Chapter 5

FIRE-FIGHTING

This Chapter describes the types of fire that may be encountered on a tanker or at a terminal, together with the means of extinguishing them. Descriptions of fire-fighting equipment to be found on tankers and in terminals are provided in Chapters 8 and 19 respectively.

5.1 Theory of Fire-Fighting

Fire requires a combination of fuel, oxygen, a source of ignition and a continuous chemical reaction, commonly referred to as combustion.

Fires are extinguished by the removal of heat, fuel or air, or by interrupting the chemical reaction of combustion. The main objective of fire-fighting is to reduce the temperature, remove the fuel, exclude the supply of air or interfere chemically with the combustion process with the greatest possible speed.

5.2 Types of Fire and Appropriate Extinguishing Agents

The classification of fires given below conforms to the European Standard EN 2. Alternative classifications may be used elsewhere.

5.2.1 Class A - Fires Involving Solid Materials, Usually of an Organic Nature, in which Combustion Normally Takes Place with the Formation of Glowing Embers

Class A fires are those involving solid cellulosic materials such as wood, rags, cloth, paper, cardboard, clothing, bedding, rope and other materials such as plastic etc.

Cooling by large quantities of water, or the use of extinguishing agents containing a large proportion of water, is of primary importance when fighting fires involving ordinary combustible material. Class A materials can support deep-seated and smouldering fires long after visible flames are extinguished. Therefore, cooling the source and surrounding area should continue long enough to ensure that no re-ignition of deep-seated fires is possible.

5.2.2 Class B - Fires Involving Liquids or Liquefiable Solids

Class B fires are those that occur in the vapour/air mixture over the surface of flammable and combustible liquids such as crude oil, gasoline, petrochemicals, fuel and lubricating oils, and other hydrocarbon liquids as well as liquefiable solids, such as tar, wax and many plastics.

These fires are extinguished by isolating the source of fuel (stopping the flow of fuel), inhibiting the release of combustible vapours or by interrupting the chemical reaction of the combustion process. Since most Class B materials burn with greater intensity and re-ignite more readily than Class A materials, more effective extinguishing agents are generally required.

Low expansion foam, defined and discussed in Section 5.3.2.1, is an effective agent for extinguishing most hydrocarbon liquid fires. It should be applied so as to flow evenly and progressively over the burning surface, avoiding undue agitation and submergence. This can best be achieved by directing the foam discharge against any vertical surface adjacent to the fire, both in order to break the force of discharge and to build up an unbroken smothering blanket. If there is no vertical surface, the discharge should be advanced in oscillating sweeps, in the direction of the wind when possible, taking care to avoid foam plunging into the liquid. Foam spray streams, while limited in range, are also effective.

Volatile liquid fires of limited size can be rapidly extinguished with dry chemical agents, but are subject to re-ignition when hot surfaces are in contact with flammable vapours.

Non-volatile liquid fires that have not been burning for an extended period can be extinguished by water fog or water spray if the whole burning surface is accessible. The surface of the burning oil transfers its heat rapidly to water droplets, which present a very large cooling surface area. The flame can be extinguished with advancing and oscillating sweeps of fog or spray across the complete width of the fire. Any oil fire that has been burning for some time is more difficult to extinguish with water, since the oil will have been heated to a progressively greater depth and cannot readily be cooled to a point where it ceases to give off gas.

Water should only be applied to oil fires as a spray or fog. The use of a water jet may spread the burning oil by splashing or overflow.

An aspect that must be borne in mind with liquid petroleum is the risk of re-ignition, so a continuing watch and preparedness should be maintained after the fire has been extinguished.

5.2.3 Class C - Fires Involving Gases

Class C fires involve natural gas, liquid petroleum gases and industrial gases.

5.2.4 Class D - Fires Involving Metals

Class D fires involve combustible metals or powdered metals such as magnesium, titanium, potassium and sodium. These metals burn at high temperatures and react violently with water, air and/or other chemicals. Fire extinguishers for use on Class D fires do not have a multi-purpose rating and must match the type of metal involved. Extinguishers rated for Class D fires have a label listing the metals that the extinguisher can be used on.

5.2.5 Class F - Fires Involving Cooking Media (Vegetable or Animal Oils and Fats) in Cooking Appliances

Class F fires involve high temperature cooking oils used in large catering kitchens etc. Conventional extinguishers are not effective for cooking oil fires, as they do not cool sufficiently or may even cause flash back, thereby putting the operator at risk.

5.2.6 Electrical Equipment Fires

These fires involve energised electrical equipment. They may be caused by a short circuit, overheating of circuits or equipment, lightning or fire spread from other areas. The immediate action should be to de-energise the electrical equipment. Once de-energised, a non-conductive extinguishing agent such as carbon dioxide should be used. Dry chemical is an effective non-conductive extinguishing agent, but is difficult to clean up after use. If the equipment cannot be de-energised, it is vital that a non-conductive agent be used.

Electrical fires are not considered to constitute a fire class on their own, as electricity is a source of ignition that will feed the fire until removed.

5.3 Extinguishing Agents

Extinguishing agents act by heat removal (cooling), by smothering (oxygen exclusion) or by flame inhibition (interfering chemically with the combustion process).

5.3.1 Cooling Agents

5.3.1.1 Water

The direct application of a water jet onto a fire is an effective fire-fighting method for Class A fires only. A wetting agent added to water may reduce the amount of water needed to extinguish fires in tightly packed Class A materials as it increases the effective penetration of water by lowering its surface tension.

For fires involving hydrocarbon liquids, water is used primarily to minimise escalation of a fire by cooling exposed surfaces. Water spray and water fog may be used for making a heat screen between the fire and fire-fighting personnel and equipment. If foam is not available, a water mist can be used to extinguish fires involving shallow pools of heavy oil.

Water in any form should not be applied to fires involving hot cooking oil or fat since it may cause the fire to spread.

Concentrated water streams should not be directed at fires involving liquefied gas as this will increase the hazard by increasing vapour cloud size as more cargo liquid is vaporised. However, water spray or water fog can be used on liquefied gas fires and spills. It will cool the area and control fire intensity as well as enhance vapour cloud dispersion.

Water jets should not be directed at energised electrical equipment as this could provide a path for electricity from the equipment with consequent danger of electric shock to fire-fighting personnel.

5.3.1.2 Foam

Foam has a limited heat absorbing effect and should not normally be used for cooling.

5.3.2 Smothering Agents

5.3.2.1 Foam

The primary extinguishing action of foam is by smothering. Foam is an aggregation of small bubbles, of lower specific gravity than oil or water, which flows across the surface of a burning liquid and forms a coherent smothering blanket. A good foam blanket seals against flammable vapour loss, provides some cooling of the fuel surface by the absorption of heat, isolates the fuel surface from the oxygen supply, and separates the flammable vapour layer from other ignition sources (e.g. flames or extremely hot metal surfaces), thereby eliminating combustion. A good foam blanket will resist disruption due to wind and draught, or heat and flame impingement, and will reseal when its surface is broken or disturbed. Foam is an electrical conductor and should not be applied to energised electrical equipment.

There are several different types of foam concentrate available. These include standard protein foam, fluoro-protein foams and synthetic concentrates. The synthetics are divided into Aqueous Film Forming Foam (AFFF) for normal use, and hydrocarbon surfactant-type foam concentrates for use with alcohols and fuels blended with significant quantities of alcohol (AR-AFFF). Normally, the protein, fluoro-protein and AFFF concentrates are used at 3 - 6% by volume concentration in water. The hydrocarbon surfactant type concentrates are available for use at 1 - 6% by volume concentrations.

Alcohol-Resistant Aqueous Film-Forming Foam (AR-AFFF) creates a physical, polymer-membrane barrier between the foam blanket and the fuel surface. AR-AFFF suppresses Class B hydrocarbon fires (diesel, gasoline, kerosene, etc.) and polar solvent/water-miscible fuel fires (alcohol (e.g. methanol, ethanol), ketones and ethers (e.g. MTBE / ETBE products)). In addition, AR-AFFF suppresses the hazardous vapours emitted from fires or spills of these materials.

High expansion foam, made from hydrocarbon surfactant concentrates, is available, with expansion ratios from about 200:1 to 1,000:1. A foam generator, which may be fixed or mobile, sprays foam solution onto a fine mesh net through which air is driven by a fan. High expansion foam has limited uses. It is most often used to rapidly fill an enclosed space to extinguish a fire by displacing free air in the compartment. High expansion foam is generally unsuitable for use in outside locations as it cannot readily be directed onto a hot unconfined spill fire and is quickly dispersed in light winds.

High expansion foam systems are being enhanced with the introduction of a new development called “Hot Foam”, which is now being increasingly used on tankers as a replacement for halon.

Medium expansion foam has an expansion ratio from about 15:1 to 150:1. It is made from the same concentrates as high expansion foam, but its aeration does not require a fan. Portable applicators can be used to deliver considerable quantities of foam onto spill fires, but their throw is limited and the foam is liable to be dispersed in moderate winds.

Low expansion foam has an expansion ratio from about 3:1 to about 15:1. It is made from protein-based or synthetic concentrates and can be applied to spill or tank fires from fixed monitors or portable applicators. Good throw is possible and the foam is resistant to wind.

Foam applicators should be directed away from liquid petroleum fires until any water in the system has been flushed clear.

Foam should not come into contact with any electrical equipment.

The various foam concentrates are basically incompatible with each other and should not be mixed in storage. However, some foams separately generated with these concentrates are compatible when applied to a fire in sequence or simultaneously. The majority of foam concentrates can be used in conventional foam making devices suitable for producing protein foams. The systems should be thoroughly flushed out and cleaned before changing agents, as the synthetic concentrates may dislodge sediment and block the proportioning equipment.

Some of the foams produced from concentrates are compatible with dry chemical powder and are suitable for combined use. The degree of compatibility between the various foams, and between the different foams and dry chemical agents, varies and should be established by suitable tests.

The compatibility of foam compounds is a factor to be borne in mind when considering joint operations with other fire-fighters.

Foam concentrates may deteriorate with time depending on the storage conditions. Storage at high temperatures and in contact with air will cause sludge and sediment to form. This may affect the extinguishing ability of the expanded foam. Samples of the foam concentrate should therefore be returned periodically to the manufacturer for testing and evaluation.

5.3.2.2 Carbon Dioxide

Carbon dioxide is an effective smothering agent for extinguishing fires in enclosed spaces where it will not be widely diffused and where personnel can be evacuated quickly (e.g. machinery spaces, pumprooms and electrical switchboard rooms). Carbon dioxide is comparatively ineffective on an open deck or jetty area.

Carbon dioxide will not damage delicate machinery or instruments and, being a non-conductor, can be used safely on or around electrical equipment even when it is energised.

Due to the possibility of static electricity generation, carbon dioxide should not be injected into any space containing an un-ignited flammable atmosphere.

Carbon dioxide is asphyxiating and cannot be detected by sight or smell. All personnel should therefore evacuate the area before carbon dioxide is discharged. No one should then enter confined or partially confined spaces where carbon dioxide has been discharged unless supervised and protected by suitable breathing apparatus and a lifeline. Canister type respirators should not be used. Any compartment that has been flooded with carbon dioxide must be fully ventilated and checked for sufficient oxygen before entry without breathing apparatus.

5.3.2.3 Steam

Steam is inefficient as a total smothering agent because of the substantial delay that may occur before sufficient air is displaced from an enclosure to render the atmosphere incapable of supporting combustion. Steam should not be injected into any space containing an un-ignited flammable atmosphere due to the possibility of static electricity generation. However, steam can be effective for fighting flange or similar fires when discharged from a lance type nozzle directly at a flange or joint leak, or a vent or similar fire.

5.3.2.4 Sand

Sand is relatively ineffective as an extinguishing agent and is only useful for small fires on hard surfaces. Its primary use is to dry up small spills.

5.3.3 Flame Inhibiting Agents

Flame inhibitors are materials that interfere chemically with the combustion process and thereby extinguish the flames. However, cooling and removal of fuel is also necessary if re-ignition is to be prevented.

5.3.3.1 Dry Chemical

Dry chemical, as a flame inhibitor, is a material that extinguishes the flames of a fire by interfering chemically with the combustion process. Dry chemicals have a negligible cooling effect and, if re-ignition due to the presence of hot metal surfaces is to be prevented, the fuel must be removed or cooled using water.

Certain types of dry chemical can cause the breakdown of a foam blanket and only those labelled as being foam compatible should be used in conjunction with foam.

Dry chemical may be discharged from an extinguisher, a hose reel nozzle, a fire truck monitor, or a fixed system of nozzles as a free flowing cloud. It is most effective in dealing with a fire resulting from an oil spill by providing rapid fire knock-down, and can also be used in confined spaces where protection against the inhalation of powder may be necessary. It is especially useful on burning liquids escaping from leaking pipelines and joints. It is a non-conductor and is suitable therefore for dealing with electrical fires. It must be directed into the flames.

Dry chemical clogs and becomes unusable if it is allowed to become damp when stored or when extinguishers are being filled.

Dry chemical is prone to settlement and compaction caused by vibration. Maintenance procedures should include a schedule for inverting or rolling the extinguishers to keep the dry chemical powder in a free flowing state.

5.3.3.2 Vaporising Liquids

Vaporising liquids, in the same way as dry chemical powder, have a flame inhibiting and also a slight smothering effect.

5.4 Fire Detection Systems

Fixed fire detection systems in combination with an alarm station are recommended and should be tested on a regular basis. See also Chapter 8 and Chapter 19.

5.5 General Precautions

For the use of fixed fire gas extinguishing systems, the following precautions are recommended:

- All personnel have to be evacuated from the space where the fire is.
- Before activating the system, ventilators must be stopped.
- All ventilation inlets must be closed.

It must be born in mind that any fixed fire gas extinguishing system can be used only once!

Take sufficient time before opening any space after the fire is extinguished. Be aware that, once air has been re-introduced into the space, re-ignition of the fire might be possible.

After the use of fixed fire gas extinguishing systems the following precautions are recommended:

- Before entering the space, sufficient ventilation must be performed.
- Oxygen concentration should be tested.
- Any significant presence of toxic gases should be tested.
- Procedures for entry into enclosed spaces must be followed.

Tanker crews should be familiar and trained in the use of fixed fire gas extinguishing systems and the system should be subject to periodical testing. The system should be periodically examined by a competent and certified company.