SETRAC COLLEGE OF OFFSHORE TRAINING

ADVANCED FIRE FIGHTING

TRAINEE HANDOUT

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ADVANCED FIRE FIGHTING

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CHAPTER – 1

INTRODUCTION, SAFETY & PRINCIPLES

Introduction

1. Fire can sustain life but fire can also destroy and is the biggest hazard onboard a ship. Any ship may have a fire at any time and at any place on board a ship due to a large number of reasons. Once a fire breaks out, it has a tendency to spread and multiply at a tremendous speed. And in a short time, a small fire may take the shape of a big fire which may be beyond the capacity of the ships personnel and the fire fighting equipment held/installed on board. A ship is not a fire brigade or a fire station as in the case ashore. Also the mobility of the ship's personnel as well as the equipment is restricted. Therefore any fire fighting plan which may sound perfect on paper and timed but in actual execution, the time factor goes out of control despite best intentions of the ship's personnel onboard.

2. Fire in a kitchen to cook or in a pyre at a crematorium is essential and intentional but unwanted and unintentional fire on board a ship or ashore can lead to death and destruction. Controlled fire is useful as in a diesel / petrol engine but uncontrolled fire is always fatal as on board passenger ship "SS SUN VISTA" in 1998, "UPHAR CINEMA" in Delhi, cracker shop fire at Sonepat, semi-conductor complex fire at Mohali, Punjab. Therefore all unwanted fires on board ships have to be taken very seriously. Safety of life, cargo and the ship against fire hazards have to be ensured. To prevent or to fight fire, we don't have to think of experts or consultants. Awareness, fire safety consciousness, education on fire prevention, fire detection, fire protection and fire-fighting is the best safe guard. Every person on board a ship must be made accountable for any unwanted fire, howsoever minor it may be, in and around the accommodation and working areas.

3. Knowledge, skill, experience and positive attitude are the most powerful tools in preventing and fighting fire. Proper housekeeping on board, provision of first aid and fire fighting appliances, training of officers and crew in use of appropriate type of extinguisher, correct loading and discharging operations, safe wielding and cutting operations and action to be taken in case of fire, organising regular drills and training, comprehensive standing fire orders for fire prevention and fire fighting are the basics of fire safety. There is a novel acronym for fire – find, inform, restrict, extinguish.

4. A Fire takes place on board usually when least expected and at places which are manned minimum or not manned at all. The most crucial periods of fire are afternoons when most of the personnel rest after lunch or at night when all operation areas are manned by bare minimum crew/watch keepers.

5. Therefore, it is essential that when ever there is a fire at any place on board, it must be detected in time/immediately before it can spread. For this, of course a large number of various types of detectors (which we will study in detail during this course) are installed at most of the fire prone areas, which raise fire alarms on sensing smoke/flame/heat. However, human beings are gifted with the most sophisticated sensor – the nose, which can smell the fire/smoke even before the detectors, if the person is alert and within the reasonable distance from the fire/smoke.

6. The ideal state on board is to have no fire i.e. to prevent fire no matter what operations

the vessel is required to carry out. We will discuss these also in detail during the course on how to prevent fire.

7. However, once a fire breaks out, there will be heat and smoke. In addition, there may be toxic / pungent / poisonous gases depending upon what flammable substance is on fire. These gases could be Carbon Monoxide (CO), Sulphur Dioxide (SO_2), Hydrogen Sulphide (H_2S), Nitrogen Oxide (NO), Chlorine (Cl), Florien (F), etc. Also there will be maximum Carbon Dioxide (CO_2) which will always be produced whenever there is any fire due to carbon (present in every flammable substance) converting to carbon dioxide (CO_2) due to oxidation during burning.

8. Even an ordinary fire in an enclosed space on board a ship, which will result only in non poisonous carbon dioxide (CO_2) is dangerous because CO2 does not support life. 9% concentration of CO_2 in an enclosed space can prove fatal. CO_2 produced due to fire takes away oxygen (O_2) from the surroundings and in due course, the concentration of CO_2 keeps increasing while the concentration of O_2 keeps decreasing.

9. A fire in accommodation spaces will cause the air to heat up. The hot gases will rise and will spread the fire in form of hot layers / waves by convection. These hot waves of air can spread the fire throughout the accommodation spaces in no time as the hot air waves full of smoke will put more spaces on fire. The smoke generated will make visibility very poor. Smoke suffocates and causes irritation in the eyes, throat and lungs. The heat and smoke in a place can make a person panic and helpless and will force a person to flee to save his life instead of resorting to fire fighting. Once a fire has taken place in an enclosed space, there is no doubt that it can be fought or extinguished with proper fire protection clothing and CABA (Compressed Air Breathing Apparatus) sets along with suitable fire extinguishing agent/s.

10. Therefore, it is better to ensure that there is no fire than fighting the fire. Fire prevention is easier than fire fighting. Besides your normal duties on board, your main duty is also to ensure that there is no fire. When we think of fire, 95% of our job is to prevent the fire and only 5% is to fight the fire. However, once a fire breaks out, your 100% job is to fight and extinguish the fire with minimum damage to the cargo/machinery/equipment by using suitable fire fighting agents.

11. Preventing, Detecting, Protecting and Fire Fighting on board ships is a continuous brain storming exercise in safe methods for the storage of inflammable and other hazardous materials, handling and maintenance of fire extinguishing systems and devices and alarms systems. There are some useful skills required in a seafarer amongst which are mechanical aptitude, endurance, strength and sense of service. Other useful qualities are a sense of self discipline and responsibility, peak physical fitness, mental alertness and presence of mind to handle crisis, calmness of mind under potentially dangerous circumstances, the ability to lead crew, to motivate them, supervise and guide them in the discharge of their duties. Ability to plan for all eventualities in fire fighting and constant updating of knowledge of techniques, devices, materials and regulations are the hallmarks of an ideal deck / engineer officer. It may be necessary to handle a panic stricken crew and to work as a team. Love for the living and strong urge to preserve life are very important for a merchant marine officer, because members of the crew work closely together under conditions of stress and danger. They should be dependable and able to get along well with others in a group. Leadership qualities are essential for officers who must establish and maintain discipline and efficiency as well as direct the activities of all fighting a fire on board a ship. A positive, cheerful, smiling but sober attitude is good for all. From the attitude of an individual, his true worth or value can be gauged by others.

CHAPTER – 2

THEORY OF FIRE

1. **Conditions of Fire.** Fire is the energy released in the form of heat & light due to chemical reaction when three elements viz. Flammable substance, ignition source and O_2 (Air) unite.

(a) **Flammable Substances.** These may be solid, liquid or gas, but it is only the Gas/vapour, which burns. In case of a solid or liquid, the substance will require to be raised in temperature to its flash point. i.e. the temperature at which the vapour/gas is released from the substance. The vapour/gas will flash fire if ignition source is provided when sufficient Air (O_2) is present.

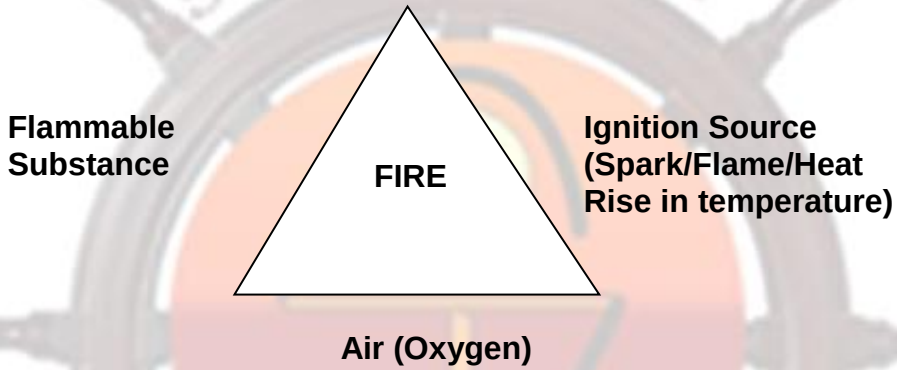


Fig 1 – Fire Triangle

(b) **Ignition Sources.** The ignition sources can be listed under four categories.

(i) **Mechanical Source of Ignition.** Friction, metal to metal contact can cause heat/spark capable of igniting gases present in an area. Chipping, hammering, sand blasting, dropping/heaving in anchor causing anchor chain to rub in the hawse pipe, grinding of tools in the workshop etc can result in spark/heat.

(ii) **Chemical Source of Ignition.** Oxidation processes of chemicals/metals produce heat, which can cause fire. All acids, alkalies, calcium carbide when in contact with water, potassium permanganate in contact with glycerine etc. produce heat/flame which may result in a major fire if not detected in time. An oily jute / rag, wet coal, wet grain, wet saw dust can cause fire due to oxidation called spontaneous ignition. Iron rust (iron oxide) in an oil cargo tank will convert into iron sulphide when tank is in an inert state, due to release of hydrogen sulphide from H/C liquids. At a later stage, when a tank is made gas free for entry, the iron sulphide present in the tank will oxidise into iron oxide. This conversion from iron sulphide to iron oxide produces tremendous heat and flame and can cause explosion due to presence of H/C gases and air (being inducted for gas freeing).

(iii) **Electrical Source of Ignition.** Substances like torches, lead lamps, electrical fittings, generators motors etc. produce sparks. Perished / loose wiring

can cause spark. In accommodation, electrical wiring is designed for certain load, exceeding that load can result in damage to the wiring and fire in the accommodation areas. On board tankers, static electricity is the biggest hazard especially during loading and discharging; Therefore it is mandatory to maintain the cargo tanks in an inert condition.

(iv) **Biological Source of Ignition.** This is the biggest source of fire on board ships. The ship's personnel themselves fall into this category. Careless smoking, misuse and mishandling of hot plates, electrical / mechanical machinery / equipment can cause fire. The reason for this source of ignition may be stress, over work, lack of knowledge / training / skills, incompetence, drugs and alcohol, poor health, poor communication, etc.

(c) **Role of Oxygen.** The role of oxygen in a fire is vital. While oxygen is essential for our survival, it is only the O_2, which causes and sustains any fire. The percentage by volume contained in Air is as follows :-

(i) Oxygen 21%

(ii) Nitrogen 78%

(iii) CO_2\CO\Helium\Argon\Xenon\Krypton\Neon etc 1%

(d) **Importance of Oxygen (O_2).** In an enclosed space, for human survival O_2 must be more than 17%. A person dies when O_2 is only 13%. However, a fire can be extinguished only when O_2 is less than 11% in the place on fire.

2. **Principles of Fire Fighting.** When fire is extinguished by controlling or eliminating fuel, it is called Fire Fighting by "starvation". When fire is extinguished by controlling or eliminating Heat/ignition source/flame, it is called Fire Fighting by "cooling". When fire is extinguished by controlling or eliminating air (O_2), it is called Fire Fighting by "smothering". When fire is extinguished by controlling or eliminating a heat producing (exothermic) chemical reaction, it is called Fire Fighting by "Inhibiting". In this case the fire doesn't extinguish by smothering because the O_2 required for sustaining the fire is contained within the substances e.g. TNT, gunpowder, RDX etc.

3. **Classes of Fire.** In order to fight/extinguish a fire promptly and effectively, fire is classified into four different categories. They are :-

(a) **Class 'A' Fire (or Solid Combustible Material Fire).** Examples of such fires are bedding, clothing, rags, wood, canvas, rope and paper fires. Cooling by large quantities of water or use of fire extinguisher containing water is very important to fight fires of such ordinary materials. Cooling the source of fire and surrounding area should continue long enough. Class 'A' fires normally involve solid materials of organic nature (compounds of carbon). Combustion occurs with formation of glowing embers. Water in the form of jet or spray is the best way to fight such fires.

(b) **Class 'B' Fires (or Liquid Fuel Fires).** Foam is an efficient agent for fighting liquid fuel fires. This method is also called "smothering". Foam is directed in the form of a jet against any vertical surface to flow down on liquid fuel to form a blanket. The principle is not to allow fresh air to the liquid / oil fire and if oxygen can be sufficiently reduced, the fire will extinguish. The foam coating over liquid burning fuel besides

limiting the supply of air and slowing down also stops forming flammable fuel vapour and also causes limited cooling. Liquid Fuel Fires or class 'B' fires can also be fought by a method called "Starvation" i.e. cutting off the fuel supply to the fire by draining of fuel from burning oil tank / by closing the concerned fuel supply valve / stopping the fuel pump if the fuel line is leaking from a pipe joint.

(c) **Class 'C' Fires (or Gas Fuel Fires).** The fire is extinguished by stopping the gas flow. If the flow of gas cannot be stopped, then the best way is to break / divide the fire into small fires by using dry chemical powder, because it is easier to fight small fires. Further in order to reach and close the valve controlling the flow of gas, it may be necessary to extinguish flames from small leaks in its vicinity. In this case also Dry chemical powder is the best medium to extinguish or to control the fire. Water jets should never be used directly on a gas fire. Also, foam cannot and will not extinguish such fires. Further, the foam will be blown away by the burning gas/leaking gas.

(d) **Class 'D' Fires (or Metal Fires).** Such fires can be extinguished by using Sodium Bicarbonate, powdered graphite; powdered talc, Soda Ash, lime stone and Dry sand mixed together and is used as dry chemical powder. Metals such as Sodium, Potassium, Barium, Magnesium, Sulphur, Phosphorous are examples of metal fires.

(e) **Electrical Equipment Fires.** Such fires may be class A, B, C or D. This may be caused by short circuit / over heating or the spreading of a fire from elsewhere. It must be noted that in electrical fires, electricity is only an ignition source. The immediate action should be to de-energise the equipment i.e. Switch off supply from the immediate switch or junction box or the main switchboard. Then a non-conducting agent, such as Carbon dioxide, halon or dry chemical powder should be used to extinguish the fire. Care must be taken not to damage sophisticated electrical/electronic equipment such as radio equipment/machinery controls/computers while fighting such fires. The aim is not only to extinguish the fire but also to ensure minimum damage to the equipment by the fire-fighting medium used.

4. **Fire Hazards and Spread of Fire.** Fire spreads in three ways viz., by conduction, convection & radiation.

(a) **Conduction.** Transfer of heat within a solid conducting substance from high temperature to low temperature. In this mode, the molecules of a substance start vibrating due to rise in temperature and pass on heat to the adjacent molecules due to colliding with each other, thus raising the temperature. But there is no actual movement of molecules e.g. when heating a metal rod at one end, the other end also becomes hot in due course. A medium is essential for transfer of heat by conduction.

(b) **Convection.** The transfer of heat by convection takes place only in liquids and gases. In this mode of fire spread, the molecules of a substance (liquid or gas) move away from the source of heat. Due to a rise in temperature, the molecules expand, their density decreases and they become lighter and move up. In their place, the heavier and cold molecules move closer to the source of heat. This sets a circulation to transfer heat by movement of molecules of the liquid or gas. In this mode too, a medium is essential. At an example when water is heated, there is a constant upward movement of heated molecules. In their place colder molecules of water move down towards the heat source. A circulation is set up till all water attains 100°C when the water starts boiling.

(c) **Radiation.** In this mode of fire/heat spread, no medium is required. The heat/fire spreads through temperature/heat excited electromagnetic waves, which move at the speed of lights (186000 miles/sec). Radiation is responsible for spread of fire to a significant degree due to its high temperature to evolution of vapour from other materials in the vicinity thus increasing & spreading the fire. As an example heat received from the sun is by radiation, in the form of ultra violet rays, infra red rays, alpha, beta and gamma rays, x-rays etc., through electro magnetic waves, which travel only in straight lines.

5. **Fire Extinguishing Agents.** The substance used for extinguishing fires is termed as fire extinguishing agents. Substances that can be used for extinguishing fires on board are water, foam, carbon dioxide, halogenated hydrocarbons, dry chemical powder, inert gas, and nitrogen. Use of halogenated hydrocarbon is now prohibited for new vessels, and is being discouraged on the existing vessels due to their damaging effect on the ozone (O_3) layer in the upper atmosphere (about 50 Kms above the earth). Ozone (O3) has the capacity to absorb the ultra violet rays from the sun (which are destructive to all forms of life / vegetation on earth). Blankets, sand or similar substance are not regarded as fire extinguishing agents though they are provided for use on small fires in some areas (galleys, near oil fired boilers).

6. **Factors to be Considered in Selecting an Extinguishing Medium.**

(a) Reactivity of the fire extinguishing medium with the burning substances.

(b) Efficiency in a particular situation, (e.g. enclosed space or open space)

(c) Electric conductivity of the fire fighting medium.

(d) Possibilities of evolution of toxic vapours, effects on life supporting environment when the fire extinguishing medium comes in contact with cargo/electrical and mechanical equipment.

(e) Possibilities of undesirable physical phenomenon (boil-over)

(f) Availability of appropriate appliances.

(g) Effects on the stability of the vessel.

(h) Possibilities of damage to cargo, equipment and machinery.

7. **Water as Fire Extinguishing Medium.**

(a) **Advantages.** Water is a coolant having a capacity for absorbing heat far in excess of any other commonly used medium. It extracts heat from the burning substance and turns it into steam, which has a smothering effect. It may be applied in a jet or spray or both on class 'A' fires involving solid materials such as wood, clothes, rope, paper and fabrics achieving deep penetration to the seat of fires. A fine spray is effective in extracting heat from the flames from the burning liquids without seriously disturbing the surface of the liquid. Water spray curtains are used to protect the front of the superstructures facing the cargo tanks from deck spillage fires. Water spray curtains generated at the nozzle of hand held hoses are also effective for the protection of the fire fighters. It is available in abundance on board & is free of cost. It has a direct cooling effect & smothering effect when converted into steam.

(b) **Disadvantages.**

(a) It conducts electricity.

(b) It can cause considerable damage to the cargo and machinery especially electrical and electronic equipment.

(c) It can cause considerable loss of stability when used in large quantities in cargo holds/engine room/accommodation.

(d) It can cause boil-over.

(e) It may ignite fire when used on cargo, which emits flammable gases when wet.

8. **Foam As Fire Extinguishing Medium.** Fire-fighting foam is an aggregate of air bubbles formed by various methods from aqueous solutions of specially formulated concentrated liquid foaming agent. Since foam is lighter than the aqueous solutions from which it is formed and lighter than flammable liquids, it floats on all flammable or combustible liquids. It produces an air excluding, cooling, continuous layer of vapour sealing, water-bearing material for purposes of halting or preventing combustion. Some foam are thick and viscous, forming tough heat resistant blankets over burning liquid surfaces and vertical areas. Some foams are thinner and more rapidly spreading. Some are capable of producing a vapour sealing film of surface active water solution on a liquid surface. Some foams are meant to be used as large volumes of gas cells for inundating surfaces and filling cavities.

Foam concentrate, as received from the manufacturer, is a concentrated aqueous solution of carefully selected foaming agents and surfactants. In addition to surfactants, they contain certain additives like preservatives for preventing growth of bacteria, iron salts in protein foam concentrates to make the foam fire resistant, anti-freeze agents, corrosion inhibitors, solvents to reduce viscosity, substances to stabilise from bubbles and certain dyestuffs for brand recognition. Due to these various additives and various characteristics foams are classified in two ways viz by their expansion and by their principal constituents.

9. **Classification by Expansion.**

(a) Low expansion foam has an expansion ratio up to 50:1 usually ranging between 5:1 to 15:1; this is typically produced by self-aspirating branch pipes or supplied pre-mixed with water, foam being formed at the monitor. This is the type of expansion ratio of foam supplied on ships, for the protection of the cargo deck area of oil and chemical tankers.

(b) Medium expansion foam has an expansion ration between 5:1 to 500:1, but usually between 75:1 and 150:1. This is produced by self aspirating branch pipes or supplied pre-mixed from a foam control station, but the nozzle has especially enlarged outlets with nets allowing more expansion to take place, Its application for shipboard use is limited to specific trade ships only, being not generally suitable for open spaces.

(c) High expansion foam has an expansion ratio between 500:1 to 800:1. This is produced by foam generators with air fans, nets and ducts.

10. **Types of Foam Concentrates.**

(a) **Protein Foam.** This foam is derived from natural protein solids. These concentrates contain high molecular weight natural pertinacious polymers derived from a chemical digestion and hydrolysis of natural protein solids. The polymers give elasticity, mechanical strength and water retention capability to foams generated from them. These concentrates are available for proportioning to a final concentration of either 3% to 6% by volume using fresh water or sea water. These concentrates produce dense viscous foams of high stability, high heat resistance and good resistance to burn back. They are non toxic and biodegradable after dilution. This type of foam is the cheapest available and most commonly supplied for, and on oil tankers for protecting the cargo deck area. (Typical expansion 7:1 to 9:1)

(b) **Fluoroprotein Foam.** This type of foam, contains the same properties as protein foam, but in addition to protein polymers they contain fluorinated surface – active agents that confer a "fuel shedding" (resistant to fuel contamination) property to the foam generated. This makes this type of foam particularly effective for fighting fire in conditions where foam becomes coated with fuel, such as in the method of sub-surface injection of foam for tank fire fighting. This type of foam is more compatible with dry chemical powders. These concentrates are available for proportioning to a final concentration of either 3% or 6% by volume using either fresh or sea water. They are non-toxic and bio-degradable. It is more expansive than protein foams but is ideally suited for handling fires in refineries and for shore storage tank installations.
(Typical expansion 7:1 to 10:1)

(c) **Fluoro – Chemical Foam (AFFF).**

(i) This type of concentrate comprises of synthetically produced foaming agents similar to foams produced by protein based foams. Additionally these agents are capable of forming water solution films on the surface of flammable liquids; hence it is termed "Aqueous Film Forming Foam" (AFFF). They contain fluorinated, long chain synthetic hydrocarbons with particular surface active properties. They are non-toxic and bio-degradable in their diluted form. They can be stored for longer periods of time without degradation in their characteristics. The undiluted concentrate may affect the skin if not washed off immediately.

(ii) The air foam generated from AFFF solutions possess low viscosity, have fast spreading and levelling characteristics and act as surface barriers to exclude air and halt fuel vaporization as all foams do. These foams develop a continuous layer of solution under the foam with surface activity which maintains a floating film on hydrocarbon fuel surfaces to help suppress combustible vapours and cool the fuel substrate. The result of the double action of AFFF is to yield a highly efficient foam extinguishing agent in terms of the quantity of concentrate needed and the rapidity with which it acts on fuel spills and flaming surfaces.

(iii) These concentrates are available for proportioning to a final concentration of either fresh or sea water. Although more expensive than the other types of foam concentrates available, but its effectiveness overshadows this criterion from the safety point of view. [(Typical expansion 9:1 to 11:1; usual concentration 3-6 %).] Other than the above mentioned main foam concentrates, there are other foaming agents available for specialized requirements, found in various shore applications and specialized chemical carriers.

(d) **Synthetic High Expansion Foaming Agents.** It is formed synthetically for control of class A and B fires particularly as a total flooding agent in confined spaces. This foam is an aggregation of bubbles mechanically generated by passage of air or other gases through a net, screen or other porous medium that is wetted by an aqueous solution of surface active foaming agent. This type of foam is a unique vehicle for transporting wet foam masses to inaccessible places, for total flooding of confined spaces and for volumetric displacement of vapour heat and smoke. This concentrate is mixed with water in 1% to 6% concentrations and depending on equipment being used to generate foam, can produce expansion ratios up to 800:1.

(e) **Alcohol Resistant Foam.** These special foaming liquids are developed for use in fires where the fuel involved is water soluble. Examples of this type of liquids are alcohols, enamel and lacquer thinners, methyl ethyl ketone, isotone, isopropyl ether, acrylonitrile, ethyl and butyl acetate, amines and anhydrides. Even a small amount of these substances when mixed with common hydrocarbon fuels (as in gasohol – gasoline and alcohol blends) may cause rapid breakdown of ordinary fire- fighting foams. These concentrates are proprietary compositions of several types containing protein, fluoroprotein or aqueous film forming foam base. The application rates are much higher. Regulations require chemical tankers to be provided with 3.3. times the foam solution required for oil tankers, to protect the cargo deck area.

(f) **Chemical Foam.** These foam producing materials have been obsolete for use in large fires because of superior economics and ease of handling of the other liquid foam forming concentrates. Chemical foam is formed from the temperature sensitive chemical reaction in an acqueous solution of aluminium sulphate and sodium bicarbonate. Foam bubbles are formed by the generation of carbon dioxide gas from the chemical reaction. This foam is quite stable and heat resistant, but generally it is very stiff and slow moving. It cakes under flame attack and will form open fissures in the foam layer which exposes the underlying fuel. The use of this chemical foam has been stopped by DG Shipping, India with effect from December 2000 vide MS 9/1999.

11. **Factors for Extinguishing Liquid Fuel Fire.** The methods by which foam extinguishes a liquid fuel fire are not clearly defined. A number of contributory factors are quite evident. They are :-

(a) Prevention of the radiant heat from the flames reaching the fuel surface and stopping evaporation of further fuel.

(b) Formation of a sealing blanket over the fuel surface to prevent vapour escaping;

(c) Cooling of the fuel,

(e) Isolation of the fuel from the oxygen of the air; and

(f) Dilution of the air with water vapour from the evaporated foam.

(g) Various factors of foam concentrate will influence the performances of the foam- these include physical properties, application rates and methods of application. The first two have been dealt with already and we now deal with the methods of application.

12. **Foam Systems.** Foam is suitable for use on Class B fires, i.e. fires involving flammable liquids or liquefiable solids. A fixed high expansion foam system may be fitted in machinery spaces and cargo pump room where accumulation of oil fuel and cargo oil could occur. A fixed low expansion system is to be used for fighting fires on the decks of ships carrying liquid cargoes of a flammable nature, such as may be caused by deck spillages or in cargo tanks which have been ruptured by collision or explosion.

13. **Low Expansion Foam System.** The risk of deck spillage during loading and discharging and the rupture of the tanks by collision or explosion require the entire cargo tanks deck area to be protected by a fixed low expansion foam system. To produce low expansion foam for fire fighting on board ships, the following equipment is essential :-

(a) Pumps for imparting energy to the water.

(b) Piping & hoses for delivering the water where required.

(c) Means of introducing foam concentrate into the water stream and

(d) Means of aerating the mixture and apparatus for projecting the resulting foam on to the fire.

(e) The system of pumps, piping and hoses for supplying water incorporated on ships, are discussed in Chapter 7. There are two methods of mixing foam concentrate with water and aerating the solution. One system incorporates portable twenty litres foam concentrate drums and the other a large capacity fixed tank. The requirements and equipment for each of these systems are discussed in detail in chapter 7.

14. **Degraded And Contaminated Foam.**

(a) The results of a recent investigation of samples of foam taken from merchant vessels showed that a large number were deficient to such an extent that total replacement of the solutions was recommended in order to provide an adequate fire fighting potential.

(b) It is difficult to trace the cause of the degradation in most cases, but exposure to excess heat and contamination with salt water appeared to be major factors. Another important cause of degradation was the use of inappropriate stock to top up existing supplies of foam solution and excessive exposure to air as a consequence of large ullage may also be a factor. It is clear that make up supplies should be of the same class of solution, but it is not widely understood that solutions of the same genetic type originating from different manufacturers are not always compatible to each other and so should not be mixed. When additional foam solution is required, it should be of the correct type from the original manufacturer. If this is not possible due to the vessels trading pattern every effort should be made to ensure the alternative supply is compatible with that onboard. Alternatively a complete charge of the available solution should be taken onboard.

(c) The first line of defence against degradation of ship borne foam solution is correct storage and an understanding of the deleterious effects of even minor contamination. However, an equally important, method of maintaining suitable standard, is to institute a system of regular testing of the solutions carried, onboard. It is not possible to lay down a general rule regarding the time between tests due to the

wide variation of foam types and carriage conditions. Stored under ideal conditions a good foam solution could last for ten years or more without deterioration, but normally testing should take place at much shorter intervals. An interval of at most two years is recommended and individual owners should undertake more frequent testing if test results indicate deterioration. In the first instance more frequent testing may be advisable to gauge the safe interval between subsequent test on particular vessels as this is very sensitive to carriage conditions.

(d) The correct method of sampling is important and care must be taken to ensure that the sample is not contaminated by the use of dirty sampling equipment nor by ingress of contamination during transit. Sampling from both top and bottom of storage tank is recommended. Instructions from the testing establishment sampling regarding methods and containers should be strictly followed.

(e) Simple testing of foam volume generated is not sufficient. A sample should be sent to a reputable Organisation ashore which has adequate test facilities. The test should include at least expansion ratio, 25 per cent drainage time and a small scale fire test. Additional tests such as specific gravity, surface tension, iron content, PH Value, viscosity and sludge content could also be included. These additional tests help assess the condition of the compound when compared with the original values of these parameters, thereby detecting early signs of degradation or contamination of foam.

15. Carbon Dioxide as Fire Extinguishing Medium.

(a) **Cylinder Sitting Precautions.** Recent resurveys of CO_2 installations employing a gang release system for total flooding of the machinery spaces has shown that in ships where the CO_2 cylinder storage room is subject to severe vibration, or in cases where cylinder clamps have not been tightened properly after the cylinders have been removed from weighting or replenishment, Cylinders have rotated resulting in some cases of malfunction and in some cases to the premature release of CO_2 gas. In many cases the rotation of the cylinders has been such that operation of the system, if it had been required, would not have been possible due to misalignment of the valve operating levers. To minimise this danger it is advisable in existing installations that arrangements for clamping and verifying the alignment of cylinders should be carefully checked at regular intervals between the surveys or inspections normally carried out by the Govt. Surveyors.

(b) **CO_2 Gas as Fire Extinguishing Medium.** At normal temperatures, carbon dioxide is a gas 1.5 times as dense as air. It is easily liquefied and bottled. It is normally contained under a pressure of approximately 50 bar in steel cylinders. As a fire extinguishing medium it acts as follows :-

(i) When CO_2 is applied to a fire, the liquid CO_2 boils off rapidly as a gas, extracting heat from the surrounding atmosphere. The gas, however, extinguishes by smothering, or reducing the oxygen content of the air. About 20 to 30 per cent of the atmosphere should contain CO_2 to completely extinguish the fire. This varies according to the nature of the burning material; in fact, materials which supply their own oxygen will continue to burn, as will any material that tends to decompose the carbon dioxide, such as burning magnesium. Apart from these considerations, carbon dioxide is quick and clean, non-conductor of electricity, non-toxic and does not harm most fabrics.

(ii) For fire situations in cargo and machinery spaces, where complete flooding of the compartment is desirable, fixed carbon dioxide installations may be provided. The advantages of carbon dioxide are :-

(aa) It is non-corrosive

(ab) It does not conduct electricity

(ac) It leaves no residue

(ad) It is not subject to deterioration in quality with age

(af) It is easily available.

(iii) Its disadvantages are :-

(aa) It is highly asphyxiating; a concentration of about 9% would produce unconsciousness within a few minutes.

(ab) It has little cooling effect and there is consequently a danger of re-ignition if air is re-admitted to the compartment too soon after the fire.

(ac) When discharged, particles of solid carbon dioxide are normally present and can generate sufficient static electricity to produce an incendiary spark which could ignite flammable atmosphere such as may be found in ships. For this reason carbon dioxide is unsuitable as an inerting medium in cargo oil tanks and pump rooms.

16. **Halon As Fire Extinguishing Medium.**

(a) As advised in Merchant Shipping Notice No. M. 1439 the use of halon as a fire extinguishing medium on board ships is to be phased out because of its damaging effect on the stratospheric ozone layer.

(b) An amendment to the Safety of Life at Sea (SOLAS) convention has been agreed and that amendment prohibits the installation of new fixed or portable systems in all ships with effect from 01 October 1994. No date for the removal of existing installations or phasing out of portable extinguishers has been set.

(c) The provision that halon may be used for agreed essential uses remains in principle but it should be noted that the International Maritime Organisation (IMO) has not accepted any proposal for such an essential use on board ship.

(d) The production of halon (other than for essential uses) in developed countries ceased at the end of 1993.

(e) In the light of these circumstances ship-owners with existing halon systems should ensure that they can obtain replacement halon for as long as may be necessary. When ships are scrapped or systems replaced the stock of halon should not be released into the atmosphere but properly disposed of or held in storage for further use.

(f) To facilitate the recycling of excess stock, the Halon Users National Consortium

(HUNC) Limited has been formed. This is a joint venture between halon users and the fire industry, operating on a non-profit making basis and funded by members subscriptions. It offers :-

(i) A clearing house service of used halon.

(ii) Provision of lists of companies who recycle used halon to a recognised specification.

(iii) Advice on the safe handling and disposal of halons and

(iv) A link between UK users and halon banks in other countries.

17. **Dry Chemical Powder As Fire Extinguishing Medium.**

(a) The basis of most chemical powders is sodium bicarbonate. This, with the addition of a metallic separate as a water proofing agent, is widely used as an extinguishing medium, not only in portable extinguishers, but also for general application in large quantities. Apart from separates, other additives are sometimes used to decrease the bulk density and to reduce packing in the cylinder.

(b) Dry chemical powder is expelled from containers by gas pressure. It is directed at the fire in concentrated clouds by means of specially designed nozzles. This cloud also screens the operator from the flames and enables a relatively close attack to be made. Dry Chemical Powder (also known as “Dry Powder”) normally used on board ships is a flame inhibitor. Discharged as a free flowing cloud, it can be effective in dealing initially with a fire resulting from a flammable liquid spill on deck or in a confined space. It is especially effective on burning liquids such as liquefied gas, or oil escaping from leaking lines and joints, and on vertical surface e.g. diesel equipment fires, although there is a possibility of some damage to the electrical machinery from its abrasion. Dry powder has negligible cooling effect and so may give no protection against re-ignition by a hot surface.

(c) Dry powder on account of its unique ability to quickly stop combustion of gases and most chemical products has become the most popular medium used in gas carriers and chemical tankers. Most multipurpose powders and polyvalent dry powders are based on sodium bi-carbonate or potassium bi-carbonate. The powder is practically non-toxic and has no harmful effect (reactivity) on materials. It is an electrical non-conductor, thus it can be utilised on fires involving live electrical equipment (not more than 1000 V). It is considered that a cloud of powder in the area of the fire inhibits the combustion reaction, since powder particles react with active species of the combustion chain reaction.

(d) Dry chemical powers are also tested for their compatibility with foam, as it was discovered that the early powders tended to break down foam. It should be confirmed whether the two complement each other on fires where foam is the standard extinguishing medium. Certain types of dry powder can cause a breakdown of a foam blanket and only those known to be “foam compatible” should be used in conjunction with foam.

(e) For extinguishing fires involving alkali metals, a special powder is used in which soda ash forms the base chemical. The dry chemical powder can also be supplied in

polythene bags for metal fires, as it is more effective to bury the fire under a pile of bags which melt and allow the contents to smother the fire. Special powders have been developed for some metal fires, especially for the radioactive metals such as uranium and plutonium. These are known as the ternary eutectic chloride group and were researched and perfected by the United Kingdom Atomic Energy authority. These powders contain an ingredient which melts, then flow a little and forms a crust over burning metal, effectively sealing it from the surrounding atmosphere and isolating the fire.

(f) Dry powder will clog and become useless if it is allowed to become damp.

CHAPTER – 3

FIRE CONTROL ON BOARD SHIPS

1. **Areas of Fire Hazards.**

(a) Machinery spaces.

(b) Accommodation.

(c) Galleys / Saloons / Mess decks.

(d) Radio room / Battery Room / Computer Room / Electrical Equipment & Electrical Control Room / Switch Board/s.

(e) Air Conditioning & Refrigeration Compartments.

(f) Steering Compartment.

(g) Cargo Holds.

(h) Workshop/s (Electrical & Mechanical).

(i) Machinery Control Room / Supply Control Room.

(j) Stores (Paint store / Chemical Store / Bosun's store / Dry & wet Ration store.

(k) Bridge.

(l) Helicopter Deck.

2. **Strategies & Tactics for Prevention & Control of Fires In Various Parts of The Ship.**

(a) **Preparation for Fire Fighting**.

(i) Regular maintenance of all fire fighting appliances, equipment and installations.

(ii) Regular fire fighting training & drills to ensure a well practised Organisation.

(iii) Techniques that would be used to fight real situation fires during practical fire drills.

(iv) A good knowledge of the ship by all officers & crew.

(b) **Access to Fire.** In case of flame/smoke/heat/structural damage, use of CABA SET & fire fighting clothing & a spray nozzle water wall can give protection from heat and flame.

(c) **Retreat Route.** A Fire fighter must always ensure a good escape or return route. Normally, the access route is the retreat route, so ensure a good access route.

(d) **Use of Firemain / Firehouses & Nozzles.** Lay out hose as much as possible before opening water from the hydrant as dry hose is easier to lay out than a wet / under pressure hose. Runner must ensure that there are no kinks & that hose is not trapped in the way. Don't open the water when the hose is still coiled.

3. **Fire Fighting.**

(a) Detection of fire

(b) Containment of fire

(c) Fire Fighting

4. **Fire in Machinery Spaces.** To fight the fire, it may be necessary to stop the running machinery equipment / main engine/D.G./pump etc. to tackle fuels/lub oil fires. Shut off the air/exhaust, blowers and the air dampers to seal the compartment from oxygen. Then use of portable 9 Litres foam extinguisher may be suitable. If fire can't be controlled with portable extinguishers, then without hesitation appropriate installed/ fixed fire fighting installation should be used such as foam/CO2 depending upon the nature of the fire. However, all personnel must be evacuated from the area before fixed fire fighting equipment is used.

5. **Fire Hazards in E/R Machinery.**

(a) Combustible liquids

(b) Oil soaked insulation

(c) Hot surfaces due to inadequate lubrication or failure of lubrication of machinery such as M/E / D/G Bearings.

(d) Hot work (such as welding or cutting)

(e) Electrical short-circuits or failure of circuit breaker or use of overrated fuses, poor insulation of electric cables – failure of safety cutouts.

6. **Fire Hazards in the Galley.**

(a) Combustible liquids

(b) Oil soaked insulation

(c) Hot surfaces

(d) Electrical equipment failure.

(e) Exhaust/smoke outlet choked or overheated due to carbon and oily deposits on outlet passages/screens.

7. **Fire Hazards in Accommodation.**

(a) Combustible materials

(b) Cigarette smoking

(c) Misuse of electrical gadgets

8. **Fire Hazards from Cargoes.**

(a) Spontaneous combustion

(b) Oxidising cargoes

(c) Flammable gases

(d) Explosives

9. **Methods of Damage Control & Fire Containment.**

(a) In some ships, certain watertight / fire doors can be shut / opened from bridge.

(b) Closing fire dampers on funnel, workshop, machinery spaces etc. and tripping of ventilation & exhaust blowers from Bridge / Remote control.

(c) By closing portholes / doors in galley, accommodation etc.

(d) By changing course of the V/L relative to wind to minimise damage by fire.

(e) By cooling fuel tank decks, bulkheads of unexposed sides.

(f) By posting fire watch after fire is extinguished.

10. **Methods to Ensure Stability of the Ship.**

(a) By calculating change in GM due to weight of water added in a hold/ E/R during fire fighting.

(b) By pumping out extra water / weight added during fire fighting from the relevant compartment / spaces.

(c) By calculating weight of cargo shifted to facilitate fire fighting.

(d) By assessing the effect of water used during fire fighting on equipment / machinery / cargo.

(e) By counter flooding or depilating to nullify the effect of newly developed movements or weights and their location

(f) By grounding the vessel intentionally if feasible if it is established that the vessel will capsize / sink beyond doubt.

11. **Use of Water for Fire Extinguishing, Ship's Stability, Precautions and Corrective Procedures.** While fighting a fire on board with water, factors affecting stability of the vessels must be considered at all times. **The centre of gravity** of a body is the point through which the force of gravity is considered to act vertically downwards with force equal to the weight of the body. It is also the point about which the body would balance. It must be noted that the centre of gravity of a body will move.

(a) Directly towards the centre of gravity of the added weight.

(b) Directly away from the centre of gravity of any weight removed.

(c) Parallel to the shift of the centre of gravity of any weight moved within the body.

(d) The upward thrust, which is equal to the weight of water displaced is known as the **force of buoyancy** and is considered to act vertically upwards through the point as the **centre of buoyancy** which is the centre of gravity of the under water volume. For a body to float at rest in still water it must displace its own weight of water and the body's centre of gravity must be on the same vertical line as the centre of buoyancy.

12. **Heel and List.** The difference between heeling and listing should be clearly understood. Heel is the transverse inclination of a ship due to external force, e.g., wave motion. List is the transverse inclination of a ship to forces within the ship, e.g. due to transverse movement/placement of weight within the ship.

13. **Metacentre.**

(a) This is the point at which the verticals through the centre of buoyancy at two consecutive angles of heel intersect. Metacentre may be defined as the point above which the ship's centre of gravity may not be raised if the ship is to retain its initial stability. The height of the initial metacentre above the keel (KM) depends upon a ship's underwater form. The vertical distance between G&M the ship's centre of gravity (G) is referred to as the Metacentric Height.

(b) Fig.Nos 2(a), 2(b), 2(c), 2(d) explain the conditions of the ship in still water, when inclined by an external force, state of stable and unstable equilibrium and the effect of free surface effect on the stability of a ship.

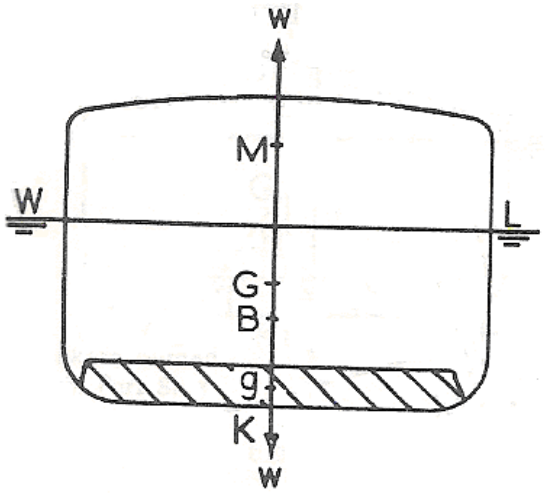


Fig 2 (a)

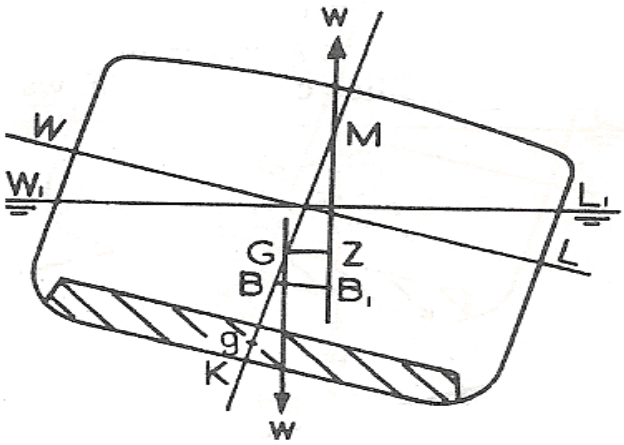


Fig 2 (b)

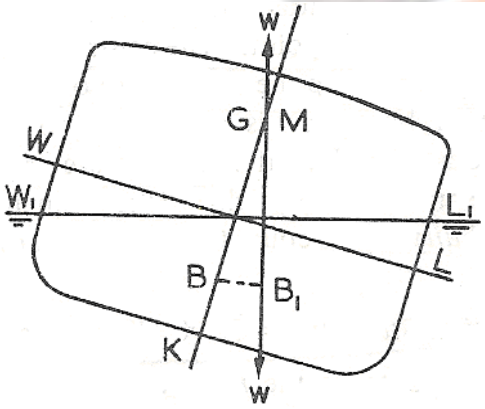


Fig 2 (c)

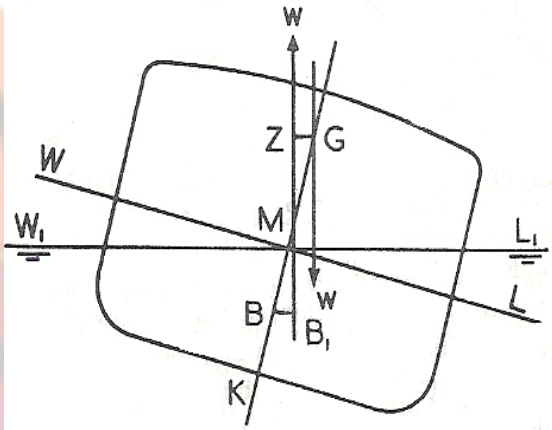


Fig 2 (d)

Fig 2 - Stability of Ship Under Various Conditions

14. **Stability.** The stability of a ship in upright position depends upon the relative positions of the ship's centre of gravity and transverse metacentre. A ship is said to be in stable equilibrium when if slightly heeled from its initial position it tends to return to its original position.

(a) For a ship to be in stable equilibrium in still water, the following factors must be satisfied :-

(i) Force of buoyancy which is acting upwards must be equal to the weight of the ship which is acting downwards.

(ii) Centre of buoyancy must be in the same vertical line as the centre of gravity.

(iii) Centre of gravity must be below the transverse metacentre.

(iv) Thus, when the centre of gravity is below the metacentre, a vessel is said to be having positive metacentric height (positive GM – stable condition) and vice versa i.e. negative GM means ship will become unstable and will capsize.

15. **Effect of Water Added to a Ship During Fire Fighting.**

(a) **Centre of Gravity Moves Towards the added weight.** Thus, if the added water collects above the position of centre of gravity, then the new position will be shifted upwards, and if it continues that way, the centre of gravity may go above the transverse metacentre making the ship unstable.

(b) **Free Surface Effect.** When tanks on board are partially full, the liquid can shift within the free space due to heel or list. This movement of the liquid causes a change in the position of centre of gravity, and it has a vital bearing on ship's stability during fire fighting operation.

(c) **Grounding.** When the vessel is in narrow/shallow waters, due to the added water, there is a risk of it's touching the bottom. The consequences of grounding depend upon the trim and list of the vessel, and upon the level or slope of the surface underneath.

(d) **Additional Precautions.** On the other hand, when in port, a decision can be taken to move the vessel to a safer area to avoid grounding with due consideration to all aspects before flooding the compartments to extinguish the fire.

16. **Practical Aspects of Stability during Fire-Fighting.** While fighting a fire with water, ship's officers are unlikely to be able to devote time for calculating changes in stability of the vessel. The prime concern then will simply be to maintain adequate positive initial stability. Therefore, most decisions and assessments are likely to be made on the basis of experience, knowledge, and feel of the situation. In a major fire incident when water is used continuously for several hours, a quantitative assessment will be useful even though accuracy may be limited by the information available and rough estimates are based on the following :-

(a) Weight of the water added (by ship, shore, fire boats).

(b) Weight of water removed (drainage overboard, pumped out).

(c) Weight of water drained from one compartment to another.

(d) Weight of cargo, material, etc totally burnt, or discharged, or shifted manually to facilitate fire fighting.

(e) Free- surface effects.

(f) Unsymmetrical loading.

(g) It must be appreciated that some estimates will be better than none at all. An approximate GZ curve and a prediction of change in GM (metacentric height) due to continued or proposed action at that time will prove to be very valuable. One must be able to distinguish between the vessel's state in loll or list, particularly when the vessel is moored at berth. It is most difficult to decide, when the ship is rolling whether she is lolled because of instability, or due to which factor listed above. Nobody will relish the thought of being responsible for the instability of a ship during a major fire. Reliable information will be hard to get. However, knowledge & experience will indeed be the greatest asset. Some of the actions that can be taken to improve stability of the vessel are :-

(i) Transfer of water, fuels, ballasting / deballasting etc.

(ii) Eliminating free-surface affect where possible.

(iii) Control excessive use of water particularly if it cannot be drained easily. In the normal course, when water is used for fire fighting in E/R or cargo holds, simultaneous action should also be taken to pump out those areas.

(iv) Supplement drainage from accommodation spaces (break WC pans, make holes, siphon).

(v) Use alternative extinguishing medium (foam), if feasible instead of water through fire hoses.

17. **Computer Based Stability Calculations.** Many ships now have computer program for routine 'stability' and 'stress' problems. However, constant reliance on computer dulls one memory of theory and practice of calculating in a traditional manner, particularly at a time of emergencies for which the computer is not likely to be programmed or may have been rendered inaccessible due to fire.

(a) For quick estimates of the changes one can calculate the dead-weight moment,(Kg m) or minimum GM from tables or curves can be very useful. At the start of an emergency, the displacement and dead-weight moment can be plotted and this point updated to show the effects of free-surface and added weight.

18. **Rontine Regular Fire Drills.** Simulated / Dummy fire fighting drills are often held at sea but rarely a thought is given to allocate responsibility towards stability considerations. An exercise assuming a time limit for fire fighting by firehoses in the accommodation

spaces and requiring a stability investigation to be made could indicate the limitation of such an exercise in the real situation.

19. **Structural Fire Protection.** Chapter 11 – 2 Solas 1974 & amended Nov 81 and resolution M Sc.1(XLV), M Sc.6(48), M Sc.13(57),M Sc 22(59) & M Sc.24(60).

(a) The structural fire protection is taken care of in the design stage itself implemented during construction. These give details of specifications of protection required for various spaces. These are achieved by the following:-

20. **Main Feature of Solas-74, Ch.2. Section Ii.**

(a) Division of ship into main vertical zones by thermal and structural boundaries.

(b) Separation of accommodation spaces from the remainder of the ship by thermal and structural boundaries.

(c) Restricted use of combustible materials.

(d) Detection of any fire in the zone of origin.

(e) Containment and extinction of any fire in the space of origin.

(f) Protection of means of escape or access for fire fighting.

(g) Ready availability of fire extinguishing appliances.

(h) Minimization of possibility of ignition of flammable cargo vapour.

21. **Non-Combustible Material.** Is a material which neither burns nor gives off flammable vapours in sufficient quantity for self-ignition when heated to approx. 750 degrees centigrade, this being determined to the satisfaction of the administration by an established test procedure. Any other material is a combustible material. If a material passes the test as is specified in resolution A.270(viii) it should be considered as “Non-Combustible” even if it consists of inorganic and organic substances.

22. **Standard Fire Test.** A standard fire test is one in which specimens of the relevant bulkheads or decks are exposed to a test furnace to temperatures corresponding approx. to the standard time-temperature curve. The specimen shall have an exposed surface of not less than 4.65 square metres and height (or length of deck) of 2.44 metres, resembling as closely as possible the intended construction and including where appropriate at least one joint. The standard time-temperature curve is defined by a smooth curve drawn through the following temperature points measured above the initial furnace temperature :-

(a) At the end of the first 5 min --- 556 degrees centigrade

(b) At the end of the first 10 min --- 659 degrees centigrade

(c) At the end of the first 15 min --- 718 degrees centigrade

(d) At the end of the first 30 min --- 821 degrees centigrade

(e) At the end of the first 60 min --- 925 degrees centigrade

23. **Divisions of Steel.** The bulkhead and decks of the ships are built with specification as “A “class Divisions, “B” class divisions and “C” class divisions.

(a) **“A” Class Divisions.** These divisions are formed by bulkhead and decks which comply with the following :-

(i) They shall be constructed of steel or other equivalent material.

(ii) They shall be suitably stiffened.

(iii) They shall be so constructed so as to be capable of preventing the passage of smoke & flame to the end of the one-hour standard fire test.

(iv) They shall be insulated with approved non-combustible materials such that the average temperature of the unexposed side will not rise more than 140^0 deg centigrade above the original temp nor will the temp at any point, including any joint, rise more than 180 deg centigrade above the original temp within the time listed below :-

(aa) Class “A – 60” - 60 min

(ab) Class “A – 30” - 30 min

(ac) Class “A – 15” - 15 min

(ad) Class “A – 0” - 0 min

(b) **“B” Class Divisions.** These are divisions formed by bulkheads, decks, ceilings or linings which comply with the following :-

(i) They shall be so constructed as to be capable of preventing the passage of flame to the end of the first half hour of the standard fire test.

(ii) They shall have an insulation value such that the average temp of the unexposed side will not rise more than 140^0 deg centigrade above the original temp, nor will the temp at any one point, including any joint, rise more than 225 deg centigrade above the original temp., within the time listed below :-

(aa) CLASS “B – 15” - 15 Min

(ab) CLASS “B – 0” - 0 Min

(iii) They shall be constructed of approved non-combustible materials with the exception that combustible veneers may be permitted provided they meet other requirements.

(c) **“C” Class Divisions.** These are divisions constructed of approved non-combustible materials. They do not meet any requirement regarding passage of smoke and flame or any limitations to the temp rise. Combustible veneers are permitted provided they meet other requirements.

24. **Structural Protection Requirements of Main Spaces.**

(a) "A" Class divisions are used for all spaces containing propulsion machinery, boilers, oil fuel units, steam and internal combustion engines, generators & other major electrical machinery, oil filling stations, refrigeration, stabilizing, ventilation and air-conditioning machinery & other similar spaces and trunks to such spaces. Ships carrying more than thirty six passengers are to have accommodation spaces and main divisional bulkheads & decks of incombustible material with either automatic fire detection & alarm system or an automatic sprinkler and alarm system. The hull, superstructure and deckhouses sub-divided by "A" class divisions on any one deck should not exceed 40 metres. Main horizontal zones of "A" class divisions are fitted to provide a barrier between sprinkler and non sprinkler zones are to be "A", "B" or "C" class divisions depending on the fire risk of the adjoining spaces and whether the adjoining spaces are within sprinkler or non-sprinkler zones.

(b) Passenger ships carrying not more than thirty-six passengers are required to have the hull, superstructure and deckhouses subdivided into main vertical zones by "A" class divisions. The accommodation and service spaces are to be protected either by all enclosure bulkheads within the space being of at least "B" class divisions or only the corridor bulkhead being of at least "B" class division where an approved automatic fire detection & alarm system is installed.

(c) Cargo ships of more than 4000 tons gross are required in general to be constructed of steel. Corridor bulkheads in the accommodation are required to be at least "B" class divisions, and bulkheads of galleys and inflammable stores adjacent to accommodation, crew lift trucks and also tramways below the weather deck are required to be of steel.

(d) In the construction of tankers, bulkheads between pump rooms and main machinery spaces and bulkheads and decks between engine room, boiler room & pump room and accommodation and service spaces are required to be of "A" class divisions. Corridor bulkheads within the accommodation spaces are to be of at least "B" class divisions.

(e) Openings in fire divisions are to be fitted with permanently attached means of closing which have the same fire resisting rating as the division. Suitable arrangements are made to ensure that the fire resistance of a division is not impaired where it is pierced for the passage of pipes, vent trunks, electrical cables etc.

Welding Plant and Equipment.

25. **Electric Arc Welding.**

(a) In recent years the carriage or installation on shipboard of electric arc welding plant intended for use by ship's personnel has become commonplace. Such equipment used in certain special locations can give rise to hazards in its use not normally encountered elsewhere. Three recent fatalities resulting from shock hazard is not fully appreciated. In each case the victim was working in a restricted hot damp situation surrounded by earthed metal work which possibly allowed large areas of his body to come into contact with the steel work of the ship to which the

welding set was “earthed”. Subsequent investigation in each case showed no faults in the electric welding equipment concerned. The sets were of the commonly used alternating current type where the open circuit (striking) voltage is in the region of 70 to 80 volts. Such voltages can be fatal in circumstances encountered while welding on shipboard, especially when the effective surface body resistance is greatly reduced due to sweating or dampness from salt water. A further reduction of body resistance can result should burning of the skin occur while welding.

(b) That electric arc welding should be undertaken only by persons properly trained in the use of such equipment is self evident if the sets are to be used effectively, it is even more important that the electrical safety precautions should be understood not only by the welder but also by those in attendance upon him. In especially damp and humid conditions the danger of electric shock can be such that consideration must be given to whether or not electric arc welding should in any case by undertaken. Such a decision and the suitability of any person to undertake welding should be taken by the senior officer in charge e.g. the chief engineer officer. The following precautions relating to electrical safety are brought to the attention of ship-owners, masters, officers and operators.

26. **Welding Sets.**

(a) Since the effect of shock from direct current (D.C) is less (at the operating voltages used) than with alternating current (A.C) the use of welding sets having a D.C output, especially those incorporating D.C. generators providing an open circuit (idling) voltage of 70 volts or less, will enhance the safety of operating personnel. Direct current obtained from rectified alternating current may however contain a degree of A.C. ripple which if excessive would greatly reduce the advantage provided by pure direct current, in which case it is recommended that the idle voltage be limited to 42 volts by provision of voltage reduction safety devices.

(b) Voltage reduction safety devices which limit the “idling” voltage to 25 volts or less are also available for use with alternating current electric arc welding plant of the type normally fitted on shipboard, as plug in or installed units.

(c) These safety devices ensure that the idling voltage only is applied until there is contact between the electrode and the “work” when the full open circuit voltage becomes available to strike the arc. Once struck, welding continues in the normal way at the voltage necessary to maintain the arc (normally 25-30 volts) until the arc is broken. There is little noticeable difference in the welding procedure but safety is greatly enhanced and the use of such devices is strongly recommended.

(d) Electrode holders should be of the fully insulated type.

(e) When joints in the cable are necessary the connectors should also be fully insulated and should be designed and used so that, when disconnected the live parts are not exposed. A ‘go and return” system where two cables are used from the welding set with one cable solidly clamped to the work piece is recommended in all cases. While not recommended, if a single cable with hull return is used exceptionally, care should be taken to ensure that both the work piece and the return terminal on the welding set are making direct contact with the hull using clamps and short lengths of “earthing” cable as necessary.

(f) Means should be available whereby the current can rapidly be cut off from the electrode holder should the operator get into difficulties. This can be achieved in several ways but the essential feature is that the time taken to de-energies the equipment should be as short as possible. Means of disconnection should be available to the welder for use when changing electrodes.

27. **Clothing.** Proper welder's gloves, apron and welding helmet or shield should be available at all times and the use of non-conducting rubber boots is recommended.

28. **Lighting.** Adequate fixed lighting or portable lighting capable of being properly secured whilst welding should also be available. Hand held lighting can be a hazard to the welder and should be avoided.

29. **First Aid.** Wall charts giving instructions on Artificial Respiration and Treatment for electric shock, should be prominently displayed where personnel likely to use the equipment can best be expected to see them. These subjects are dealt with in the chapter entitled "first aid" in the ship captain's Medical guide.

30. **Operational Guidelines.**

(a) **Attendant.** Normally welding should be undertaken only when a knowledgeable attendant is standing by the operator. The attendant should be prepared at all times to cut off the current at once in the event of accidents, and he must appreciate that when the operator experiences an electric shock he may be unable to let go of the live metal due to the effects of the current. The attendant should therefore break the supply to the live metal, having regard for his own safety while so doing, noting that it may be possible to pull the electrode holder away from the victim by using the comparative safety of the insulated flexible cable (Recommendation will be found on the instructional wall chart previously mentioned.)

(b) **Clothing.** Protective clothing mentioned above should be used on every occasion and particularly when welding in the prone position where large areas of the body might otherwise be in contact with the earthed "work" or ship's structure. The body should be fully clothed and the clothing maintained as dry as possible to provide insulation against the open circuit voltage which even when using the safety devices mentioned above, will momentarily be of the order of the striking voltage. Although not a guarantee and by no means always effective, use of a non-hygroscopic insulating material between the welder and exposed metal parts should be considered. Welding gloves must always be maintained in a dry condition.

(c) **Working Condition.** It should be ensured that the ventilation is adequate, and the work is well lighted and is as accessible as safety requires. Welding should not be undertaken when standing in, or when any part of the body is resting in water.

(d) **Handling Electrodes.** Operators should appreciate some electrode coatings have extremely low resistance and should therefore be handled (like bare electrodes) with the greatest care especially when being inserted into the electrode holder. Even a flux coating which is normally insulating can become damp from sweating hands and thus potentially dangerous. It follows therefore that electrodes should never be inserted into a live holder and similar precautions should apply to their removal.

(e) **First Aid.** Operators and their assistants should read and digest the instructions given on the wall charts mentioned above so as to be ready to give effect to them in case of need. Practice in artificial respiration should be undertaken & demonstrations, particularly by those giving instructions to welders, are recommended.

31. **Safety Guidelines While Using Electric Equipment.**

(a) In recent years there have been a number of fires involving electric heaters or drying equipment incorporating an electric heater.

(b) In a number of cases fires have resulted from items of clothing, bedding or other objects being placed too close to, or inadvertently falling onto, unguarded electric heaters. In another incident a drying cabinet was overfilled thereby blocking the ventilation apertures, with the result that the contents overheated and caught fire. Other incidents have involved portable electric heaters installed as temporary heating during very cold weather, or for use in cold climates, when insufficient attention was given to the positioning of the heaters, so that they were too close, or immediately below, flammable objects.

(c) It is important that all fixed electric heaters are fitted with suitable guards securely attached to the heater and that the guards are maintained in position at all times. Temporary arrangements to hang clothing above the heaters or to dry clothing on the heaters should not be permitted and drying of clothing should only be carried out by using suitable designed equipment.

(d) When using drying cabinets or similar appliances, care should be taken so that the ventilation apertures are not obscured by overfilling of the drying space. As the ventilation apertures of drying appliances may become blocked due to accumulation of fluff from clothing any screens or fine mesh covers associated with the ventilation apertures should be regularly inspected and cleaned.

(e) The use of portable heaters should be avoided. However, if they are used with the ship in port as temporary heating during repairs and as additional heating during inclement weather, the heaters should not be positioned on wooden floors or bulkheads, carpets or linoleum, without the provision of a protective sheet of a non-combustible material. Portable heaters should be provided with suitable guards and care should be exercised when positioning the heater in relation to furniture and other fittings in the cabin or other space. Again, drying arrangements in relation to these heaters should not be permitted.

(f) The construction and installation of electric heaters in merchant ships and fishing vessels should take due account, as appropriate, of the requirements of the relevant Rules and Regulations as expanded by the various acts of instructions and Guidance Notes where appropriate.

(g) Permanent electric heaters are normally supplied with installation instructions by the manufacturers and these should be carefully complied with.

(h) Attention is also drawn to chapter 2 and chapter 26 of the code of safe working practices for merchant seamen.

32. **Recommendation as to use of Organic Foam in Certain Spaces.**

(a) **Accommodation and Service Spaces.** These spaces are the subject of statutory regulations and are therefore not covered by this notice or the test procedures developing for the purpose of this notice.

(b) **Cold Provision Storerooms.** If these materials are to be used as the insolent they should be covered with a suitable incombustible protective facing. Such storerooms should be sited as remotely as possible from sleeping accommodation, and place of high fire risk.

(c) **Machinery Spaces.** In general these materials should not be used. Limited use might be considered, however, in small machinery spaces where real fire hazard exists, or for insulating small tanks, provided the foam is sandwiched and sealed within incombustible material, preferably steel sheeting.

(d) **Cargo Spaces.** Where such foams are to be used as an insulant they should be completely covered by a suitable protective facing. This facing should preferably be incombustible and able to withstand wear and tear and the flexing of the ship's structure without fracture.

(e) **Fish Holds in Fishing Vessels.** As the possibility of a fire originating in a fish hold is considered to be extremely remote, such foams could continue to be used as the insolent provided the normal practice of lining the hold with stout wooden boards or metal sheeting in a near watertight manner is undertaken.

(f) **Electrical Equipment and Wiring.** Electrical equipment and wiring should be effectively isolated from organic foam materials by steel sheet or conduit as appropriate, and there should be an adequate space between the foam and the protective sheet or conduit.

33. **General Recommendations When Organic Foams are to be installed.** It is recommended that the following measures be adopted when organic foams are to be installed :-

(a) **Fire and General Precautions.** Whilst organic foam materials are being fitted :-

(i) A competent fireman should be in attendance.

(ii) Efficient fire fighting equipment including a primed water hose with jet nozzle, and rescue equipment consisting of breathing apparatus, lifelines and stretchers, should be readily available.

(iii) Effective and adequate means of escape from the compartment concerned should be arranged;

(iv) Where fire protective facings are required they should be applied to the foam surface as soon as possible having regard to the curing time of the foam.

(v) A person should be delegated to collect and remove all organic foam

waste material at frequent intervals. Clouds of foam dust are potentially very dangerous.

(b) **Application.** As the application of most organic foam materials can give rise to both toxic and fire risk, it is recommended that the guidance of factory inspectorate and the suppliers of the basic materials should always be sought prior to spraying or the use of other methods of application.

(c) **Warning.** As particular danger could exist whilst a ship is under construction or repair, it is considered essential to display warning notices prominently in permanent positions inside any compartment insulated with organic foam material and also on the external surfaces of such a compartment, stressing the need to exercise great caution whenever welding or burning operations are contemplated in the vicinity. The organic foam material should be removed locally from the repair area before heat is applied.

(d) **Regular Inspection.** Once organic foam materials & their associated protective facings have been installed in a ship they should become items of regular inspection.

CHAPTER – 4

SHIP'S FIRE FIGHTING ORGANISATION

1. **Emergencies Normally Experienced An Board Ships.**

(a) Fire in a machinery compartment, accommodation, galley, saloon, cargo space etc.

(b) Flooding due to grounding or underwater shipside bulkhead holed.

(c) Collision with another vessel due to poor visibility or hitting the jetty due to vessel out of control due to engine/steering not responding as required / wind taking charge. This could also result in flooding and the vessel may capsize if it can't be controlled.

(d) Man fallen overboard.

(e) Serious breakdown of the main Engine/s.

(f) Shifting of Cargo in bad weather due to poor stowage / Loading plan.

(g) Black out i.e. failure of ship's main electric supply which can be due to any number of reasons.

(h) A person seriously hurt due to any number of reasons.

(i) Vessel taken over by pirates.

(j) However, out of all emergencies, which are likely on board a ship, fire is the most serious and alarming emergency. If fire is not controlled and extinguished in time, the cargo, the ship and the life on board may be totally lost. Therefore every ship has certain emergency stations where ships officers and crew muster on hearing emergency alarm /ordered by the master on ship's P.A. System.

2. **Muster Bills.** The emergency duties of every individual on board is listed in a list called "muster list" in which an individual name, rank and his three stations viz., Boat station, Oil spill control station and emergency station are listed along with the specific duty on those stations. Muster lists are frequently upgraded as and when officers/crew sign 'off' /sign 'on'. For emergency duties such as fire fighting, all ship's personnel are divided into five teams, viz :-

(a) Bridge Team

(b) Emergency Team – I

(c) Emergency Team – II

(d) Technical Team or Engine room team

(e) Support Team

3. **Composition of Teams.** The composition of the above five teams is as follows :-

(a) **Bridge Team.**

Master – In charge and also overall In charge of all teams.
3rd Officer – Assistant
R/O – Manning internal and external communications and recording events of the emergency as they occurred on date/time/location etc. and the action's taken/orders given
AB – Helmsman (For manual steering)
AB – For messenger duties

(b) **Emergency Team – I.**

Chief Officer – Incharge
3rd Engineer – Assistant
Cadet -
Bosun - } As ordered
AB -
Oiler -

(c) **Emergency Team – II.**

2nd Engineer – Incharge
2nd Officer - Assistant
5th Engineer – }
Fitter - } As ordered
Oiler -
AB -

(d) **Technical Team.**

Chief Engineer	-	Incharge
4th Engineer	-	Assistant
Electrical Officer	-	Assistant
Oiler	-	As required

(e) **Support Team.**

Catering Officer – Incharge
Chief Cook – Assistant
2/Cook -
G.S. - } As required
Utility Hand -

Note : If Catering Officer is not borne on board, then Chief Cook will be Incharge of Support Team.

4. **Composition & Allocation of Personnel to Fire Parties.** On sounding of emergency alarm, the Emergency Response Plan (ERP) goes into action immediately. As a general rule no team will have more than 8 persons and the persons who have been on board for longer periods (are more familiar and conversant with the V/L as well as the equipment) are detailed in emergency I and emergency II teams. All supernumeries such as Ladies and Children muster on the bridge in case of an emergency.

5. **Emergency Response Plan & Muster Bills.**

(a) The emergency response plan or the "muster list" is displayed on following places :-

(i) In every cabin – giving the emergency stations of the individual.

(ii) On the bridge.

(iii) In Engine Control Room & Cargo control rooms.

(iv) In all office spaces.

(v) Crew mess and officer's saloon.

(vi) At all muster / emergency stations.

(vii) In main alleyways.

(b) The 'ERP' displayed in cabins indicate the occupant's, emergency, lifeboat and oil spill muster stations, so that every person serving on board knows his stations and duties.

(c) Frequent realistic emergencies are simulated to improve the command and control of operations and to improve the effectiveness of the teams. Further for getting the maximum enthusiasm and commitment of the ship's staff, sub committees are formed who plan and decide the nature of simulated emergencies and report to the senior management on board i.e. the master, with their ideas & suggestions for improvement.

6. **System Approach of Conducting Fire Drills & Awareness in Sea Farers.**

(a) In any emergency situation on board a vessel, an organised and well-scheduled response plan goes into immediate action. On joining a ship, a crewmember already knows what the basic Organisation is and will have to determine in what capacity he fits into the emergency Organisation.

(b) The basis of the 'ERP' is that small and well trained teams would tackle any emergency that may arise e.g. fire, explosion, enclosed space rescue, grounding, collision, pollution, etc. Each situation must be properly evaluated before taking remedial action.

(c) After initial assessment of any incident, it is the master's or officer in command's duty to direct the teams. The safety of personnel is the prime consideration and unnecessary risks are avoided.

(d) The advantage of the team concept is that small teams are more easily accounted for and managed and can be rapidly deployed with equipment from a muster station.

7. **Emergency Alarms and Muster.** Irrespective of whether the ship is at sea, at anchor or in port, on hearing an emergency alarm, teams must muster at their designated stations. This enables the master/senior officer to know the available manpower and resources and identifies the missing persons. This establishes maximum state of readiness promptly and a standardised response to emergency situation can be achieved, allowing remedial actions to be taken and can be easily co-ordinated and controlled. An individual's initial response to an emergency should therefore be as follows :-

(a) On discovering an emergency, raise the alarm.

(b) Inform the bridge (control centre) with as much information as possible.

(c) Attempt to control the emergency by whatever means are available until relieved by an emergency team. Should the situation become hazardous to the individual, he must retreat immediately to the primary emergency team / muster station and report arrival there to the bridge.

(d) On hearing the alarm, all personnel must proceed immediately to their designated muster stations and perform the initial allotted tasks.

(e) Emergency team leaders or their deputies muster and report to the bridge. When reporting team's, "readiness" it must be preceded by the following :-

(i) The teams identity

(ii) Name of any person/s missing

(iii) The available manpower ready for immediate deployment

(iv) Equipment and / or machinery the team is responsible for operating / monitoring.

8. **Role of Each Team and Team Incharge**. Each team In charge must be capable of carrying out any task that would be assigned to members of his team. The team in charges must never become so involved in actual operation that control is lost of his team's actions, which may jeopardise their lives. To achieve the desired results, in charge must ensure that his team is efficiently trained and that they have confidence in their leader and in each other's abilities. Each team in charge reports to the bridge after muster on hearing emergency alarm / fire alarm or ordered by the master on ship's P.A. System.

9. **Role / Duties of Teams**

(a) **Bridge Team.** Bridge team is responsible for command and control of the situation and for ensuring that an efficient muster of personnel is carried out. If required, the bridge team will institute a controlled search for any person not accounted for. The bridge team must also establish immediately external communication; establish internal communications between the bridge, Engine Room, emergency and support teams. Maintain safe Navigation of the vessel and

keep a detailed time events record and log the vital information and events in a proper way for legal formalities at a later stage.

(b) **Technical Team.** This team must advise the bridge the state of readiness of the main and auxiliary machinery / ship's systems/services. The advice must indicate the status of main and emergency systems, which must be placed in a state of maximum readiness. The Technical team also must establish whether the emergency has had any adverse effects on the operation of the main engine/s and generators and associated machinery / equipment and then determine what action, if any need to be taken to remedy any deficiencies to the main or emergency systems. The team should be able to maintain essential emergency services.

(c) **Emergency Team I & II.** The emergency teams first muster and report to the bridge. They then make equipment ready and report their readiness to the bridge, and ready to take action as directed by the master.

(d) **Support Team.** The support team reports its readiness to the bridge and provides support to the emergency teams as and when instructed by the master. e.g.

(i) Hospital and First aid Kits.

(ii) Prepare to provide breathing apparatus if required to emergency teams.

(iii) Provide logistic support to emergency teams like recharging SCBA cylinders.

(iv) Provide additional fire fighting equipment.

(v) Maintain security patrols.

(vi) Provide boundary cooling.

(vii) Provide stretcher and immediate First Aid when / if necessary.

(viii) The success of this team is measured by the effective support it can provide to the emergency teams. There fore the individual.

(ix) In case, a vessel's complement exceeds 26 persons, additional suitable personnel may be designated to each team as considered fit. However, no team ever exceeds eight people.

10. **Individual's Response to Any Emergency.** All personnel should be in boiler suits, safety helmets and safety shoes and with their life jackets when reporting at muster stations. The initial response from following personnel on hearing emergency alarm must be :-

(a) C/E/O, who will ensure the readiness of emergency generator and the emergency fire pump. He is to also ensure that the relevant ventilation and exhaust blowers are stopped and water tight doors, if any, closed before proceeding to muster station.

(b) Chief Officer, who will ensure securing the cargo hatches / ballasting / deballasting systems checked before proceeding to muster station.

(c) Chief Cook, who will secure the galley and switch off all hot plates and galley blowers before proceeding to the muster station.

(d) Bridge messenger, is to distribute portable-radios (walkie-talkies) to all team in charges.

11. **Record of First Hand Information Data.** The following relevant information must be passed on to the bridge / central control station by the relevant teams immediately on the muster on hearing the emergency alarm.

(a) Time at which the fire alarm was given.

(b) Location and nature of fire.

(c) Report on muster of teams and on fire fighting equipment / clothing.

(d) State of firemain. In case main supply is not available, then starting of emergency (Diesel driven) fire pump.

(e) Effectiveness of portable fire extinguishers used / likely to be used.

(f) Effect of fire on ships various services – lighting, blowers, A/C and refrigeration machinery, fresh water system, sanitary system, service air etc.

(g) Head count of all personnel borne on board and if any person is trapped in fire area or is unaccounted for.

12. **Information Readily Available on Bridge.** Following information is always readily available on bridge of a vessel, which can be of assistance in fire fighting.

(a) Arrangement / Layout drawings of the ship's Engine room, accommodation etc.

(b) Details of access and escape routes of different zones of the ship.

(c) Fire control plan i.e. details of portable, mobile and fixed fire fighting Equipment / installations on board.

(d) Ships stability information/plan with regard to flooding due to fire fighting by water.

(e) Details of various emergency survival equipment and its location.

(f) Cargo stowage plan and if any dangerous goods are carried on board.

(g) Internal Communication on board ship.

13. **Internal Communications.** The following internal communications is normally available on board ships.

(a) Telephones in all zones of the ship.

(b) Public Address system / direct speech system in each zone.

(c) Walkie Talkies (portable radios).

(d) Intercom – for selected places only.

(e) Sound power telephone system for selected places only like bridge / MCR / Radio Room / Steering Compartment / pump room (on tankers).

(f) Loud Hailers.

(g) Messengers.

14. **Regulation Requirements Regarding Fire Drills, Musters & on Board Training.**

(a) Fire drill should include :-

(i) Reporting to muster stations & preparation for duties described in the muster list.

(ii) Starting a fire pump using at least two required jets of water to show that the system is in proper working order.

(iii) Checking the fireman's outfit and other personal rescue equipment.

(iv) Checking the relevant communication equipment.

(v) Checking the operation of watertight doors, fire doors and fire dampers.

(vi) Checking the necessary arrangements for subsequent abandonment of ship.

(b) Fire drills should be planned in such a way that due consideration is given to regular practice in various emergencies that may occur depending on the type of ship and its cargo.

(c) The equipment used during drills should immediately be brought back to its fully operational condition and any fault and defects discovered during the drills should be remedied as soon as possible.

(d) Drills should as far as practicable be conducted as if there were an emergency.

(e) On-board training and instructions in the use of the ship's fire – extinguishing appliances should be given as soon as possible but not later than two weeks after a crewmember joins the ship. Individual instructions may cover different fire extinguishing appliances, but all fire extinguishing appliances should be covered within any period of two months. Each member of the crew should be given instructions, which should include, but not necessarily be limited to the operation and use of fire – extinguishing appliances.

(f) The date when the musters are held, details of fire drills and on-board training should be recorded in the log book. If a full muster, drill of training session is not held at the appointed time an entry should be made in the log book stating the circumstances and the extent of the muster, drill or training session held.

(g) Clear instruction to be followed in the event of an emergency should be provided for every person on board. Muster lists complying with the requirements should be exhibited in conspicuous places including the navigating bridge, engine room and crew accommodation spaces.

(h) The muster list should specify details of the general alarm signal and also the action to be taken by the crew and passengers when this alarm is sounded. The muster list should show duties assigned to the different members of the crew including :-

(i) Closing of watertight doors, fire doors, valves, scuppers, side scuttles skylights, portholes and similar openings in the ship.

(ii) Use of communication equipment

(iii) Manning of fire parties.

(iv) Special duties assigned for use of fire fighting equipment.

(v) Preparation and launching of survival craft.

(i) Muster list should specify which officers are assigned to ensure that fire appliances are maintained in good condition and ready for immediate use. Muster list should specify substitutes for key persons who may become disabled, taking into account that different emergencies may call for different action. Muster list should be prepared before the vessel proceeds to sea and revised whenever any changes in crew occur.

15. **Emergency Signals.**

(a) The general emergency alarm signal is the signal for summoning the crew and passengers, if any, to their assembly stations and for initiating the actions shown in the muster list. This signal consists of seven or more short blasts followed by one long blast sounded on the ship's whistle or siren and on a bell, klaxon or similar warning system on ships required to be provided with such system.

(b) On a cargo ship with a fire alarm system which can be manually activated from locations within the accommodation or where a system such as a fire or smoke detection system automatically activates alarms throughout the ship, the signal made by such means may be used to summon the crew to their assembly stations. Such alarm signal should be accompanied by the general emergency alarm signal sounded on the whistle or siren.

(c) Signals for incidents not requiring an assembly of the passengers or of the whole crew, or for dealing with a minor incident, are at the Master's discretion.

(d) On a cargo ship a signal may be allocated to summon the crew to survival craft embarkation stations only, for the purpose of a drill or assembling the crew at the survival craft embarkation's stations during an emergency.

(e) The means by which the order to abandon ship is given is at the master's discretion and may be by a signal or by word of mouth, but arrangements should be such that everyone on board including those in emergency parties in remote location will receive it.

(f) All signals must be described in the muster list, in the crew emergency instructions and, as appropriate, in the emergency instructions for passenger.

(g) The relevant signals referred to in this section should be used when musters and drills are to be conducted. All persons on board should be notified beforehand that a practice muster or drill is about to be held.

16. **Fire and Other Emergency Drills.**

(a) A fire or other emergency drill should be held simultaneously with the first stage of the abandon ship drill.

(b) For the purpose of a fire drill an outbreak of fire should be assumed to have occurred in some part of the ship and fire control measures simulated. The complete co-operation of the personnel of all departments is essential in fire fighting,. The type and position of the supposed fire should be varied from time to time and can include:-

(i) Cargo fires in holds or other spaces.

(ii) Fires involving oil, gas or chemical cargoes as appropriate.

(iii) Fires in engine, pump or boiler rooms.

(iv) Fires in crew or passenger accommodation.

(v) Fifes in galleys due to burning oil or cooking fats.

(c) The engine room staff should ensure that the fire pumps in the machinery spaces are prepared for operation, started, and that full water pressure is on the fire mains. Where there is an emergency fire pump situated outside the machinery space, this pump should be started up as indicated below. The fire party or parties at the scene of the assumed fire should lay out hoses and here practices water should be played and where practicable water should be played through them, the water being supplied fire from the machinery space pump and then from the emergency pump only, with the machinery space isolating valve closed. A number of portable fire extinguishers should be available and members of the fire party should be instructed in the use of the type of fire extinguisher for a particular type of fire.

(d) The crew should be exercised in the closing of openings, ie. Side scuttles, deadlights, doors, ventilating shafts, fire doors, the annular space around the funnel, etc both to reduce the supply of air to a fire and isolate it from other parts of the ship, especially stairways and life shafts. As many of the crew as possible and particularly

the officers should be made familiar with the position of remote controls for ventilation fans, oil fuel pumps and oil tank valves and be instructed in the method of operations thereof.

(e) Fixed installations for extinguishing fire, such as halon, CO_2, inert gas, steam or drencher systems in the cargo spaces, and sprinklers systems in passenger accommodation together with fire alarm and detection systems should be tested with as much realism as practicable. The fire party should also be exercised in the use of the breathing apparatus and protective clothing and such emergency appliances as axes and safety lamps, which should be brought out, checked and deployed by appointed members of the party at all fire drills. Where the number of sets of breathing apparatus permits, it is recommended that persons using them should practice in pairs.

(f) It is important that members of the crew who are not allocated to fire parties are familiar with the use of and can identify the types of fire extinguisher they will encounter in the accommodation and in their work areas. Such crewmembers should be instructed in the use of the type of extinguishers appropriate to the kind of fire, eg. Those discharging water, foam, dry powder, CO_2, etc.

(g) At each fire drill at least one extinguisher should be discharged by a different crew member in order that both crew members in fire parties and other crew members gain experience in using fire extinguishers. Crewmembers should also be familiar with the location and means of activating the fire alarms in the accommodation and in their working areas. It is also important that all crew members and particularly those whose place of work is in a machinery space are familiar with the escape routes from any part of the ship they are likely to be in when on or off duty. Such familiarity should enable escape routes from any part of the ship they are likely to be in when on or off duty. Such familiarity should enable escape to be made in darkness or through smoke and should include familiarity with the location and the means of opening any emergency escape windows or hatches.

(h) All fire protection systems and appliances should at all times be in good order and available for immediate use during the voyage and in port. Compressed air bottles of breathing apparatus and fire extinguishers should be refilled after any drill. Where refilling facilities are not available on board additional equipment may be carried to facilitate training. Discharged equipment should be clearly marked and stored for refilling when in port. Equipment dedicated for training purposes should be marked ‘for training purposes only’.

(i) Participation in fire drills may not necessarily imply direct involvement with fighting a fire and may include back up to fire parties, being a member of the first aid party or controlling passengers at their assembly stations while the fire fighting part of the drill is being undertaken. On the other hand, on cargo ships with small crews it will usually be necessary for every members of the crew to be familiar with all aspects of fire fighting and the use of all the fire fighting equipment provided on board the ship.

(j) Instruction should cover fire prevention, particularly in galleys, machinery spaces, cargo compartments, pump rooms and accommodation spaces. On-board instruction in fire-fighting is supplementary to training available at fire fighting

courses ashore and is primarily concerned with the particular equipment available on board and the nature of on board fire hazard.

(k) To ensure the ready availability of fire protection systems and appliances periodic checks should be performed. The following checklist may be used as guidance for this purpose :-

(i) Monthly testing and inspection should be carried out to ensure that :-

(aa) All fireman's outfits, fire extinguishers, fire hydrants, hose and nozzles are in place and in serviceable condition.

(ab) All escape routes including stairways and corridors are free of obstructions and properly maintained.

(ac) Public address system and ship's alarms are serviceable.

(ad) All fixed fire fighting installation valves are set in the correct operational position.

(ae) Dry pipe sprinkler systems are pressurized, where appropriate, and gauges indicate correctly;

(af) Sprinkler system pressure tank water levels are correct as indicated by glass gauges.

(ag) All sprinkler system pumps operate automatically on pressure loss in the systems.

(ah) All fire pumps are operational;

(ai) All fixed gas fire extinguishing installations are free from leakage.

(ii) Quarterly testing and inspection should be carried out to ensure that :-

(aa) All fire extinguishers are at correct pressure and are not due for servicing.

(ab) All automatic alarms for sprinkler systems activate using the section test valves.

(ac) The international shore connection is serviceable.

(ad) Fire fighting equipment lockers contain their full inventory and the equipment they contain is in serviceable condition.

(ae) All fire doors, fire dampers and closing devices can be operated locally.

(iii) Annual testing and inspection should be carried out to ensure that :-

(aa) All fire doors and ventilation dampers where appropriate, operate remotely.

(ab) Where practicable all aqueous foam and water spray fixed fire fighting installations operate correctly.

(ac) All accessible components of fixed fire fighting systems, typically nozzles, are free from damage or obstruction on visual inspection.

(ad) All fire pumps, including sprinkler system pumps, develop correct pressures and flow rates.

(ae) All hydrants operate.

(af) All antifreeze solutions are correctly maintained and cross connection between fire main and sprinkler system operates correctly.

(ag) Fixed fire detection systems operate correctly, according to manufacturers test instructions.

(iv) Fire or other emergency drills should be followed by the second stage of the abandon ship drill i.e. the muster and drill at the survival craft stations. This stage of the abandon ship drill should be announced by the abandon ship signal or by the particular means by which abandon ships announced, or by a signal used for the purpose of summoning crew members to their survival craft stations.

CHAPTER – 5

PROCEDURES OF FIRE FIGHTING

Ships At Sea.

1. The procedure for fire fighting for ships at sea is described.

(a) Raise the fire alarm

(b) Crew assemble at muster / emergency stations

(c) Fire parties assemble and prepare for action

(d) Communication between teams and bridge is established

(e) Ship's speed and course is altered if necessary

(f) Ship's emergency generator and emergency fire pump is started. Further if situation demand or enforced, normal steering / manual steering from the bridge may be carried out.

(g) Fire fighting is started as per orders / guidance from master /officer taking In charge

(h) Continuous communication / feedback is maintained between teams and the bridge on walkie talkies

(i) Inform the nearest port Authority and the port fire brigade and inform nearby ships for assistance if required. Inform the shipping company office. Inform the coast guard and port for tugs / rescue boats if fire is out of control and evacuation of ship's personnel has to be done.

Procedure for Fire Fighting when the Ship is in Port.

2. The procedure for fire fighting when a ship is in port is described.

(a) Fire fighting initiated as per procedure stated above for vessel at sea.

(b) Inform / Call the port fire brigade.

(c) Inform the port authority / U.S. Coast Guard if in US waters.

(d) Confirm to the port authority and port fire brigade if the master is in charge or any other senior officer on board is directing the fire fighting operation.

(e) Master / Port authorities to be informed of any hazards to the dock installations due to fire.

(f) Evacuate non-essential personnel from the ship.

(g) If feasible get the main engine/s ready to move out of port. Inform if tugs are required for movement as own power may not be feasible due to any number of reasons.

3. **Ship In Dry-Dock / Shipyard / Laid Up.** When a ship is in dry-dock, the cooling effect of water on the submerged hull is missing. Therefore the danger of fire spreading by conduction increases. In case of such fires, boundary cooling from outside may be necessary using dock's fire main system. Also shore based fire fighters / fire station must be informed immediately for assistance. The timber shoring used to stabilise the ship resting on timber / concrete chocks in the dry dock may also be effected due to fire. Further, the water used for fire fighting inside the ship may result in additional moments thereby affecting the ship's stability. When a vessel is in dry dock / shipyard / laid up, the individual team strength will be reduced due to less overall complement of the ship. Therefore after the initial muster, the various teams' composition may require modification. A fire on board a vessel when in dry dock / shipyard / laid up, the immediate response must be as follows :-

(a) Activate the fire alarm and inform the master or the officer in command.

(b) Immediately call up and request help from shore / port fire services / emergency services.

(c) Inform a senior / responsible officer of the shipyard / dry dock authorities and seek his guidance.

(d) Deal with the fire so far as is safe, reasonable and practical.

(e) Ascertain promptly what services are available on board in such a situation.

4. **Procedure For Co-ordination with Shore Based Fire Fighters.**

(a) Once the resources for an immediate attack on fire have been assembled by the shore based fire fighters, the basic strategy is considered in consultation with the master. The choice could be :-

(i) Attack and extinguish

(ii) Initial containment

(iii) Prevent immediate local spread or

(iv) Investigate further spread of fire

(b) The master should pass on as much information as possible needed by the shore staff. Some of the questions that may be asked by the shore assistance staff are :-

(i) Is anyone missing or injured and if so, where is he?

(ii) Locating the fire?

(iii) Details of cargo, stowage plan,

(iv) What is burning? Risk of spread of fire.

(v) Have the electrical supplies to the ship or fire zone been isolated?

(vi) How did the fire start?

(vii) What action has been taken by the ship's staff?

(viii) What are the emergency systems / services available?

(ix) Are there any dangerous goods onboard and what is the state of adjacent compartments?

(x) What is the state of ship's emergency parties?

(xi) How critical is the ship's stability?

(xii) How much has been founded in?

(xiii) What fixed fire fighting installations are available?

(xiv) What are the ship's internal communication systems?

(xv) Have any fixed fire fighting installations already been operated/ used?

(c) With the above information, the best course of actions may be to make a direct attack. But if not, it may be necessary for the Breathing Apparatus users men to follow the ship's guidelines from the weather deck to the fire. They are then guided to the fire by ship's personnel in B.A. who are familiar with that part of the vessel. Once the guideline is positioned, hoses can be laid and fire fighters can quickly and safely find their way through thick smoke to and from the fire.

(d) Experience has shown that, it is unadvisable to give breathing apparatus user detailed instructions on a complicated route through smoke to the seat of the fire. The going is painfully slow for safety reason and becomes totally disoriented. Where a deep penetration through smoke is necessary, it is of utmost importance that the first B.A. team is of two fire brigade men and two men from the ship's company. If available, a thermal imaging camera should be used.

(e) Once the fire is located, the first hurdle is over and the correct extinguishing media can be selected and the attack begun. If this is not possible then the fire must be contained until additional resources are available, or with the compartment closed down, the fixed fire fighting installations can be used. These systems should be used early to control the fire rather than after the fire has grown too big to be controlled effectively.

(f) The correct extinguishing media must always be used and occasionally water is very wrong media. However, whether extinguishing or controlling a fire below decks, to cool it, using minimum amount of water is the correct action.

5. **Location of Fire Control Plan for the Assistance of Port / Shore Fire Fighting Personnel.** Regulation 11-2/ 20.2 of 1974 SOLAS convention (as amended) requires ships to be provided with fire control plan for the assistance of Port / Shore fire brigade. The plan is to be permanently stowed in a prominently marked weather tight enclosure on the main deck near the gangway on both port and starboard sides.

6. **Location & Specification of the Containment.**

(a) The enclosure should be readily available to shore/port fire fighting personnel, so that any fire on board can be effectively tackled. The enclosure and contents of the enclosure should be indicated by red silhouette on white background as given below :-

(b) **Specification.** Dimensions of the steel tube should not be less than 297 x 400 mm. If the enclosure is not adjacent to the gangway, there should be a guide sign to enable the shore fire fighting personnel to locate the fire plan. The enclosure should be capable of easily opening and it should be located in a well-illuminated position. It should be protected against marine environment.

(c) Shore fire brigade and other rescue organisations should be informed of the Contents of the fire control plan and the signs indicating the location of the fire control plan enclosure.

7. **Notice to Ship-owners, Shipmasters, Shipbuilders and Repairers.** (M.1267)

(a) Following a number of fires in ships in port Merchant shipping notice M. 393 was published to draw attention to the problem and to the report of a working party set up to consider and make recommendations for circulation to all interests concerned on the fire prevention and fire fighting arrangements to be observed in connection with ships in dock and harbor areas and in shipbuilding and repair yards. The report of the working party was published in 1950 and contained a number of recommendations covering most aspects of fire prevention and fire fighting in ships in port, with particular emphasis on the care necessary in regard to passenger ships. Many of the points made by that working party remain valid and this notice is intended to re-emphasise the precautions discussed in the earlier Notice and to update them. M. Notice No. M. 393 is now superceded by M. 1267. A second report of the working party published in 1980, is directed mainly at shore side fire services.

(b) **Responsibility.** It is reaffirmed that responsibility for fire prevention and fire fighting in ships under construction is the builder's responsibility and in ships under repair the owner's responsibility, unless, in either case, there is a written agreement to the contrary.

(c) **Patrols.**

(i) Particular care should be taken in selecting personnel for patrols. They should be both physically and mentally suitable for the job, reliable, and well trained in first aid fire fighting measures. They should be provided with whistles, personal radios or other suitable means of raising alarms.

(ii) Exercises of a realistic nature should be arranged so as to maintain a high level of efficiently and to impress upon personnel, the importance of their work.

(iii) Patrols in large passenger ships should be so organised as to ensure that every part of the vessel is visited at least once every hour.

(iv) The patrols should report at a point which is manned at all times. Arrangements should be made to ensure that the bells of the sprinkler, fire detector and other alarm systems ring at that point. The items of equipment maintained there should include breathing apparatus, lifelines, and spare hydrant keys, and in addition to the information about the ship necessary for the effective conduct of fire fighting operations should be available.

(d) **Co-operation with Public Fire Brigades.** Ship to shore communication should be reviewed to ensure that they provide the quickest possible contact with the public fire brigade at all times. All concerned should take steps to ensure that the facilities available to a particular ship and well known to those whose responsibility it would be to give the alarm in event of fire. Liaison between shipbuilder, ship repairers, dock authorities and local fire brigades should not, however, be confined to communications matters, but should also embrace training and fire fighting arrangements generally.

(e) **Smoking.** The need for care and caution when smoking is permitted in the designated areas, to be strictly implemented.

(f) **Ship's Fire Extinguishing Appliances.**

(i) At all times water supplies of adequate pressure should be immediately available on board ship, either in the ship's fire main or in hoses run on board from other sources.

(ii) Extra apparatus such as adapters for hose couplings, booster, pumps, etc. should always be available and the provision of any additional apparatus considered necessary for the particular ship should not be left until there is an outbreak of fire. Any fire appliances removed for repair or recharging should be calibrated at regular intervals in accordance with the manufacturer's instructions and the ships staff trained in the use of the equipment. Regular gas monitoring of the cargoes provides the necessary information for detecting at an early stage potential problems and following appropriate procedures for safe carriage.

(g) With the exception of ships engaged on coastal voyages of short duration which need not be provided with carbon monoxide gas monitoring equipment, all ships engaged in the trade should be provided with the equipment fitted out as

required by the code as soon as possible. Ship-owners, masters and shippers are requested to note the changes and to observe the new provisions of the code in cargo operations.

Search And Rescue Operations

8. If it is suspected that a man is trapped within a smoking / fire area, a search by a team in pair must be carried out immediately. A Team in pair can tackle the casualty / obstruction more easily. The following action must be taken :-

(a) The search team be briefed properly about the method and the area to be searched.

(b) Danger to the life of rescuers must be kept in mind with respect to duration of CABA set.

(a) A lifeline must be used and attended by a third man outside in the safe area.

(b) The rescuers may carry one additional CABA set for the casualty.

(e) In situation when a SCBA wearer enters an enclosed space or approaches a fire, it must be noted that when wearing protective clothing, air circulation will be minimum. The protective clothing also prevents radiation heat loss, which may result in the body absorbing heat rather than losing it.

(f) As a hot and humid atmosphere prevents perspiration, there will probably be no body-cooling effect from this process. It should also be borne in mind that hard physical work would generate body heat. Therefore any person working in an enclosed space or approaching a fire must be made fully aware of every real dangers of heat strike.

9. **Working within Safe Time Limits.** All above factors cause the body's heat regulation system to break down and can produce the following symptoms, which must be brought to the notice of the search and rescue team members.

(a) Blood flow is increased to the blood vessels in the skin especially if the ambient temperature is greater than the body.

(b) The pulse rate increase with a corresponding rise in breathing rate and the blood pressure drops, causing the blood supply to the brain to reduce leading to failure of senses and unconsciousness.

(c) Heat stroke occurs, perspiration ceases and the individual becomes increasingly irritable and complains of headache and a burning sensation of the skin.

(d) Unconsciousness soon follows and the person may then pass into a coma & die.

(e) It is therefore imperative that an individual must not be allowed to work in a hot and humid atmosphere for longer than is absolutely necessary, nor must they make successive entries into an enclosed space without suitable entries into an enclosed space log without suitable recovery equipment.

10. **Smoke Inhalation.**

(a) Smoke inhalation must be avoided or reduced to the absolute minimum. SCBA teams must wear their equipment in fresh air and ensure proper sealing of the facemask. The effect of smoke inhalation are cumulative and are not overcome by bringing an affected person to fresh air, although their condition can be eased by this changed location. Soot particles from the smoke filled environment would have passed into the person's lungs.

(b) Under no circumstances must any person who has been affected by smoke be allowed to make further breathing apparatus entries into any enclosed space because recovery from exclusive exposure to smoke takes considerable time.

11. **Evacuation Signals.** Whenever a SCBA team is inside a space and the team leader requires the team to evaluate, a whistle can be used if other communication methods have failed. A continuous series of whistle blast means evacuate the space immediately.

12. **Preparation of Contingency Plans / Fire Control Plan.**

(a) Ship's fire fighting Organisation :-

(i) Control station is always on the bridge.

(ii) The master is in charge.

(iii) Fire fighting team in-charges communicate with the bridge.

(iv) Methods of damage control and containment.

(v) Monitoring of ships stability.

(vi) Organisation of fire parties.

(b) Organisation of fire parties :-

(i) Identification of fire parties

(ii) Identification of each member of a fire party

(iii) Co-operation between members in a fire / emergency party

(iv) Duties of each fire / emergency party

(c) Damage control and containment of fire :-

(i) Bridge operated watertight doors and fire doors

(ii) Stopping of ventilation fans

(iii) Closing of fire dampers

(iv) Closing of doors and portholes

(v) Turning ship to direction for better fire fighting to contain / avoid spreading fire.

(v) Cooling hot spots

(vi) Fire watch

(d) Information to be given to the bridge :-

(i) Time of fire alarm

(ii) Position and nature of fire

(iii) Information on fire parties

(iv) Pressurisation of firemain

(v) Reports on fire fighting

(vi) Effect of fire

(v) Persons unaccounted for

(e) Information readily available on bridge :-

(i) Arrangements drawings

(ii) Details of accesses and escape routes

(iii) Details of fire extinguishing equipment (i.e. fire control plan)

(iv) Stability information

(v) Survival equipment

(vi) Stowage plans

(vii) Information on dangerous goods

(f) Fire precautions :-

(i) Constructional provisions

(ii) Fire fighting equipment and systems

(iii) Operations

(iv) Organisation

(v) Procedure at repair yard

(g) Areas of Fire hazards :-

(i) Machinery spaces

(ii) Accommodation

(iii) Galleys

(iv) Radio room, Battery room and Electrical equipment and Electrical control room / switch board.

(v) Cargo holds

(vi) Store rooms

Fire Fighting for Ships Having Cargo of Dangerous Goods on Board

13. **Basic Requirement During Loading of Dangerous Cargo.**

(a) The stowage plan is prepared prior to loading clearly marking the position and the type/class of dangerous cargo.

(b) In case of fire due to dangerous cargo or in the vicinity of the dangerous cargo, the fire fighting plan must be prepared indicating which fire fighting medium / appliances can be used safely.

(c) The layout / plan of dangerous cargo loaded is always displayed in saloons / mess decks / accommodation / alleyways so that the dangers and the risk is well understood and assessed by all personnel on board.

(d) When the fire alarm / emergency alarm is sounded, the emergency procedure to fight the fire is put into operation keeping in mind the risks involved due to the nature of the dangerous cargo.

(c) When fighting dangerous cargo fires, the nature of the cargo must be taken into account.

(d) After extinguishing dangerous cargo fires, it is mandatory to maintain a fire watch on such cargo due to danger and possibility of re-ignition.

(e) A through investigation must be carried out after fighting such fires – why & how the fire took place.

14. **Cotton Bales Fires.**

(a) Cotton is considered dangerous cargo as it can lead to fire due to spontaneous ignition (i.e. production of heat due to oxidation and the heat-accumulated can lead to fire). Such fires are difficult to fight / bring under control. Cotton is always stored in tightly packed bales and each bale may weigh from 200-300 Kg. Being heavy cargo, it is stored in lower holds for stability. This also acts as a base for the other cargo loaded on top of cotton bales.

(b) Cotton bales loaded should be dry and oil free Bales should be tightly bound and in good condition at the time of loading. Strict compliance of " No Smoking" in and around such cargo holds should be observed by ship's personnel / stevedores. The hold's bottom bare metal should be covered to prevent moisture seeping into the cotton bales while the bales are kept slightly clear from the bulkheads.

(c) In case of fire, the ideal procedure to extinguish cotton fire is to dig out the affected area. This may be impossible if the other cargo loaded on top of cotton bales is not easily removable. In a bad case, the ship may even have to be directed to the nearest port if fire can't be controlled / restricted.

(d) However, if the affected bales can be lifted out, such bales are discarded and thrown overboard to prevent their re-ignition, despite being immersed in water (as in wet bales re-ignition is more likely due to their faster oxidation process). For effective fire fighting, CO_2 is the best fire extinguishing agent in the hold and cooling of bulkheads by water from outside may be necessary.

15. **Coal Fires.**

(a) Coal cargoes give off flammable gases, which can form explosive mixture when they come in contact with air within certain proportions. The flammable gas viz. methane (CH_4) given off by coal is lighter than air and during the voyage, the gas will find its way into the upper surfaces of the cargo. It is therefore necessary to ensure "surface ventilation" to allow / enable the flammable gases to escape into the atmosphere and do not get accumulated in the holds.

(b) To provide surface ventilation, hatch covers for entrance to the hatch are opened. Further, steel hatch covers are raised on wheel if the weather permits. Also ventilation and exhaust blowers to the hatches are kept running to sweep away the flammable gases released by coal.

(c) A close watch on the coal cargo is maintained during voyage and cargo hold's temperatures are recorded during each watch because all types of coal (viz. Anthracite, Lignite, and Brown coal) can set on fire due to spontaneous ignition. In case of unusual rise in temperature, extra ventilation is resorted into the coal cargo holds to bring down the temperature and overheating is prevented. The temperature rise takes place as the coal absorbs oxygen (from air) and this process of oxidation is an exothermic chemical reaction (produces more and more heat)

(d) In case of coal fire, the only early action can be water spray / jet on the coal by the hose (from firemain system). This may not be easy to do for a prolonged period due to excessive heat and smoke in the hold. In such circumstances, the fire fighter will have to be in proper fire protective clothing and to use the self contained breathing apparatus.

(e) Another suitable method to fight such fires will be to release CO_2 gas into the coal cargo hold, which can provide quick smothering action. This option not only contains / restricts the fire/blaze but also gives sufficient time for arrival at the nearest safe port.

(f) The last option to tackle coal cargo fire is to flood the hold with water. But depending on the size of the hold, the ships stability must be taken into account.

Alternatively, while the hold is being constantly flooded with water through, jets / sprays, the pumping out of the water from the holds may be resorted to reduce the free surface effect and to bring down the temperature.

(g) Finally, following precautionary measures must be taken prior to loading coal cargo :-

(i) Cargo holds / spaces must be cleaned of coal dust / debris.

(ii) Remove additional / tween deck pontoons to ensure free escape of flammable gases and heat into the atmosphere.

(iii) Do not allow any dunnage in the holds.

(iv) There must be sufficient provisions to observe the temperatures at different places and levels of coal cargo.

(v) Coal cargo should be well trimmed during loading and on completion.

16. **Fish Meal Fires.** Fish meal is loaded in bags and has the tendency to absorb oxygen (from the air), thereby producing sufficient heat due to oxidation process which leads to spontaneous ignition / combustion. Extensive ventilation of fishmeal cargo is essential to avoid this cargo setting on fire during a voyage. Therefore strict precautions are taken while loading this cargo for ventilation. For this, cargo is loaded in channels so that there is sufficient circulation of air all around the cargo to take away the heat produced due to oxidation. Precautions are taken to ensure that these channels provided for ventilation are not blocked during loading or during passage by falling of fish meal bags. During loading, the temperature of the bags is checked by injection thermometers; so that any bag with excessively high temperature can be rejected. During the voyage, hold temperatures are normally noted 2-3 times in a day. Provisions are made to position the thermometers at all levels of cargo in various spaces containing fishmeal bags.

17. **Methods of Fighting Fish Meal Fires.**

(a) In case of fire in fishmeal cargo hold, all ventilation is closed as soon as possible. For small fires, dry chemical powder is used.

(b) However, in case of a major fire, immediately after stopping all ventilation, CO_2 is released to smother the fire. In case the fire can't be contained / extinguished by releasing CO_2 into the hold, fire fighting by water hose is the last option. In this fire fighting method, care must be taken to direct water only on the fire area because after the fire is extinguished, the wet fish meal bags will have to be discarded and thrown overboard to avoid re-ignition. As far as possible, the stage of fire fighting by water must be avoided to save the cargo as well as to maintain ship's stability.

(c) In conclusion, it may be stated that if the fishmeal cargo is loaded / stowed properly with due care for ventilation and frequent checking of temperature is carried out during voyage, this cargo will remain safe and free of fire.

18. **Procedures for Fire Fighting on Oil Tankers.** When an emergency alarm is given for fire on board an oil tanker, the initial emergency procedure into action is same given

earlier for ships at sea. The additional requirement for fire fighting on board an oil tanker is as follows :-

(a) A fixed fire extinguishing system is provided for the pump room.

(b) Foam monitors are provided on the decks

(c) An inert gas system is provided for the oil cargo tanks

(d) Isolating valve/s are provided in the fire main system for water supply under high pressure (7-9 Bar) for foam monitors, in the event of damage to the firemain. This is also necessary to control the water supply when emergency fire pump is in use.

(e) Spaces are well marked into gas dangerous and gas free.

(f) There is clear-cut segregation between cargo spaces its system and accommodation / machinery spaces and its systems.

(g) After the fire is extinguished, a fire watch is kept till investigations are carried out for the cause of fire.

Fire Fighting Process Hazards

19. **Dry Distillation Hazards.** Dry distillation is a combustion process in which a flammable substance burns with insufficient oxygen leading to incomplete combustion. This can occur only in enclosed spaces such as cabins, stores etc. When such a place is exposed to air due to entry of a person to fight fire, the incomplete combustion of the flammable material can lead to fresh fire or explosion depending upon the nature of the flammable substance :-

(a) Following sequence of events take place in the case of dry distillation (i.e. insufficient burning due to insufficient oxygen) which can cause injury to a fire fighter due to flash back. When fire takes place in an enclosed space such as a cabin or store :-

(i) Heat builds up over a period of time but the complete burning of the flammable substance has not yet taken place because the enclosed space is cut off from further supply of air (oxygen).

(ii) On opening of that enclosed space for fire fighting, it will directly expose the area to fresh air (oxygen).

(iii) Entry of fresh (oxygen) will immediately result in re-ignition of the flammable substance/s.

(iv) The person entering such an area to fight fire is directly exposed to flash back / re-ignition and can get serious burns unless protected by fireproof clothing.

(b) Methods of fighting dry distillation fires :-

(i) By externally cooling such enclosed space to bring down the temperature, so that on entry of fresh air (oxygen), the possibility of flash back/re-ignition is minimised.

(ii) By entering such spaces behind a water screen by a spray nozzle.

(iii) By directing a jet of water towards ceiling of the enclosed space on fire, which will result, spray downwards after hitting the ceiling to result in immediate cooling.

(iv) Due to dry distillation hazards, it is advisable not to enter the enclosed space immediately when the area is exposed to fresh air, i.e. entry only after flash back or re-ignition.

20. **Chemical Reaction Hazards.** There are a large number of chemicals which react with different fire fighting media causing release of toxic fumes/gases which may cause fire or explosion, flammable gases/vapours produce intense heat due to self sustaining chemical reactions (Exothermic) which in turn may result in fire. Therefore, it is imperative to use a proper fire-fighting agent to fight a fire. Chemical reactions during fire fighting are more likely to occur with fire in accommodation and Cargo spaces.

(a) The different fire fighting agents are :-

(i) Water which may be fresh water or seawater.

(ii) Steam which may be saturated or superheated.

(iii) Foam, which may be of high, medium or low expansion type. Also there are different foam making mode from different materials / equipment.

(iv) Carbon dioxide / Halons 1301 or 1211

(v) Dry chemical powder, which may be just sodium Bicarbonate or a mixture of large number of substances like sodium Bicarbonate, powder silica, powdered clay, powdered limestone, Graphite, sand, talc (Soapstone) and sodium chloride etc.

(b) Effects of Chemical reactions :-

(i) Fire due to explosion due to production of flammable gases.

(ii) Spontaneous combustion.

(iii) Release of toxic fumes / gases.

(iv) Generation of smoke which may be toxic / pungent.

(c) Chemical reactions which can cause fire / explosions :-

(i) Release of acetylene when calcium carbide comes in contact with water.

(ii) Decomposition of steam into hydrogen and oxygen when burning metal like steel comes in contact with water due to decomposition of water.

(iii) Oxidising cargoes such as Ammonium phosphate, potassium phosphate, Calcium phosphate (i.e. the fertilisers) which can sustain fire even if smothered by an extinguishing gas like CO_2 / Halon 1301 or Halon 1211.

(iv) Cargoes such as phosphorous can spontaneously ignite in air when their packagings get damaged.

(v) Self-heating cargoes such as grain, coal, fishmeal etc. due to oxidation when directly exposed to air.

(vi) Release of methane (CH_4) in coal cargoes to dangerous levels when their ventilation is restricted.

(vii) The response required for fire fighting the dangerous goods is well explained in emergency procedures for ships carrying dangerous goods. For fire fighting the bulk materials of chemical hazards is to be guided by the emergency schedules of the code of safe practice for solid bulk cargoes. For Ships carrying dangerous goods, the fire fighting emergency procedures are to be guided by international maritime dangerous cargo code.

21. **Hazards of Boiler Uptake Fires.** Boiler uptake fires: are those which occur in Boiler uptakes, economisers and air heaters of steam ships and exhaust pipes, economisers, heavy fuel oil heaters or waste heat boilers of diesel ships. The main cause of such fires is accumulation of carbon deposit and oil, which catch fire due to overheating are the following :-

(a) Inaccessibility to the boiler uptake in the upper section of the engine room.

(b) Possibility of explosion when access doors of the economiser are opened.

(c) Possibility of economiser tubes reaching a temperature of 700°C which can result in the following :-

(i) The iron of the tube will start burning in steam.

(ii) The reaction will be self-sustaining and will generate more and more heat (Exothermic reaction).

(iii) The products of combustion will be black iron oxide and free hydrogen (due to decomposition of water H_2O into Hydrogen and Oxygen)

(iv) The burning of iron in steam will not need outside oxygen to sustain burning due to decomposition of water.

(v) The hydrogen produced is a highly flammable gas, which will sustain burning.

(vi) Hydrogen burning will cause explosion.

22. **Methods / Procedures of Fighting Boiler uptake Fires.**

(a) The main engine / boiler rooms must be shut down immediately.

(b) Water spray the external surfaces in way of the fire to bring down the temperature.

(c) Close all relevant dampers and trip ventilation and exhaust blowers to isolate air from the fire.

(d) Protect essential electrical and other equipment below the fire areas against water damage. Electric supply to all such equipment must be cut off immediately. To overcome the supply problem to fire pump or fire and bilge pump which are normally electric driven, diesel engine driven, fire pump (which are normally located outside main machinery / boiler areas) must be started.

(e) Continue cooling operation of boiler and surrounding areas is carried out till it is considered safe to open the economiser doors for examination to carry out through cleaning on the boiler exhaust (fire) side.

23. **Fires In Water Tube Boilers.**

(a) Fire explosion may result due to iron burning in steam when the temperature rises to about 700°C in water tube boilers due to shortage of water in the boiler.

(b) The main causes of above fires are due to :-

(i) Shortage of water in the boiler which will directly result in overheating of the tubes above the water level and undue delay in shutting down the boiler subsequently.

(ii) An uncontrollable soot/carbon particle fire in the furnace after the boiler has been shut down. This will add to the uncontrollable heating of the tubes above the water level (due to shortage of water in the boiler).

24. **Procedure for Fighting Boiler Fires.** If the fire is discovered before the temperature of the tube has reached 700 - 750°C, the most suitable method for fire extinction is :-

(a) To direct maximum amount of water through the feed pumps to the source of fire, assuming the boiler tubes have fractured.

(b) To keep air casing and boiler uptake cool by hosing them with water from outside.

(c) Avoid using carbon dioxide / foam appliances / water through fire spray nozzles directly on fire.

Important Note. While carrying dangerous goods, onboard merchant ships, instructions and guidelines laid down in the IMDG code must be strictly followed.

CHAPTER- 6

FIRE DETECTION, FIRE ALARM, FIRE FIGHTING APPLIANCES, EQUIPMENT AND FIXED INSTALLATION

Fixed Fire Detection And Fire Alarm Systems.

1. **General Requirements.**

(a) Any required fixed fire detection and fire alarm system with manually operated call points shall be capable of immediate operation at all times.

(b) Power supplies and electric circuits necessary for the operation of the system shall be monitored for loss of power or fault conditions as appropriate. Occurrence of a fault condition shall initiate a visual and audible fault signal at the control panel which shall be distinct from a fire signal. There shall be not less than two sources of power supply for the electrical equipment used in the operation of the fire detection and fire alarm system, one of which shall be an emergency source. The supply shall be provided by separate feeders reserved solely for that purpose. Such feeders shall run to an automatic change – over switch situated in or adjacent to the control panel for the fire detection system :-

(i) Detection and manually operated call points shall be grouped into sections. The action of any detector or manually operated call point shall initiate a visual and audible fire signal at the control panel and indicating units. If the signals have not received attention within two minutes an audible alarm shall be automatically sounded throughout the crew accommodation and service spaces, control stations and machinery spaces of category A. This alarm system need not be an integral part of the detection system.

(ii) Indicating units shall denote the section in which a detector or manually operated call point has operated. At least one unit shall be so located that it is easily assessable to responsible member of the crew at all times, when at sea or in port except when the ship is out of service. One indicating unit shall be located on the navigating bridge if the control panel is located in the main fire control station.

(iii) Clear information shall be displayed on or adjacent to each indicating unit about the spaces covered and the location of the section.

(iv) No section covering more than one deck within accommodation, service and control station shall normally be permitted except a section which covers an enclosed stairway. In order to avoid delay in identifying the source of fire, the number of enclosed spaces included in each section shall be limited as determined by the administration. In no case shall more than fifty enclosed spaces be permitted in any section.

(v) In passenger ships a section of detectors shall not serve spaces on both side of the ship not on more than on deck and neither shall it be situated in more than one main vertical zone except that the Administration, if it is

satisfied that the protection of the ship against fire will not thereby be reduced, may permit such a section of detectors to serve both sides of the ship and more than one deck.

(vi) A section of fire detectors which cover a control station, a service space or an accommodation space shall not include a machinery space of category A.

(vii) Detectors shall be operated by heat, smoke or other products of combustion, flame, or any combination of these factors. Detectors operated by other factors indicative of incipient fires may be considered by the Administration provided that they are no less sensitive than such detectors. Flame detectors shall only be used in addition to smoke or heat detectors.

(viii) Suitable instructions and component spares for testing and maintenance shall be provided.

(ix) The function of the detection system shall be periodically tested to the satisfaction of the Administration by means of equipment producing hot air at the appropriate temperature, lor smoke or aerosol particles having the appropriate range of density of particles size, or other phenomena associated with incipient fires to which the detector is designed to respond. All detectors shall be of a type such that they can be tested for correct operation and restored to normal surveillance without the renewal of any component.

(x) The fire detection system shall not be used for any other purpose except that closing of fire doors and similar functions may be permitted at the control panel.

2 **Fire Detector Installation Requirement.**

(a) Manually operated call points shall be installed throughout the accommodation spaces, service spaces and control stations. One manually operated call point shall be located at each exit. Manually operated call points shall be readily accessible in the corridors of each deck such that no part of the corridor is more than 20 m from a manually operated call point.

(b) Smoke detectors shall be installed in all stairways, corridors and escape routes within accommodation spaces. Consideration shall be given to the installation of special purpose smoke detectors within ventilation ducting.

(c) Where a fixed fire detection and fire alarm system is required for the protection of spaces other than those specified in the previous paragraph at least one detectors operated by heat, smoke, or other products of combustion shall be installed in each such space. Detectors shall be located for optimum performance. Positions near beams and ventilation ducts or other positions where patterns of air flow could adversely affect performance and positions where impact or physical damage is likely shall be avoided in general, detectors which are located on the overhead shall be a minimum distance of 0.5 m away from bulkheads.

Type of Detector	Maximum Floor Area Per Detector	Maximum Distance Apart Between Centres	Maximum Distance Away from Bulkhead
Heat	37 m^2	9 m	4.5 m
Smoke	74 m^2	11 m	5.5 m

(d) The administration may require or permit other spacing based upon test data which demonstrate the characteristics of the detectors.

(e) Electrical wiring which forms part of the system shall be so arranged as to avoid galleys, machinery spaces of category A, and other enclosed spaces of high fire risk except where it is necessarily to provide for fire detection's or fire alarms in such spaces or to connect to the appropriate power supply.

3. **Design requirement.**

(a) The system and equipment shall be suitably designed to withstand supply voltage variation and transients, ambient temperature changes, vibration, humidity, shock, impact and corrosion normally encountered in ships.

(b) Smoke detectors required to be installed in stairways, corridors and escape routes shall be certified to operate before the smoke density exceeds 12.5 % obscuration per metre, but not until the smoke density exceeds 2% obscuration per metre. Smoke detectors to be installed in other spaces shall operate within sensitivity limits to the satisfaction of the Administration having regard to the avoidance of detector insensitivity or over sensitivity.

(c) Heat detectors shall be certified to operate before the temperature exceeds 78^0 C but not until the temperature exceeds 54^0 C, when the temperature rise, the heat detectors shall operate within temperature limits to the satisfaction of the administration having regard to the avoidance of detector insensitivity or over sensitivity.

(d) At the discretion of the Administration, the permissible temperature of operation of heat detectors may be increased to 30 ^{0} C above the maximum deckhead temperature in drying rooms and similar spaces of a normal high ambient temperature.

Sample Extraction Smoke Detection Systems Requirement As Per Solas-74.

4. **General Requirement.**

(a) Wherever in the text of this regulation the word "system" appears, it shall means sample extraction smoke detection system.

(b) Any required system shall be capable of continuous operation at all times except that systems operating on a sequential scanning principle may be accepted, provide that the interval between scanning the same position twice gives an overall response time to the satisfaction of the administration.

(c) Power supplies necessarily for the operation of the system shall be monitored for loss of power. Any loss of power shall initiate a visual and audible signal at the control panel and the navigating bridge which shall be distinct from a signal indicating smoke detection.

(d) An alternate power supply for the electrical equipment used in the operation of the system shall be provided.

(e) The control panel shall be located on the navigating bridge or in the main fire control station.

(f) The detection of smoke or other products of combustion shall initiate a visual and audible signal at the control panel and the navigation bridge.

(g) Clear information shall be displayed on or adjacent to the control panel designating the spaces covered.

(h) The sampling pipe arrangements shall be such that the location of the fire can be readily identified.

(i) Suitable instructions and components spares shall be provided for the testing and maintenance of the system.

(j) The functioning of the system shall be periodically tested to the satisfaction of the Administration. The system shall be of a type that can be tested for correct operation and restored to normal surveillance without the renewal of any component.

(k) The system shall he designed, constructed and installed so as to prevent the leakage of any toxic or flammable substances or fire – extinguishing media into any accommodation and service space, control station or machinery space.

5. **Installation Requirement.**

(a) At least one smoke accumulator shall be located in every enclosed space for which smoke detection is required. However, where a space is designed to carry oil or refrigerated cargo alternatively with cargoes for which a smoke sampling system is required, means may be provided to isolate the smoke accumulators in such compartments for the system. Such means shall be to the satisfaction of the administration.

(b) Smoke accumulators shall be located for optimum performance and shall be spaced so that no part of the overhead deck area is more than 12 meter measured horizontally form an accumulator. Where systems are used in spaces which may be mechanically ventilated, the potion of the smoke accumulators shall be considered having regard to the effects of ventilation.

(c) Smoke accumulators shall be positioned where impact or physical damage is unlikely to occur.

(d) Not more than four accumulators shall be connected to each sampling point.

(e) Smoke accumulators from more than one enclosed space shall not be connected to the same sampling point.

(f) Sampling pipes shall be self draining and suitably protected from impact or damage from cargo working.

6. **Design Requirement.**

(a) The system and equipment shall be suitably designed to withstand supply voltage variation and transients, ambient temperatures changes, vibration, humidity, shock, impact and corrosion normally encountered in ships and to avoid the possibility of ignition of flammable gas air mixture.

(b) The sensing unit shall be certified to operate before the smoke density within the sensing chamber exceeds 6.65 % obscuration per meter.

(c) Duplicate sample extraction fans shall be provided. The fans shall be of sufficient capacity to operate with the normal conditions or ventilation in the protected area and shall give an overall response time to the satisfaction of the Administration.

(d) The control panel shall permit observation of smoke in the individual sampling pipe.

(e) Means shall be provided to monitor the airflow through the sampling pipes so designed as to ensure that as far practicable equal quantities are extracted from each interconnected accumulator.

(f) Sampling pipes shall be a minimum of 12 mm internal diameter except when used in conjunction with fixed gas fire-extinguishing systems when the minimum size of pipe should be sufficient to permit the fire extinguishing gas to be discharged within the appropriate time.

(g) Sampling pipes shall be provided with an arrangement for periodically purging with compressed air.

Fixed Fire Detection And Fire Alarm Systems For Periodically Unattended Machinery Spaces.

7. (a) A fixed fire detection and fire alarm system of an approved type in accordance with the relevant provisions of regulation 13 shall be installed in periodically unattended machinery spaces.

(b) This fire detection system shall be so designed and the detectors so positioned as to detect rapidly the onset of fire in any part of those spaces and under any normal conditions of operation of the machinery and variations of ventilation as required by the possible range of ambient temperatures. Except in spaces of restricted height and where their use is specially appropriate, detection systems using only thermal detectors shall not be permitted. The detection systems using only thermal detectors shall not be permitted. The detection system shall initiate audible and visual alarms distinct in both respects from the alarms of any other system not indicating fire, in sufficient places to ensure that the alarms are

heard and observed on the navigating bridge and by a responsible engineer officer. When the navigating bridge is unmanned the alarm shall sound in a place where a responsible member of the crew is on duty.

(c) After installation the system shall be tested under varying conditions of engine operation and ventilation.

Ship's Fixed Fire Fighting Extinguishing Equipment.

8. The following fixed fire fighting installations are provided on board ships :-

(a) Automatic water sprinkler system for accommodation, paint/chemical store/s

(b) Fixed foam smothering system

(c) Fixed CO_2 Flooding System or Halon 1301 smothering system in old ships but has to be phased out by 01-01-2001.

(d) Inert gas system (for oil tankers and chemical carriers)

(e) Fixed dry chemical powder fire fighting system (for gas carriers)

Automatic Water Sprinkler System.

9. **Purpose.**

(a) It is installed in accommodation spaces, alleyways, saloons and paint store / chemical store.

(b) It is a fixed device to fight fire automatically by sprinkling water.

(c) The sprinkling system clears the smoke by washing it out.

10. **Salient Features.**

(a) It is fitted with an alarm system, which gives alarm in case of fire as well as fights the fire.

(b) A small test valve is fitted to test the fire alarm, which rings on drop in pressure in the system.

(c) The sprinkler heads are fitted to the pipeline leading to each cabin.

(d) A quartzoid bulb filled with alcohol is fitted to stop flow of water to the sprinkler by keeping a seal in place.

(e) Quartzoid bulb is filled with a high expansion liquid (alcohol).

(f) The quartzoid bulb bursts when the temperature rises (between 68^{o}C to 79^{o}C) and allows the water to flow to the sprinkler.

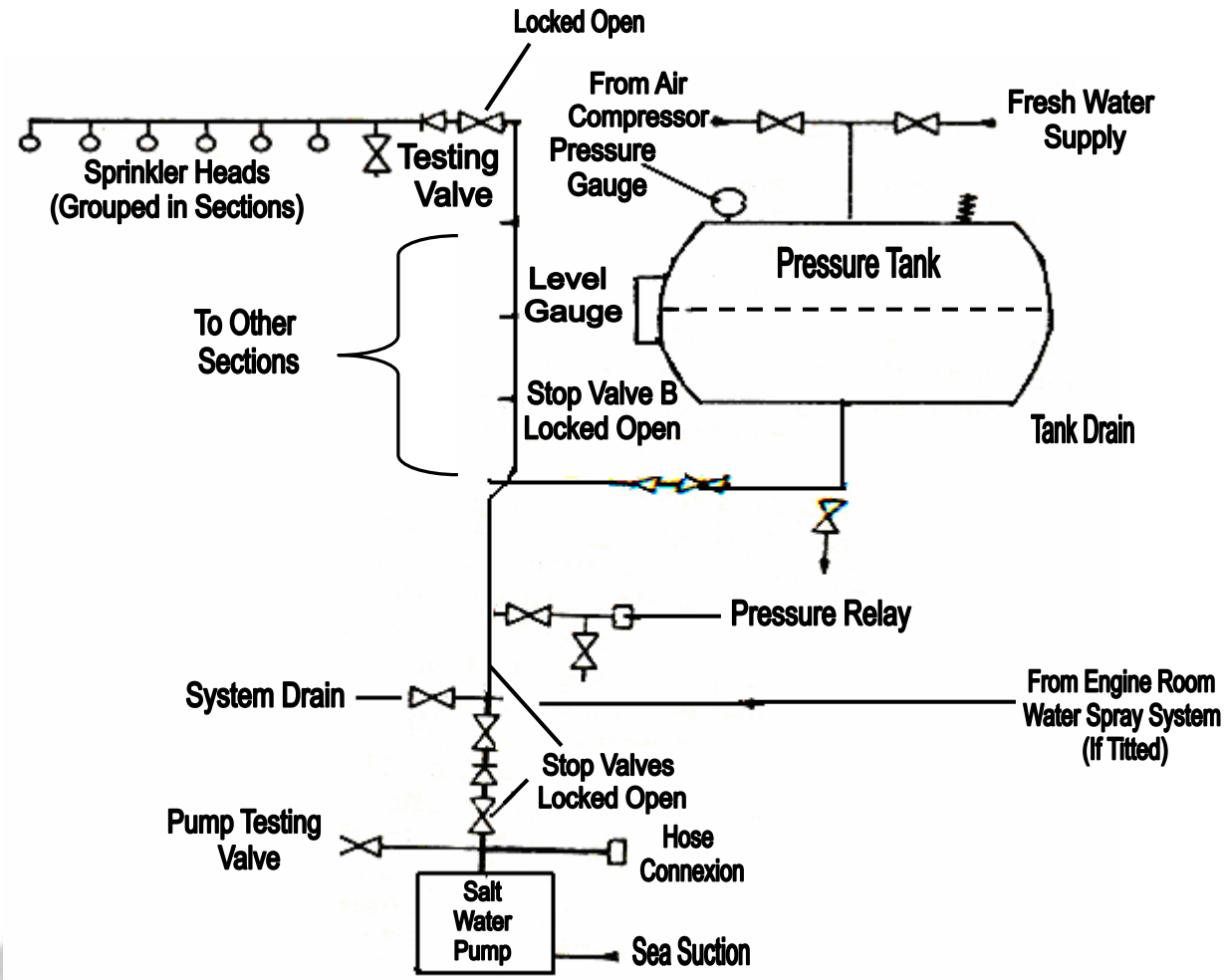


Fig 3- Automatic Sprinkler System

(g) The pipelines are attached to the reservoir tank containing fresh water under pressure.

(h) Reservoir tank is maintained at 6 – 7 bar pressure.

(i) Reservoir tank filled with fresh water is fitted with a level indicator.

(j) This system is also connected to a sea water pump which operates automatically (when the pressure in the system falls) by a pressure switch.

(k) The seawater pump line is connected to the sprinkler system line.

(l) After use of the seawater, the lines have to be flushed thoroughly with fresh water to prevent corrosion and wear and removal of salt from the moving parts of the sprinkler.

11. **Detailed Description of Automatic Water Sprinkler System.**

(a) The installation is always kept ready for use by pressuring the water tank by compressed air. Temperature due to fire will also rise and operates an individual sprinkler head and the resulting pressure drop in the system will start the seawater

pump, through a pressure switch. Water supply is then maintained by the sea water pump. Sprinkler heads are fitted throughout the accommodation but the number of sprinkler heads in any section is limited to about 150 (IMO Regulations allow up to 200). Pipes are of steel galvanised for corrosion protection and the system is initially filled with fresh water. If part of the system become filled with salt water due to operation of seawater pump, it has to be subsequently drained, flushed and again filled with fresh water.

(b) A test circuit is fitted so that the pressure switch can be isolated and by draining the test circuit, the system alarm as well as the automatic "cutting in" of sea water pump can be tested.

12. **Seawater Pump.** The pump's sea suction and discharge (N/R) valves are permanently kept in open position. The pump is only for the sprinkler system. The pump prime mover (electric motor) is connected to main and emergency power supplies. There is also a provision through a screw down non-return valve (kept locked) from the fire main system so that the back flow from the sprinkler to the firemain is prevented.

13. **Water Tank.** The water level in the tank of automatic water sprinkler system is indicated by a gauge glass and is specified as equivalent to one minute's discharge of the pump. Tank volume is at least twice that of the water specified. Initially the flow of water through a sprinkler system is due to the pressure exerted by the compressed air. It must be so arranged that during expulsion of the standing charge of fresh water from the tank, the air pressure remains sufficient to overcome the head to the highest sprinkler & to provide enough working pressure for the sprinkler. Therefore a compressor is connected having automatic starting to supply air. Supply pressure must be higher than that in the tank so that air can be replenished under pressure. The tank is also provided with a fresh water supply, drain and relief valve. The pipe from the tank to the system has a non-return valve to prevent entry of seawater to the tank.

14. **Section Alarm Valve.**

(a) The sprinklers are grouped in sections with a limited number of heads. Normally a section is confined to one fire zone or area. There is a stop valve for each section either locked open or fitted with a telltale alarm to prevent unauthorised closure. A special non-return valve is the means of operating the alarm and visual indicator which is positioned on the bridge / fire control centre. The indicator is a panel showing a section of the fire zones with an alarm and light for each. Thus, when a sprinkler head operates, the approximate location is displayed.

(b) The alarm is a pressure switch and water from the system reaches it when the non-return valve is lifted by water flowing to any sprinkler head. Normally the N/Rvalve covers the annular channel in the seat. The drip orifice prevents build up of water pressure in the alarm pipe due to leakage. The gauge at each stop valve shows section pressure and a drilled hole through the valve accommodates expansion due to temperature change. The test valve gives a discharge of water equivalent to that of one sprinkler and is used to test the section alarm.

(c) Any part of the system, which might be subjected to freezing, must be

protected. Anti-freeze can be added to fresh water for this purpose. Some vessels, which trade in low temperature areas, have dry pipe sections installed.

15. **Dry Pipe Section Alarm.**

(a) The dry pipe extends upwards from the section valve which also acts as the link between the sprinkler system water pressure and the dry pipe pressurised with air. Water pressure is contained by the water clapper, which is held on its seat by the centre valve. The space above the centre valve is filled to the level with water and the pipe above that is filled with air under pressure. The centre valve is made watertight by a joint and the intermediate space is dry.

(b) When operation of a sprinkler head releases the pressure in the dry pipe, the centre valve is pushed up by the force of water under the clapper. The clapper lifts and rotates on the yoke, being swung to one side by the effect of water flow on the skirt. The water floods up through the dry pipe causing the centre valve to lock open and in filling the intermediate chamber, pressurises and operates the alarm.

(c) Pressure gauges for air and water are required. The section valve opens when air pressure drops to $^{1}/_{6}^{th}$ that of the water pressure. The cover has to be removed to reset the valve.

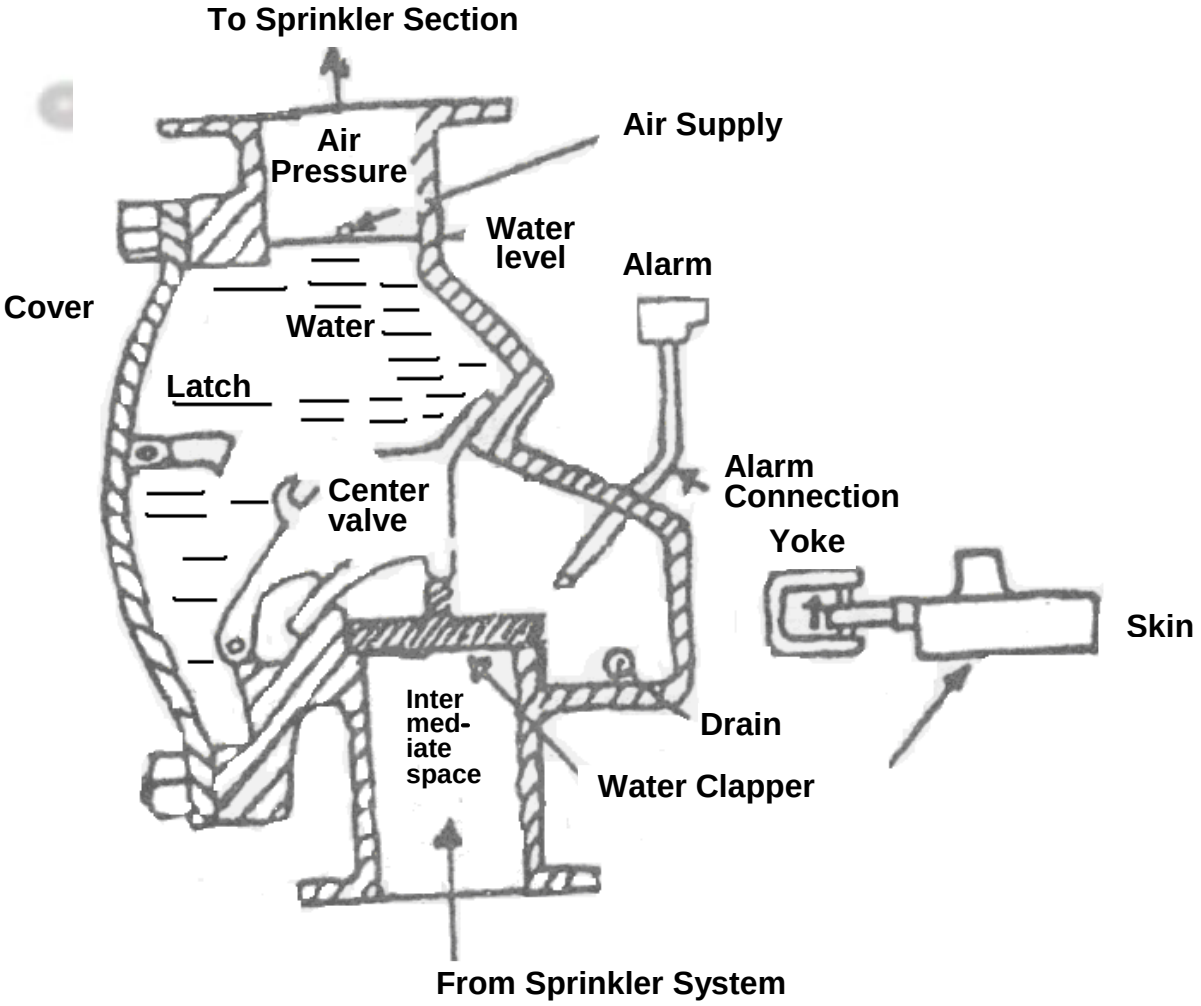


Fig 4 –Dry Pipe Section Alarm

16. **Sprinkler Head.**

(a) Sprinklers must give a minimum cover of 5 litres per square metre area per minute over the protected area.

(b) The head is closed by a valve, which is held in place by a quartzoid bulb. Excessive heat causes the bulb to shatter by expansion of the liquid it contains. Heads are designed to act at a particular temperature and the bulbs are colour coded (red: 68°C, yellow: 79° C). Sprinklers in the accommodation are normally these types. Higher temperature sprinkler heads are fitted if necessary.

(c) Spares must be carried and the temperature code is marked on the deflector.

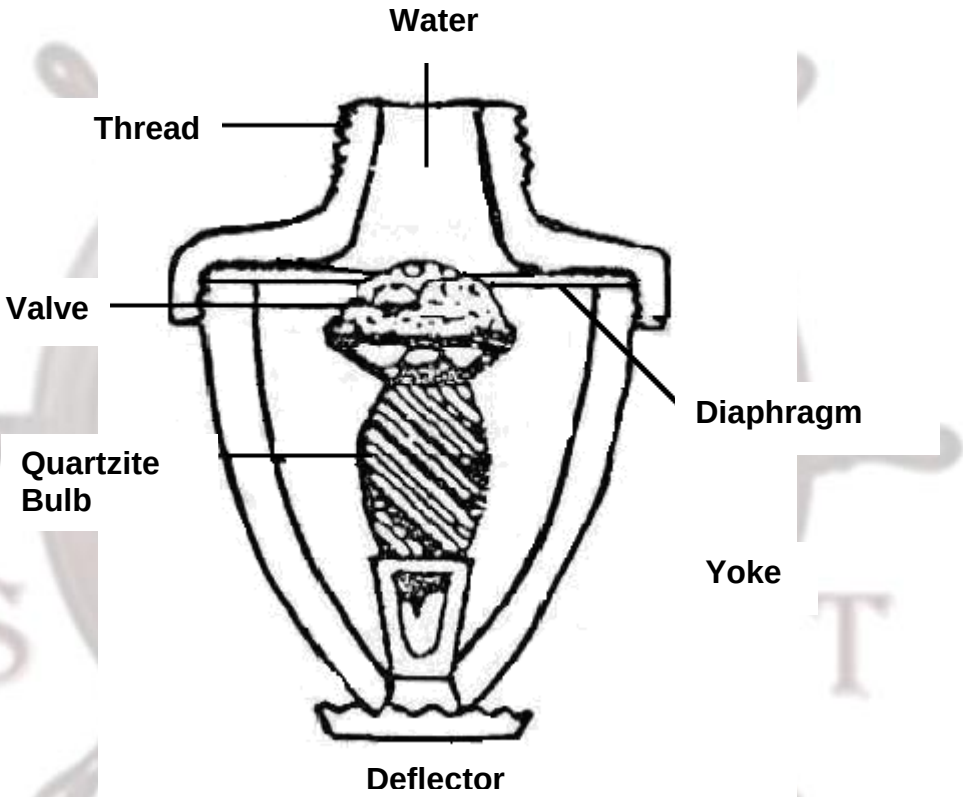


Fig 5 - Sprinkler Head

17. **Fire Alarm Only.** Thermal or smoke detector heads can be fitted in the accommodation as an alternative to the sprinkler system. The heads are similar to those used for machinery spaces.

18. **Automatic Water Sprinkler System Regulations Requirements.**

(a) System should be capable of immediate automatic operation, if subject to freezing it should be suitably protected against it.

(b) Alarm should be visual and audible at local station and navigating bridge or control room, with a provision for testing the alarm without sprinkler head operating.

(c) Each group shall not serve more than two decks and shall not be situated in more than on vertical zone.

(d) Gauge indicating pressure in the system shall be provided at each local

station and main control station.

(e) Application rate available per sprinkler head should be not less than 5 litres/m_2/min. over the nominal area covered by sprinklers.

(f) Pressure tank is to be provided with level gauges indicating level; quantity sufficient to cover rate of discharge of sea water pump for one minute running time; plus maintain air pressure sufficient to provide efficient discharge for the highest fitted sprinkler.

(g) The pump provide should be capable of providing sufficient throughput for simultaneous coverage of a minimum area of 280 m_2 at the application rate of sprinklers (5 litres/m^2/min).

(h) Sprinkler pressure tank and pump should not be located in spaces they protect and located reasonable remote from any machinery space.

(i) Sources of power for pumps and alarm system should be available from two independent sources of power with automatic change over.

(j) Means provided to test the automatic operation of the pump, on reduction of pressure in the system.

(k) Sufficient spare sprinkler heads should be provided with bulbs.

Fixed Pressure Water Spraying System.

19. **Brief Description.**

(a) The machinery spaces of certain cargo ships and passenger ships – depending on the type and horsepower of the machinery and the vessels size and class are fitted with fixed pressure water spraying system. This system incorporates an almost similar layout as the automatic sprinkler system excepting that the sprinkler head has no bulb. Thus in this type of protection the fire has to be detected by other means, the system only provides ready availability of water at stipulated rates through numerous sprinkler or nozzle outlets.

(b) The water from this system is capable of being sprayed on the tank tops and other areas over which oil may spread; or any other main fire hazard areas. Each of these areas is controlled by a valve. A valve is normally situated just adjacent to the area protected. This is similar to the zones in an automatic sprinkler system. The line from the valve to the supply tank is filled with fresh water and kept under constant pressure. An air vessel is incorporated into the system to prevent the pump from operating at minor pressure drops. When the control valve of any section is opened the pressure drop created cuts in the pump provided automatically.

(b) Regulations stipulate that :-

(i) Nozzle / sprinkler heads provided must be of approved type only.

(ii) Number and arrangements such that the spaces protected are

provided with water at rate of 5 liters /m^2/min.

(iii) Nozzles/sprinkler heads so fitted and designed that they do not get clogged with debris or by impurities in water.

(i) System divided into sections and isolated by valves suitably located outside such spaces protected.

(ii) System kept charged continuously, with pump starting automatically with a pressure drop occurs.

(iii) Pump capacity should be sufficient to supply requisite throughput at stipulated rates per nozzle/sprinkler head in the protected space (any on compartment or area to be protected)

(iv) Location of pump should be outside the space protected.

(v) Power supply should also be available from emergency source of supply cutting in automatically.

(d) The system is also used to protect cargo spaces in Roll on Roll off ferries where access to the deck is required and smothering gas system is therefore inappropriate. Regulations require A60 fire divisions to be fitted in vehicular decks, a water spray system has been accepted as an alternative. In this system the vehicle deck is divided into zones, the minimum length of each being equal the length of the longest vehicles permitted on the roads. Each such zone has a control valve and the pump capacity is such that two adjacent zones can be catered to simultaneously at their rated capacity. The water application rates are similar as for sprinkler systems coverage being entire and 5.0 litres/m_2/min. reduced to 3.5 litres/m_2/min. when deckhead height is less than 2.5 mtrs. The system is manually controlled for application initially water being then made available continuously on the same stipulations as for pumps required in pressure water system in machinery spaces.

Fixed Foam Fire Fighting System.

20. **Introduction.**

(a) This system is installed to fight major class ‘B’ fires (Liquid Fuel Fires) in E/R, Boiler Areas, Helicopter decks, paint store etc.

(a) This system is based on Educator System.

(b) Firemain system must be pressurised to 7-9 Bar prior to operating this system.

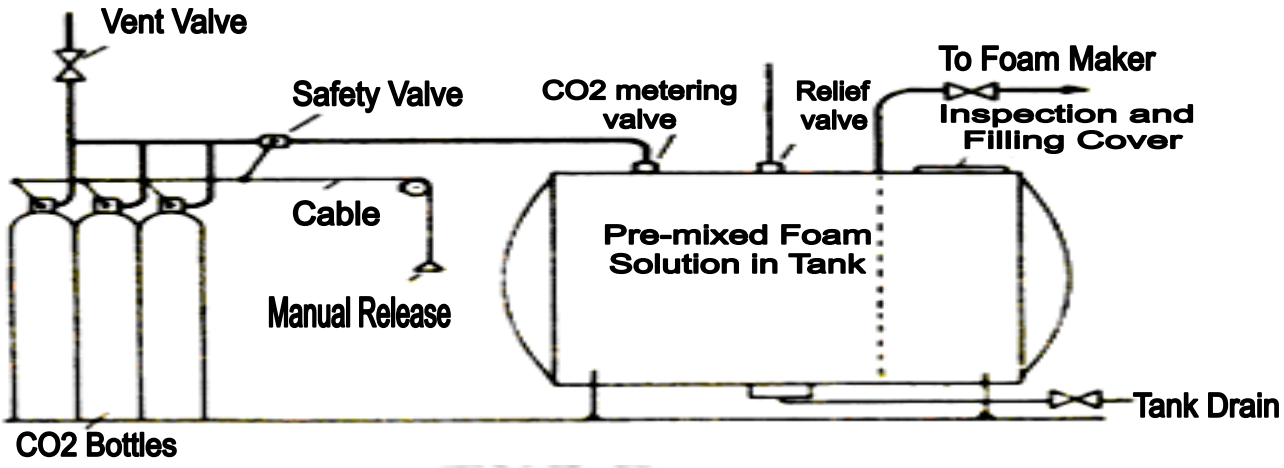


Fig 6 – Pre- Mixed Foam Installation

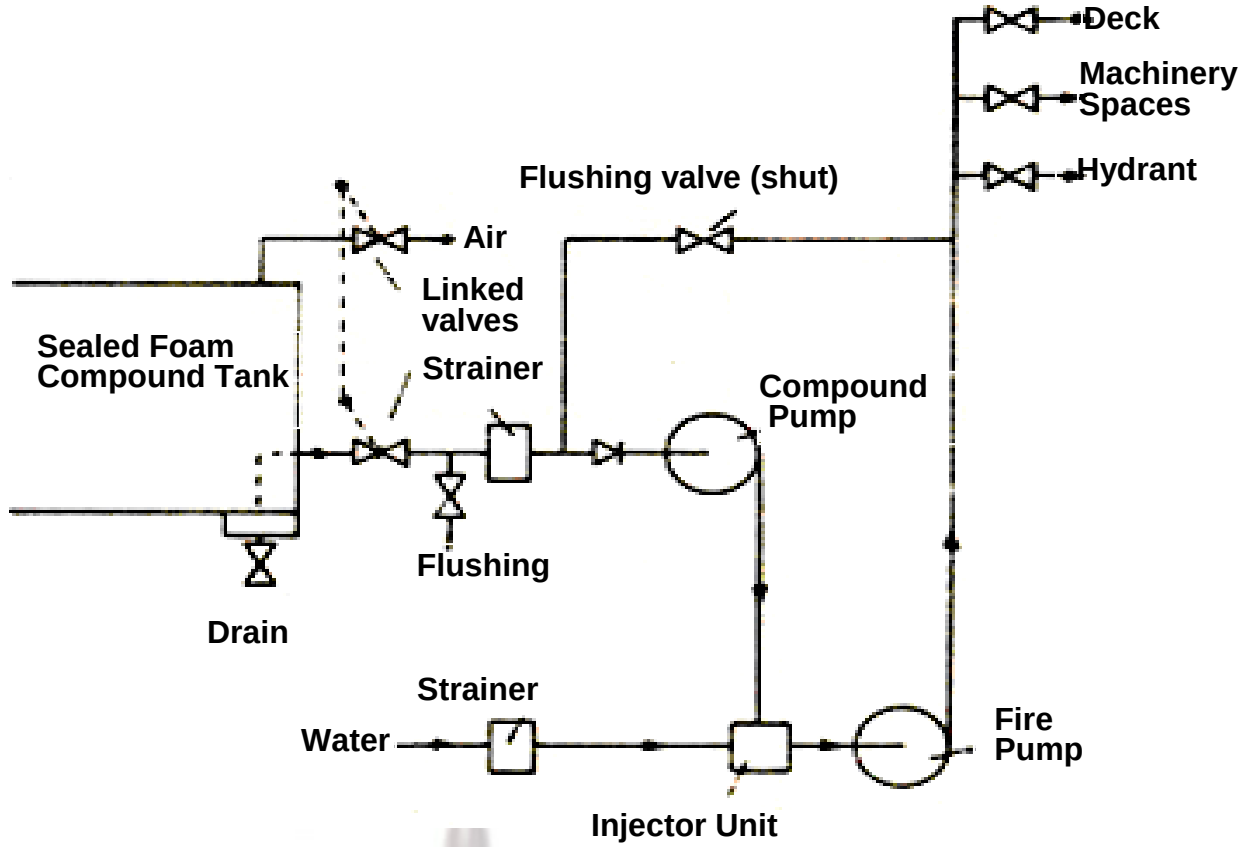


Fig 7 - Foam Compound Injection System

(d) A convergent – divergent nozzle is used to create partial vacuum by increasing velocity of driving fluid (seawater from ships fire main system at pressure 7 - 9 Bar) at the neck, thereby allowing the driven fluid (foam) to be sucked into the neck of the nozzle and mixes with the driving liquid (sea water).

21. **Description.**

(a) A foam tank installed on ship's upper deck of capacity 450-500 Ltrs.

(b) Foam from tank gets lifted into sea water line through ejector/ educator.

(c) Foam gets mixed with seawater and is driven to the area of oil fire through a valve on the manifold and pipelines.

(d) In case of E/R, the foam pipe is provided with a nozzle at the exit, which helps in sucking away the air in the fire area, thereby increasing the smothering effect by reducing Oxygen content, and in turn expands the foam.

(e) The air in fire area is used for expansion of the foam for better smothering action.

(f) The expansion of foam may be as high as 1: 800 in Engine room / Enclosed spaces.

(g) For Helicopter deck, the high expansion foam is not suitable and the expansion is restricted to 1: 150 only to avoid foam being flown away by Air / Breeze.

22. **Working of Fixed Foam System for Fighting Major Class 'B' (Liquid Fuels) Fires.**

(a) A large tank on upper deck is filled with low expansion foam for protection from oil fires (Class 'B' fires) for machinery spaces. The system is designed to deliver correctly proportioned amount of foam compound into the water supply to the deck main. The foam is drawn from the large tank fitted with vent arrangement by the foam pump. The pump itself has a relief valve but foam compound excess to requirements is discharged back to the tank via the diaphragm valve, which is controlled by two sensing lines.

(b) As demand varies due to number of outlets, the diaphragm valve will deliver the correct amount of foam compound into the water main for any set of conditions. Foam monitors are fitted on deck and supplied through the deck main.

(c) Foam drencher nozzles in the machinery spaces are situated above areas of high risk. The control valves are located in the foam compartment, which is outside of the machinery spaces. A second water supply is available from the emergency fire pump fitted outside the main machinery compartments. The foam plant must be capable of providing foam for fire fighting in machinery spaces even when water is supplied by the emergency fire pump, which normally gives pressure less than the main fire pump.

High Expansion Foam.

23. **General Descriptions.**

(a) High expansion foam is generated by blowing air through a mesh, which has been wetted by a solution of foam concentrate in water. This is usually used for main engine room and cargo hold fires. The mesh is corrugated and its hole size governs the expansion ratio of the foam normally limited to 800:1 by IMO rules. This limit is required because the foam is composed largely of air and easily breaks down when in contact with a fire. However, in the 800:1 expansion foam, the original one volume of liquid evaporates and produces enough steam to reduce the percentage

of oxygen in the steam / air mixture to about 7.5 %, which is ideal to extinguish any fire.

(b) The foam concentrate is metered / mixed with the water to give 1.5 % solution of concentrate in water, and sprayed onto the screen. An electrically driven fan blows through air. Delivery ducts are necessary to carry the foam to the fire area and for this even the normal ventilation trunking may be used in emergency generation and sufficient generation of foam must be rapid to fill the largest space to be protected at the rate of one metre per minute.

24. **Fixed Foam System Using Educator / Ejector.**

(a) In this system a convergent-divergent nozzle is used to create partial vacuum by increasing velocity of the driving fluid. Sea water from the ship's fire main system at pressure 7~9 Bar is used for efficient working of the ejector to allow the foam to be sucked into the neck of the ejector and is driven out mixed with sea water.

(b) A foam tank is installed on ship's upper deck of capacity 500 ~ 600 Ltrs. filled with foam concentrate. The tank's foam mixed with sea water under pressure can be directed to the fire space by opening the appropriate valve of the foam manifold/distributor and led to the fire area through the pipelines.

(c) In case of engine room, the other end of the foam pipe ending in the engine room is provided with the nozzles at the exit which help in sucking away the air (O_2) from the engine room thereby not only expanding the foam but also eliminates the air (O_2) and acts as double smothering agent in extinguishing fire. In this case, the foam expansion ratio may be maximum as high as 800:1 in an enclose space.

(d) However, for helicopter deck or other open areas, the expansion ratio is limited to only about 150:1 to avoid foam being blown away by wind/breeze.

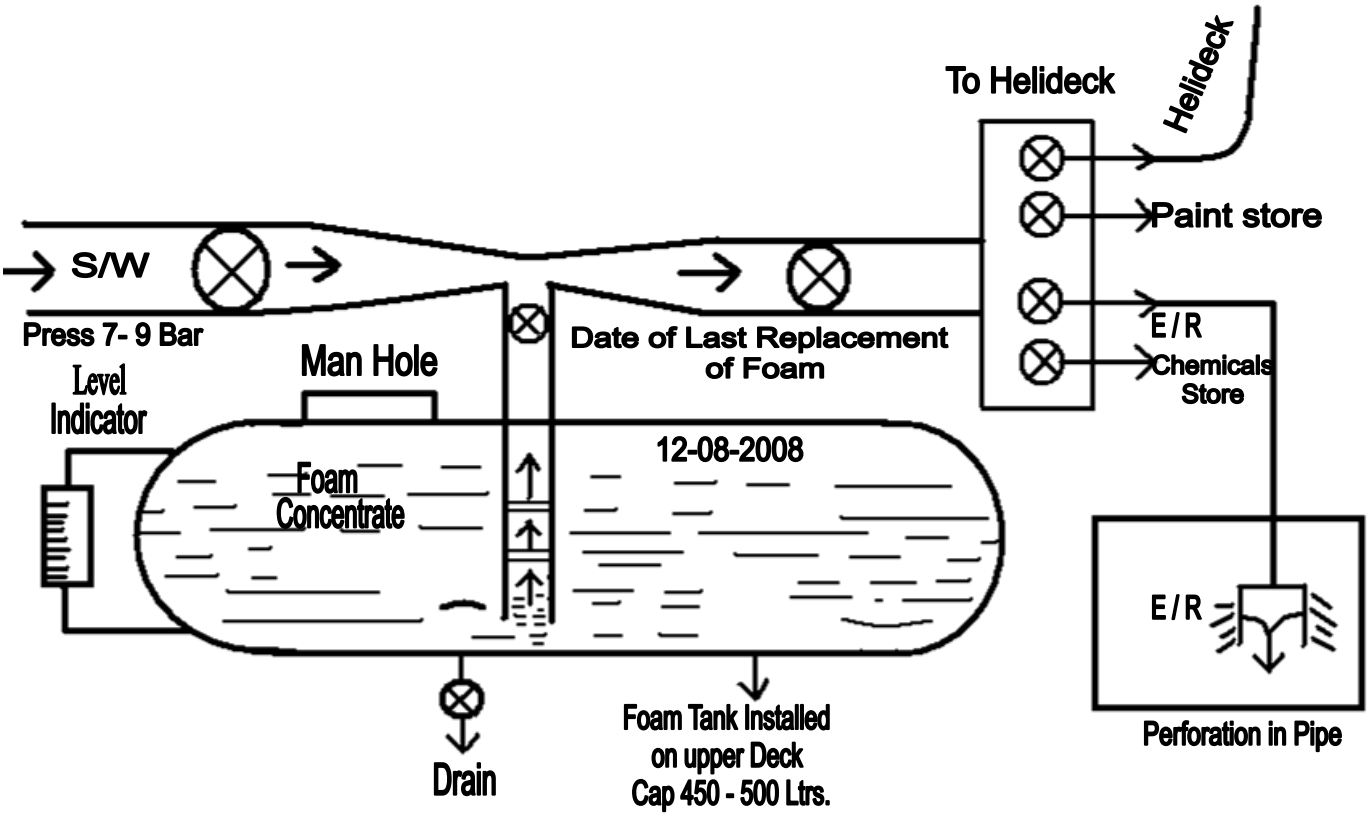


Fig 8 – Foam System

25. **Solas Regulation for Fixed Deck Foam System (Oil Tankers).**

(a) The deck foam system and the ships fire main system are to be capable of simultaneous operation in order that the personnel operating the foam fire fighting equipment may be cooled by water spray supplied from the fire main through a hose and nozzle. The main fire pumps should therefore have sufficient capacity to satisfy the requirements of the foam system and simultaneously provide two jets of water from the fire hydrants.

(b) The rates of supply of foam solution should not be less than the greatest of the following :-

(i) 0.6 litres/minutes per square metres of cargo tanks deck area, where cargo tanks deck area means the maximum breadth of the ship multiplied by the total longitudinal extent of the cargo tank spaces.

(ii) 6 litres/minutes per square metre of the horizontal sectional area of the single tank having the largest such area.

(iii) 3 litres/minute per square meter of the area protected by the largest monitor, such area being entirely forward of the monitor, but not less than 1250 litres /minutes.

(c) Sufficient foam concentrate at the above rates is to be supplied to ensure at least 20 minutes of foam generation in tankers fitted with inert gas systems and 30 minutes in tankers not fitted with inert gas systems. The foam expansion ratio should not exceed 12 to 1.

(d) The number of monitors provided and their positions is to be such as to ensure that foam can be delivered to any part of the cargo tanks deck area. The distance from the monitor to the farthest extremity of the protected area forward of that monitor should not be more than 75% of the monitor throw in still air conditions.

(e) Applicators are to be provided to ensure flexibility of action and to cover areas screened by the monitors. The capacity of any applicator is not to be less than 400 litres/minute and the throw in still air conditions not less than 15 meters. Not less than four applicators are to be provided. Sufficient foam hydrants are to be provided to ensure that foam from at least two applicators can be directed to any part of the cargo tanks deck area.

(f) Applicators may replace monitors in ships less than 4000 tones deadweight. The capacity of each applicator should be at least 25% of the foam solution rate required.

(g) A monitor and hydrant is to be fitted both port and starboard at the poop from of accommodation spaces facing the cargo tank.

26. **High Expansion Foam System.**

(a) High expansion foam systems are only suitable for use in enclosed spaces. The high expansion foam generator consists essentially of a power driven fan, a net or gauze, a supply of high expansion foam concentrate, and a spray nozzle

arrangement. Foam solution is uniformly sprayed over the net, which is usually made of nylon, and air is blown through it. Foam of uniform size having an expansion ratio of 800:1 is produced and ducted away to the protected space.

(b) The foam is tough and persistent and is an excellent insulator and absorber of radiant heat. When such foam reaches a fire, unit volume of water in the foam is turned into approximately 1700 volumes of steam, the resulting atmosphere not contains approximately 7.5% by volume of oxygen, far less than the percentage required to sustain combustion. At the same time, the surrounding foam prevents access to further oxygen to the fire.

(c) High expansion froam is generated by units capable of rapidly discharging through fixed discharge outlets a quantity sufficient to fill the greatest space to be protected at a rate of at least 1 metre in depth per minute with a maximum filling time of 10 minutes. If the gross horizontal area of the protected space exceeds 400 m^2 at least two foam generators are provided. Sufficient foam concentrate is provided to produce foam for five fillings of the largest space protected. The expansion ration of the foam should not exceed 800 to 1.

(d) Ducts made of steel or other suitable material are arranged to deliver the foam quickly to high-risk areas. The ducts include means, such a as an automatic flap, so that a fire in the protected space will not affect the foam generating equipment.

(e) The foam generator, its source of power supply, foam concentrate and means of controlling the system should be readily accessible, simple to operate and grouped in as few locations as possible at positions not likely to be cut off by fire in the protected space.

(f) The water supply is from a source outside the protected space and can be from the emergency fire pump provided the capacity is sufficient to satisfy the requirements for the foam system and the demand for two hydrants at the required pressure.

(g) High expansion foam will not flow against pressure must above atmospheric pressure and arrangements are to be provided for venting the protected space whilst it is being filled with foam.

(h) High expansion foam has the disadvantage that once an engine room fire has developed it cannot be supplied from above because it is carried away by convention currents. Also heat radiation from above rapidly destroys the foam surface. Thus it can be argued that for a machinery space such a high filling rate would be required as to render this medium impracticable.

27. **Medium Expansion Foam System.** Medium expansion foam with an expansion ration between 50 to 1 and 150 to 1 could be used but it is generally restricted to vessels constructed for domestic use in Eastern bloc countries.

28. **Example of Calculation of Foam Required on an Oil Tanker.** Calculate the quantity of 3% foam concentrate required on board an oil tanker, equipped with IGS, having the following relevant dimensions.

Cargo tanks deck area	:	1800 m^2
Horizontal sectional are of the largest single tank	:	700 m^2
Area protected by the largest monitor	:	750 m^2

Quantity of foam solution required per minute = Regulation Spreadage Rate X Area

This is the greatest of :-

(i)	0.6 litres/min/m^2 X 1800 m^2	=	1080 litres/min.
(ii)	6.0 litres/min/m^2 X 700 m^2	=	4200 litres/min.
(iii)	3.0 litres/min/m^2 X 750 m^2	=	2250 litres/min.

The applicable quantity of foam solution required per minute to protect the tanker is 4200 litres /min Quantity of foam solution required :-

For the duration (20 minutes)	=	20 X 4200 litres
Stipulated by the regulation	=	84000 litres
Quantity of 3% foam concentrate	=	0.03 X 84000 litres
required	=	2520 Litres

Ship's Fixed Co_2 Flooding System.

29. **General Descriptions.**

(a) Fire smothering is achieved by diluting the oxygen content of the atmosphere in the compartment from normal 21% to a level, which is insufficient to support combustion. For most flammable substances, this is in the range of 9~11%, but for smouldering solid combustible materials a reduction of O_2 to 6~7% is necessary for complete extinction.

(b) To fight a major fire especially in a engine room, cargo holds and for enclosed spaces with sophisticated electric and electronic machinery/equipment like engine control room, cargo control room, computer room, radio room, bridge spaces with navigational equipment, utmost care is essential to ensure not to damage the equipment with the fire fighting agent. For such places on fire, the most suitable and effective fire-fighting agent is carbon dioxide (CO_2).

30. **Advantage of using CO_2 as Fire Fighting Agent.** It is non corrosive and does not conduct electricity. It leaves no residue and doesn't deteriorate in quality even after prolonged storage. It is extremely effective and most suitable for inaccessible fires especially in switchboard/s and other sophisticated electronic machinery and readily available at a reasonable cost.

31. **Disadvantages of using CO_2 as Fire Fighting Agent.** It is highly asphyxiating and slightly toxic. Concentration of 9% CO2 in an enclosed space produces unconsciousness within a few minutes and can even prove fatal. CO_2 has no cooling affect; therefore there is always a possibility of re-ignition if air is re-admitted to the compartment too soon after the fire. CO_2 normally contains solid carbon dioxide particles, which can

generate sufficient static charge to produce an instant spark that can ignite inflammable gas atmosphere in an enclosed space on board a ship. Therefore CO_2 alone is unsuitable as inerting medium for cargo oil tanks.

32. **CO_2 Flooding System.**

(a) This is used for fighting major fires in the engine room, boiler room, pump room, machinery control room, cargo control room, supply control room/switch board. The CO_2 system consists of a large number of CO_2 bottles (called Battery of CO_2 bottles) under pressure of 50~52 Bar with a gang release arrangements.

(b) CO_2 Bottles are connected in parallel by pipelines leading to the manifold/distributor panel, which has valves for different spaces; so that CO_2 can be discharged to a particular compartment on fire. The pipelines in compartments are fitted with diffuser nozzles, so that CO_2 which is in the liquid state when discharged due to high pressure, can quickly evaporate and convert into gas to spread quickly.

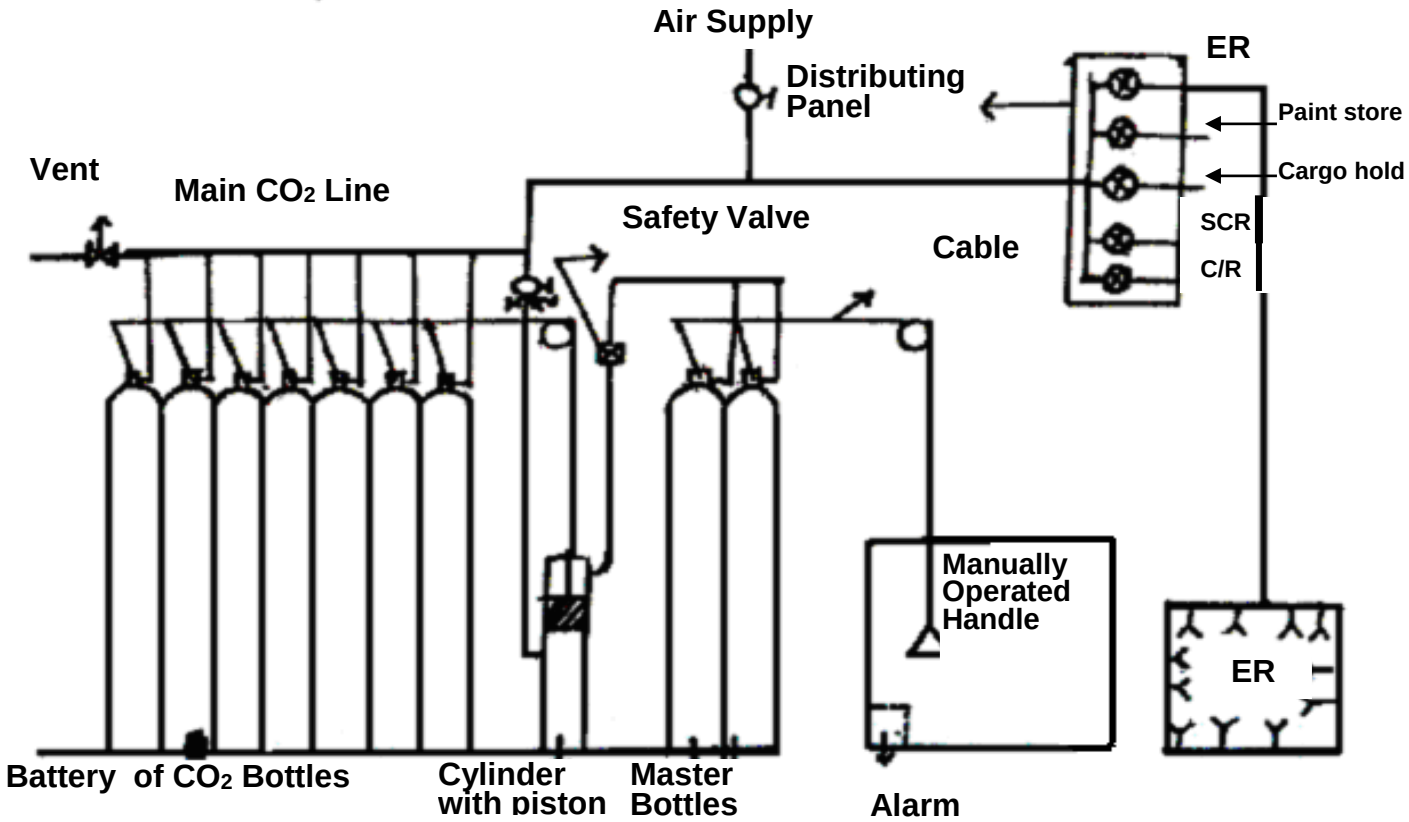


Fig 9- Co_2 Flooding System

(c) Two master/pilot bottles under pressure up to 200 bar are provided which are operated manually to discharge the main battery of CO_2 cylinders through pipelines and mechanical operating unit. With the pressure of CO_2 from the master/pilot bottles, the mechanical unit is triggered thus puncturing the rubber seals of the battery of CO_2 bottles.

(d) When main CO_2 bottles seals get punctured, the CO_2 reaches the main lines leading to the CO_2 distributor / manifold. From the distributor / manifold, the compartment under fire will be fed CO_2 by opening the particular compartment valve.In case the master / pilot valves do not work or the CO_2 pressure is insufficient in the pilot bottles, then the main battery of CO_2 cylinders can also be operated

manually by pulling the handle attached to the steel wires rigged to puncture the main CO_2 bottles.

(e) Once in 3~6 months, service air at pressure 7~8 bar is fed into the CO_2 main lines leading to the various compartments like engine room, cargo hatches etc., to clear the choked lines / to check if any line is damaged or disconnected. It is the IMO requirement that 85% of the required quantity of CO_2 gas must be released into the fire space within 2 minutes of operating the CO_2 system. In the actuating system for release of CO_2 from the main battery of CO_2 cylinders, the actuating handle opens an operating bottle of CO_2 and the gas from this pushes down the piston to release the other bottles. To avoid sticking, all the handles must be in good alignment. The bottle valves may be of quick release type as shown in the diagram where the combined seal / bursting disc is pierced by a cutter. The latter is hollow for passage of liquid CO_2 to the discharge pipe. Bottles should not be stored where the temperature is likely to exceed 55° C. The seal / bursting discs are designed to rupture spontaneously at pressure of 177 Bar produced at a temperature of about 63° C. The master valve allows the CO_2 released in this way from reaching the engine room and it is dispersed safely from the manifold.

(f) Rapid injection of CO_2 is necessary to combat an engine room fire, which has attained such magnitude that the space has to be vacated. This is due to the reason that 85% of the gas must be released within 2 minutes. The quantity of gas carried must be sufficient to give free gas volume equal to 40% of the volume of the space except where the horizontal casing area is less than 40% of the general area of the space or alternately must give a free gas volume equal to 35% of the entire space; whichever is greater.

(g) The closing of all engine room openings and vent flaps will prevent entry of air to the space. All ventilation and exhaust fans/blowers, fuel pumps and vent flaps to be shut to prevent entry of air into the fire space. All fans/blowers and fuel pumps can be shut down remotely. Also, valves on fuel lines for fuel oil tanks/ service tanks/ settling tanks/ storage tanks etc. can be shut from the “quick closing valves” system installed outside the engine room normally in the same compartment where the battery of CO_2 bottles are installed.

(h) CO_2 bottles are solid drawn steel, and hydraulically tested to 228 bar. The contents of CO_2 gas/liquid are checked by weighing CO_2 by means of a radioactive level indicator. Recharging of CO_2 is necessary if there is 10% weight loss. The pipelines are of solid drawn mild steel and galvanised for protection against corrosion. The siphon tubes in each bottle, ensures that liquid is discharged from the bottom of the bottles. Without the siphon tubes the CO_2 would evaporate from the bottles to the surface and would take the latent heat, which would cause the remaining CO_2 in the bottles to freeze.

33. **Preparation for Operating CO_2 Flooding System.**

(a) Raise emergency / fire alarm to evacuate the fire areas / compartment

(b) All machinery operating in the place of fire to be stopped

(c) Electrical supplied in the area to be cut off.

(d) Ventilation and exhaust blowers/fans to be stopped and fire dampers to be closed.

(e) Ensure no person is left inside the compartment when CO_2 is being released by ensuring head count.

(f) Obtain consent from the master prior to releasing CO_2 to the compartment on fire

(g) Seal the compartment as much as possible to eliminate air (oxygen) prior to release of CO_2.

Solas-74 Regulation.

34. **Fixed Gas Fire Extinguishing Systems.**

(a) **General.**

(i) The use of a fire – extinguishing medium which, in the opinion of the Administration either by itself or under expected conditions of use gives off toxic gases in such quantities as to endanger persons shall not be permitted.

(ii) The necessary pipes for conveying fire – extinguishing medium into protected spaced shall be provided with control valves so marked as to indicted clearly the spaces to which the pipes are led. Suitable provision shall be made to prevent inadvertent admission of the medium to any space. Where a cargo space fitted with a gas extinguishing system is used as a passenger space the gas connection shall be blanked during such use.

(iii) The piping for the distribution of fire extinguishing medium shall be arranged and discharge nozzles so positioned that a uniform distribution of medium is obtained.

(iv) Means shall be provided to close all openings which may admit air to or allow gas to escape from a protected space.

(v) Where the volume of free air contained in air receivers in any space is such that, if released in such space in the event of fire, such release of air within that space would seriously affect the efficiency of the fixed fire extinguishing system, the Administration shall require the provision of an additional quantity of fire extinguishing medium.

(vi) Means shall be provided for automatically giving audible warning of the release of fire extinguishing medium into any space in which personnel normally work or to which they have access. The alarm shall operate for a suitable period before the medium is released.

(vii) The means of control of any fixed gas fire extinguishing system shall be readily accessible and simple to operate and shall be grouped together in as few locations as possible at positions not likely to be cut off by a fire in a protected space. At each location there shall be clear instructions relating to the operation of the system having regard to the safety of personnel.

(viii) Automatic release of fire extinguishing medium is required to protect more than one space, the quantity of medium available need not be more than the largest quantity required for any one space so protected.

(ix) Except as expressly permitted by these rules, pressure containers required for the storage of fire extinguishing medium, other than steam, shall be located outside protected spaces in accordance with these rules.

(x) Means shall be provided for the crew to safely check the quantity of medium in the containers.

(xi) Containers for the storage of fire extinguishing medium and associated pressure components shall be designed to pressure codes of practice to the satisfaction of the Administration having regard to their locations and maximum ambient temperature expected in service.

(xii) When the fire extinguishing medium is stored outside a protected space, it shall be stored in a room which shall be situated in a safe and readily accessible position and shall be effectively ventilated to the satisfaction of the Administration. Any entrance to such a storage room shall preferably be from the open deck and in any case shall be independent of the protected space. Access doors shall open outwards, and bulkheads and decks including doors and other means of closing any opening therein, which form the boundaries between such rooms and adjoining enclosed spaces shall be gas-tight. For the purpose of the application of the fire integrity regulations such storage rooms shall be treated as control stations.

(xiii) Spare parts for the system shall be stored on board and be to the satisfaction of the administration.

35. **Carbon Dioxide Systems.**

(a) For Cargo spaces the quantity of carbon dioxide available shall, unless otherwise provided, be sufficient to give a minimum volume of free gas equal to 30% of the gross volume of the largest cargo space so protected in the ship.

(b) For machinery spaces the quantity of carbon dioxide carried shall be sufficient to give a minimum volume of free gas equal to the larger of the following volumes, either :-

(i) 40% of the gross volume of the largest machinery space so protected, the volume to exclude that part of the casing above the level at which the horizontal area of the casing is 40% or less of the horizontal area of the space concerned taken midway between the tank top and the lowest part of the casting or.

(ii) 35% of the gross volume of the largest machinery space protected, including the casing. Provided that the above-mentioned percentages may be reduced to 35% of 30% respectively for cargo ships of less than 2,000 tons gross tonnage; provided also that if two or more machinery spaces are not entirely separate they shall be considered as forming one space.

(c) For the purpose of this paragraph the volume of free carbon dioxide shall be calculated at 0.56 m^3/kg.

(d) For machinery spaces the fixed piping system shall be such that 85% of the gas can be discharged into the space within 2 minutes.

(e) Example of typical calculation for a cargo ship's hold/machinery space protection by fixed carbon dioxide gas extinguishing system is given in the following page.

(f) Particulars of ship and equipment available.

CO_2 capacity per cylinder - 45.5 kg (100 lbs)

Water capacity per cylinder - 65.1 ltrs.

(i) Engine room gross volume (to upper deck) 4658 m^3

(ii) Engine room gross volume to casing top 5358 m^3

(iii) Volume of largest cargo hold (Hold no. 2) 6849 m^3

(iv) Volume of air reservoir (Comp. Air cyl) 375 m^3

(g) Calculation for number of CO_2 bottles required as per regulations.

(i) $\frac{(4658+375)0.4}{0.56}$ divided by 45.4 = 80 cyl.

(ii) $\frac{(5358+375)0.35}{0.56}$ divided by 45.4 = 79 cyl.

(iii) $\frac{(6849 \times 0.3)}{0.56}$ divided by 45.4 = 81 cyl.

Total requirements as per regulations = 81 cylinders.

36. **Carbon Dioxide, Fixed Fire Smothering Installations.**

(a) In recent years there have been a number of incidents involving loss of life when the CO_2 fixed fire smothering system has been released accidentally while a ship has been in port undergoing maintenance or repair. Similar incidents have also occurred due to careless actions by crew members when the ship has been in service, either the ship at sea or during a period in port.

(b) The accidents have occurred when work is being carried out either on the CO_2 system or in the space containing the co cylinders./ The lives of men working in that space, in the engine room in the cargo spaces or in other spaces connected to the

CO_2, system were endangered by a failure to issue suitable instructions or where necessary to guard against accidental release.

(c) Shipowners will be aware that responsibility for fire protection and initial fire fighting measures remains with them unless and until they delegate that responsibility; in which case there should be a clear written agreement between them and the ship repairer. Paragraph 30 of the "Report of Working Party on fire prevention and fire fighting on ships in port", reproduced for information as an appendix to this notice, deals with this point.

(d) Similarly where work is to be carried out on any part of the CO_2 system, including the remote controls, or in any space containing CO_2 cylinders or a CO_2 bulk storage unit, the Department considers that the responsibility for ensuring continued protection against accidental release of gas remains with the owner, unless there is a clear written agreement which delegates that responsibility to the ship repairer or the company undertaking the work.

(e) When the nature of the work requires the system to be made inoperative or where it has to be temporarily immobilised to permit safe working, the owner or his representative should first give careful consideration to the various fire risks in the space normally protected by the CO_2 system. In addition, during the period while the system is not available, work which would increase the hazard within the protected spaces should not be permitted.

(f) Where the system has been made inoperative or temporarily immobilised to permit safe working the owner or his representative should ensure that the system is restored to its operating condition on the completion of the work. In the cases where the responsibility for ensuring against accidental release has been delegated in writing to the ship repairer or to a company undertaking work on the system, the owner or his representative in conjunction with a representative from the other company should ensure that the system is restored to its operating condition.

(g) To prevent unauthorised use, the space containing the CO_2 cylinders or the CO_2 bulk storage unit should normally be kept locked at all times, with on of the keys being readily available in glass fronted case near to the entrance to the space.

Carbon Dioxide Cylinders.

37. **Siting Precautions.**

(a) Recent re-surveys of CO_2 installation employing a gang release system for total flooding of the machinery spaces has shown that in ships where the CO_2 cylinder storage room is subject to severe vibration, or in cases where cylinder clamps have not been tightened properly after the cylinders have been removed for weighting or replenishment, cylinders have rotated resulting in some cases to malfunction and in some cases to the premature release of CO_2 gas. In many cases the rotation of the cylinders has been such that operation of the system, if it had been required would not have been possible due to misalignment of the valve operating levers.

(b) To minimise this danger it is advisable in existing installations that arrangements for clamping and verifying the alignment of cylinders should be carefully checked at regular intervals between the surveys or inspections normally carried out by the Govt. surveyors.

Inert Gas System (on Oil / Chemical Tankers and LPG/LNG Carriers).

38. **General.**

(a) The fire hazard on oil and chemical tankers and gas carriers is more than on general cargo ships due to the fact that H/C gases are predominant in cargo tanks as well as on upper decks in the vicinity of tanks. The H/C gases can cause fire / explosion even with minor sparks when sufficient air (oxygen) is present especially inside the cargo tanks where possibility of ignition source is always there due to static electricity. Therefore the only way to prevent fire/explosion on board tankers especially of cargo tanks is to ensure insufficient air (oxygen) inside the cargo tanks. To achieve this, the ullage spaces inside the cargo tanks is filled with inert gases (which has oxygen limited to maximum 8% which is even below the safe limit of 11% oxygen) to prevent any fire or explosion.

(b) The inert gases filled in the cargo tanks are basically the boiler exhaust gases (Flue gases). But the flue gases cannot be used directly for inerting the cargo tanks due to the following reasons :-

(i) The temperature of the boiler flue gas is very high (about 400° C).

(i) Flue gases contain carbon particles, ash, soot and other solid foreign particles due to incomplete combustion and also carry static charge.

(iii) Flue gases contain corrosive gases such as Sulphur dioxide (SO_2) and Sulphur Trioxide (SO_3) (about 0.3%) which form Sulphuric acid when mixed with water and nitrogen oxides which form nitric acid with water.

(iv) Oxygen (O_2) percentage in the flue gases is not known and could be more than the permissible limit of 5%.

(v) Flue gases have moisture content about 2 – 3 % (in the form of steam)

(c) In order to ensure clean and dry inert gas free from unwanted gases and particles and containing maximum of 8% oxygen, the boiler exhaust gases (Flue gases) are fed into an inert gas plant where all unwanted gases/solids are removed. The gases are cooled down to within 5 degrees Centigrade of sea water temperature and is made moisture free and dry to ensure safety of the petroleum / petroleum products.

39. **Requirement of Inert Gas Plant.** The inert gas plant using the boiler flue gases to produce inert gas must be able to meet the following requirements :-

(a) To produce cool and dry inert gas.

(b) To remove water droplets from the gas.

(c) To remove as much as possible the sulphur oxides in the flue gases.

(d) To remove solids from the gas to the maximum possible extent.

(e) To transport the cooled and clean gas to the cargo tanks.

(f) To regulate the quantity of gases according to the demand for gas in the cargo tank.

40. **Working of Inert Gas Plant.**

(a) The boiler flue gas is fed into a scrubber unit through the flue gas-isolating valve located near the boiler uptake on the flue gas line. The primary function of the scrubber unit is to cool the flue gas to a temperature close to the sea water temperature and to remove soot and other solid matter and sulphur oxides from the flue gas. The flue gas entering the bottom of the scrubber unit passes through a water seal and while rising up the unit are cooled by water sprayers. During this process, all the sulphur oxides, soot and other solid particles are removed. The minute particles if any are subsequently removed while the gas passes through baffle plates and filtering elements.

(b) Cooling sea water to the scrubber unit is supplied by an independent scrubber pump. The water level in the scrubber unit is indicated by audible and visual alarms when it is less than the predetermined set limits. Any reductions in pressure of sea water below the set limits automatically shuts down the inert gas blowers.

(c) The top section of the scrubber unit consists of demister unit to dry the gas either by fine wire mesh or by revolving unit working on centrifugal forces created by spinning the gas at high speed causing the water droplets to be thrown outwards on the scrubber walls.

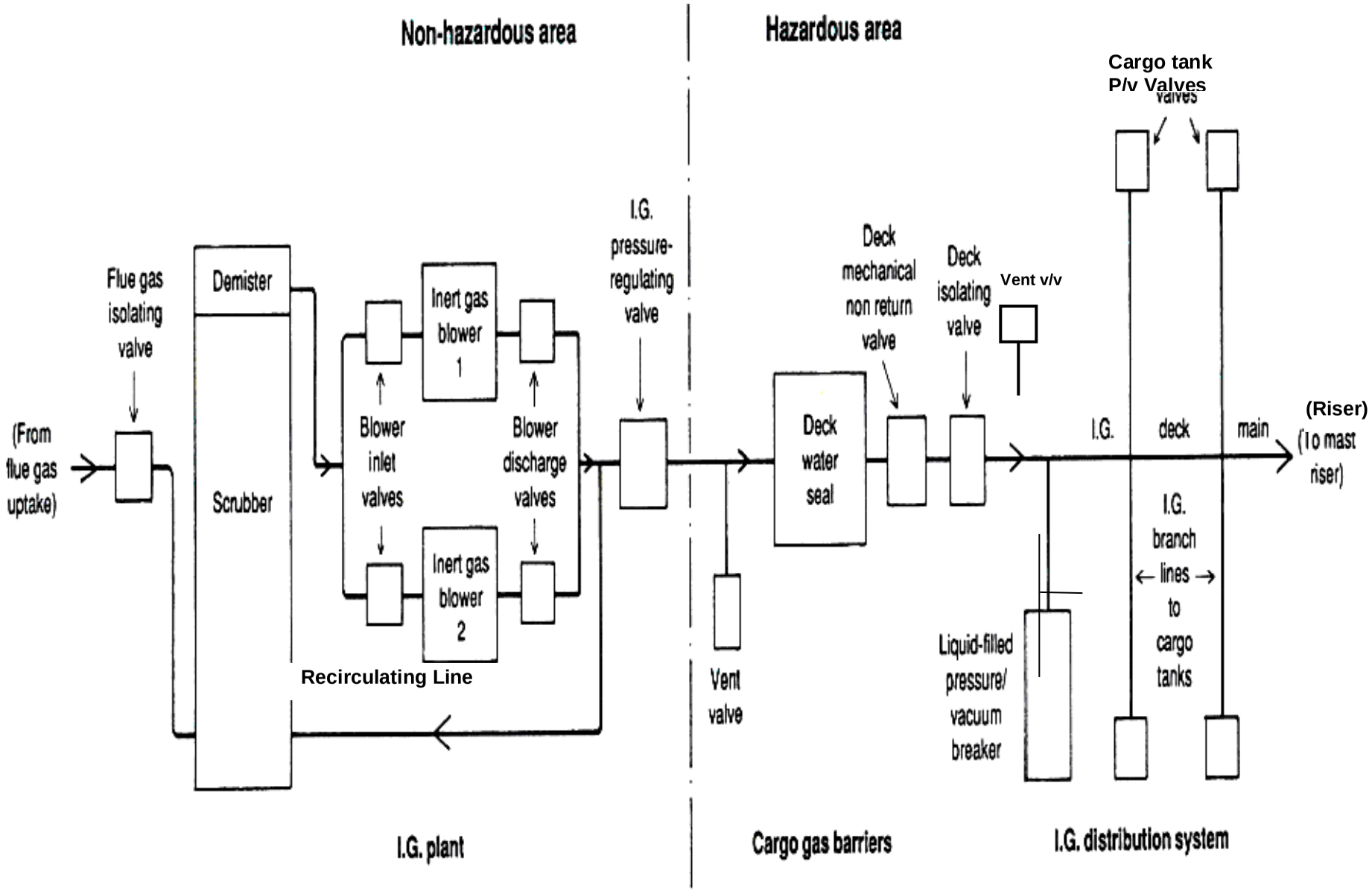


Fig 10 - A Typical Attangement for an Inert – Gas System

(d) The inert gas leaving the demister of the scrubber unit consists of the following :-

Oxygen	less than	8%
Sulphur oxide	less than	0.02%
Water Vapour	less than	1%
Solids	less than	8 mg/m3
CO2		About 13.5%
Nitrogen		Balance (About 77%)
Soot		About 30mg per cubic metre
Temperature		sea temperature + $\overline{5}$ ° C

(e) From the scrubber unit, the flue gas is led to the blower (2 no. blowers are provided, only one is used while other is kept standby / under maintenance). Each blower is capable of meeting SOLAS-74 requirements to maintain positive pressure in the cargo oil tank.

(f) The inert gas discharge from the blower is subsequently controlled by an oxygen analyser / Pressure Regulating valve (which, depending upon the requirements of the inert gas is either re-circulated back to the scrubber unit). In case the O_2 content is more than 8%, it is released into the atmosphere through a vent valve automatically controlled by an oxygen analyser. When the inert gas has less than 5% oxygen content, it then passes through a unit called wet type deck seal so that the inert gas can have only forward gas flow towards cargo tanks but tanks inert gas / H/C gases cannot come towards the scrubber unit / blower. Thus the gas supplied by the inert gas blower bubbles through the water in the deck seal tank to the outlet pipe leading to the deck distribution system. The height of the water column in the deck seal tank doesn't exceed the tank test pressure. Since the inert gas passing through the wet deck seal becomes moist and can carry the water into the deck main, a demister similar to the one provided in the scrubber unit is also provided in the wet deck seal unit. The inert gas coming out of the deck seal passes through a mechanical non-return valve and then through a screw down non-return deck isolating valve which is operated manually.

(g) The inert gas then is led to tank distribution system, which consists of a manifold / distributor incorporating the individual cargo tank valves. The pipe lines leading from the deck isolating valve to the manifold is provided with a pressure / vacuum beaker to ensure that the inert gas pressure/vacuum is maintained within the safe limits of the cargo tanks pressure and vacuum and do not cause any structural damage to the cargo tanks.

(h) The pressure / vacuum (P/v) breaker is an oil seal containing oil or an anti-freeze mixture of 40% Ethylene and 60% water. The level cock of (P/V) breaker is to ensure that the liquid level in the P/V Breaker does not exceed the set limit during filling. The space above the liquid level in the P/V Breaker in the concentric inner pipe is always at atmospheric pressure. Under equal pressure conditions i.e. when the cargo tanks pressure is equal to atmospheric pressure, the liquid in the concentric inner pipe and the annular space surrounding the P/V Breaker maintains the same level.

(i) When the pressure in the cargo tank/s is more than the atmospheric

pressure, the liquid is pushed out from the annular space into the concentric inner pipe. But if the pressure in the cargo tanks exceeds the pressure setting of the P/V Breaker, the liquid in the P/V Breaker will be blown out on to the deck and the excess pressure will be released to the atmosphere.

(j) When the cargo tank/s pressure is negative i.e. less than the atmospheric pressure (which may occur especially during discharging and the tank not being supplied with inert gas), then the atmospheric pressure acts on the surface of the liquid in the concentric inner pipe of the P/V Breaker and will force the liquid down into the annular space depending on the negative pressure in the cargo tank/s. If the negative pressure in the cargo tank/s is below 700 mm w.g., the entire column of liquid in the concentric inner pipe will be forced down causing air to bubble through the liquid in the annular space and enter the cargo tanks through the inert gas main thus releasing the excess vacuum.

(k) The P/V valve can be set to open automatically or manually. When set to open automatically, the valve opens when pre-set pressure or vacuum limits are reached. Limits are usually not more than 1800 ~ 1900 mm w.g pressure and 700 mm w.g vacuum.

41. **Fixed Dry Chemical Powder System.**

(a) Gas carriers are provided with a fixed dry chemical powder extinguishing system covering the gas carrier deck areas. LPG and LNG (i.e. gases such as methane CH4, ethane C2H6, propane C3H8, butane C4H10, pentane C5H12) are carried in tanks under pressure at deeply refrigerated in the liquid state (their boiling point at ambient pressure is about minus 162 ° C). Any leakage of such liquefied gases from joints / valves etc. on deck vaporises quickly. The vaporisation speed varies with ambient temperature, area of spill, quantity of spill. With liquid gas temperature being very low, in case of fire, use of seawater (comparatively warm) through a fire hose or foam hastens the change of state from liquid to gas, which can lead to explosion. To fight such fires on board gas carriers, fixed dry chemical powder system is most useful and effective. This arrangement consists of dry chemical powder in one or more tanks, which can be pressurised by nitrogen (N2) from a bank of nitrogen cylinders.

(b) The dry chemical powder tank/s are directly controlled and operated from control stations on the upper deck. The control station consists of appropriate controls, a dry chemical powder monitor/hose with nozzle and a pilot nitrogen (N2) cylinder under pressure.

(c) On opening the pilot nitrogen cylinder in the control box, the nitrogen gas flows through the reducing valve to the dry chemical powder tank/s installed and pneumatically opens the appropriate distribution valve. Simultaneously, the pilot cylinder nitrogen also opens the main nitrogen cylinders by the action of the pneumatic piston release lever and release mechanism.

(d) The nitrogen gas thus flows from the main nitrogen cylinders into the dry chemical powder cylinders through the pressure regulator. When the pressure in the DCP tanks reaches 16 Bars, the main DCP valve opens automatically and the DCP flows to the release station/monitor/hose with nozzle via the distributor/manifold automatically opened prior to the monitor/control station valve.

(e) The pressure in the DCP container/tank remains constant until a very little DCP is left in it. When the DCP in the first container is used, the second container can be brought into action by manually opening its bank of nitrogen cylinders. Flow of DCP into the first empty container is prevented by the automatic closing of its valve by pneumatic release piston. Flow of DCP then continues as before.

(f) After use, the DCP lines are blown through with compressed air and nitrogen (N2) cylinders are replenished and DCP containers are refilled. It may be noted that heavy spillage of deeply refrigerated liquids is extremely dangerous. It can cause embattlement of the deck and its contact with the human body causes serious cold burns.

Firemain, Hydrants, Hoses & Nozzles.

42. **Firemain System.** Water is the chief fire-fighting medium on a ship and the fire main is the basic installation for fighting fires. The system shown has two independently powered pumps, which are also used for general service and ballast. These pumps supply two engine room hydrants and the deck main through the isolating valve. The latter is required to prevent loss of water through pipework in the engine room if damaged. To maintain the deck supply, the emergency fire pump has to be used. The emergency fire pump is located outside the engine room normally in steering compartment. In such cases there is always a watertight door to isolate the engine room spaces from the emergency pump location. The deck main has a drain at the lowest position so that the pipe can be emptied in cold weather. If this is not done, the water freezing can damage the pipes but more important, it will be blocked by the ice and will not be usable.

43. **Hoses and Nozzles.** Fire hoses must be of approved material. They are positioned adjacent to the hydrants together with suitable nozzles. Dual purpose nozzles can be adjusted by rotation of the sleeve to produce a jet or spray. These are alternative to having one nozzle for a jet and another for a spray or fog to be used for oil fires. Foamite branch pipes similar to those used in deck installations for tankers are fitted for use with the hydrants in some machinery spaces, car decks etc. These are available in various sizes for operation at a range of pressures and outputs. The branch pipe is connected through a hose to the hydrant and the water flow produces a venturi effect which draws up Foamite liquid through the pickup tube, from a container. The action also draws in air. Mixing of the three components in the tube causes formation of a jet of foam. Initially, only water issues from the branch pipe and the nozzle is directed away from the fire until foam appears. When the foam compound is exhausted, water will again appear at the nozzle. Foam continuity is achieved by dropping the pickup tube in a bucket and keeping the bucket topped up with foam liquid.

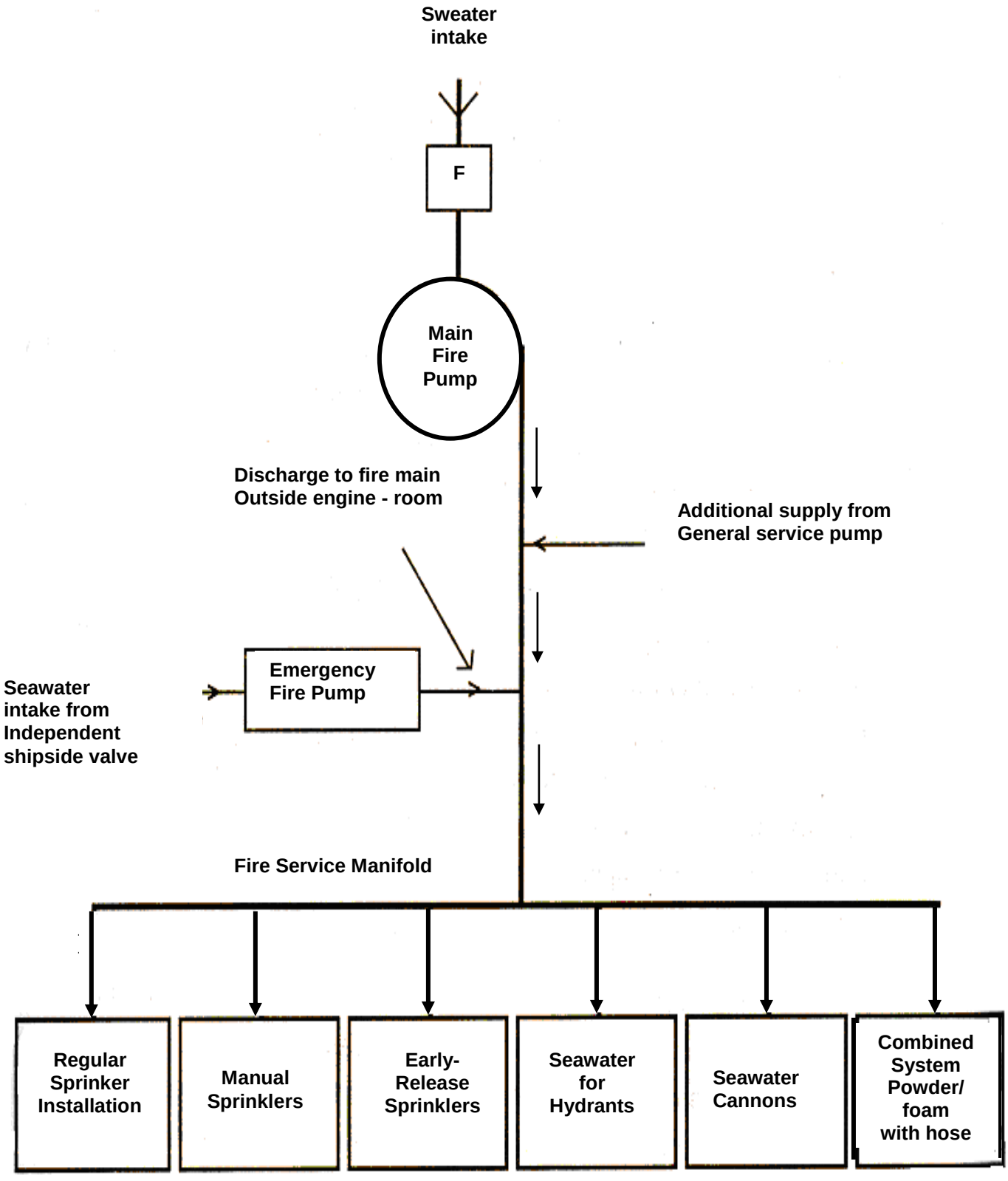


Fig 11 – A Fire Main System

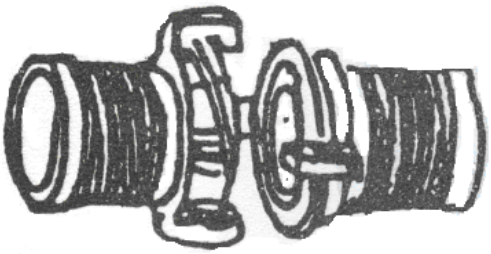


Fig 12 - Admiralty Standard Bayonet Joint Coupling

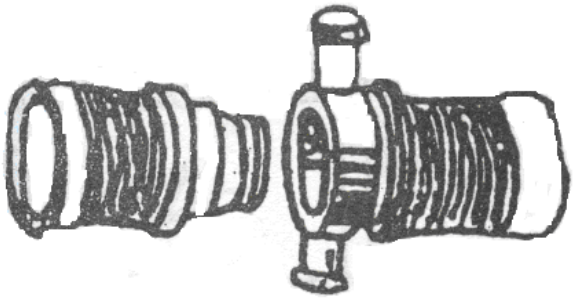


Fig 13 - Instantaneous Coupling

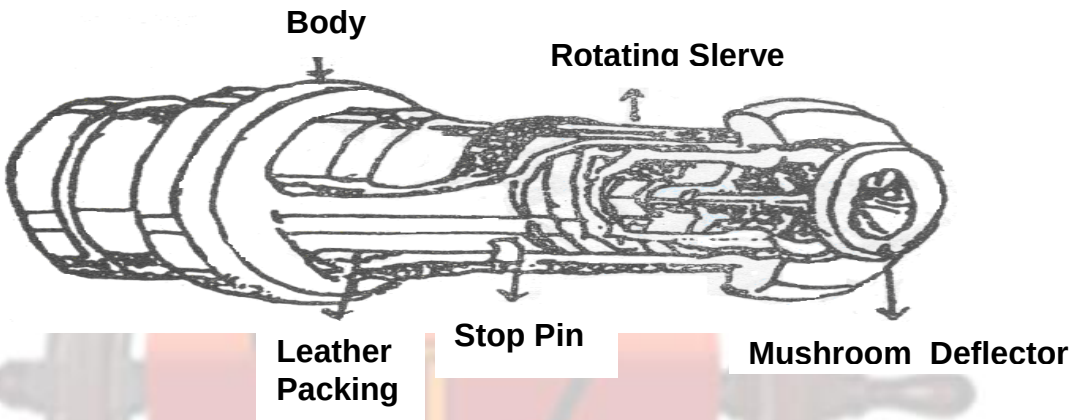


Fig 14 - Jet / Spray Nozzle

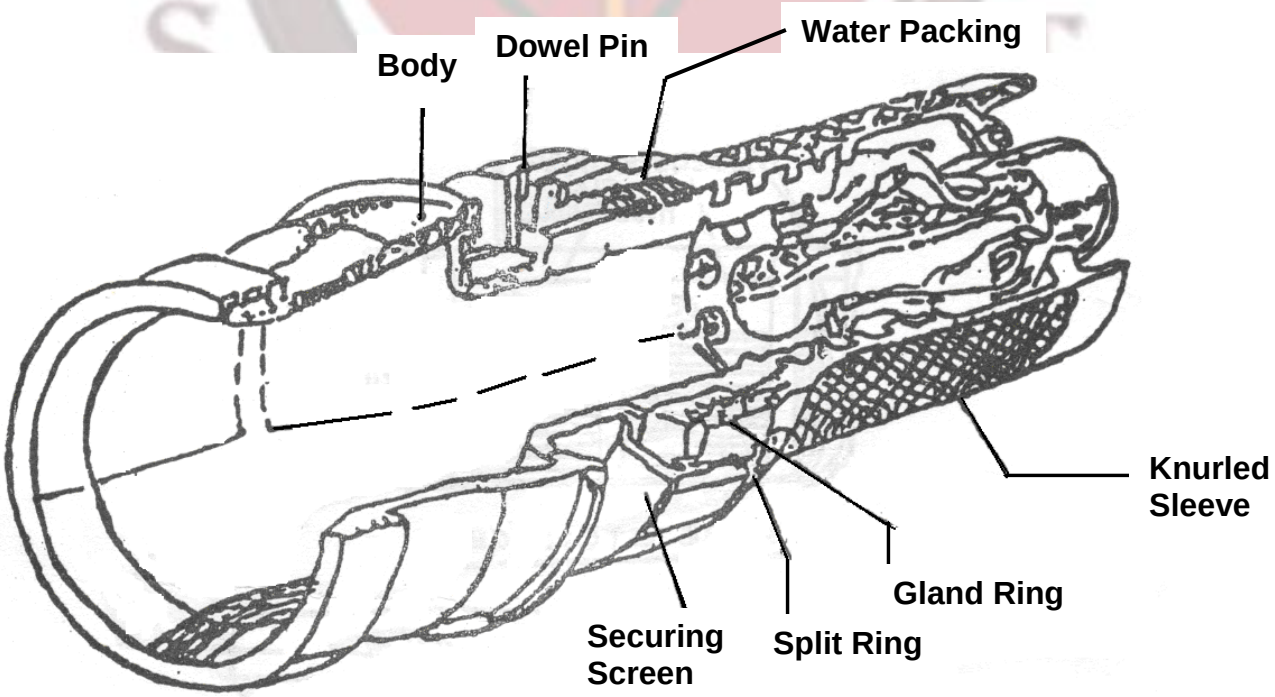


Fig 15 - Admiralty Spray / Jet Nozzle

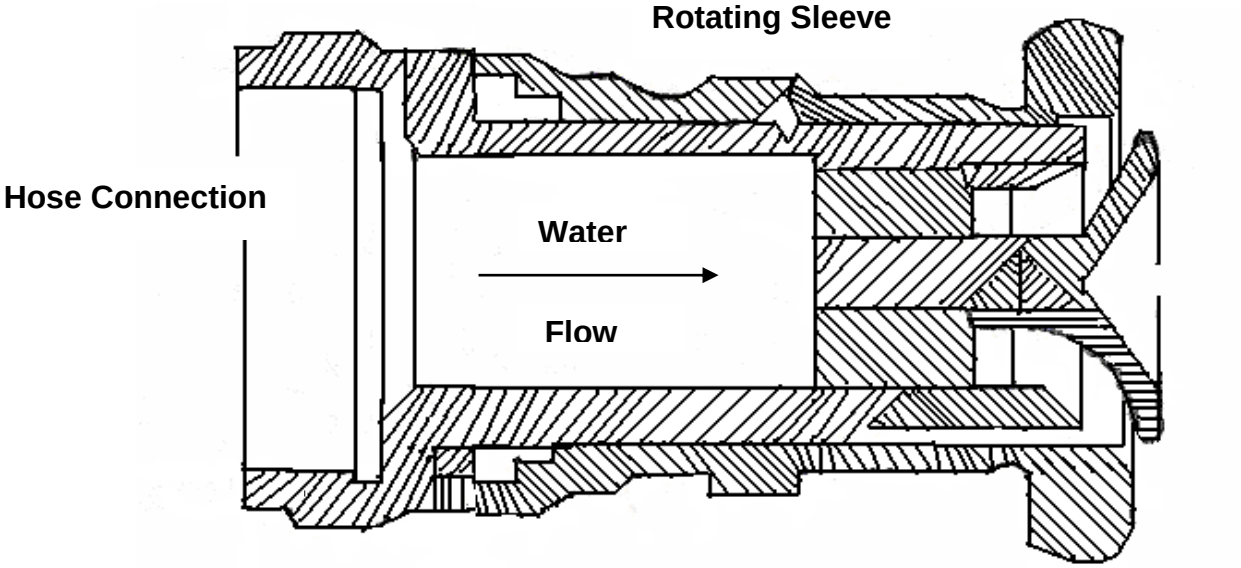


Fig 16- Dual Purpose Nozzle

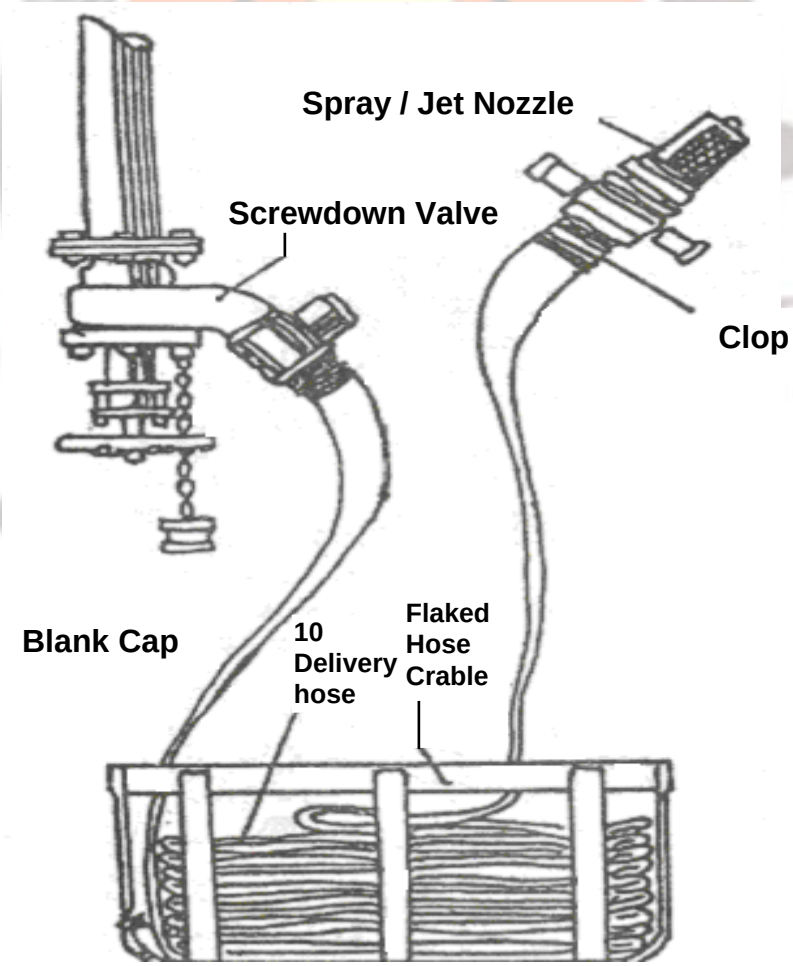


Fig 17 – Hose Stowage

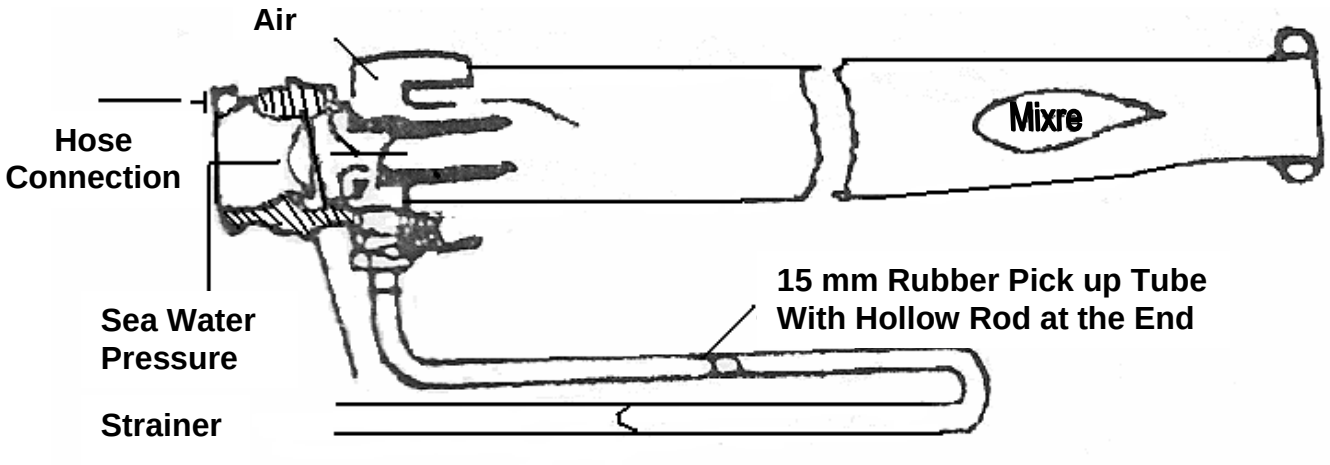


Fig 18 – From Branch Pipe

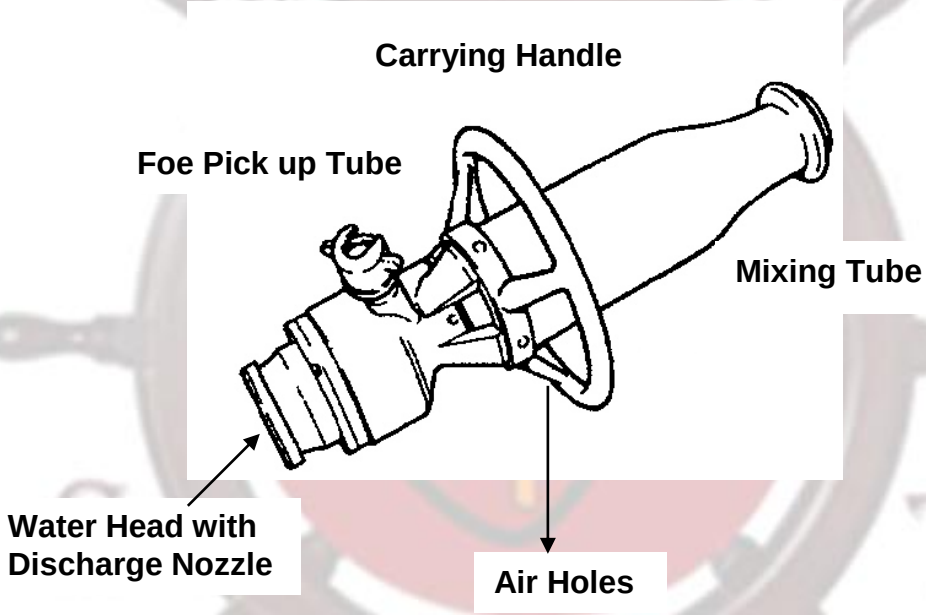
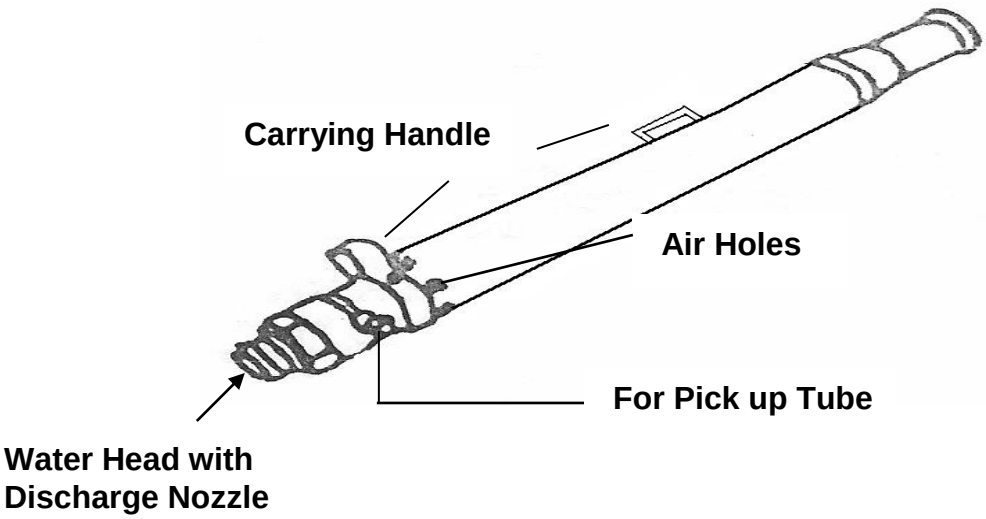


Fig 19 – From Making Branch Pipe 5 (X)



20 - Foam Making Branch Pipe 10

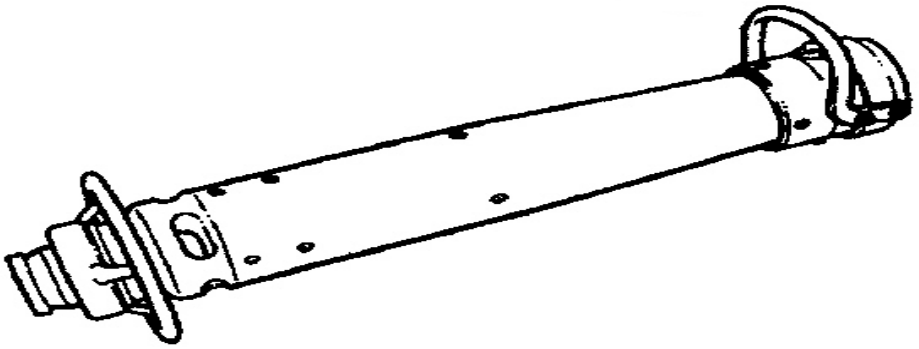


Fig 21 - Foam Branch Pipe Fb 10 (X)

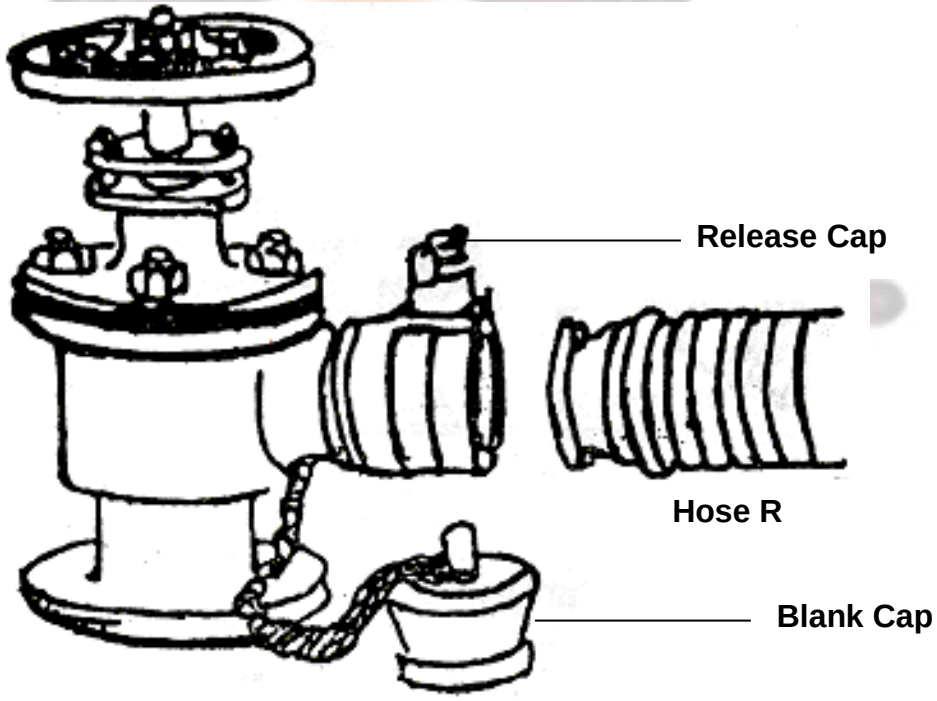


Fig 22 - Hydrant

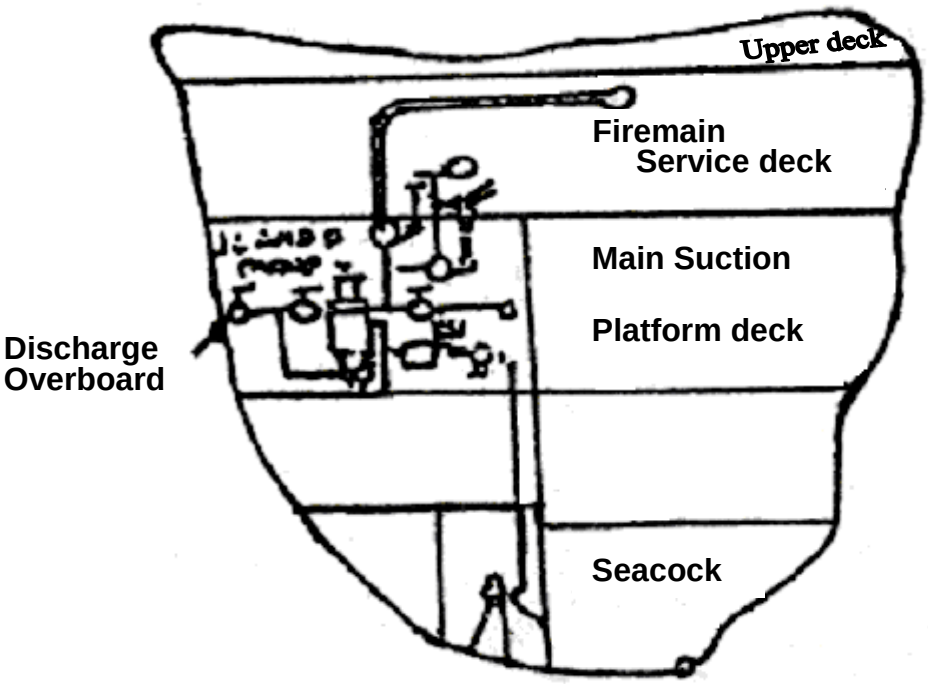


Fig 23 - Arrangement Of Fire Main

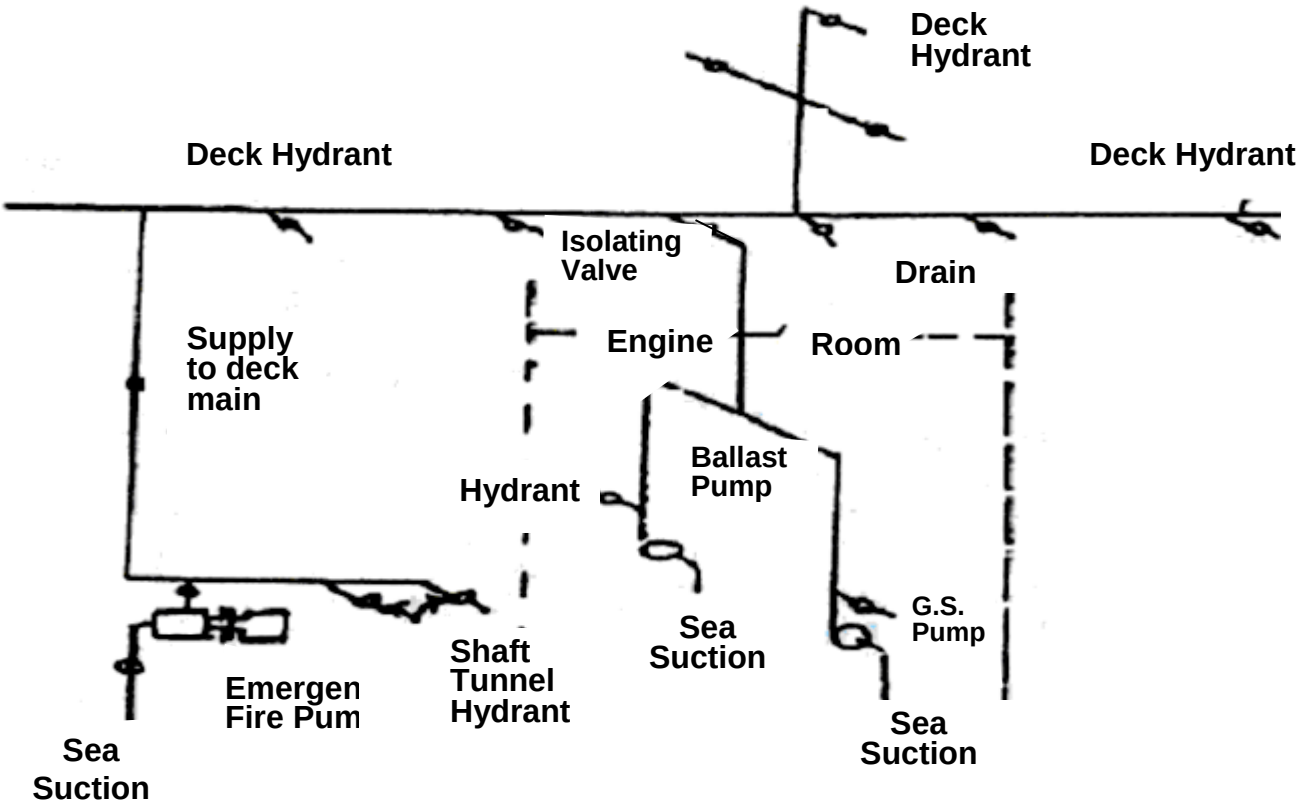


Fig 24 - Ships Fireman Arrangements

44. **Pumps.** Two independently powered pumps must be provided in all cargo ships of 1000 tons gross and over and in passenger ships of less than 4000 tons gross. Larger passenger vessels must have three such pumps. The pumps are fitted with non-return valves if they are of the centrifugal type, to prevent loss of water back through open valves when not running. A relief valve is necessary in the system if the pumps are capable of raising the pipeline pressure to greater than the design figure. Minimum line pressures and capacities are governed by the regulations. While fire pumps may be used for other duties such as ballast, bilge or general service, they should not normally be used for pumping oil. Changeover arrangements are fitted if a pump can be used for ballast or deballasting of tanks etc.

45. **Emergency Fire Pumps.** Normally, cargo vessels are provided with emergency fire pump/s because a fire in the engine room could put all of the other pumps out of action. Such a pump is indicated in the Fig. and is located away from the engine room in the tunnel or steering gear or in the forward part of the ship. The suction lift of any pump is limited and for this reason emergency pumps are usually at a maximum of 6 metres from the water level at light draught, or installed below water level :-

(a) The fire main line is spread all over the ship.

(b) Fire main line is fitted with the fire hydrant valves and couplings to which hoses can be connected.

(c) Every fire hydrant has a fire box in which a hose and a nozzle is stored. Hoses are kept either in a flaked manner or in rolled position in the firebox.

(d) Hoses are connected to the hydrants and nozzle is attached to the other end of the hose for fire fighting by jet/spray.

(f) On large vessels a special two-stage pump arrangement may be used. The first stage below the waterline is driven by a hydraulic motor. The second stage and the hydraulic power unit are driven by electric motor as the prime mover, which can be positioned at more than the normal distance from the waterline.

(g) An emergency pump has an independent diesel engine drive or some alternative such as an electric motor powered from the emergency generator, or an air operated pump with its own air supply.

(h) Where steel pipes are used, they are galvanised after bending and welding. Diameter is between 50 mm and 178 mm depending on the size and type of ship. Engine room hydrants must have hoses and nozzles for jet and fog or dual-purpose nozzles.

46. **International Shore Connection / Coupling.** The International shore coupling is a standard sized flange with nuts, bolts and washers and a coupling for the ship's fittings. The dimensions are shown in the diagram. The fitting and joint must be suitable for a working pressure of 10.5 bar. Four bolts are required of 16mm diameter and 50 mm length, used with eight washers.

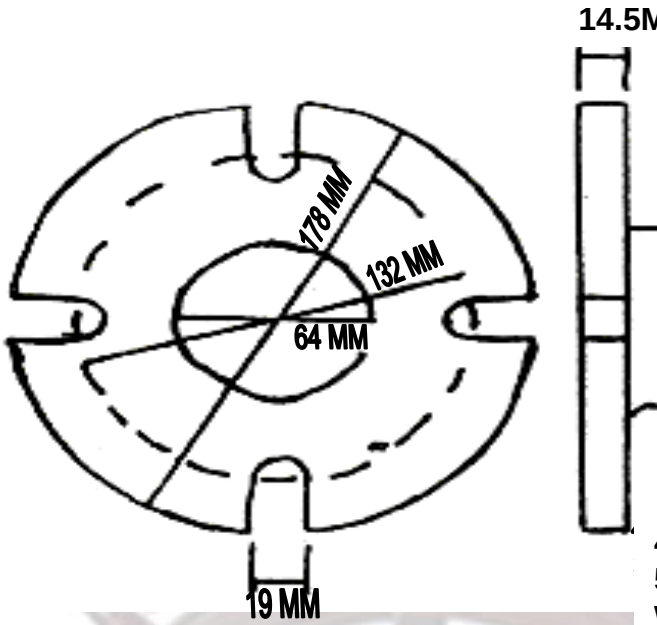


Fig 25 - International Shore Connection

Portable & Mobile Fire Extinguishing Equipment.

47. **Portable Fire Extinguishers.**

(a) Portable fire extinguishers are for immediate use in the early stages of a fire. They should not be expected to deal with large fires since they have a limited duration of use and capacity.

(b) Portable fire extinguishers may be divided into four categories according to the extinguishing agent they contain, namely :-

(i) Water

(ii) Foam

(iii) Dry chemical powder

(iv) Carbon dioxide / Halon 1211

(c) The capacity of a portable fire extinguisher vary from 2 Kg to 9 Litres / 10 Kg. The choice of a portable fire extinguisher to be used for a particular fire is decided in relation to the nature of fire anticipated. Portable fire extinguishers are located in conspicuous positions from where they can be readily seen / used by persons. They are sited near to room exits, in corridors / stairways and are stored near places containing major fire risks. Spare charges are provided for each type of extinguisher.

(d) Every portable extinguisher is marked to indicate :-

(i) Name of manufacturer

(ii) Type of fire on which the extinguisher is suitable

(iii) Type and quantity of extinguishing medium

(iv) Approval details

(v) Instructions for use and recharge

(vi) Year of manufacturer

(vii) Temperature range over which the extinguisher will operate Satisfactorily

(viii)Test pressure

(e) Following portable extinguishers are provided on board merchant ships in places like Engine room, Accommodation, M/C/R, Galley, Alleyways, Paint store, steering compartment, Boiler platform etc :-

(i) 9 litre water extinguisher

(ii) 9 litre mechanical foam extinguisher

(iii) 4.5 Kg. Or 10 Kg. Dry chemical powder extinguisher

(iv) 2 Kg CO_2 extinguisher

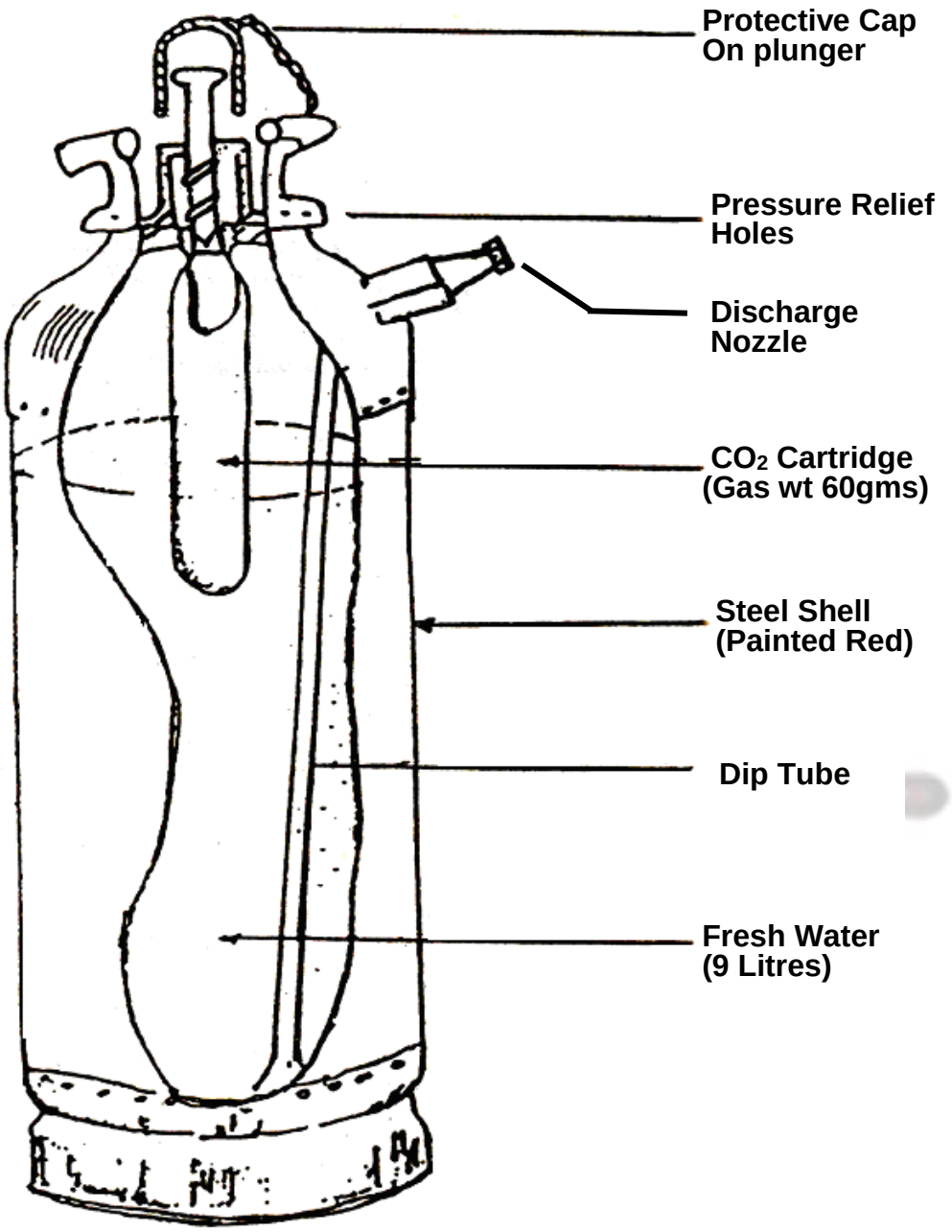


Fig 26 - 9 Ltrs Water Extinguisher

48. **9 Litre Water Extinguishers (For Class 'A' Fire).**

(a)	**Identification.**	:	Painted red
	Extinction	:	By cooling
	Duration	:	60 – 70 sec.
	Discharge distance (min)	:	6 meters.
	Uses	:	To extinguish solid inflammable material fire
	e.g. Wood, paper (class 'A' fire)		

(b) **Description.** Cylindrical container contains 9 litres of fresh water. A CO_2 cartridge of 60 gms. A wheel cap fitted with striking knob attached with plunger. A dip tube extended from top to bottom. A discharge hose with nozzle. Vent holes on wheel cap.

(c) **Operating Procedure.**

(i) Pull out safety clip and check wheel cap is tightly closed.

(ii) Uncoil discharge hose.

(iii) Point nozzle towards seat of fire.

(iv) Strike the knob.

(d) **Note.** Never use class 'A' fire extinguisher on oil / electrical fire. This will cause fire to spread / and cause shock.

(e) **Important.** While operating it is possible that the extinguisher is pressurised but is not discharging, due to blockage in dip tube or hose. In this case the extinguisher is to be depressurised by laying down the extinguisher flat on the ground. Unscrew the wheel cap by 2-3 turns. The vent holes will now be clear of threads and will depressurise the cylinder.

49. **9 Litre Mechanical Foam Extinguisher (For Class 'B' Fires).**

(a) It is painted red and its duration is 60 – 90 seconds and can cover a distance of 3 to 5 meters.

(b) In this extinguisher, foam concentrate is stored as a solution in water.

(c) A CO_2 gas cartridge (CO_2 weight is about 120 gms) is provided, which when pierced provides the pressure to discharge the foam solution. The solution is carried upwards through the dip tube due to the gas pressure above it.

The solution is aerated at the discharge nozzle to form foam.

(c) The construction of the body and method of operation of this extinguisher is similar to that of a water-carbon dioxide type extinguisher but its discharge rate is same as that of a chemical foam extinguisher.

(d) While using this extinguisher, do not allow the foam to strike the surface of the burning liquid. Direct the jet on to a vertical surface so that foam can flow down gently to spread on the burning liquid.

Protective Cap On Plunger

Pressure Relief Holes

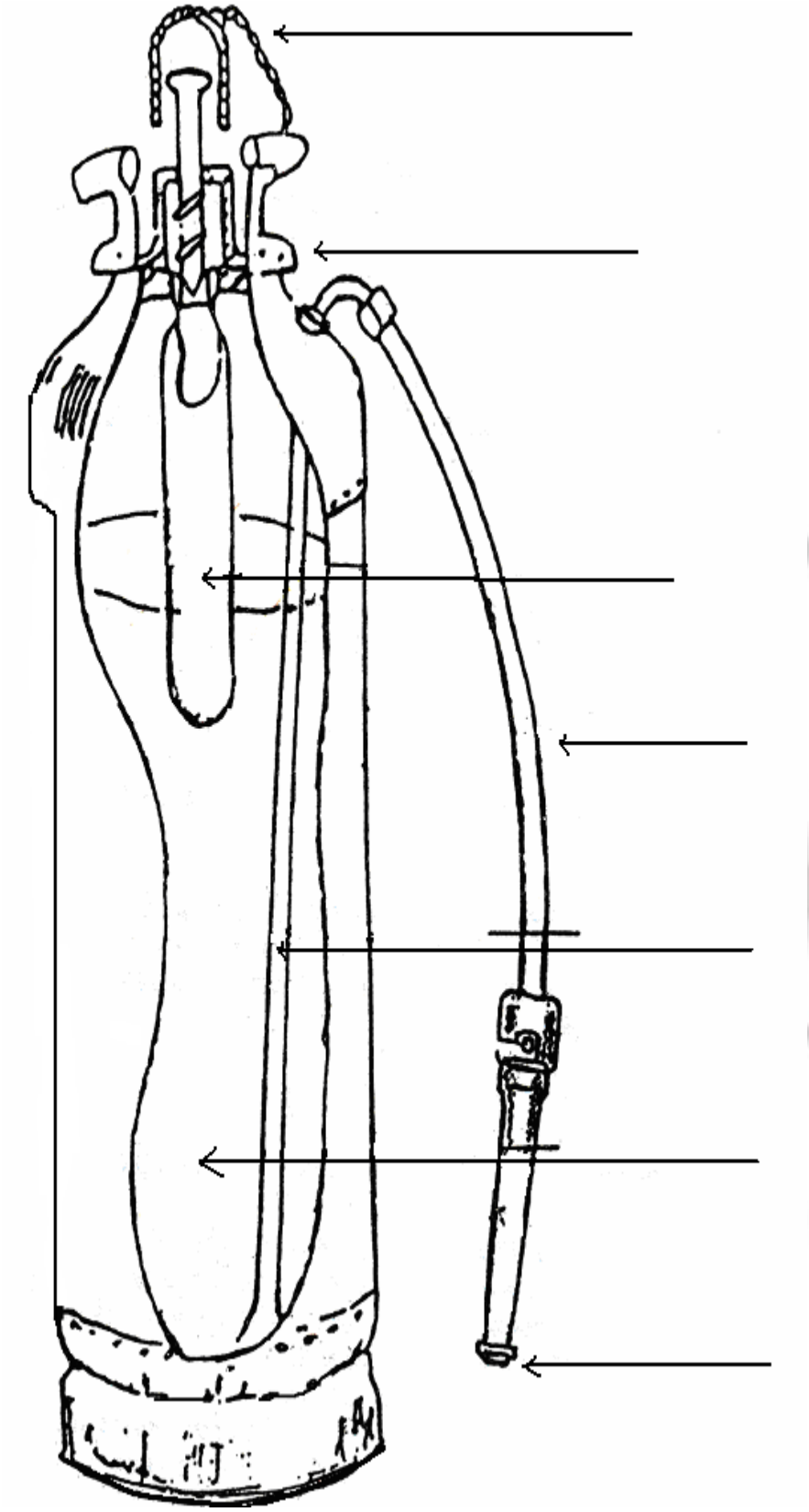


Fig 27 - 9 Litre Mechanical Foam Type Extinguisher

50. **Dry Chemical Powder Extinguisher (DCP) (For Class 'B' & 'C' Fires).**

(a) These extinguisher are used mainly for low flash point liquid fires and high pressure gas fires. They have very little cooling effect.

(b) Dry chemical powder extinguisher is for tackling petroleum fires, gas fires, electrical equipment fires and surface fires of textile fibre.

(c) DCP is very quick & is very useful due to the speed with which DCP put out fires.

(d) Chemical powders employed are normally sodium bicarbonate based for class 'B' & 'C' fires. When used on fire the powder undergoes a chemical reaction. The free radicals, which cause and sustain fire, are put out of action by Dry Chemical powder & thus the fire is extinguished very fast.

(e) For metals (like Sodium, Magnesium, Barium, Potassium, Sulphur, Phosphorus etc) fires (Class 'D' Fires), special dry powders containing mixtures of Sodium bicarbonate and Sodium Chloride based compounds are mixed with powdered fire clay, powdered graphite, powdered soapstone (talc), powdered limestone and dry sand.

(f) There are two types of DCP extinguishers :-

(i) Gas Cartridge type

(ii) Stored pressure type

Above extinguishers are normally available in 4.5 and 10-Kg capacities.

51. **4.5 Kg / 10 Kg Gas Cartridge Type Dry Chemical Powder Extinguisher.**

(a) It is painted blue and is used to extinguish fire by interruption of chemical reactions.

(b) See the figure for the construction of this type of fire extinguisher. The dry chemical powder is contained in the main shell of the extinguisher and CO_2 gas is held under pressure in a sealed cartridge. When the extinguisher is operated, the CO_2 cartridge (180 to 240 gms gas) seal is broken allowing the CO_2 gas to escape to the main shell and push out the powder in the form of fog.

Safety Clip

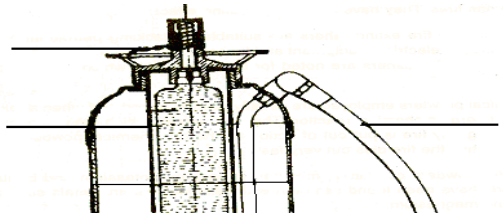


Fig 28 - Dry Chemical Powder Extinguisher

52. **Dry Chemical Powder Extinguisher.**

(a) **Method of Operation.**

(i) Carry the extinguisher to the place of fire and keep it upright. Remove the safety clip and strike the knob located in the cap to activate the piercing mechanism, which in turn breaks the sealing disc of the CO_2 cartridge.

(ii) Direct the stream of escaping powder at the base of the flame. For effective result stand about 1.5 to 2.5 metres away and direct the stream near the seat of the fire. Move forward, moving the nozzle rapidly with a side to side in a sweeping motion. It is useful for flight deck and helicopter landing platform, machinery spaces and metallic fires.

(iii) When using on outdoor fires, always operate the extinguisher from the upwind side of the fire to increase the effective range of the spray & to avoid the spray to fall on the user.

53. **2 Kg Carbon Dioxide Fire Extinguisher.**

(a) It is painted black and has duration 6~8 seconds.

(b) Carbon dioxide (CO_2) is effective as an extinguishing agent primarily because it reduces the oxygen (O_2) content of air (Smothering) to a point where combustion cannot continue. CO_2 is non-combustible and spread to all areas affected by air.

(c) Carbon dioxide fire extinguishers are used for putting out fires on oils, petroleum products, gaseous substances under pressure and on sophisticated electric and electronic equipment.

(d) CO_2 extinguishers should not be used in fires involving chemicals that contain their own oxygen supply (e.g. gunpowder, TNT, Cellulose nitrate and other explosive chemicals which contain free O_2 atoms released during their burning / chemical action). Also it should not be used for reactive metals like sodium, potassium, magnesium as carbon dioxide is of no use in extinguishing such fires.

(e) Construction: See the figure in which the main parts of the CO_2 extinguisher

are shown. CO_2 is retained in the cylinder as liquid under pressure. The cylinder is filled with the charge to about two-thirds (2/3) by weight of its total water capacity.

(f) **Method of operation.**

(i) Carry the extinguisher to the place of fire, remove the safety pin and operate the discharge device/unscrew the valve. CO_2 is discharged through a high-pressure flexible hose and horn type diffuser (made of Plaster or an insulating material to avoid frost bite).

(ii) Direct the jet at the base of fire and sweep across the fire surface. In open space, stand on up wind side and discharge gas in down wind direction as close as possible on fire. For electrical fires first switch of the supply. The extinguisher should be held with one hand on the insulated handle and the other on the insulated horn type diffuser.

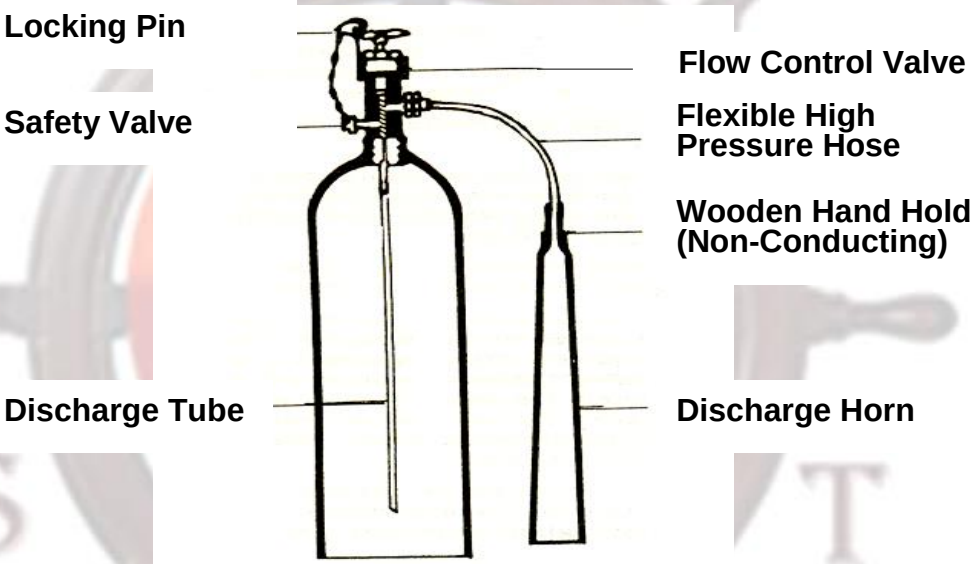


Fig 29 - 2 Kg Co_2 Extinguisher

54. **Maintenance and Ready Availability of Fire Appliances.**

(a) It is a principle of fire fighting that all equipment must be maintained in good order and be kept available for immediate use at all times. This applies equally to such equipment as fire extinguishers and hoses as it does to fire pumps and fixed fire extinguishing systems.

(b) A number of cases have arisen in which non – portable fire extinguishers have been secured in such a manner that, in an emergency, they could not have been immediately brought into use. The extinguishers concerned where of the 10 gallon capacity chemical foam type mounted either on two wheels or turnings and supported on a steel foot or let. Operation of the extinguishers included rotating it from the vertical through 90 degree to a horizontal position thus mixing the chemical solutions. It has been found that the foot or leg supporting the extinguisher has been adapted as a means of bolting the appliance to the deck in order to prevent

inadvertent operation in a seaway. When required in an emergency, the

extinguishers could not be released without the use of spanners.

(c) It is recommended that extinguishers of this type should be secured by a bend type bracket fitted in halves round the body of the extinguisher with a non – corrodible hinge and securing pin. Whatever method is chosen to secure the extinguisher it should be capable of ready release without the use of tools.

(d) In other cases, emergency fire pumps have been found to be defective when required in an emergency or in the course of testing for statutory survey. It should be recognized that a defective emergency fire pump would involve the detention of a ship until the pump is repaired or other acceptable arrangements are made:

(e) Ships staff should regularly examine and test all safety equipment to ensure that it can be brought into use immediately in an emergency.

55. **Mobile Fire Extinguishers.**

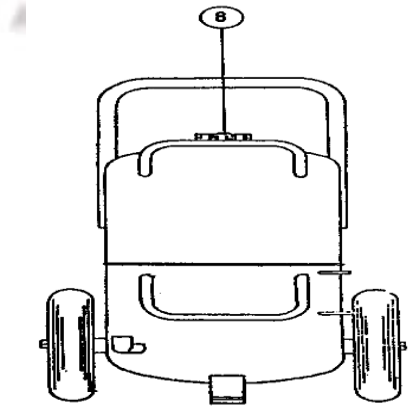
(a) 135 Ltrs Mobile Foam Extinguisher or high expansion Foam generator

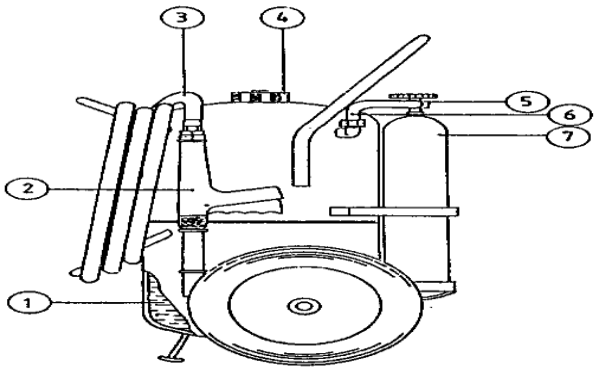
(b) 50 Kg. Or 75 Kg Mobile Dry Chemical Powder Extinguisher

(c) 6 Kg or 9 Kg Mobile Carbon Dioxide (CO_2) Extinguisher

56. **135 Ltrs Mobile Foam Extinguisher And 50 Kg / 75 Kg Mobile Dry Chemical Powder Extinguisher.**

(a) A tank containing foam compound or dry chemical powder is mounted on a trolley fitted with two wheels and a cycle type of handle to move it to the fire point on the same deck in a particular zone on board ship is provided. On the same trolley adjacent to the tank is a small cage holding a CO_2 bottle (containing about 2 Kg CO_2 under pressure).The CO_2 bottle has a manually operated valve. From the manual valve a steel pipe is led into the tank (containing foam compound or DCP).





	SYPHON TUBE	293-553032
	INSTRUCTION LABEL, USE	293-553222
	HEADBLOCK O-RING	293-552927
	CO2 CYLINDER, COMPLETE	294-553693
	CO2 HIGH PRESSURE HOSE	293-553172
	CO2 VALVE	293-553149
	NUTRING & HEADBLOCK	293-553180
	DISCHARGE HOSE	293-553198
	POWER LANCE & SWIVEL	293-553206
	BC POWER 50 KG	294-553719
ITEM	DESCRIPTION	EDP.

TECHICAL DESCRIPTION	
CLASS	BC
CAPACITY	50 KG
DISCHARGE TIME	42 SEC.
DISCHARGE RANGE (MINIMUM)	14 MTR
TEST PRESSURE	31 BAR
CO2 CYLIDER SIZE	2.0 KG
HEIGHT	1015 MM
DIAMETER	560 x 610 MM (W x D)
WEIGHT EMPTY	52 KG
WEIGHT FULL	104 KG
COLOUR	BLUE

Fig 30 - Mobile Foam / DCP Extinguisher

From the main container, a flexible outlet pipe is provided from the bottom of the

container. The end portion of the flexible pipe is fitted with a suitable foam making nozzle (in case of the mobile foam extinguisher) or a regulating control nozzle (in case of the mobile dry chemical powder extinguisher).

(b) The mobile foam fire extinguisher is normally provided near the main engine bilge platform and near the auxiliary boiler platform (For oil fires – Class 'B' fires).

57. **Ms Notice 9 of 1999 Prohibiting the Use of Certain Types of Fire Extinguishers.** The Director General of Shipping has been giving approval to 9 litre portable chemical fire extinguishers, 9 liter portable soda acid extinguishers and 45 litre non portable chemical fire extinguishers for a number of years. These portable and non portable extinguishers are manufactured as per Bureau of Indian Standards (BIS) specifications by various approved manufacturer. In recent times BIS has withdrawn both the above manufacturing specifications for the extinguishers. BIS is also going to withdraw its specifications for the refills of the above extinguishers by Dec 2000. Since the Director General of shipping follows a national standard for manufacture of these extinguishers for marine use, it has been decided that the 9 litres chemical foam fire extinguishers, 9 litre soda acid extinguishers and 45 litre non portable chemical foam extinguishers are no longer acceptable for marine use with immediate effect. These extinguishers, wherever they are fitted on board ships/barges/tugs/off shore vessels has to be replaced by acceptable equivalent by Dec 2000.

58. **High Expansion Foam Generator.**

(a) Another effective method to fight enclosed space medium class 'B' fires (oil fires) is to use mobile high expansion water turbine foam generator. This consists of a fan driven directly by the shaft of a water turbine which blows air to a nylon net. The net is wetted by foam water solution from spray nozzles which are supplied from the discharge of the water turbine and the foam concentrate which is drawn into the water discharge stream by means of a built –in-inductor system.

(b) A special feature in this foam generator is a "By-pass" system which allows the foam generator to operate against a high blood pressure due to using of long length of ducting or when forcing the foam to a height.

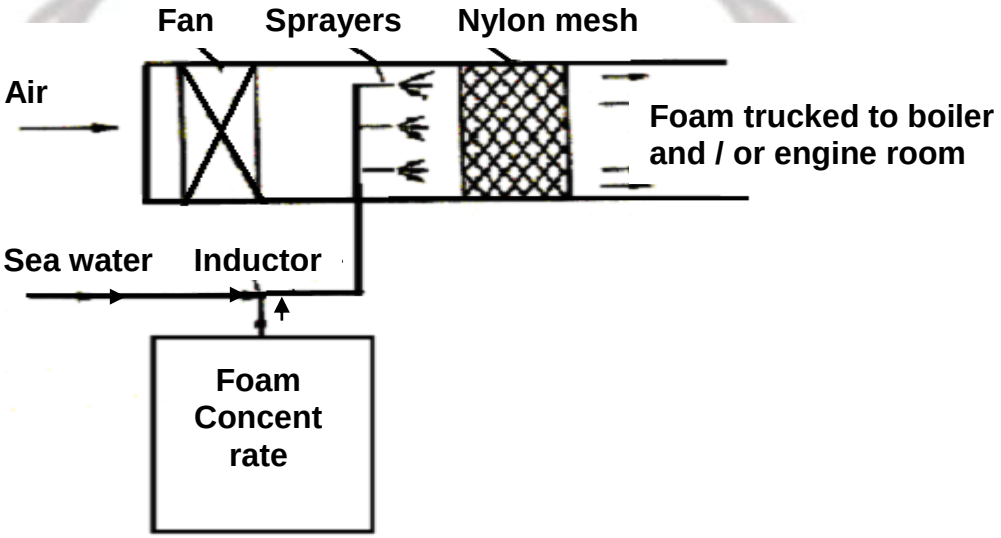


Fig 31 - High Expansion Foam System

(c) With the by-pass shut, all the water passing through the generator is used for

driving the tribune and for foam production; thereby producing reduced expansion foam.

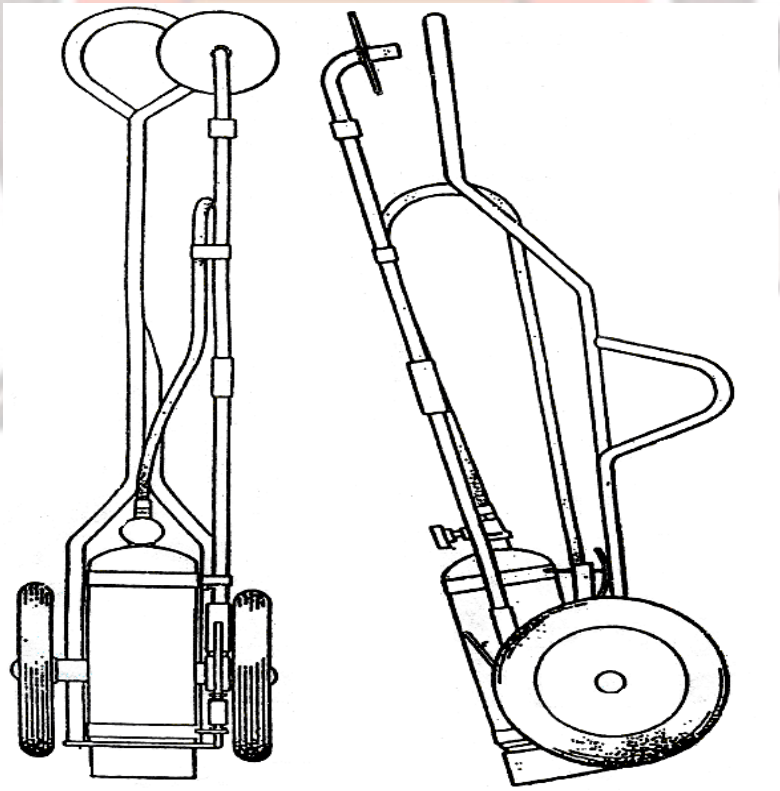
(d) In order to overcome high back pressure which occurs when high expansion foam is ducted through long lengths of tubing, the by pass is opened and some water is diverted to pass through the turbine to waste leaving less for foam production. This results in a higher expansion foam and it also increases the water flow to the turbine, speeding up the fan and consequently the air flow.

(e) The foam generator can also be used as a smoke extractor for this purpose, the valve controlling the foam solution supply to the spray nozzle is closed and the direction of the air flow instead of towards the open air is changed towards the space desired to be made free of smoke.

(f) The mobile dry chemical powder fire extinguisher is normally provided in the engine room at a suitable place for any type of fires due to main engine or diesel generators exhaust pipes/lines.

59. **7 Kg ~ 9 Kg Carbon Dioxide (Co_2) Extinguisher.**

(a) This extinguisher is also mounted on a trolley similar to foam/DCP trolley and is provided for electrical/electronic equipment fires. Mobile CO_2 extinguisher is normally provided for machinery control room, main switch board/s, cargo control room and the supply control room (SCR).



`Fig 32 - 7.0 And 9.0 Kg CO2 Mobile Extinguisher For E/R, Helideck / Helicopter Fires.

(b) The CO_2 cylinder is provided with a manually operated valve and a flexible

hose. The other side of the flexible hose has an insulated horn type diffuser to prevent frostbite to the user. While operating this extinguisher, the user must ensure that he operates this extinguisher from the compartment's EXIT door to prevent him getting trapped inside due to suffocation caused by CO_2.

Protective Clothing For Fire Fighting.

60. **Fire Fighting Suits.** There are two types viz fearnaught suit and aluminised proximity suit.

(a) **Fearnaught Suit.**

(i) Comprises of a jacket, trouser and gloves.

(ii) Fabricated by the mixture of two materials asbestos and wool.

(iii) Can resist temperature up to 450^{o} C temp

(iv) Safety helmet to be worn.

(v) CABA set to be worn if required (in case of thick smoke)

(vi) Used for minor fires.

(b) **Aluminised Proximity Suit.**

(i) Comprises of a one length suit from top to bottom (like boiler suit) with aluminised shoes and helmet with visor.

(ii) Having provision of securing CABA set inside the suit.

(iii) Used for fighting major fires.

(iv) Made up of 3 layers :-

(aa) Ist layer – Aluminium coating – reflects heat.

(ab) IInd layer – Fibber glass fabric – adds strength to the material

(ac) III rd layer – Woollen layer – vapour sealing between body & fabric.

(v) Stitched with – Keble thread.

(vi) Can resist up to 1400^{o} C temp

Note. Always cotton fabrics to be worn while going for fighting the fire no tricot or synthetic garments to be worn as they catch fire very fast.

61. **Fire Man's Outfits.** Fire man's outfits consists of fire proof clothing and breathing

apparatus etc. which give protection from heat / fire and foul ambient conditions to a fire fighter.

62. **Compressed Air Breathing Apparatus (CABA) Set.** CABA set is a self contained compressed air breathing apparatus to supply fresh clean air free from dust and moisture for use in emergency for enclosed spaces. This may be essential for fire fighting or for rescuing operations. The detailed description of a CABA set is as follows :-

(a) It consists of a high pressure air cylinder charged with fresh air upto 200 Bars which normally lasts for 35 minutes for normal working or 28 minutes when working under hard conditions. The cylinder is carried / supported on a steel back plate by means of padded webbing harness which is fully adjustable for comfort. The flow of air from the cylinder to the face mask is controlled by a two stage pressure reduction system consisting of a simple piston pressure reducer and a high performance demand valve mounted to the face mask by a bayonet connection.

(b) The demand valve incorporates a first-breath actuating mechanism to facilitate donning and testing procedures and manually operated by pass which admits a continuous flow of air to the mask when required. The face mask is made of non-dermatitis materials and is retained by a fully adjustable head harness. A facemask incorporates a speech diaphragm and an inner mask to reduce carbon dioxide dead space and also prevents misting of the visor (which facilitates a wide-angle panoramic viewing).

(c) An assembly of a cylinder pressure gauge and a audio alarm system / warning whistle (which indicates when approximately 48 ~ 50 Bar pressure of air supply remains in the cylinder) is attached to the pressure reducer by a stainless steel reinforced hose. Connection of the regulator to the cylinder valve outlet is by means of a hand tight coupling. The face mask can be made airtight by tightening / adjusting head harness (tighten lower straps first and do not overtight. The wearing of beards, sideburns or spectacles may adversely affect the sealing of the mask to the wearer’s face) so that outside air cannot enter the mask and thus the wearer is completely protected from the outside foul air or oxygen deficient air.

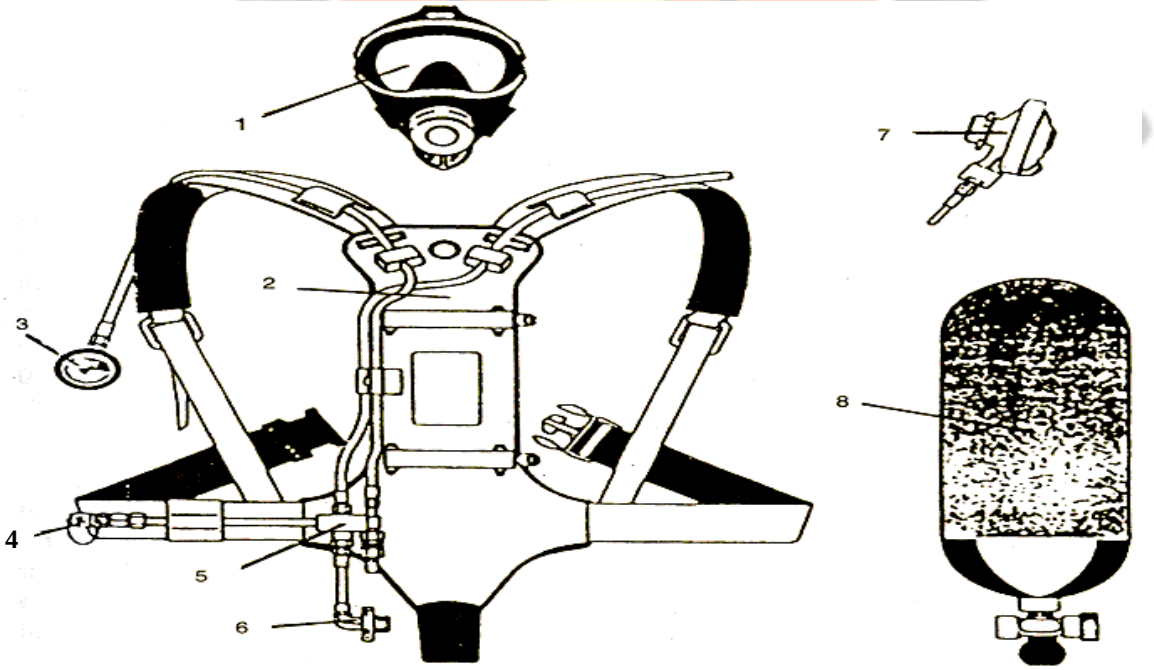
(d) A fully charged cylinder (200 Bar) contains about 1235 litres of air. An average person in normal working conditions consumes about 35 litres per minute. Therefore the effective duration of the cylinder is about 35 minutes. The warning whistle is set at about 48 ~ 50 Bar pressure in the cylinder which makes an effective duration of about 8 minutes. Therefore the effective duration of a fully charged cylinder is only 35 – 8 = 27 minutes as the air supply for 8 minutes duration (on blowing of warning whistle) is basically for retreat only.

(e) The demand valve regulates the flow of air to the wearer and maintains a positive pressure in the face mask. The face mask is fitted with a spring – loaded exhalation valve so that the pressure inside the face mask will always remain above the outside ambient air pressure by the air from the demand valve. To facilitate donning and testing procedures, the demand valve incorporates a first breath mechanism which when reset by pressing a button closes the demand valve. The first subsequent inhalation actuates the mechanism and reopens the demand valve and thus restores the demand valve to normal working operation. A by-pass knob attached to the inlet stem allows the stem to be rotated to align a port in the stem with another in the body thus allowing a continuous flow of air to the face mask

independent of the normal demand valve operation.

63. **CABA Set Donning Procedure.** With shoulder straps and waist belt fully slackened, don the CABA set and adjust the shoulder straps until the cylinder is held snugly on the back. Hang face mask strap around neck. Now, fit waist belt and adjust as required. Check that the demand valve is switched off (depress reset button) and by-pass is closed. Turn "ON" the cylinder valve slowly and check cylinder pressure by reading the pressure gauge. With right hand thumb inside the head harness straps, put chin into the face mask first and pull straps overhead. Position the face mask so that the chin fits snugly into the chin-cup and then gently tighten head harness (Lower straps first). Now gently lift face mask away from the cheek to get a good outward flow of air from the face mask showing that the face mask pressure is positive. Allow mask to re-seal.

64. **Checking of Warning Whistle and Face Mask Leakage.** Close cylinder valve, continue to hold hand wheel of the cylinder valve and breath normally. Check that the whistle sounds at 48 ~ 50 Bar. When pressure gauge shows zero, pull the mask gently onto the face and hold breath for 10 seconds. Any leakage will be indicated by the mask moving away from the face. If a leak is detected, open cylinder valve and readjust face mask and its head harness and repeat test. If no leak is detected, open cylinder valve fully and check operation of the by-pass by turning the red knob (on the demand valve) clockwise until it clicks on to the "ON" position and check for a good flow of air. Close by-pass.



1. **Face Mask**
2. **Backplate & Harness**
3. **Contents Guage**
4. **High Pressure**
5. **Mainfold**
6. **Cylinder Connector**
7. **Demand Valve**
8. **Cylinder & Valve**

Fig 33 - Compressed Air Breathing Apparatus (Self Contained)

Fig 34 – Procedure for Fitting Premier Demand Valve to Facemask

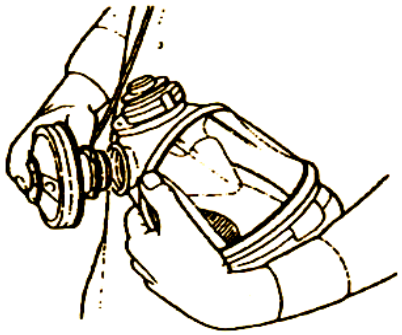
1

This illustration shows the final correct alignment of the demand valve hose and mask. To achieve this the following procedure should be applied.

2

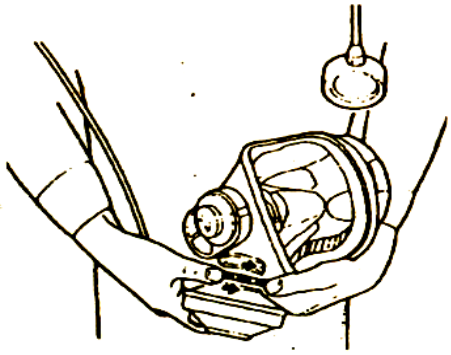
To ensure correct alignment of the demand valve and hose. don the set (with the facemask disconnected) and hold the demand valve in palm of the hand. There should be no strain on the hose when the demand valve outlet is laid flat against the cheek. If this is not correctly aligned please contact designated maintenance personnel.

3



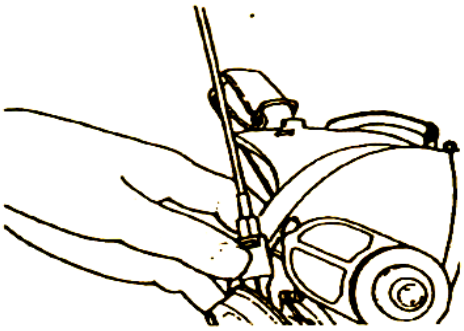
When wearing the set. hold the facemask as illustrated. Allow the demand valve and hose to hand free. present the facemask to the demand valve. ensuring that the handwheel of the demand valve spins freely prior to connecting the demand valve to the facemask.

4



Screw the demand valve hand wheel into the side port on the facemask. The hand wheel should be screwed in sufficiently until resistance of rotation is felt between the sealing face on the demand valve in relation to the rubber seal in the facemask port.

5



Check that the demand valve and hose are aligned with the screw in the base of the front port.

6

Lock the demand valve securely in position by using two thumbs to rotate the hand wheel a minimum of one castellation. It should not be possible to rotate the demand value in the port

Forced Air Breathing Apparatus.

65. **Brief Description.**

(a) This consists of a facemask with an integral speech diaphragm; rubber breathing tube, harness assembly with shackle, hemp covered wire rope lifeline, signal plate, air hose, non-collapsing type and double acting foot-operated bellows.

(b) Fresh air is drawn up the hose by the wearer's own respiratory effort. An exhaling valve allows the escape of excess and vitiated air. The apparatus is connected to a set of bellows which can be foot or hand operated.

(c) This bellow should be situated in fresh air. With the effort of a second person, continuous supply of fresh air for breathing can be provided to the user of this breathing apparatus.

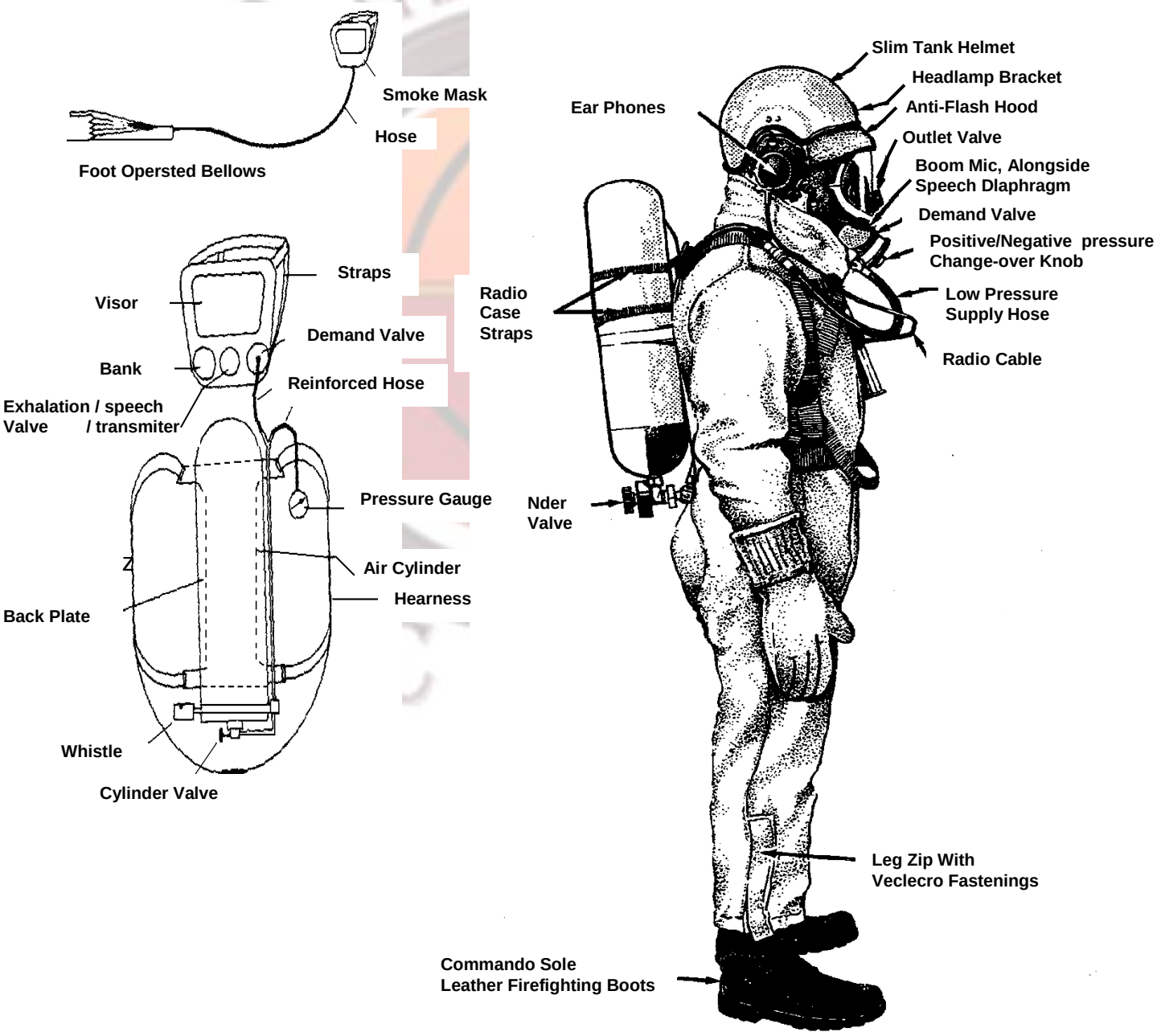


Fig 35 - Forced Air Breathing Apparatus

66. **Disadvantages of Forced Air Breathing Apparatus.**

(a) Constant supply of fresh air for breathing is dependent on the second person.

(b) Air tubing/hose has to be trailed behind the wearer thus restricting his movements and limiting his area of operation.

(c) The air hose may be cut or damaged during operation.

(d) The apparatus is bulky and not very comfortable compared to compressed Air breathing apparatus set (CABA set). Good care is essential to maintain the bellows in good working and unpunctured condition.

67. **Life Line Signals.**

(a) **One Pull** – Fire Attended asks fire fighter if he is ok. Fire fighter replies with one pull means “I AM OK”.

(b) **Two Pulls** – By Fire fighter “Pay out the line, I want to proceed further” The fire Attended acknowledges by two pulls and pays out more lifeline.

(c) **Three Pulls** – By Fire fighter or by Fire Attended “I am in danger, I am coming out or ”There is danger to your life, you come out”. The other person acknowledges with three pulls and takes appropriate action.

(e) **Four Pulls or More** – By fire fighter / fire Attended – “there is impending danger- I am coming out immediately” / “you must come out immediately due to impending danger”. The other person acknowledges and takes appropriate action immediately.

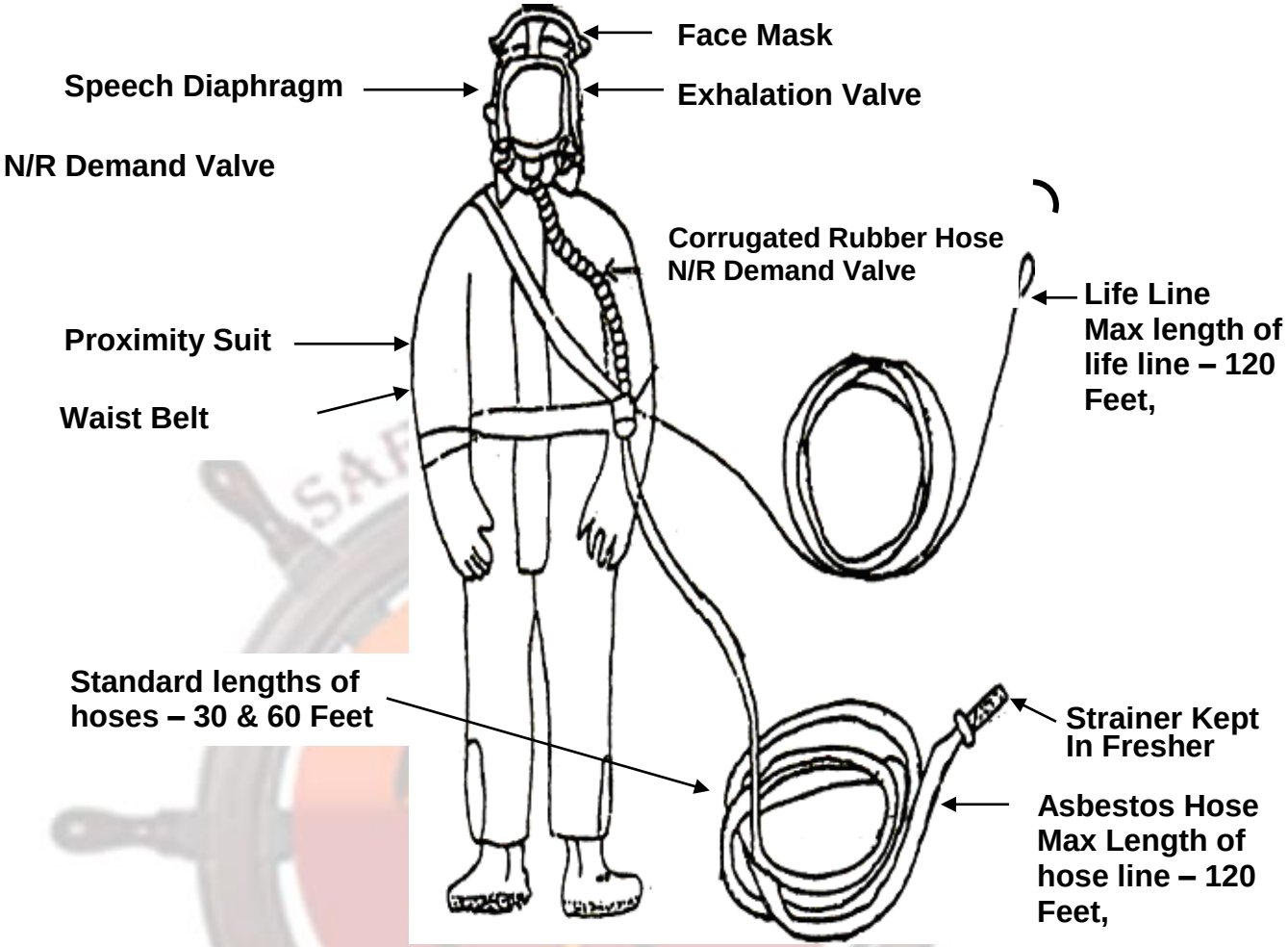


Fig 36 - Smoke Mask

68. **Fire Control Plans.**

(a) Fire control plan is the detailed drawings which give complete details of ship's total fire fighting equipment viz. portable extinguishers, mobile extinguishers and fixed fire fighting installations and their exact locations in each zone on board including the refills for the portable extinguishers where stored and the location of fire party lockers and their contents.

(b) Fire control plan is displayed in the form of big scale drawing in crew messes, officer's saloon, bridge, machinery control room and main alleyways.

(c) The fire control plan also indicates clearly the access and escape routes in different zones of the ship and the fire fighting equipment / fire hydrants – hoses-nozzles etc. available in each zone and their exact location.

(d) The location of fire pumps / fire and bilge pumps / emergency fire pumps, the complete layout of the iremain system, the various main / bulkhead / isolating valves and the points / switches from where these pumps can be started in emergency.

(e) The plan also gives the complete layout of different machinery compartments /spaces and accommodation, dinning and galley areas, main stores, various ventilation and exhaust blowers fitted and their dampers and the location from where they can be operated/shutdown in case of emergency / fire.

(f) In case of a major fire, to assist the shore fire fighting Organisation, a copy of fire control plan is also kept safely in a steel tube painted red and marked “Fire Control Plan” in white. The steel tube is normally welded on bulkheads under cover near the gangway or on the wings of the Navigation Bridge. The steel tube is closed on one side and the other side has an easily opening threaded cap. In case of a major fire on board ready help / information may not be available to the shore fire fighting personnel or ship’s personnel may have abandoned the ship. In such cases, the fire control plan kept in the steel tube becomes handy and a guide for the shore personnel in fighting the fire.

(g) Fire control plan drawing is periodically checked and updated and is duly approved by the competent Shipping Authority (M.M.D. / Director General of Shipping).

(h) Any change in number of portable or mobile fire extinguishers or change in their locations on board or any modifications / alterations in firemain system or other fixed fire fighting installations is incorporated in the fire control plan and approval for the new fire control plan is taken from the approving authority.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CHAPTER – 7

INSPECTION AND SERVICING OF FIRE APPLIANCES AND EQUIPMENT

1. **Fire Alarms.**

(a) Every ship is provided with fire alarms in all zones of the ship, so that in case of fire, the fire alarm is audible in every place on board ship irrespective of its location from the central control station viz. the bridge. Further, a fire alarm can be triggered not only from the bridge (the central control station) but also from a number of places on each deck. These fire alarm trigger switches are normally fitted on bulkheads enclosed in a glass cover so that it can't be operated accidentally. Further, these fire alarm trigger switches are located in conspicuous places and are marked "Fire Alarm".

(b) Any person noticing fire on board must trigger the fire alarm by breaking the glass cover of the fire alarm switch. A suitable drawing is also held on board giving location of the "fire alarms" switches fitted from where the fire alarms can be triggered. The "fire alarms" as well as the "fire alarm switches" are surveyed at regular intervals by the competent Authority and a record on board is maintained of the surveys, inspection, testing and maintenance carried out in the past.

(c) A record is also maintained of defects observed and repairs carried out in the past on "fire alarms" fitted on board ships. The maintenance of "fire alarms" and "fire alarm switches" on board ships is usually based on manufacturers manual which guides regarding inspection and change of electric wiring / equipment, cleaning of electrical contacts and switches and testing / proving that equipment functions correctly.

2. **Fire Detection Equipment & Types of Various Detectors.**

(a) An automatic fire alarm and detection system is required to be installed in the cargo holds/ spaces, accommodation and service areas, machinery spaces, machinery control room, supply control room, computer room etc. on board ships.

(b) The prime function of detectors is to detect flame, smoke or heat (change in temperature in the protected environment) which will be caused due to fire. The detectors on board are usually mounted on ceilings or in air ducts.

(f) The fire / smoke / heat detectors can be activated to sound alarm by smoke, by heat (rise in temperature) or by flame radiation (due to infra red rays or ultra violet rays) emitted from flames.

(d) The various detectors fitted on board ships are mainly :-

(i) Heat detectors, which operate at a predetermined temperature (bimetallic strip or fusible link type).

(ii) Heat detectors, which operate when the rate of rise in temperature of the surrounding air reaches a set limit (pneumatic type).

(iii) Smoke detectors, which operate when smoke scatters or absorbs a beam of light on a photoelectric cell.

(iv) Smoke detectors, which operate when an electric current flowing through an ionised atmosphere is changed due to smoke.

(v) Flame detectors which operate due to radiation of ultra violet rays omitting from a flame falls on a photo-electric cell (which is sensitive to ultra violet rays)

(vi) Flame detectors which operate due to radiation of infra red rays omitting from a flame falls on a photo-electric cell (which is sensitive to infra red rays).

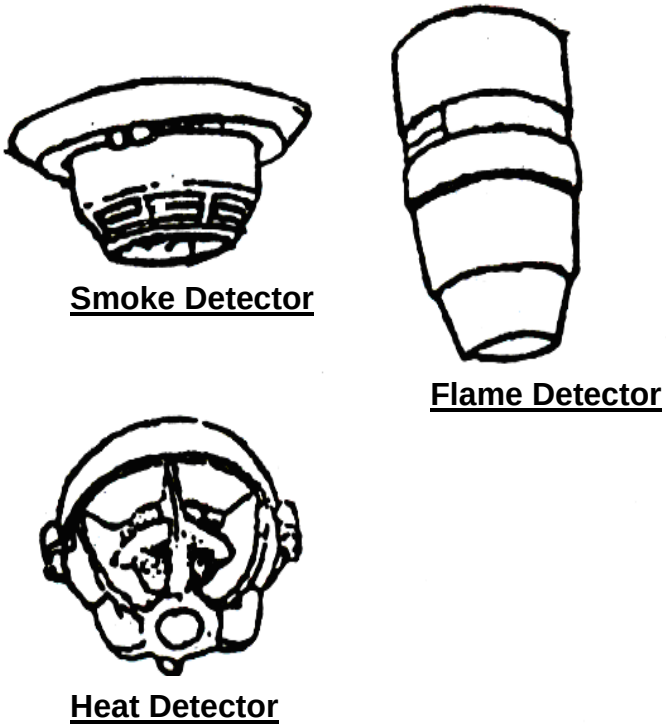


Fig 38- Fire Detectors

3. **Heat Detectors.** Are used to protect large areas where safety of life and early warning are not the major concern, because the next detectors can start in response. The heat detector which operates at a fixed predetermined temperature are of two types :-

(a) **Bi-Metallic Strip Type.** It has a bimetallic device which uses two different metals of different co- efficient of thermal expansion. When bonded together of two different metals, the metal with the major expansion rate bends towards the metal with lower expansion rate such detectors can protect and cover an area of about 36 M^2.

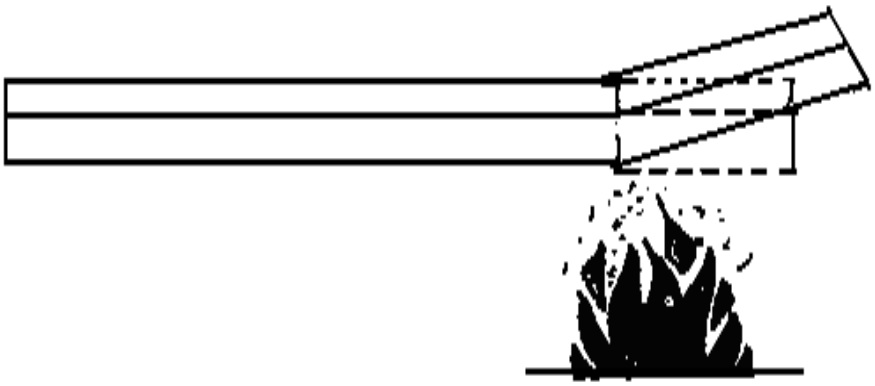


Fig 39 - Illustration of the Effect of Heat on a Bi-Metal Strip

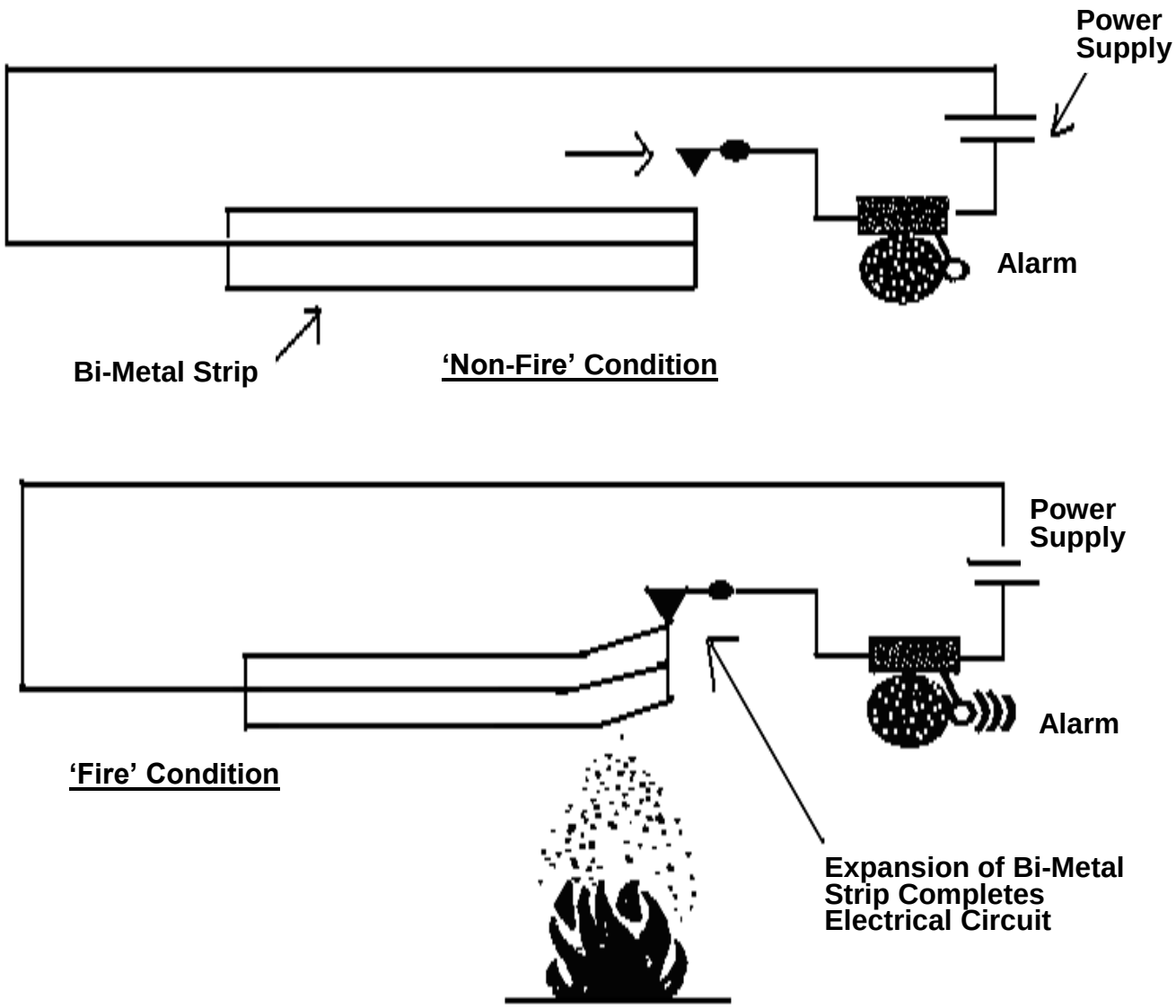
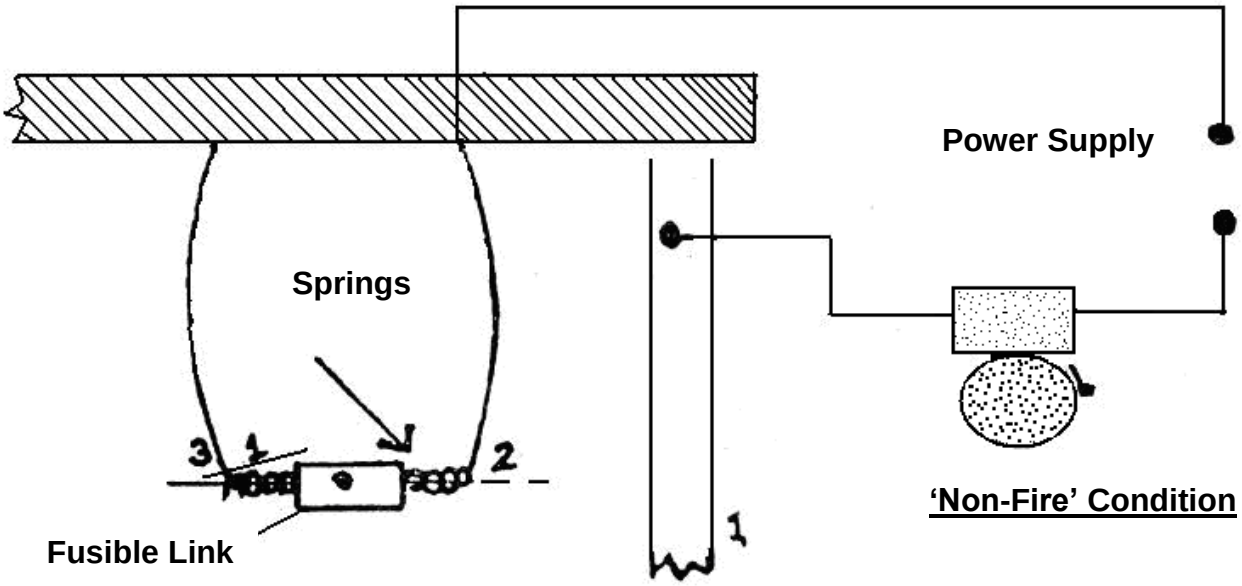
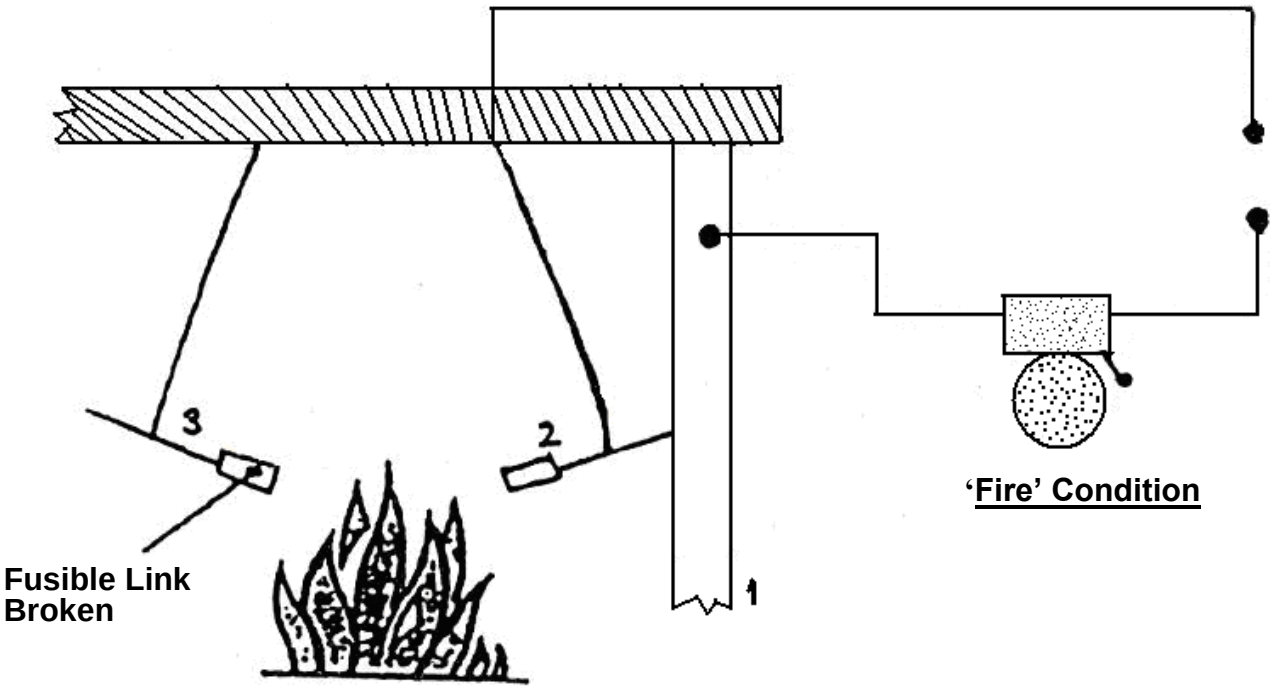


Fig 40 - Iiiustration of a Bi-Metal Strip as a Heat Detector



'Non-Fire' Condition



'Fire' Condition

Fig 41- Diagram of ‘DImac’ Heat Detector (Fusible Link Type)

(b) **Fusible Link Type.**

(i) This detector is based on principle that certain metal, alloys melt at relatively low temperature. The general range is from 70° C to 90° C. The alloy chosen depends on the temperature at which alarm is required to be sounded.

(ii) The detector consists of a pair of fixed contacts separated by a pair of springs and the contact is held under expansion by a fusible alloy link. When the surrounding area reaches the predetermined temperature, thereby melting the fusible metal link, the springs makes contact thus completing the electric circuit to sound the fire alarm.

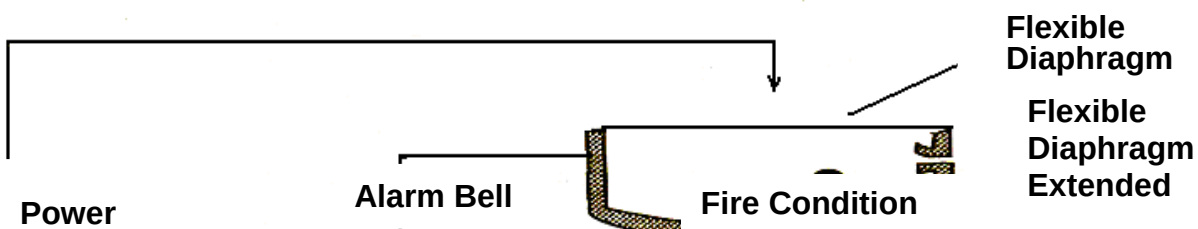
(c) **Pneumatic Type (or Rate of Rise in Temperature Type).**

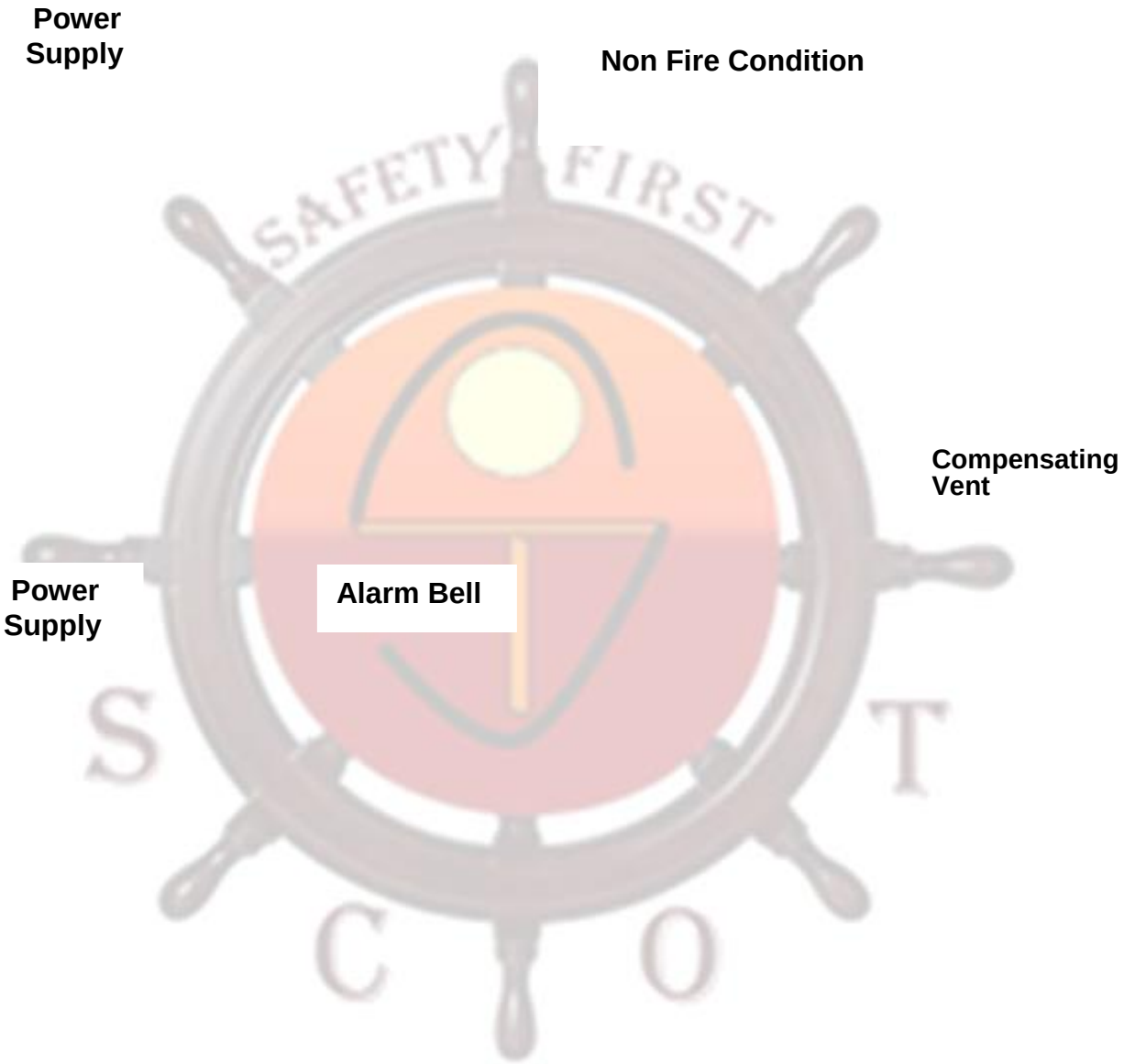
(i) This detector consists of a chamber and a diaphragm assembly with air filled inside the chamber. When subjected to heat, the air in the chamber expands and exerts pressure on the flexible diaphragm thereby expanding it. The expansion makes the electrical contact thereby completing the circuit to trigger an alarm. In other words, the detector operates on the principle of expansion of air.

(ii) By introducing a small compensating vent on the side of the air chamber, the expansion of the diaphragm or the rate of rise in temperature for triggering the alarm can be adjusted. The compensating vent allows a certain amount of expanding air to escape so as to compensate only for the expansion caused by the actual increase in temperature of the ambient conditions

(iii) When there is a rapid rise in temperature of the surroundings where this detector is fitted, the air in the chamber expands more rapidly than the compensating vent can release it. As a result, the expanding air pushes the diaphragm against the electrical contact on the base of an adjustment screw for adjusting “the rate of rise in temperature”. This completes the circuit and triggers the alarm.

(iv) If the fire develops too slowly for the “rate of rise in temperature” element to detect it, then the “fixed temperature” element operates which is set at a predetermined temperature (varying from 60 degrees centigrade to 80 degrees centigrade). This operates due to expansion of contact spring support which absorbs the heat from the metal base of the diaphragm assembly. On expansion due to heat, the support pushes the contact spring against the contact on the base of the fixed temperature adjustment screw, thus triggering the alarm. The detector resets itself after the alarm has been triggered and the fire has been extinguished.




Power Supply
Non Fire Condition
Compensating Vent
Power Supply
Alarm Bell

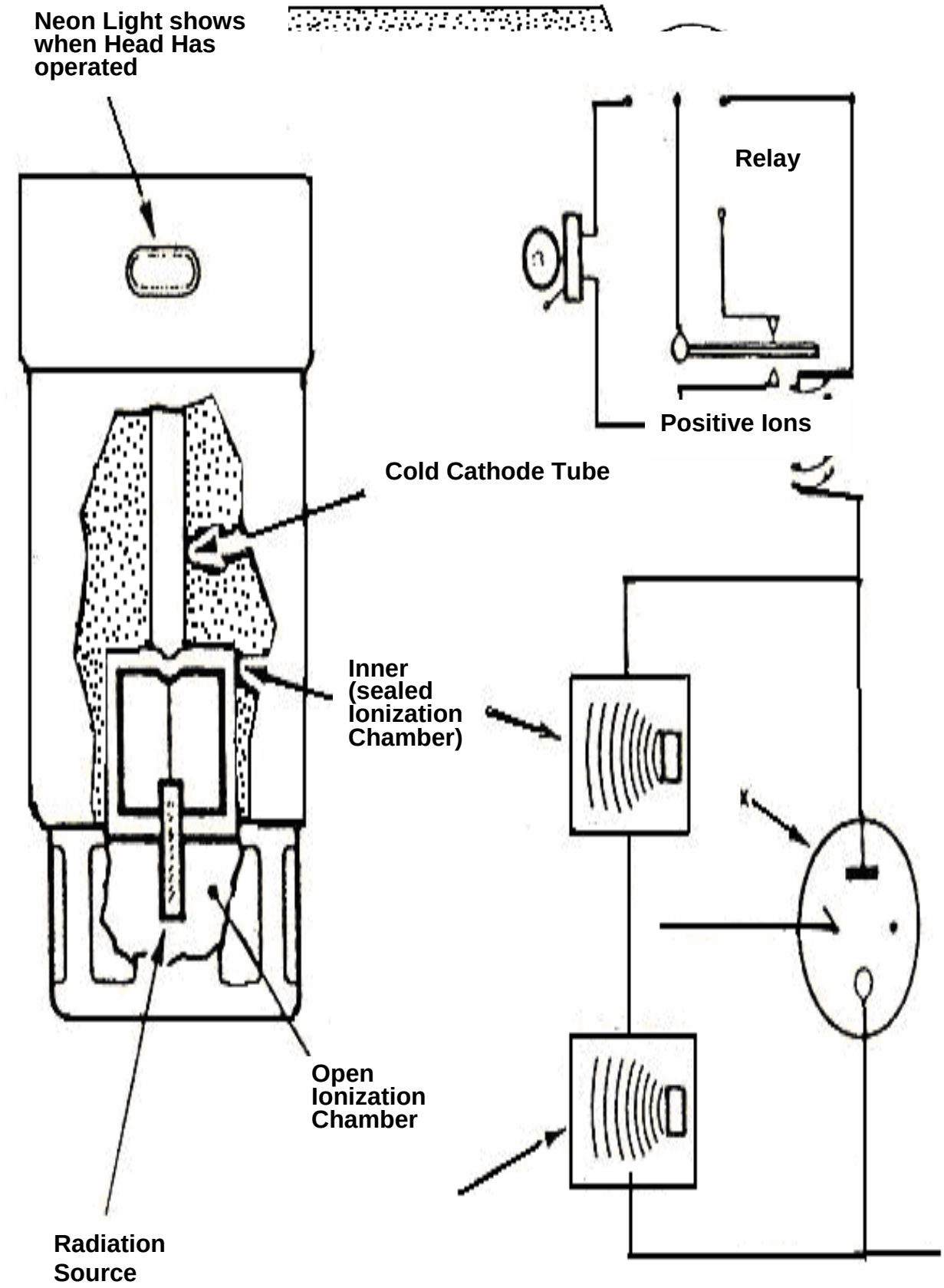


Fig 43- Illustration of an Ionization Detector

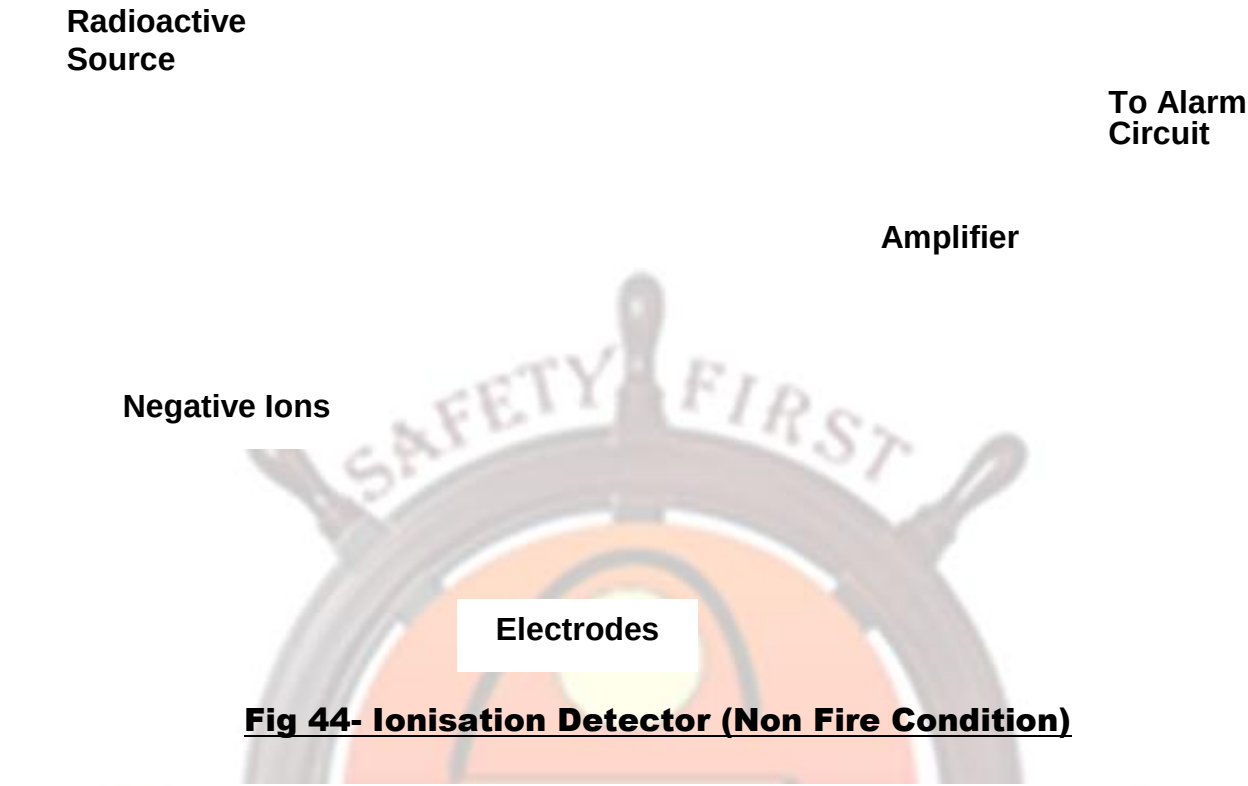


Fig 44- Ionisation Detector (Non Fire Condition)

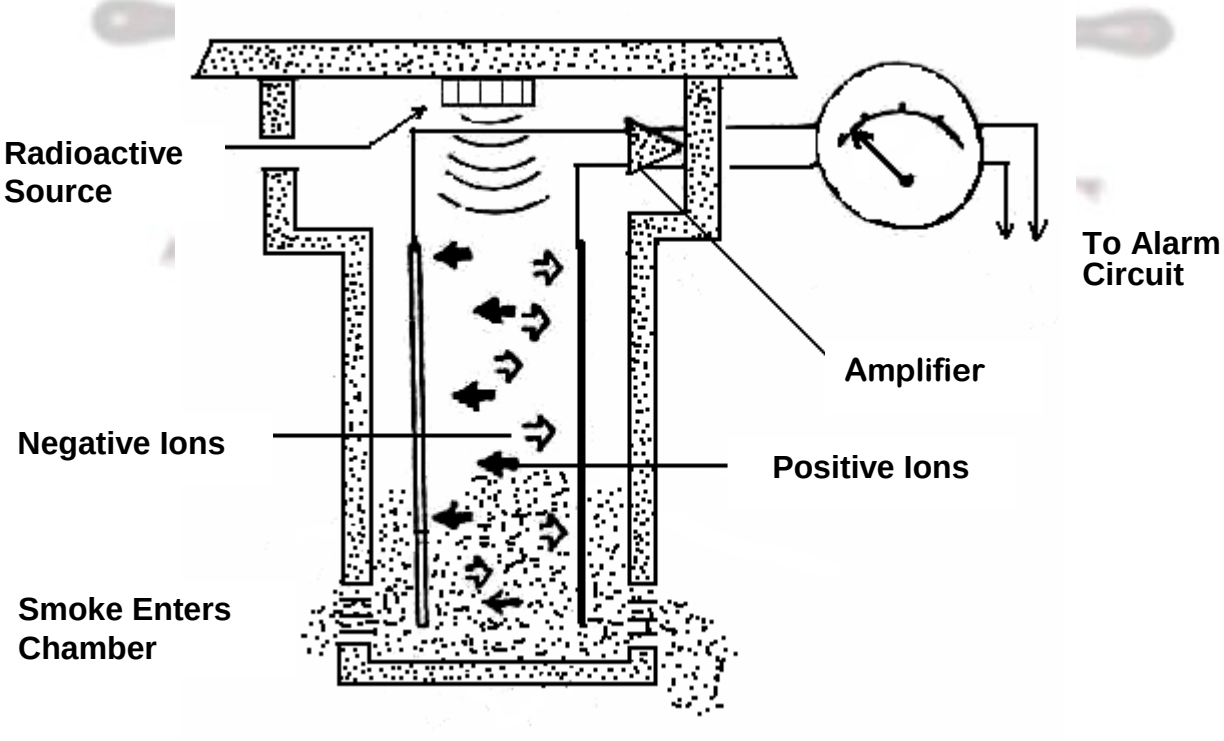


Fig 45 - Ionisation Detector (Fire Condition)

4. **Smoke Detectors.**

(a) **Ionisation Type.**

(i) These detectors respond rapidly even with small particles of smoke created by fire. Ionisation detectors consist of two chambers, one that allows the smoke to enter freely and a second chamber, which is virtually sealed and acts as a reference chamber. The two chambers stabilise the unit and make it less sensitive to unwanted alarms caused by change in humidity, temperature and pressure but respond quickly to smoke.

(ii) The two chambers contain a small radioactive source. Alpha and Beta rays emitted from the radioactive source ionise the air between two electrically charged plates in the sensing chamber and cause a current to flow.

(iii) In a fire condition, smoke particles entering the chamber become attached to the ions because of Electro static attraction and slow their movement. This causes a reduction in the flow of ions due to fall in electric charge. When the current falls below a predetermined level, the amplifier senses it and initiates an alarm. The sensitivity of this type of detector can be raised by altering the level of radiation in the chamber or by altering the voltage necessary to excite the cold cathode tube.

(iv) Such detectors are most suitable in machinery spaces and accommodation spaces and can be adjusted to high level of sensitivity especially when unwarned operation is required but prompt detection of fire is imperative.

(b) **Photoelectric Cell Type.**

(i) Photoelectric smoke detectors operate by responding to the reflection (Either by scattering or by absorption) of light by smoke particles. The most common type uses the light scattering principle.

(ii) Light scatter type: A light source, usually a light emitting diode is used so that the photoelectric cell is not directly exposed to the light emitting diode. Smoke particles entering the detector reflect light on the receiver, changing its conductivity and causing the device to trigger the fire alarm. The light absorption (obscuring) beam type detector electrically measures the reduction in the transmission of light caused by smoke particles. In this case, the photoelectric cell is directly opposite to the light emitting diode so that the light is continuously received. The voltage change that occurs when / smoke particles interrupt the light beam, triggers an alarm.

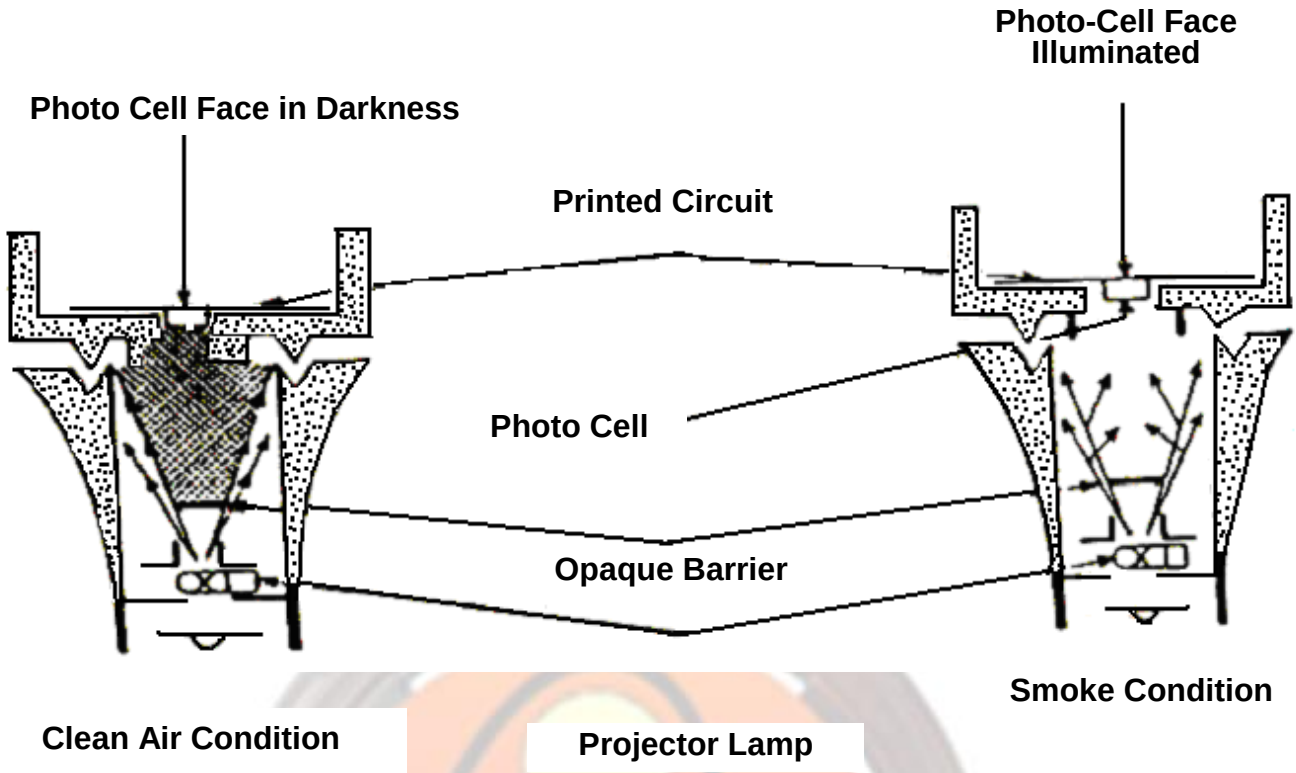


Fig 46 - Smoke Detector Light Scatter Type Showing Principle of Operation

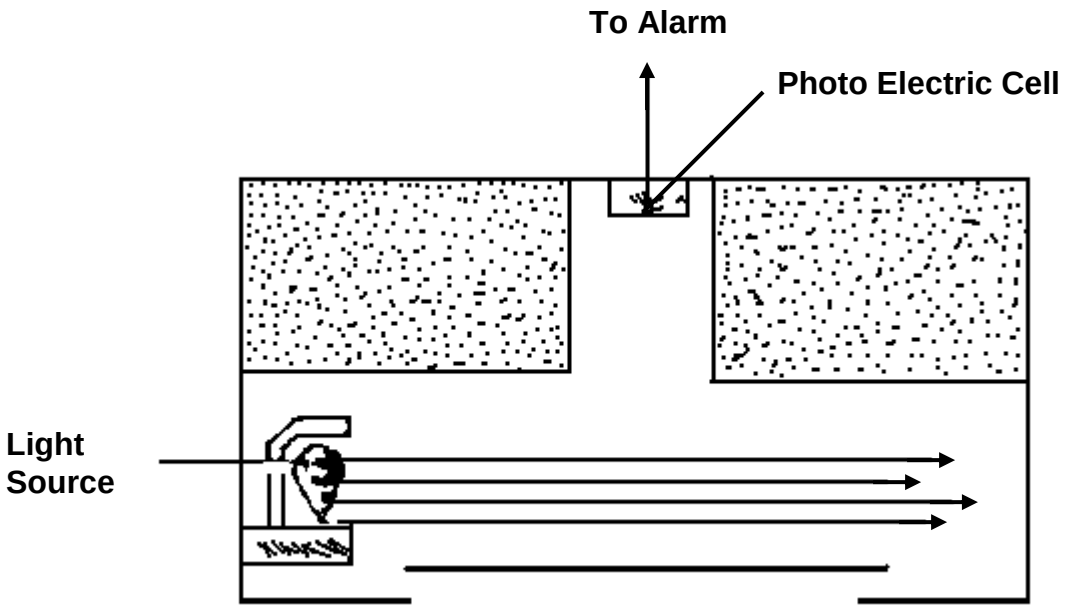


Fig 47- An Optical Smoke Detector 'Light-Scatter Type' (Non-Fire) Condition.

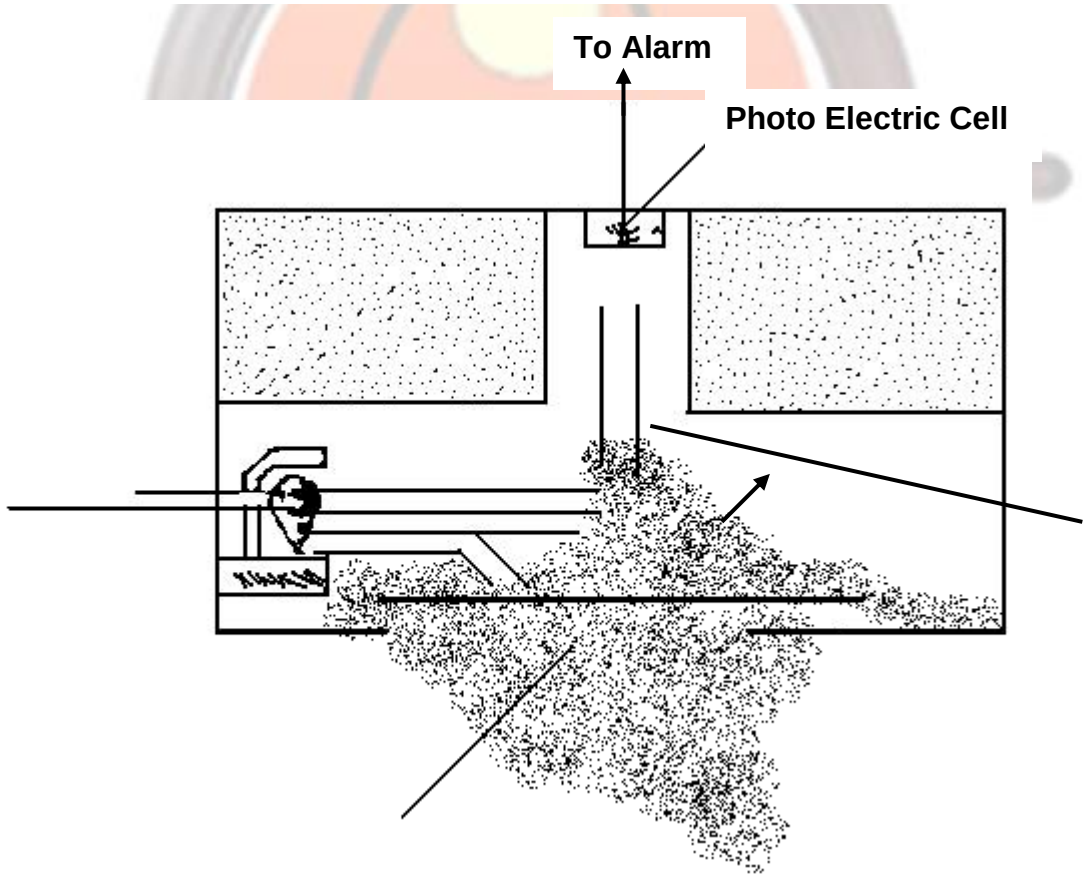
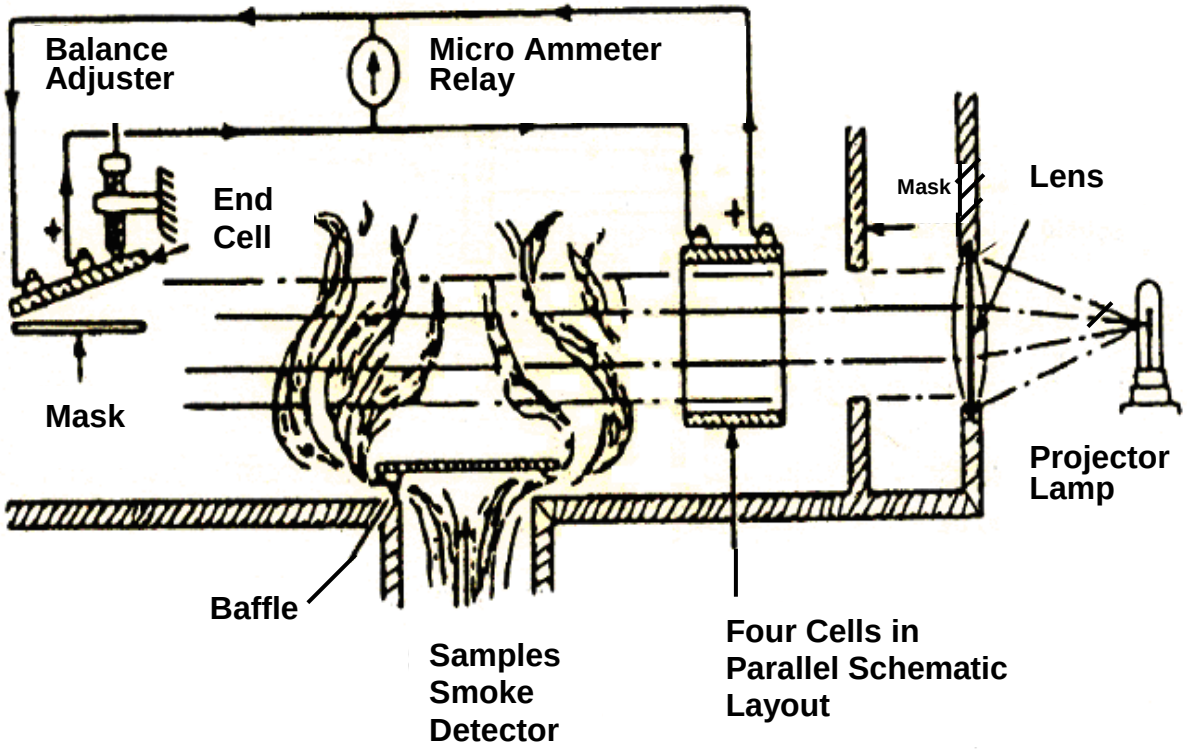


Fig 48- An Optical Smoke Detector 'Light-Scatter Type' (Fire Condition).



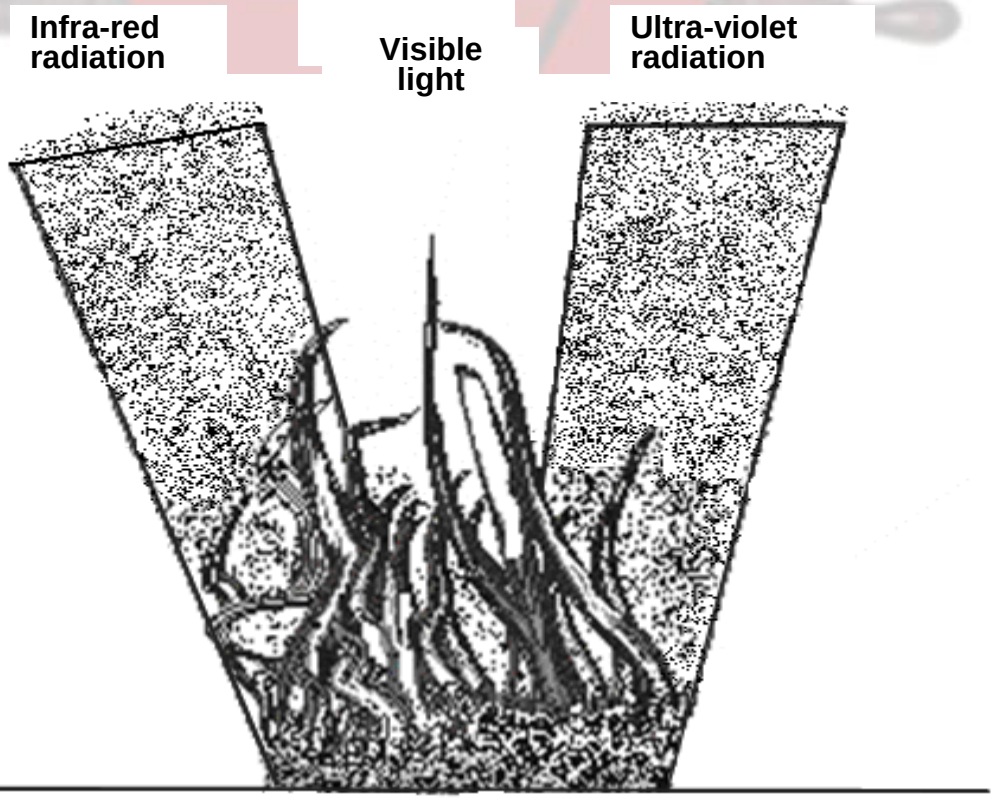


Fig 49 - Illustration of Forms of Radiant Energy Produced by Fire

5. **Flame Detectors.** Fire releases radiant energy in the form of infra red radiation and ultra violet radiation. Flame detectors are designed to respond to either infra red radiation or ultra violet radiation. Using a photoelectric cell, which is sensitive to one of these two rays :-

(a) **Infra Red Rays Type.**

(i) The main components of this type of detector are a lens cum filter, photo electric cell, filter amplifier, integrator/timer and an audio visual fire alarm.

(ii) It is essential to protect the photoelectric cell and electrical components from dust and moisture but the protective covering must allow the infra red radiation to pass through it. Quartz, which is transparent to infra red radiation is commonly used as the protective shield. The lens cum filter allows only infra red radiation to fall on the photoelectric cell. On being stuck by radiation, the cell transmits a signal to the filter amplifier.

(iii) A flame emitting infra red rays are, normally in frequency of 4 Hz to 15 Hz. The filter amplifier notably amplifies the signal but also obstructs the signal not in the range of 4 – 15 Hz. The signal is then fed to the integrator / timer which will activate the alarm circuit only if the signal persists for a pre-set period (normally 5 – 15 seconds). The detector panel has neon lights to indicate which particular detector head has been activated giving the location of the flame on board.

(b) **Ultra Violet Radiation Type.**

(i) Ultra violet rays flame detector: This consists of an amplifier and a photo electric cell or gas filled tube sensitive to ultra violet radiation. When ultra violet radiation strikes the gas filled tube, it ionises the gas in the tube. A small current is set up between the two electrodes and the tube becomes a conductor of electricity, which is amplified and triggers a fire alarm through a timer unit.

(ii) When the current flow is greater than the set point of the amplifier, the alarm relay closes immediately and causes the fire alarm to operate. The detector is not affected by sunlight or artificial light but is sensitive to a flame, which emits ultra violet rays.

(iii) An ultra violet detector installation has an amplifier to cater for about 4 detector heads, which can detect 1.8 m^2 of flame from a distance of 12 meters.

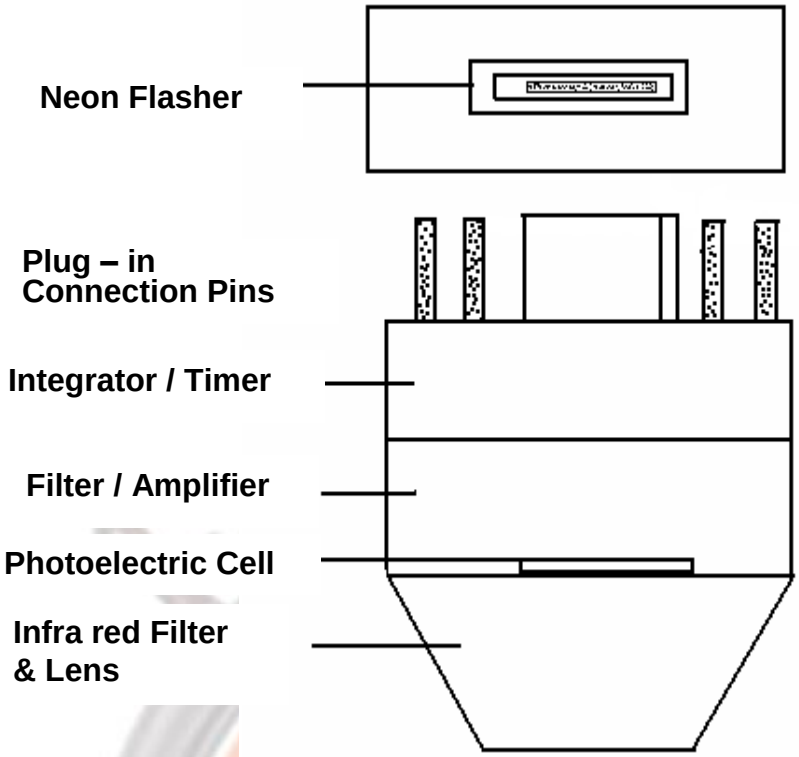


Fig 50 - Schematic Diagram of an Infra-red Radiation Detector

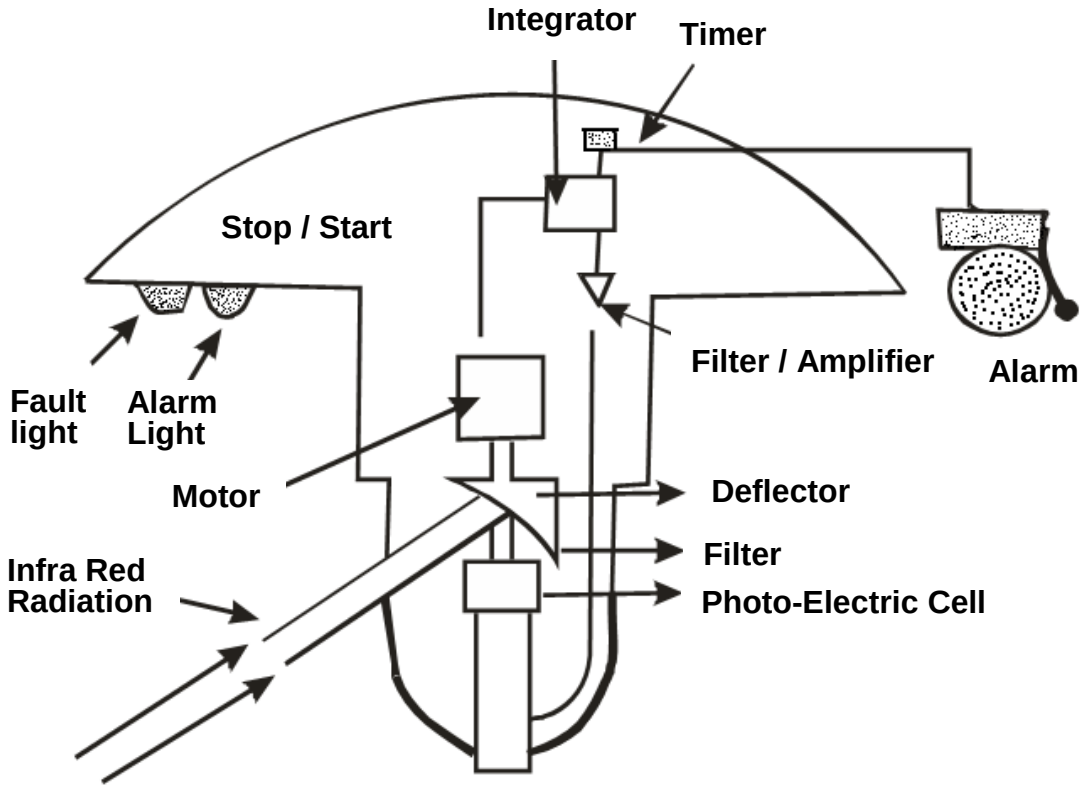


Fig 51 - Diagram of an Infra-red Radiation Detector

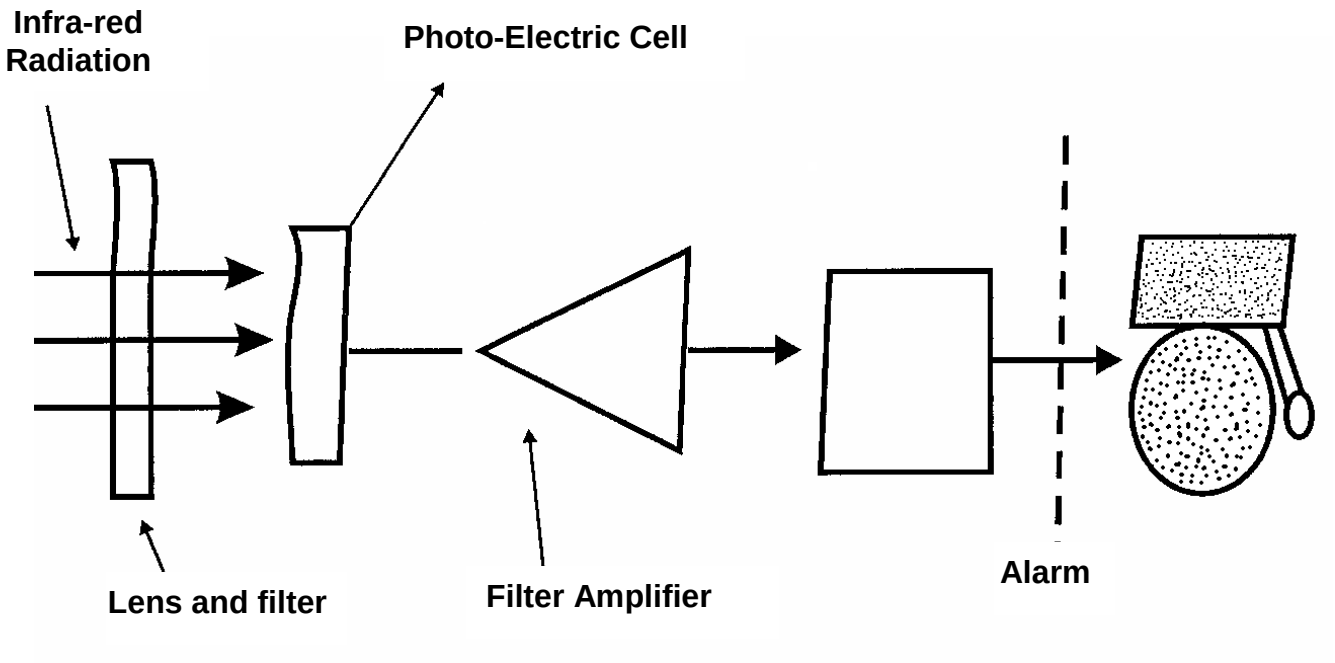


Fig 52 – Schematic Diagram of Components of an Infra red Detector

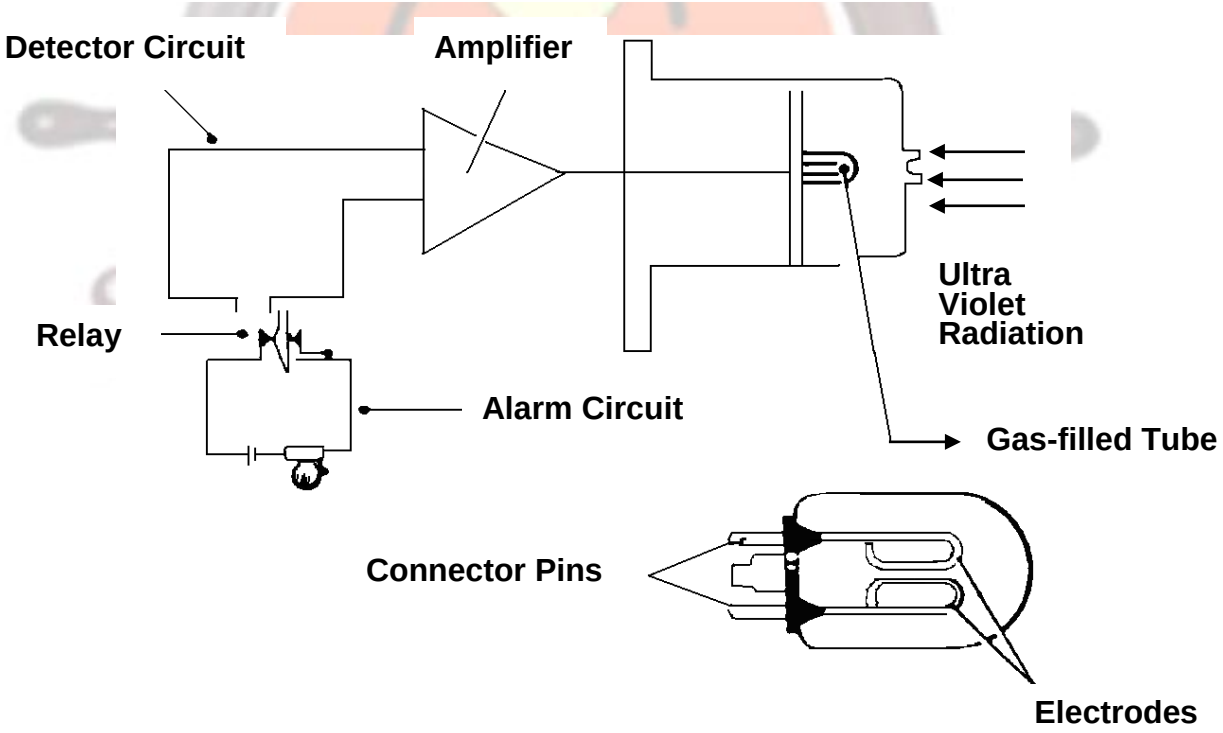


Fig 53 - Diagrammatic Illustration of an Ultra violet Detector

CHAPTER – 8

TRAINING OF SEAFARERS IN FIRE FIGHTING

1. **Education (Skill / Knowledgement / Attitude).** Education (knowledge, understanding, appreciation, development of motor skills etc) as such is an inherent part of training. A list of items for training a ship's complement is suggested below. The list can be modified and many other items can be included as well. However, the important factor is the implementation of a training Programme. The training needs will vary with the rank of personnel, or group, and the effectiveness of training will further depend upon previous qualification and experience of individuals concerned. One can prioritise the items on the basis of immediate requirements, and prepare a training plan with appropriate allocation of time, and methodology for each section of priority depending on the objectives to be achieved. The training can be achieved through instructions, demonstrations, practice, and discussions. Emphasis should be on development of appropriate attitudes towards safety. It is the most difficult task, but is the most crucial element in prevention of fire and accidents and in dealing with any emergency.

2. **Essentials of Tanning in Fire Fighting.** Emphasis on the following is essential while training in fire fighting :-

(a) Systematic approach in finding a fire, informing, restricting and fighting a fire.

(b) Emphasis on fire prevention, safe working procedures and maintaining fire appliances.

(c) Appropriate action in fighting a fire depending upon the location of the vessel at sea/port/dry-dock.

(d) Location of water tight doors, fire doors, dampers, vents, fans and methods of closing / stopping.

(e) Locations of other emergency stops, remote controls and their use, which valve to be closed e.g. the quick closing valves of fuel tanks / ready use tanks / settling tanks etc.

(f) Which machinery to be shut down in case of fire.

(g) Location and operation of fire alarms and detection systems and schedule of their testing and maintenance.

(h) Type of extinguishers and their location on board and their appropriate Applications.

(i) Duties of every individual on board in case of fire and other emergencies.

(j) Location of the nearest fireman's outfit on board.

(k) Starting of emergency generator, its limitations and the ship's /services/systems possible with emergency generator.

(l) Starting of emergency fire pump.

(m) Patrolling and maintaining an 'eye' for fire or potential conditions.

(n) Use of portable extinguishers for different categories of fire.

(o) Use of water for extinguishing fires and its limitations to maintain stability.

(p) Moving and searching for victims in smoke filled spaces.

(q) Moving through restricted areas wearing CABA SET / SMOKE MASKS.

(r) Rescuing victims from enclosed spaces.

(s) Donning and testing of protective gear.

(t) Communication links/system on board in emergency from different vital locations.

(u) Means of emergency exits from machinery compartments, accommodation areas etc.

3. **Periodic Ship Board Drills, Patrol Systems.** In order to achieve an efficient ERP (Emergency Response Plan), it is imperative that regular realistic drills are carried out on board, so that they can be more effective and useful in real situations. Following are some of the essential features, which may be borne in mind when planning drills.

(a) **Breathing Apparatus Log.** Whenever a person is entering an enclosed space using B.A., following entries should be made in B.A. Set LOG :-

(i) Name of the person using B.A. Set.

(ii) Cylinder pressure gauge reading prior to entry.

(iii) Time when B.A. weaver opens cylinder valve to enter space.

(iv) Work out and note the latest whistle time i.e. when about 8 min air is left in cylinder and whether the weaver should be making his way out of space.

(v) Time of B.A. wearers entry into the enclosed space.

(b) **Know your Ship.** On joining a ship, all personnel must know their lifeboat station, emergency station and oil spill control station and determine their role in the ERP. They should also familiarise themselves with the general layout of the ship e.g.

(i) Accommodation.

(ii) Machinery spaces.

(iii) Paint store and other combustible material stores.

(iv) Position of fire alarms.

(v) Position of muster stations and emergency equipment lockers.

(vi) Location of fire hoses, fire hydrants and portable fire fighting equipment.

(vii) Operation and location of emergency fire pump/s.

(viii) Position and operation of fixed fire fighting systems.

(ix) Familiarity with emergency alarms / signals and expected initial response to those signals.

(c) **Anticipate Situations.** When planning drills, potential emergencies such as fire, grounding, collision, man overboard, oil spillage, steering failure, rescue from enclosed space, blackout etc. that may occur in real life should be anticipated.

(d) **Mental Rehearsal of Action to be Taken in Emergencies.** In addition to formal drills, opportunity may be given for individuals to imagine or anticipate emergencies that may / could occur and define actions that could be taken in each of those circumstances. The drills need not be only limited to practical drills but also could be a classroom brain-storming sessions, leading to suggestions to be put into operation at some future drill.

(e) **Identification of Probable Fire Prone Areas / Types of Fire.** When planning drills, thought should be given to the probable areas and types of fire that could occur both at sea and in port. The master should create a safety committee, which may report directly to the master and have the responsibility for the efficient / effective drills and making recommendations for improvement in the ERP. It should also be encouraged to plan every drill as if it is the actual emergency.

(f) **Awareness of Alternative Escapes Routes.** When tackling an emergency or evacuating from an enclosed space, especially machinery and accommodation spaces, all personnel must know their ship and be aware of all alternative routes. Drills should be arranged to cover alternative routes. Whenever new personnel join the ship, the team in charges should conduct sessions to check their knowledge of the ship and their capabilities / effectiveness in the teams.

(g) **Awareness of the Capability of Equipment.** It is essential that all personnel onboard understand and are aware of the capabilities and limitations of their fire fighting appliances and life saving appliances. It is vital that emergency teams are fully conversant with their equipment. Equipment in emergency control lockers must be looked after and maintained by the teams. Equipment checks and maintenance sessions should be conducted.

(h) **Drills – Frequency, Attitudes, Testing and Training.** Emergency drills must be conducted weekly. The objective of these drills is to encourage initial quick response on sounding of an emergency alarm. On board, training must encourage

the attitude that drills are not just a regulatory requirement but a rehearsal of actions taken for specific emergencies. Drills must be devised so that all emergency equipment is tested in simulated emergency conditions at frequent intervals. Training and safety matters on board must be made the responsibility of the safety committee. Training of safety committee members may first have to be instituted by the master and his management team to ensure all committee members know their ship and the equipment on board.

4. **Ventilation of Enclosed Space Fires.** The correct response of closing down the ventilation of an enclosed space on fire must be stressed which is the principle of fire fighting to contain fire and smoke. However, rescue of casualty may be enhanced by exercising appropriate ventilation of the affected space. Such decisions can only be made with a full appreciation of the risks involved of fire spreading. Therefore contingency plans must be made to combat such circumstances.

CHAPTER - 9

FIRE INVESTIGATION AND REPORTING

1. **Fire Investigation may be Based on Answers to the Following Questions.**

(a) How fire was discovered (Manual alarm/Fire alarm by the detector)

(b) Time of fire alarm

(c) Initiation of fire alarm by whom? Whether by a person or by a detector.

(d) Initial action taken on the sight of fire

(e) Initial attempts to extinguish the fire

(f) What is the flammable substance on fire (Thereby to establish the class of fire and the appropriate fire fighting medium)

(g) Any fireman's outfit used/CABA set used

(h) Fire fighting equipment/ medium used?

(i) Manpower used?

(j) Time of fire extinguishment?

(k) Any casualty and what treatment given?

(l) Total damage caused by the fire and any damage caused by the fire extinguishing medium.

2. **Report on the Investigation of Fire.** In the report on the investigation of fire, following details regarding fire fighting procedures used / adopted should be high lighted.

(a) What timetable / procedure was followed since the time of fire occurrence?

(b) What all actions were taken and the time taken for each action?

(c) All facts about the fire viz. The site, the causes of ignition and the flammable substance/s on fire.

(d) The fire extinguishing appliances, which were available, and how many should have been available as per the requirement / fire control plan and number of each type used.

(e) Number of ships personnel, officers and crew (and shore fire fighting personnel if applicable) who were actually engaged in fire fighting.

(f) The number of fireman's outfits and CABA sets used.

(g) The damage caused by the fire (to machinery, cargo, accommodation etc. as the case may be).

(h) The damage caused by the fire fighting agents used viz. Water/foam/DCP.

(i) Which ship's services were affected or immobilised due to the fire and to what extent and for how long.

3. **Conclusions in the Report.** The report should have the detailed analysis of the fire based on all the facts / discussions with the personnel who actually fought the fire / the casualty if any / master's comments and views / chief engineers comments and views / any previous such fire/s taken place on board that ship. Also if any blame can be attributed to the design, operation and effectiveness of the fire fighting equipment or the personnel serving on board so that future training courses could be improved / modified. The report must give recommendations to avoid such fire/s on board in future to improve fire prevention & fire fighting measures. The report must give a peep into the past if the particular fire/s could have been prevented if certain measures (which should be listed) had been taken by the ship's staff / shipping company staff ashore/agent/stevedores gangs. The conclusion also should give if there are actual limitations of certain machinery like main engine / diesel generators / fire pumps etc. which may not be reflected in actual practice. The conclusion should also bring out if any lack of maintenance / repair is attributed to the particular fire.

ANNEX – I

F.S.S. CODE

(a) The purpose of this code is to provide international standards of specific engineering specifications for the fire safety systems required by the revised chapter II-2 of the SOLAS-74.

(b) F.S.S. code will be mandatory requirement by the SOLAS-74 on or after 1st July 2002. Unless expressed otherwise, the F.S.S. code in applicable to ships whose keel is laid down or which are at a similar stage of construction on or after 1st July 2002.

(c) Under this code ELSA set is replaced with EEBD set which is used for escape from a compartment that has a hazardous atmosphere. The main particulars of EEBD are :-

(i) Minimum duration for 10 minutes.

(ii) Face & hands shall be made of flame –resistant materials and include a clear window for viewing.

(iii) The set should be capable of being carried hand-free.

(iv) Brief instructions or diagram clearly illustrating their use shall be printed on the EEBD.

(v) Manufacturers name, address and contact numbers should be clearly marked. All training units for EEBD shall be clearly marked.

ANNEX – II

CASE STUDIES OF MAJOR FIRES

1. **S.S. Svnvista.**

(a) Passenger ship S.S. Svnvista has a major fire which resulted in her sinking off malacca straits, 70 nautical miles west of Penang at 0120 hrs on 21 May 1999. GRT of the vessel 30,400 tons, BHP 40,000 (2 steam turbines of 20,000 HP each), 3 No. boilers, 3 No. diesel generators and 1 No. emergency diesel generator and 1 No. electric driven emergency fire pump.

Vessel Registered – Bahamas
Owners – Singaporean & Chinese

(b) At about 1330 hrs on 20 May 1999, when vessel was underway, a fire broke out on vessel's main switchboard in engine room. The fire detector fitted on the deck head above the switchboard sounded the fire alarm. However, before the E/R watch-keeping engineer could respond, there was a total black out due to 2 No. diesel generators which were on load, tripped. However, the emergency lights (on batteries) switched on.

(c) The watch keeper rushed to the switch board and discharged the portable DCP fire extinguisher kept near by on the switch board fire. The fire / smoke from the switchboard continued and the E/R was filling up with the smoke. The watch keeper ran out from the E/R along with his assistant after emergency stopping of both the steam turbines.

(d) The watch keeper rushed to the bridge to inform the master / duty officer. Soon, the Chief engineer also came on the scene and directed to start the emergency diesel generator immediately and activate the firemain. The emergency diesel generator located in a separate compartment on the main deck was started and was taken on load from the local panel located next to the generator. As soon as the generator was put on load, there was heavy sparking and flashback from the local panel and immediately the emergency generator stopped itself.

(e) In the meantime, the E/R was smoking excessively and was completely evacuated and all air entries were sealed by closing both the E/R doors and the E/R skylights. SOS was also sent to nearby ships, Penang port authorities and the company's head office at Singapore was also informed. The Captain and the Chief engineer appeared dazed. Captain insisted on trying the emergency diesel generator once again but the C/E was not willing as he suspected that the fire on the main switch board in the E/R is also causing earthing of the emergency diesel generator and could further escalate the fire if taken on load. Therefore, there was no way to get the firemain activated when it was most needed.

(f) Immediately two men were dressed up in fireman's outfits with CABA sets to enter the E/R to fight and assess the fire with the mobile foam extinguisher located near the diesel generators in the E/R. These men also carried with them one each

portable DCP and CO_2 fire extinguisher and walkie talkies. Use of lifeline was suggested but was not used as its use did not appear practical / feasible.

(g) At about 1430 hrs, the two men went down into the E/R but retreated within a few minutes due to intense heat and smoke without carrying out any actual fire fighting. However, they reported that the main switch board was only smoking while there were flames under the switch on the bilge platform near the viscinity of the oily bilge separator. By about 1500 hrs, the flames / smoke / heat in E/R was so alarming that the idea of manually fighting the fire was given up and any man entry into the E/R considered suicidal.

(h) Finally, the master and the C/E decided to release CO_2 into the E/R from the CO_2 flooding system installation. In the meantime, the captain ordered his deck officers and crew to abandon all the 1750 passengers to 18 No. lifeboats and 4 No. life rafts. Soon all the lifeboats were lowered to the embarkation decks.

(i) At about 1545 hrs, out of 56 No. CO_2 flooding system bottles, 28 No. CO_2 bottles were released into the E/R. The black smoke coming out of the funnel turned grey white but after about 15-20 mins, there was a reflash and flames and thick black smoke re-appeared from the funnel. At about 1630 hrs, the balance 28 No. CO2 bottles were also released into the E/R. Again there was a lull in the fire for about 20-25 mins when only smoke was emitting from the funnel. But by 1710 hrs, the funnel was again emitting flames and thick black smoke.

(j) By 1600 hrs, the vessel was in total blackout as emergency lights batteries had totally run down while the sea was getting choppy with strong westerly wind blowing. By 1730 hrs, 2 rescue ships, 2 fire fighting tugs and 1 ferry craft arrived near the vessel. The rescue ships kept away from the vessel at about 1.5 nautical miles while the tugs came closer and started preparing to fight the fire and to tow the ship.

(k) At about 1730 hrs, the disembarking of 1750 passengers started and by 1900 hrs all the passengers had been disembarked into lifeboats and life rafts. At 1930 hrs, out of 48 ships officers and crew, the captain asked 32 of them to abandon the ship. 16 officers and crew (master, deck officer, staff captain, chief officer, second officer, additional second officer, one cadet, chief engineer, staff C/E, one machinist, 2 firemen, 2 A/B, security manager and ship’s owner’s son who was also casino’s incharge) remained on board to recover records / documents / valuables / cash etc.

(l) From about 1800 hrs to about 1930hrs, the 2 fire fighting tugs continuously directed their powerful water jets into the engine room through the funnel. At about 1915 hrs, the ship developed about 1.5 – 2 degrees port list due to continuous ingress of water into the E/R. The officers and crew (16 people) who were still onboard managed to recover most of the valuables, vital documents, CDCs, passports, cash etc. and transferred them to the ferry craft. However, by 0045 hrs / 21 May 1999, the vessel had developed about 7 degrees port list. At 0100 hrs, captain ordered all remaining on board to abandon ship. By 0120 hrs / 21 May 1999, with about 12 degrees port list the ships stern started sinking and by 0122 hrs / 21 May 1999, the vessel totally disappeared into the dark choppy sea.

(m) **Exercise.**

(i) What you could have done to fight the fire / save the ship?

(ii) As per your assessment, what were the short comings on board S.S. Sunvista for fire fighting and safety.

Case Study No. 2

2. **M.V. Xyz.**

(a) On 23 Oct 1994, at about 0200 hrs. a minor fire broke out on board ship M.V XYZ (Name withheld due to information being classified) in the galley while the vessel was berthed alongside. A hot plate (440 Volts, 45 Kw) was left ON by the chief cook by mistake at night.

(b) The grease/oil filters fitted in the galley exhaust trunking / hood wire mesh had not been cleaned for the last 4-5 months and were almost chocked with carbon and wet with cooking oil vaporous.

(c) The heat radiation from the red hot plate directly on the exhaust trucking filters ignited the carbon/oil accumulated at the entrance of the trunking which subsequently spread to throughout the exhaust trucking and to the bulkhead's damaged lagging. This resulted in thick black smoke filling up the complete galley and also partly escaping to the saloon through the serving window shutter.

(d) The galley ventilation blower (which should also have been switched off at night along with the hot plate) was also left ON and exhaust blower was also 'ON' and this facilitated the spread of thick black smoke to all galley's adjoining areas. The galley door however was locked by the cook.

(e) The smoke detector fitted in the galley deck head did not operate the fire alarm.

(f) At about 0230 hrs, an engine room watch keeper who happened to pass through the alleyway close to the galley noticed the smoke emanating from the galley door raised the verbal alarm and also informed the duty officer.

(g) The duty officer raised the fire alarm and mustered the emergency parties. The galley door was opened. But due to thick black smoke the location of fire was not directly visible. A team of 2 people wearing CABA sets were sent inside with high power torches. But they were also unable to locate the fire as there were no visible red hot spots (because the fire was spreading through the bulk heads lagging).

(h) The visibility in the adjacent compartment – the dining hall was also very poor as the smoke had leaked into that area through the serving window shutter gap.

(i) The biggest blunders had been committed – by the emergency party which entered the galley did not stop the ventilation blower and foolishly left the galley door open. This caused free flow of fresh air into the galley, which multiplied the fire. However the actual location of fire was still not clear to any body.

(j) Immediately, the port authorities and the shore fire brigade were informed. Within minutes the fire party was organised by the shore fire tender and the port authorities took the complete charge of the fire fighting operation. Ship's fire control plan was examined and fire party dressed in fire protection clothing, CABA sets, with walkie – talkies and floodlights entered the smoky areas to locate and fight the fire. Meantime, fire hoses were rigged – up with spray/jet nozzles.

(k) The fire party surveyed the galley areas and the adjoining spaces and reported that the galley and the adjoining dinning hall (which also had a small library inside) were totally on fire. The furniture / books/ bulkhead lagging ./ electric cables were completely gutted. The shore fire parties attacked the fire with powerful water jets from inside and resorted to the bulkheads cooling from outside with spray water nozzles. They also cut open the shipside bulkhead from outside in the galley area to fight the fire more effectively.

(l) By about 0530 hrs, the ship listed to almost 10 – 12 degrees on the star board side. But the fire on the port side was still in flames. The water from their fire main system directed on the port side hardly made any effect as it immediately drained on the starboard side due to excessive list. It took nearly 13-14 hrs before the fire/smoke could be completely controlled. By that time, the galley, the dining hall, the cabins, most of the electrical cables/equipment on the bridge and the radio room were completely gutted.

(m) **Exercise.**

(i) Why the fire broke out and how it can be prevented in future?

(ii) What essential maintenance work has to be done in the galley to prevent such fires?

(iii) Based on this case study, give your recommendations to prevent similar fires on board ships?