electrical fire there are two important things to be taken into consideration: namely (a) damage to the equipment far beyond what the fire could do, and (b) danger to the individuals fighting the fire. To avoid these two possibilities, deenergize the circuit and use only the types of extinguishment recommended for class C fires.

2.1.4. Class D: Combustible metals such as magnesium, titanium, sodium, potassium, lithium, and zirconium.

III. Portable Fire Extinguishers

3.1. Types and Usage. All extinguishers of a portable type act as a "first-aid" appliance for extinguishing fires in their incipient stage, and they cannot be expected to be effective after a fire has spread to involve a large amount of combustible material. The action of all extinguishers is by cooling the burning substance below its ignition temperature or by excluding the air supply (blanketing out the oxygen), or by a combination of these methods. Also, some types tend to inhibit oxidation by chemical action.

3.1.1. Extinguishers for Class A Fires.

- ✓ Multipurpose dry chemical
- ✓ Foam extinguishers
- ✓ Loaded stream extinguishers

3.1.2. Extinguishers for Class B Fires.

- ✓ Multipurpose dry chemical
- ✓ Foam
- ✓ Carbon dioxide (CO_2) Dry chemicals
- ✓ Loaded stream extinguishers
- ✓ Bromotrifluoromethane Halon 1301

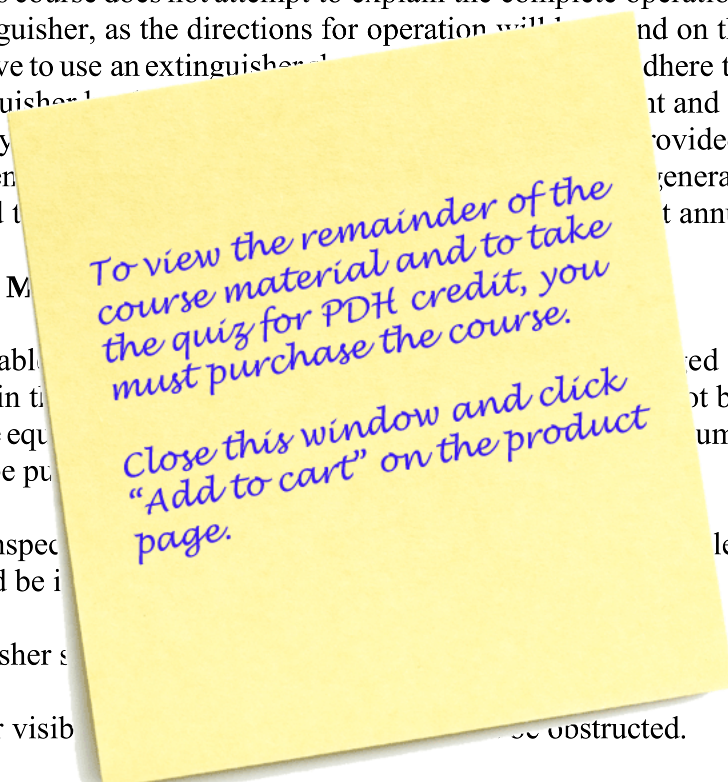
3.1.3. Extinguishers for Class C Fires.

- ✓ Multipurpose dry chemical
- ✓ Bromotrifluoromethane Halon 1301
- ✓ Carbon dioxide (CO_2) Dry chemicals

3.1.4. Extinguishers for Class D Fires.

Extinguishers or extinguishing agents for class D fires shall be types approved for use on the specific combustible metal.

3.2. Operation. This course does not attempt to explain the complete operation of each individual fire extinguisher, as the directions for operation will ... nd on the equipment. All persons who may have to use an extinguisher ... dhere to the instructions placed on the extinguisher ... nt and at least annually thereafter, all employ... rovided training in the use of such equipmen... general principles of fire-extinguisher use and t... t annually.



3.3. Inspection and M...

3.3.1. General. Portabl... ed and operable condition, and kept in t... t being used. Each extinguisher must be equ... uminum tags on which the date can be pu...

3.3.2. Inspection. Inspec... le and will operate. Extinguishers should be i...

(1) The extinguisher ...

(2) Access to, or visib... obstructed.

(3) The operating instructions on the extinguisher nameplate shall be legible and face outward.

(4) Any seals or tamper indicators that are broken or missing shall be replaced.

(5) For water types without gauges, their fullness shall be determined by "hefting."

(6) Any obvious physical damage, corrosion, leakage, or clogged nozzles shall be noted.

(7) Pressure-gauge readings, when not in the operable range, shall be noted.