Introduction and review of basic principles

This course has been designed to meet the requirements of STCW Regulation VI/3, Section A-VI/3, Table A-VI/3 and is based on the guidelines of IMO Model Course 2.03. It also covers the training recommended in Annex 2 of IMO Assembly Resolution A.437 (XI) – Training of Crew on Fire Fighting.

After successful completion of the course, the trainees should be able to practice and demonstrate the following competencies:

- Control fire-fighting operations aboard ships
- Organize and train fire parties
- Inspect and service fire detection and extinguishing systems and equipment
- Investigate and compile reports on incidents involving fire

▪ Principles of survival in fire emergency

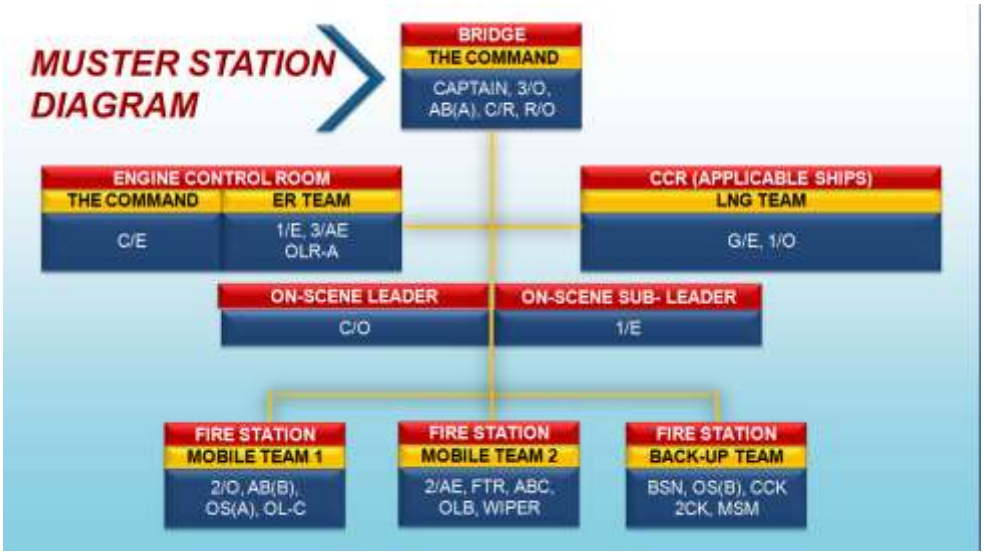
Every year lives are lost and millions of dollars' worth of damage is caused through fires in ships. Human error is by far the most common cause of fires. It is often a single careless act that endangers the lives of all the crew.

Every member of the crew has a part to play in preventing fires. And this applies not only to fire-fighting methods. In order to survive the emergency situation onboard with regard to fire, the following must be considered:

- Knowledge of the Fire Theory
- Regular training and drills
- Preparedness for fire emergency
- Knowledge of escape routes
- Knowledge of dangers of smoke and toxic fumes
- Regular inspection and maintenance of fire-detection equipment, fixed fire extinguishing equipment, portable fire extinguishers, compressed-air-breathing apparatus and fireman's outfit

COMPETENCE: CONTROL FIRE FIGHTING OPERATIONS ABOARD SHIPS

1. Firefighting procedures at sea



- Firefighting at sea
  - *Command*
    The Master, as the overall command, must check the activities of the On-scene Leader and Fire Team with the fire control plan, and give instructions to the On-scene Leader as occasion demands.

  - *B.A. Record Sheet*
    The Third Officer must record in the B.A. Record Sheet the air cylinder pressure of the self-contained breathing apparatus and the time of start of use as reported by the On-scene Leader, calculate the duration that the cylinder can be used, and relay it to the On-scene Leader.

  - *Navigation and operations*
    The Master, in order to engage in safe and effective firefighting activities, must navigate and operate the ship as follows:
    - Navigate so that the flames and smoke go downwind
    - When moored to a buoy, have a tug boat turn the ship's bow around
    - Stop the ship, if necessary
    - Ready fire wires at the bow and stern

  - *Preparation of records*
    The Third Officer must prepare a record of the activities of the firefighting stations using Fire Control Station Checklists.

  - *On-scene Leader/On-scene Sub-leader*
    - The On-scene Leader must take overall command of the firefighting operation on the basis of instructions given by the Command.
    - If the scene of the fire is in the engine room, or he is so otherwise instructed by the Master, the On-scene Sub-leader must assist, or deputize for, the On-scene Leader.
    - Have the Fire Teams respectively carry out fire extinguishing with water sprays, isolating the fire zone, ventilating operations (including removal of smoke and heat), etc.
    - Have the Back-up Team support the Fire Teams, bring spare air cylinders, etc.
    - Have search and rescue carried out by persons wearing air breathing apparatus
    - Report to the bridge the start of time breathing apparatus to be used and the remaining pressure
    - Keep close contact with the Command at all times, so that it may be able to grasp the situation

  - *Fire Teams*
    As a rule, firefighting by spraying water must be done by each Fire Team, and must be carried out in accordance with the following procedure:
    - Two persons (nozzle man and assistant nozzle man), wearing fire protective clothing and self-contained air breathing apparatus must be directly engaged in fire attack with a fire hose.
    - The assistant nozzle man must also function as a hose man who removes twists and kinks in the hose.
    - Other team members must spray water to protect firefighters, as necessary.
    - Open the fire hydrant only after the hose is laid out.

- Keep the life lines appropriately taut (they are also a means of communication).
- The team leader must check the pressure remaining in the breathing apparatus at the start of the firefighting activities, and report it to the On-scene Leader.
- Control of ventilation of the relevant zone with consideration to removal of smoke and heat (operation of fire doors, watertight doors, fire dampers, windows, fans, etc.)
- Remove flammable articles from the adjacent zones (the zone over the fire Zone is likely to burn the most).
- Cool down the adjacent zones (by spraying water).
- Under the instructions of the Chief Engineer, cut off the electric power to the fire zone as occasion demands.

- Procedures for Fighting Fire

REMEMBER: F – I – R – E

- **F**ind the fire, the location, and its size

- **I**nform the Captain immediately to:
  - Sound the general alarm to muster the crew and notify all hands
  - Make a distress call to Coast Guard and nearby vessels
  - Activate emergency firefighting equipment

- **R**estrict the fire
  - Shut off air supply to the fire - close hatches, ports, etc.
  - De-energize electrical systems in affected space
  - Set fire boundaries to confine the fire
  - Shut off fuel supply and ventilation
  - Maneuver vessel to minimize the effect of wind on the fire
  - Prior to activating fixed extinguishing system, ensure that all personnel have been evacuated from the space

- **E**xtinguish the fire
  - Determine class of fire, appropriate equipment, extinguishing agent and method of attack
  - Overhaul and set re-flash watch
  - Muster crew to account for all personnel
  - If unable to control fire, prepare to abandon the vessel

2. Firefighting procedures in port

- Detection by fire detector

- The Master must go to the bridge (except cases where the Command is posted at a place other than the bridge)

- The Officer of the Watch must, if the bridge is equipped with a fire control panel or fire detector indicator, mark the indicator lamp which was first activated, showing the fire zone

- The Chief Engineer and the Engineer on UMS duty are to hasten to the fire station

- The Chief Officer, after confirming the indicated fire zone at the fire station, must hasten to the zone, carrying a transceiver, to check the scene

  If the scene of the fire is in the engine room and he cannot approach the fire zone through an ordinary route because of smoke, etc., he must report to the bridge and go to the scene of the fire, wearing Fire Protective Clothing, by entering the engine room through an entrance situated below the scene of the fire.

- The First Engineer must, after checking the fire zone indication at the fire station, hasten to the engine control room, carrying a transceiver.

  If the scene of the fire is in the engine room and he cannot approach the fire zone through an ordinary route because of smoke, etc., he must wear Fire Protective Clothing and report to the scene of the fire immediately, together with the Chief Officer, by entering the engine room through an entrance situated below the scene of the fire.

- The Chief Engineer must, after checking the indicated fire zone, report to the engine control room immediately, carrying a transceiver, if no inconvenience is expected.

- Procedure for coordination with shore-based fire fighters states that the following additional procedures must be followed:

- Call the port brigade
- Inform the appropriate authority
- Confirm with harbor master that the fire brigade will take charge of the firefighting operations, assisted by the crew as required
- Confirm with the harbor master that he will keep the master informed of any hazard to the dock installation and any actions required
- Check who is onboard
- Make preparations for ship to leave the port, either by own power or with help of tugs
- Evacuate non-essential personnel

3. Use of water for fire extinguishing

- VESSEL STABILITY

Remember the following:

- Vessel is made of steel, therefore heat radiates back into the center compartment.
- Use minimal water to avoid rolling or sinking of the vessel
- Officers in charge must also pump the water off the vessel once water is used to extinguish fire to avoid stability problem
- Free surface effect – unimpeded movement of water inside a vessel; causes vessel to capsize when crew tries to counteract a listing vessel
- It is highly recommended that a salvage engineer or naval architect with firefighting/salvage experience be present at the command post at marine fires to make recommendations to the OIC.

- Fire extinguishing effect on ship stability

  - Seawater can be used to extinguish fire onboard ships through Emergency Fire Pump or the Hyper Mist Pump
  - Water mist – preferred alternative to Halon 1301 total flooding to extinguish fires in ship machinery space and pump rooms

Water mist systems produce a drop size distribution with a range of drop sizes under 1000 µm, while the more conventional sprinkler systems produce much coarser particles. The smaller particle sizes have greater cooling efficiencies because evaporation and cooling are controlled by surface area, and the surface area of a large number of small droplets is greater than that of a small number of large droplets of the same total volume. Coarse droplets from sprinkler systems are efficient at providing boundary cooling to large surfaces such as deck walls and floors, and penetrating flames to get to the seat of a fire, but the large drop sizes that make up these sprays are not as effective on spilled fuel fires or in providing cooling to the regions around a flame. Mist systems also have lower water demands than sprinkler systems, which is beneficial in shipboard applications where prolonged sprinkler discharges may affect stability.

Situations where stability may be a critical factor include:

- Addition of water in large amount, particularly in cargo hold, causes stability problem due to the free surface effect of water which reduces the GM of the ship. Flooded cargo hold must be drained to avoid the free surface effect of water
- Addition of water in cargo holds such as grains and paper pulp is risky as cargo swells which could cause rupture of shell plates and bulkhead plates. Addition of water for fighting fire must be monitored during the entire firefighting operation
- Firefighting, where water is used may reduce the Metacentric height.
- Collision or grounding, where compartments may be bilged or holed. Depending on the compartment and its contents (permeability) stability may be reduced; the vessel may list or alter its trim.

- Precautions and corrective procedures

  a. Dewatering

  - Pre-fire planning:
    - Estimate amount of water to be used for a given scenario
    - Calculate effect of using water to extinguish fire on the vessel's stability
    - Plan how to dewater

  - Ways to dewater:
    - Use existing drains and scuppers
    - Use fixed and portable pumps or ejectors
    - Facilitate the flow either over side or to the lowest possible point in the ship

b. Estimating quantities

- Consider stability when planning emergency response to fire
- Estimate volume of water required to extinguish fire in a given compartment using the following formula:

  (length x height x width) ÷ 100 = gallons per minute required

  The exact volume required for extinguishment will vary according to the contents (fuel load) of the compartment and the duration the fire has been burning. However, a reasonable volume may be "guesstimated" and converted to metric tons.

- The effect due to Free Surface Effect of a given compartment may be estimated by calculating the moment. The formula for the moment is: $i = LB^3 \div 12$

4. Communication and coordination during fire fighting operations

Internal communications

- By voice and by radio handsets
- Radio handsets must always be ready and fully charged, together with fully charged spare batteries
- Portable radio communication – most efficient method for emergency communications
- Use of public address, intercoms and fixed telephone systems must also be considered
- Correct and controlled radio procedures must be devised and rehearsed.

External communications

- At sea

As soon as is practical, a telephone call and a confirming telex or cable to Fleet Headquarters could be of assistance, especially when the services of salvage/fire-fighting tugs are volunteered.

- In port or Lay up

Immediate contact must be made with port authorities (or shipyard fire brigade if the vessel is in shipyard). As a routine, every Master and Radio Officer must be fully cognizant with emergency shore contact procedures whenever the vessel arrives in port.

5. Ventilation control, including smoke extraction

Ventilation – refers to the tactic of creating a draft with an opening above or opposite the entry point so that heat and smoke will be released, permitting the firefighters to find and attack the fire.

- Large fire not properly ventilated are harder to fight; could create poorly burned smoke which causes smoke explosion, or enough heat to create a flashover
- Poorly timed ventilation may increase the fire's air supply, causing it to grow and spread rapidly

- As per SOLAS Chapter II-2 Regulation 4

  - *Ventilation systems in cargo pump room*

Cargo pump room shall be mechanically ventilated and discharges from the exhaust fan shall be led to a safe place on the open deck. The ventilation of these rooms shall have sufficient capacity to minimize the possibility of accumulation of flammable vapours. The number of air changes shall be at least 20 per hour, based upon the volume of the space. The air ducts shall be arranged so that all of the space is effectively ventilated. The ventilation shall be of the suction type using fans of the non-sparking type.

  - *Ventilation systems in combination carriers*

In combination carriers, cargo spaces and any enclosed spaces adjacent to cargo spaces shall be capable of being mechanically ventilated. The mechanical ventilation may be provided by portable fans. An approved fixed warning system capable of monitoring flammable vapours shall be provided in cargo pump-rooms, pipe ducts and cofferdams, adjacent to slop tanks. Suitable arrangements shall be made to facilitate measurement of flammable vapours in all other spaces within the cargo area. Such measurement shall be made possible from the open deck or easily accessible positions.

- As per SOLAS Chapter II-2 Regulation 5

  - *Closing appliances and stopping devices of ventilation*

The main inlets and outlets of all ventilation systems shall be capable of being closed from outside the spaces being ventilated. The means of closing shall be easily accessible as well as prominently and permanently marked and shall indicate whether the shut-off is open or closed.

Power ventilation of accommodation spaces, service spaces, cargo spaces, control stations and machinery spaces shall be capable of being stopped from an easily accessible position outside the space being served. This position shall not be readily cut off in the event of a fire in the spaces served.

In passenger ship carrying more than 36 passengers, power ventilation, except machinery space and cargo space ventilation and any alternative system, shall be fitted with controls so grouped that all fans may be stopped from either of two separate positions which shall be situated as far apart as practicable. Fans serving power ventilation systems to cargo spaces shall be capable of being stopped from a safe position outside such spaces.

  - *Means of control in machinery spaces*

Means of control shall be provided for opening and closure of skylights, closure of openings in funnels which normally allow exhaust ventilation and closure of ventilator damper.

Means of control shall be provided for stopping ventilating fans. Controls provided for the power ventilation serving machinery spaces shall be grouped so as to be operable form two positions, one of which shall be outside such spaces. The means provided for stopping the power ventilation of the machinery spaces shall be entirely separate from the means provided for stopping ventilation of other spaces

Means of control shall be provided for stopping forced and induced draught fans, oil fuel transfer pumps, oil fuel unit pumps, lubricating oil service pumps, thermal oil circulating pumps and oil

separators (purifiers).The controls required mentioned above shall be located outside the space concerned so they will not be cut off in the event of fire in the space they serve.

In passenger ship, the controls for any required fire-extinguishing system shall be situated at one control position or grouped in as few positions as possible to the satisfaction of the Administration. Such position shall have safe access from the open deck.

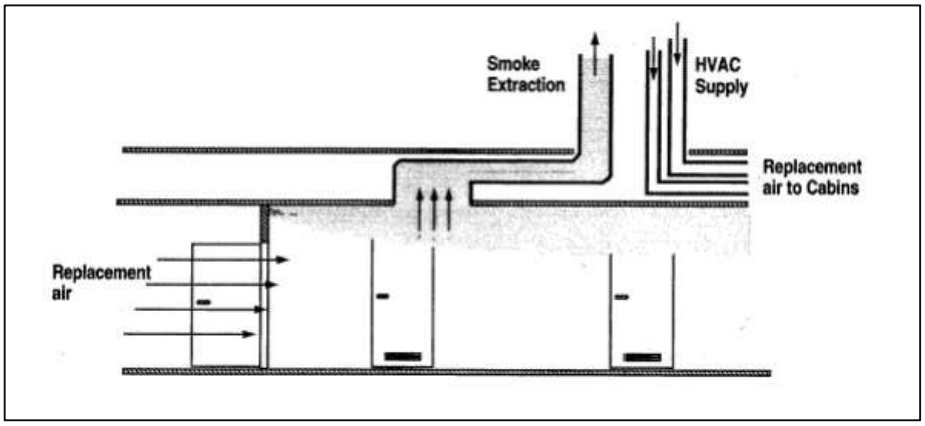
Additional requirements for means of control in periodically unattended machinery spaces

For periodically unattended machinery spaces, the Administration shall give special attention to maintaining the fire integrity of the machinery spaces, the location and centralization of the fire-extinguishing system controls, the required shutdown arrangements (e.g. ventilation, fuel pumps, etc.) and that additional fire extinguishing appliances and other fire-fighting equipment and breathing apparatus may be required.

- As per SOLAS Chapter II-2 Regulation 9

○ *Smoke extraction systems in atriums of passenger ships*

Atrium shall be equipped with a smoke extraction system. The smoke extraction system shall be activated by the required smoke detection system and be capable of manual control. The fans shall be sized such that the entire volume within the space can be exhausted in 10 minutes or less.



The main purposes of using smoke extraction systems are the following:

- To keep escape routes and some areas free from hot and toxic fire gases
- Control and stop smoke mitigation to other areas than the room containing the fire
- Annihilate the damaging impact of a fire on the constructions
- Make it easier for the fire rescue service to perform their tasks, such as find and rescue survivors, locate and extinguish the fire, etc.
- Clear affected areas from smoke after the fire has been extinguished

Uses of Heating Ventilation and Air Conditioning (HVAC) system

- Evacuate cold smoke from the initiating fire
- Evacuate smoke for a time long enough to secure egress from the premises
- Keep the premises free from smoke to such an extent that the fire brigade can locate and extinguish the fire

- Operate in a temperature of up to 300°C for the time intended, normally the time for the fire resistant construction. This could be compared to French and German regulations stating operation demands for 2 hours and 400°C or 1 ½ hour and 600°C respectively /25

Make-up air supply

The supply air for the smoke control system on a passenger vessel can be taken from either separate supply fans, natural inlets through the hull, or from over pressurized adjacent compartments, like stairways etc.

Exhaust system

The exhaust intake must be located above the smoke layer interface, preferably as close to the top of the space as possible. This maximizes the amount of smoke extracted and decreases the risk of extracting too much clean air. Extraction of clean air will be an unnecessary load to the system, causing the system to operate insufficiently if not considered in the design process. On the other hand, even if extraction of clean air is considered in the design process, it will lead to over dimensioned system capacities and thus unnecessary costs.

6. Control of fuel and electrical systems

- As per SOLAS Chapter II-2 Regulation 4

- *Oil fuel tanks*

As far as practicable, oil fuel tanks shall be part of the ship's structure and shall be located outside machinery spaces of Category A. Where oil fuel tanks, other than double bottom tanks, are necessarily located adjacent to or within machinery spaces of Category A, at least one of their vertical sides shall be contagious to the machinery spaces boundaries and shall preferably have a common boundary with the double bottom tanks, and the area of the tank boundary common with the machinery spaces shall be kept to a minimum. Where such tanks are situated within the boundaries of machinery spaces of Category A, they shall not contain fuel having a flash point of less than 60° Celsius.

In general, the use of free-standing oil fuel tanks shall be avoided. When such tanks are employed their use shall be prohibited in Category A machinery spaces on passenger ships. Where permitted, they shall be placed in an oil-tight spill tray of ample size having suitable drain pipe leading to a suitably sized spill oil tank.

No oil fuel tank shall be situated where spillage or leakage there from can constitute a fire or explosion hazard by falling on heated surfaces.

Oil fuel tanks, which, if damaged would allow oil to escape from a storage, settling or daily service tank having a capacity of 500 l and above situated above the double bottom tank, shall be fitted with a cock or valve directly from the tank capable of being closed form a safe position outside the space concerned in the event of a fire occurring in a space in which such tanks are situated. In special case of deep tanks situated in any shaft or pipe tunnel or similar space, valves on the tank shall be fitted, but control in the event of fire may be affected by means of an additional valve on the pipe or pipes outside the tunnel or similar space. If such an additional valve is fitted in the machinery space, it shall be operated from a position outside this space. The controls for remote operation of the valve for the emergency generator

fuel tank shall be in a separate location from the controls for remote operation of other valves for tanks located in machinery spaces.

When fire in the engine room occurs, the first thing that comes to mind that we need to isolate is the fuel oil supply. By cutting the supply of fuel, we are controlling the spread of fire and reducing its degree. By activating the shut off valves from each fuel tank from a remote location, the risk of spreading the fire is being eliminated.

- *Remote stopping of fuel pumps and thermal fluid circulating pumps*

To minimize the spread of a fire, it is important to eliminate any additional sources of fuel that could feed the fire; accordingly, arrangements are required to shut off auxiliary machinery, such as oil-fuel transfer pumps, oil-fuel unit pumps and other similar fuel pumps and thermal-oil heating pumps. The shut-off arrangements for this type of equipment are required to be located outside the space concerned so that they may be stopped in the event of a fire arising in the space where they are located and include the following:

- Oil-fuel pump remote stop
- Remote stops for circulating pumps for thermal oil heating systems
- Purifier room remote closures and stops

7. Firefighting process hazards

Dry Distillation

- a combustion process in which a flammable material burns with insufficient oxygen to achieve complete combustion of the material.

- *Dangers of dry distillation:*

- Fire is in a closed space
- Heat builds up but there is incomplete burning
- The opening of an access introduces fresh air
- The result is a flash towards the access opening
- People entering will be injured or burned unless they are protected

- *How to reduce danger:*

- Cooling the compartment externally by hosing it with water
- Entering the access in a crouched position behind a water screen (spray nozzle)
- Directing water towards the deck head of the space on fire

Chemical reaction

- a process that leads to the transformation of one set of chemical substances to another
- usually characterized by a chemical change, and they yield one or more products, which usually have properties different from the reactants
- result from adding one or more of the following substances to a chemical:
  - water
  - heat
  - steam
  - oil

- foam
- carbon dioxide
- sand

○ *Effects of chemical reactions:*
- Explosion following production of flammable gas
- Spontaneous combustion
- Toxic fumes generated
- Smoke generated

○ *Examples of chemical reactions which cause or aggravate fires:*
- Production of acetylene when calcium carbide comes into contact with water
- Decomposition of steam when applied to coal fires
- Production of hydrogen when direct reduced iron (DRI) comes into contact with water
- Oxidizing cargoes, such as some fertilizers, sustaining a fire even if blanketed in an extinguishing gas
- Cargoes spontaneously igniting in air, e.g. phosphorus when its packaging gets damaged
- Self-heating of cargoes such as grain when wet
- Production of dangerous levels of methane in coal cargoes when ventilation is restricted

Boiler uptake fires

▪ Soot fire in exhaust gas boilers

A fire in the exhaust gas boiler may develop in two or three stages. The ignition of soot normally develops into a small and limited fire, but under extreme conditions it may develop into a high-temperature fire.

Ignition of soot may arise in the presence of sufficient oxygen when the deposits of combustible materials have a sufficiently high temperature (higher than the flash point) at which they will release sufficient vapour, which may be ignited by a spark or a flame. The main constituent of the soot deposit is particulates but, in addition, some unburnt residues of fuel and lubricating oils may be deposited in the boiler because of faulty combustion equipment and, in particular, in connection with starting and low speed running of the engine. The potential ignition temperature of the soot layer is normally in the region of 300-400 ° C, but the presence of unburnt oil may lower the ignition temperature to approx. 150 ° C, and under extreme conditions even down to 120 ° C. This means that ignition may also take place after stop of the main engine as a result of glowing particles (sparks) remaining on the boiler tubes.

Small soot fires in the boiler
- most likely to occur during maneuvering with the main engine in low load operation
- do not cause damage to the boiler, or damage is very limited, but should be carefully monitored
- Heat from the fire is mainly conducted away with the circulation water and steam and with the combustion gases

○ *Difficulties and hazards of fighting soot fires:*
- Inaccessibility of all sections of the uptake in the upper section of the engine room
- Possibility of explosion if access doors to the economizer are opened

- Possibility of economizer tubes reaching a temperature of 700° Celsius, when following can take place:
    - iron in the tubes will burn in steam
    - reaction will be self-sustaining and will generate heat
- Products of combustion will be black oxide of iron and free hydrogen
- Burning of iron steam will be independent of a supply oxygen
- Hydrogen produced will burn if air is introduced
- Explosion

- *Procedure for containing and extinguishing fire in the boiler*
    - Shut down the boiler or main engine
    - Spray external surfaces in the way of the fire with water to keep the temperature down
    - Close dampers and boiler crossovers to exclude air from fire
    - Protect essential electrical and other equipment below the fire zone against water damage
    - Continue cooling until it is safe to open the economizer for examination and thorough cleaning on the fire side

On break out of an uptake fire the priority is to boundary cool to contain the fire and give cooling effect.

Set nozzle to solid jet and aim at the seat of the fire if direct attack should be made on hot non-pressurized parts. Doing this may cause steam explosion. Dry powder is a suitable extinguishing medium.

- Fires in water tube boilers
    - Water tube boilers – most common type of Exhaust Gas Boiler (EGB)
    - EGBs have inlet temperature of exhaust gases at 300-400° Celsius
    - Has a risk of fire

In water tube type of arrangement, the water passes through tube stack, which is arranged in the path of exhaust gas inside the exhaust gas-trunking of the main engine. The exhaust gas flows over the tube stacks and heats the water, thus producing steam.

- *Fires in water tube boilers can occur due to:*
    - Shortage of water in the boiler causing overheating of the tubes above the water level and undue delay in shutting down the boiler
    - Uncontrollable soot fire in the furnace after a boiler has been shut down in a port, coupled with a shortage of water in the boiler causing overheating of the tubes above the water level

- *If the fire is discovered before the temperature of the tube has reached 700 degree Celsius, the preferred method of fire-fighting is to:*
    - Direct to burner aperture, or equivalent, the maximum amount of water available as solid jets and through feed pumps to the source of the fire, assuming boiler tubes have fractured or burned
    - Keep air casings and uptakes cool by hosing them with water
    - Avoid using fire spray nozzles, foam appliances or carbon directly on the fire

- *If the iron in steam fire has developed, procedures for containing and extinguishing the fire is to:*
  - Shut down the boiler or main engine
  - Spray external surfaces in the way of the fire with water to keep the temperature down
  - Close dampers and boiler crossovers to exclude air from fire
  - Protect essential electrical and other equipment below the fire zone against water damage
  - Continue cooling until it is safe to open the economizer for examination and thorough cleaning on the fire side

8. Firefighting involving dangerous goods

- Classes of dangerous goods

Explosives Class 1 – In the event of a fire, everything should be done to prevent the spread of the fire to containers which contain class 1 goods. If it is not possible to prevent the spread of the fire, all personnel should immediately withdraw from the area.

(No. 1)
Divisions 1.1, 1.2 and 1.3
Symbol (exploding bomb): black; Background: orange; Figure '1' in bottom corner

(No. 1.4)
Division 1.4

(No. 1.5)
Division 1.5

(No. 1.6)
Division 1.6

Gases Class 2- Gases are substances usually transported in cylinders, flasks, portable tanks, aerosol dispensers and bottles under varying degrees of pressure. The gases may be flammable, toxic or corrosive and may be compressed, liquefied or refrigerated. Gases will not start burning at the valve, unless there has been an ignition source nearby (e.g. fire or heat).

(No. 2.1)
Division 2.1
Flammable gases
Symbol (flame): black or white;
(except as provided for in 5.2.2.2.1.6 (d))
Background: red; Figure '2' in bottom corner

(No. 2.2)
Division 2.2
Non-flammable, non-toxic gases
Symbol (gas cylinder): black or white;
Background: green; Figure '2' in bottom corner

(No. 2.3)
Division 2.3
Toxic gases
Symbol (skull and crossbones): black;
Background: white; Figure '2' in bottom corner

Flammable liquids Class 3 – It is dangerous to direct a jet of water onto a fire involving flammable liquids. Many flammable liquids float on water and the water jet would spread the liquid, thus creating a greater danger. Closed containers exposed to fire will become pressurized and a rupture will occur.

(No. 3)
Symbol (flame): black or white;

Flammable solids Class 4.1 – This class of substances includes flammable solids, water-wetted explosives (i.e., desensitized explosives) and self-reactive substances. Flammable solids will easily ignite.

(No. 4.1)
Division 4.1
Flammable solids
Symbol (flame): black;

(No. 4.2)
Division 4.2
Substances liable
to spontaneous combustion

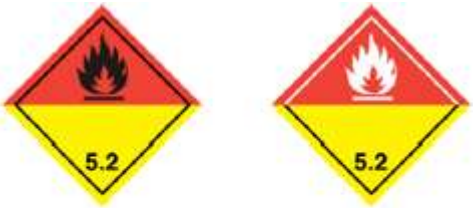
(No. 4.3)
Division 4.3
Substances which, in contact
with water, emit flammable gases

Spontaneously combustible substances Class 4.2 – This class of substances includes pyrophoric substances, which will instantly burn on contact with air, and self-heating substances, which lead to spontaneous combustion.

Substances dangerous when wet Class 4.3 – This class of substances reacts violently with water evolving flammable gases. The heat of the reaction is sometimes sufficient to initiate a fire.

Oxidizing substances Class 5.1 – This class of substances is liable to evolve oxygen and therefore to accelerate a fire. These substances, while in themselves not necessarily combustible, may cause the combustion of other material (e.g. sawdust or paper) or contribute to the fire leading to an explosion.

(No. 5.1)
Division 5.1
Oxidizing substances
Symbol (flame over circle): black;



(No. 5.2)
Division 5.2
Organic peroxides
Symbol (flame): black or white;

Organic peroxides Class 5.2 – This class of substances is liable to burn vigorously. Some substances have a low decomposition temperature and are transported under temperature-controlled conditions, where the control temperature will depend upon the specific properties of the substance being transported.

Toxic substances Class 6.1 – Substances of this class is poisonous by contact or inhalation and, the use of self-contained breathing apparatus and fire fighters outfits is therefore essential.

(No. 6.1)
Division 6.1
Toxic substances

(No. 6.2)
Division 6.2
Infectious substances

Infectious substances Class 6.2 – These are substances that are known or reasonably expected to contain pathogens, (i.e. microorganisms that are known or reasonably expected to cause infectious disease in humans or animals). Pathogens may survive the fire and self-contained breathing apparatus should therefore be used.

Radioactive material Class 7 – Many radioactive materials are transported in packages designed to retain their containment and shielding in accidents. However, under extreme fire conditions, failure of containment or loss of shielding or criticality safety could result in significant hazard to personnel. Long-term exposure of any class 7 package to extreme heat should be avoided and in emergencies should be kept as cool as possible using plenty quantities of water. If a packaging of radioactive material has been exposed to any significant fire, expert advice should be sought. Suspected contamination of safety and fire-fighting equipment should be removed as quickly as possible.

(No. 7A)
Category I – White
Symbol (trefoil): black;
Background: white;
Text (mandatory): black in lower half of label:
'RADIOACTIVE'
'CONTENTS .....'
'ACTIVITY .....'
One red bar shall
follow the word 'RADIOACTIVE';
Figure '7' in bottom corner

(No. 7B)
Category II – Yellow

(No. 7C)
Category III – Yellow

Symbol (trefoil): black;
Background: upper half yellow with white border, lower half white;
Text (mandatory): black in lower half of label:
'RADIOACTIVE'
'CONTENTS .....'
'ACTIVITY .....'
In a black outlined box: 'TRANSPORT INDEX';
Two red vertical bars shall follow the word 'RADIOACTIVE';
Three red vertical bars shall follow the word 'RADIOACTIVE';
Figure '7' in bottom corner

(No. 7E)
Class 7 fissile material

Corrosive substances class 8 – These substances are extremely dangerous to humans, and many may cause destruction of safety equipment. Burning cargo of this class will produce highly corrosive vapors. Consequently, wearing self-contained breathing apparatus is essential.

(No. 8)
Symbol (liquids, spilling from two glass vessels and attacking a hand and a metal): black;

Miscellaneous dangerous substances and articles class 9 – This class includes those substances, materials and articles which are deemed to possess some danger, but which are not classified within the criteria of classes 1 to 8. No general guidelines are applicable to these goods.

(No. 9)
Symbol (seven vertical stripes in upper half): black;
Background: white;
Figure '9' underlined in bottom corner

Marine pollutants Class 10 – A number of substances within all of the above classes has also been designated as Marine Pollutants. Packages containing these substances will bear a Marine Pollutant mark. In the case of leakage resulting from burning cargo, it is important to be aware that any spillage of a marine pollutant that is washed over board will pollute the sea. It is, however, more important to fight a fire on board a ship rather than to prevent pollution of the sea.

- Points to consider in handling dangerous goods fire

BE PREPARED – Preventing a fire from occurring is the most important part of a shipboard safety program. In case of fire, crew must be ready to respond in a timely and effective manner. This can be achieved through training and regular drills.

IDENTIFY THE DANGEROUS GOODS INVOLVED – identify the dangerous goods involved in the fire in order to combat fire effectively. Some dangerous goods are incompatible with some fire-fighting media and could worsen the situation (e.g. use of a water-based extinguishing medium on water-reactive cargoes).

COOL AND SUFFOCATE – The aim of fire fighting is to exclude oxygen and to cool the cargo. On board ship, using water-spray or gas extinguishing systems generally carries this out.

SEEK ADVICE – Seek expert advice no matter how insignificant the fire may seem to be when dealing with dangerous goods fires. Such advice could be given by Ship operating companies, emergency information center, specialized agencies, professional responders, port state authorities, coastguard, fire brigades; and manufacturers of the products.

EVACUATION – Abandon ship at an early stage of fire may be necessary depending on the type of ship and volume of dangerous goods. In this case, the master should be aware of the hazard and should decide whether the ship requires assistance.

FIRE-FIGHTING MEDIA

- Water is the obvious fire-fighting medium at sea and is recommended for most fires involving dangerous goods. However, it should be noted that shore-based fire fighters might use a different medium.
- If a fixed gas fire-extinguishing system is used for incidents under deck, all hatches and vent dampers should be closed and ventilation shut-off before the system is activated. If smoke is seen coming from around the hatches, the leaks should be sealed with any suitable material available.
- Fixed pressure water spraying systems may be used in some ships (e.g. ro/ro ships and car ferries), some cargo spaces may be fitted with a water drencher or spray system instead of a fixed gas fire-extinguishing system. There will be instructions on board, which should be followed.
- Foam is an effective fire-fighting medium for fires involving flammable liquids. The foam forms a layer on the liquid thereby excluding oxygen and reducing heat. However, it is less effective on solid substances on fire. Most foam contains water and should not be used on fires where the use of water is restricted because of adverse chemical reaction.
- Dry chemicals may be an effective extinguishing medium for fires involving water-reactive substances and metals. The dry chemical should not react with the dangerous goods involved in the fire. Some dangerous goods require a specific dry chemical to extinguish a fire.

DANGEROUS GOODS EXPOSED TO FIRE

- Remove packages from vicinity of the fire
- Heated material will expand thus needing more volume and creating pressure in the package, affecting the integrity of the package, which could lead to rupture, and dispersal of the contents.
- Effective cooling can lower the possibility of rupture.

- Leakage of dangerous goods could be very dangerous for the crew and for the ship. Fire and explosion can rupture nearby packages or tanks, creating a spillage.

PERSONAL PROTECTION

- Many vapors and gases of dangerous goods produced by a fire are hazardous to health. In the case of fire, the use of a firefighter's outfit and self-contained breathing apparatus is essential. Only trained personnel should use this equipment, which should be well maintained. Particular attention should be given to ensuring that toxic vapors or fumes do not penetrate occupied areas of the ship (e.g. bridge, living quarters, machinery spaces, working areas, etc.).

FIRE-FIGHTING TEAM

- Chapter II-2 of SOLAS requires firefighter's outfits, full chemical protective suits and self-contained breathing apparatus to be readily available on board. Masters are reminded that personnel will need regular training in the use of self-contained breathing apparatus and that special attention should be given to ensure that face masks fit satisfactorily at all times.

FIRST AID AND ACTIONS AFTER TERMINATION OF FIRE-FIGHTING

- Any contamination with hazardous material should be immediately removed from the skin and then washed, for example with copious quantities of water. Information on medical first aid is provided in the Material Safety Data Sheet (MSDS) / IMO/WHO/ILO Medical First Aid Guide for Use in Accidents Involving Dangerous Goods published by IMO.

▪ Fire control onboard ships carrying dangerous goods

The following should be taken into consideration when controlling fire onboard ships carrying dangerous goods:

- Stowage plan should be marked to show the position and class of dangerous goods
- Firefighting plan should be prepared showing which firefighting media and appliance can safely be used
- Danger and consequent risk to crew should be assessed when the cargo is loaded
- Fire procedure and emergency procedure are put into effect when the fire alarm is given
- Danger of rushing into action without knowing the nature of the cargo
- When the fire is extinguished, a fire watch is kept

○ *Fire control for tankers*

Oil tanker – Danger is always present in tankers but can be handled safely. Care is absolutely necessary throughout the whole loading and unloading operation.

Chemical tanker – Chemical tankers are much more complicated than ordinary tanker ships. They may have more tanks, valves, pumps, blanks, and lines. They may also carry different kinds of cargo at the same time, which could be a possible cause of auto-ignition and fire caused by oil dripping on hot surfaces.

Liquefied gas tanker – Some of the toxic cargoes carried on gas tankers are very flammable, pungent and irritating.

- *Additional requirements for tanker ships*
  - Fixed fire extinguishing system in the pump room
  - Remotely controlled foam monitors on the deck
  - Inert gas system for the cargo tanks
  - Isolation valves fitted in the fire main at the poop front and at specified distances forward of the poop front (control of the water supply to the foam monitors in the event of damage to the fire main, control of the water supply in the emergency fire pumps is in use)
  - Division into gas-dangerous and gas-free spaces
  - Segregation between cargo spaces and system and machinery/ accommodation spaces and system

9. Fire precautions and hazards associated with the storage and handling of materials

▪ Regulation for paint lockers

Both the SOLAS and the U.S. Coast Guard regulations as published in the Code of Federal Regulations (CFR) include requirements for paint lockers.

Requirements:

- explosion-proof electrical equipment within the paint locker
- "A" Class bulkheads - made of steel and have sufficient structural integrity to prevent the passage of flame if exposed to a fire meeting the standard time-temperature curve for one hour; -not required to have any thermal fire resistance; the principle exception being requirements for 30-60 minute thermal fire resistance on passenger vessels when the paint locker is adjacent to control stations, stairway and elevator enclosures, staterooms and public spaces, and isolated storerooms.

Table 1. Fixed Fire Protection System Requirements

	US CFR	IMO SOLAS	PROPOSED IACS	PROPOSED DENMARK
Passenger Vessel	Smoke Det. CFR 46-67 & Manual CO_2 CFR 46-75.15	Appropriate and Approved	None if: < 4 sq m or if: < 10 sq m and outside main superstructure Else: Dry Chem.,Water Spray or Other	Smoke Detector & Manual Gas Foam System Pressure Water Spray or Spray Water System
Tank Vessels	Manual CO_2 or Water Spray CFR 46-34.05 (a) (3)			
Cargo and Misc. Vessels	Manual CO_2 or other appr. CFR 45-95.05-10			

- *SOLAS Chapter II-2 Regulation 10*

Spaces containing flammable liquid

Paint lockers

Paint lockers shall be protected by:

- a carbon dioxide system, designed to give a minimum volume of free gas equal to 40% of the gross volume of the protected space;
- a dry powder system, designed for at least 0.5 kg powder/m3;
- a water spraying or sprinkler system, designed for 5 l/m2 min. Water spraying systems may be connected to the fire main of the ship; or
- a system providing equivalent protection, as determined by the Administration

In all cases the system shall be operable from outside the protected space.

Flammable liquid lockers shall be protected by an appropriate fire extinguishing system approved by the Administration. For lockers of deck area less than 4 m^2, which do not give access to accommodation spaces, a portable carbon dioxide fire extinguisher that provides a minimum volume of free gas equal to 40% of the gross volume of the space may be accepted in lieu of a fixed system. A discharge port shall be arranged in the locker to allow the discharge of the extinguisher without having to enter into the protected space. The required portable fire extinguisher shall be stowed adjacent to the port. Alternatively, a port or hose connection may be provided to facilitate the use of fire main water.

Flammable or combustible material

Flammable liquids have a flash point of 100°F or below; combustible liquids, greases, and paste shave a flash point of 200°F or below. Items that are flammable or combustible include the following:

- Gasoline, oils, kerosene, and other petroleum products
- Chemicals
- Stencil paints, marking inks, and printer's ink
- Solvents, thinners, primers, compounds, varnishes, and lacquers
- Alcohol, acetone, ether, and naphtha
- Greases and pastes

Except for drummed petroleum products, which may be stored in racks on the weather deck, flammable liquids and other flammable or combustible material will be stored in the flammable liquids storeroom.

Approved storage areas include:

- Paint stores
- Deck lockers

Approved methods for handling between shore and ship are to be taken into account in order to avoid:

- Spillage
- Ignition from any cause
- Delay in transporting materials

Acetylene

- Inherently unstable and may explode when subjected to heat or shock, or upon contact with chlorine or certain metals such as copper, silver, and mercury
- Must be stored separately from oxygen or any other materials with which it forms an explosive compound
- The gas must never be allowed to escape into an enclosed area and the cylinders must be protected from flames, sparks, lightning, and static electricity
- Testing for suspected leaks should be done with soapy water

Aerosol Products

- Liquids, solutions, or powders suspended in a gas propellant and contained in dispensers equipped with release valves.
- Containers of aerosol are used for the disposal of paints, enamels, lacquers, insecticides, silicones, rust preventives, and so forth.
- Should be stored in the flammable liquids storeroom, or in cabinets away from oxidizing materials; and mechanical ventilation should be used, when necessary, to remove accumulated vapors.

○ *IACS Proposal*

The lACS has issued an interpretation entitled, "Uniform Interpretation of SOLAS 1989 AMS. Chapter 11-2, Reg. 18.7." This interpretation covers fire-extinguishing arrangements for paint lockers as follows:

(1) Paint lockers and flammable liquid lockers of deck areas 4 m2 and more shall be provided with a fire extinguishing system enabling the crew to extinguish a fire without entering the space. Fixed arrangements as specified below may be provided. C02 systems designed for 40 percent of the gross volume of the space. Dry powder systems designed for at least 0.5 kg powder/m3. Water spraying systems designed for 5 L/m2, min.

(2) Water spraying systems may be connected to the ship's main system.

(3) Other systems than those mentioned above may be accepted.

(4) For lockers of deck areas less than 4 m^2, CO2 or dry powder fire extinguishers may be accepted."

The IACS has submitted this interpretation with an additional paragraph stating the following: "Portable fire extinguishing equipment stowed near the entrance may be accepted for paint lockers of deck area less than 10 m2 (108 ft2) located outside the main superstructure block and having no contiguous boundary with accommodation machinery spaces of Category A, or gas danger spaces.

○ *Review of Denmark Representation Remarks*

Subsequent to the IACS submission, the Denmark Representation on the Subcommittee for Fire Protection has offered general remarks for such unified interpretation as follows:

(a) The appropriate fire extinguishing system should be of a fixed type. Only gaseous firefighting foam or pressure-water systems should be used. Spray water systems may be supplied from the ship's fresh water supply.

(b) The release arrangement for the fixed fire extinguishing system should be manually operated and located outside the space concerned.

(c) One or more smoke detectors should be installed in the space concerned. An early fire warning is especially important in such spaces since paint and similar substances can be spontaneously ignited.

10. Management and control of injured persons

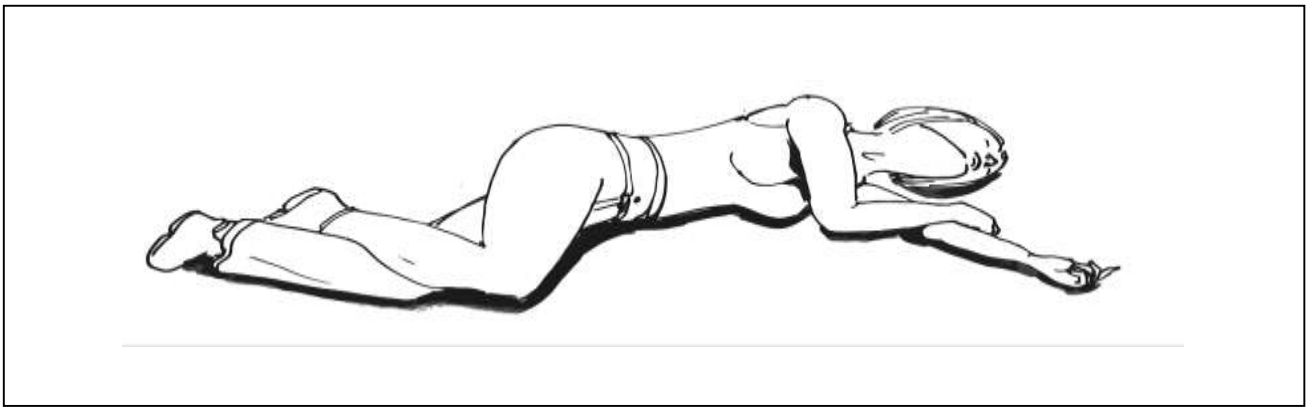
- First Aid

First aid measures are very important, as it is the provision of initial care for an illness or injury. It is usually performed by a non-expert person to a sick or injured person until definitive medical treatment can be accessed. It generally consists of a series of simple and in some cases, potentially life-saving techniques that an individual can be trained to perform with minimal equipment.

Asphyxiation

Asphyxiation describes the situation in which the body is being deprived of oxygen. There will be either no air or insufficient air is getting into the body leading to low brain oxygen. Asphyxiation may be the result of fires causing oxygen shortage or an extinguishing gas replacing air.

- *First aid measures in cases of asphyxiation:*
  - Removal of victim from danger area
  - If unconscious, placing the victim in recovery position
  - In the absence of breathing, applying artificial respiration
  - In the absence of pulse, applying cardio-pulmonary resuscitation



The recovery position is designed to prevent suffocation through obstruction of the airway. All forms of the recovery position share basic principles. The mouth is downward so that fluid can drain from the patient's airway; the chin is well up to keep the epiglottis opened. Arms and legs are locked as to stabilize the position of the patient.

- *Signs of asphyxia*
  - Congestion (non-specific)
  - Cyanosis (non-specific)
  - Edema of the face (non-specific)
  - Petechial hemorrhage: always around the eyes, on eyelids, behind ear and inside the mouth

Poisoning

Poisoning may be caused by carbon monoxide, which is produced in most fires, or from toxic combustion products of fire.

Secondary shock

Secondary shock is a serious condition caused by the collection of body fluids in blisters, and must always be suspected except with minor burns.

Damaged tissues

Damaged tissues may lead to loss of function of the affected parts of the body, infection and / or mutilation, scarring and disfigurement.

Burns

Burns result from the destruction of tissue by the application of any form of heat, or of any chemical substance.

This can result from exposure to:

- Flame
- Contact with hot surfaces
- Radiant heat from hot objects
- Hot liquids or steam e.g. water, hot oil
- Corrosive chemicals e.g. sulphuric acid
- Radiation
- Electric current

- *Categories of burns*

1. First-degree burns

- Injuries are superficial / mild
- Swelling & redness of the injured area
- Pain develops
- No blisters seen
- Burned area becomes white on touch
- Takes 3-6 days to heal

Treatment

- Remove patient from heat source
- Remove the burnt clothing
- Run cool water over burnt area
- Gently clean the injured area
- Gently dry
- Apply antibiotic such as Silver Sulphadiazine
- Use a sterile bandage to cover burns
- Take tetanus vaccination, if required

2. Second-degree burns

- Burns extend to middle skin layer, dermis
- Swelling, redness and pain observed
- Burnt area may turn white on touch
- Blisters develop, that ooze a clear fluid
- Scars may develop
- Restricts movement, if injury occurs at joint

- Dehydration may occur
- Healing time varies, depends on extent of injury

Treatment

- Clean the affected area thoroughly
- Gently dry
- Apply antibiotic cream over affected area
- Make the patient lie down
- Keep burnt body part at a raised level
- Skin graft may be required
- Physical therapy may be essential to aid mobility
- Splints may be used to rest affected joints
- Hospitalization is essential

3. Third-degree burns

- Damage occurs to all 3 skin layers
- Destroys adjacent hair follicles, sweat glands, nerve endings
- Lack of pain due to destroyed nerves
- Injured area does not turn white on touch
- No blisters observed
- Swelling occurs
- Skin develops leathery texture
- Discoloration of skin observed
- Scars develop
- Crusty surfaces (Eschars) develop that impairs circulation
- Dehydration occurs resulting in shock
- Symptoms may worsen with time
- Disfigurement may result
- Healing depends on extent of injury
- 90% body surface injury results in death
- 60% body surface injury in elderly is fatal

Treatment

- Requires immediate hospital care
- Dehydration treated through intravenous fluid supply
- Oxygen is administered
- Scars are surgically opened
- Periodically run clean cool water over burns
- Nutritious diet helps to heal quickly, regular monitoring essential
- Mental depression treated by anti-depressants

11. Procedures for coordination with shore-based fire fighters

- In port / shipyard or lay-up
  - Various team composition may require modification as individual team strength reduces
  - Initial response in port must be to notify the shore fire and emergency services immediately so that additional expert assistance becomes available promptly.

Special circumstances will apply when a vessel is in a shipyard or laid-up as the availability of a ship's complement will be minimal. The initial conditioned response must thus be:

1. To activate the emergency alarm and inform the Officer in Command.

2. To call up and request help from the shore emergency services.

3. To deal with the emergency so far as is safe, reasonable and practicable.

4. To ascertain promptly what services are available on board in such situation.

5. To be ready to guide the shore emergency service personnel to the scene of the emergency and provide them with as much information as is possible.

- External communication at sea

The master, on receiving reports from the team leaders, must assess the gravity of the situation and communicate via the Radio Officer accordingly. The options that the Master has at his disposal are:

- An alert message to all ships and shore-based stations (as appropriate) in the vicinity advising that an emergency exists on board the ship and to stand by for further information. The text of this message must include the vessel's name, its position, the nature of the emergency plus the course and speed if applicable

- An advice message transmitted when all the facts are known in order to update the alert message.

- A distress message sent if outside assistance is required indicating the type of help that is required.

- A cancellation message transmitted when the emergency is over and no further assistance is required.

COMPETENCE: ORGANIZE AND TRAIN FIRE PARTIES

12. Preparation of Contingency Plans

- Central Control Station during fire will be on bridge
- The Master has absolute authority to summon salvage assistance on his own assessment of the situation and exercise of this authority should not be unreasonably delayed while seeking advice from company.
- The fire officer / officers will report to the bridge and receive instructions

- In the event of fire, the information which central control station requires includes:
  - Time at which the fire alarm was given
  - Position and nature of the fire
  - Confirmation that fire parties are at their assembly points and that the firefighter's outfits are available
  - Confirmation that the fire main is pressurized
  - Report on the initial attempts to extinguish fire using portable extinguishers
  - Report on the effect of fire on services, e.g. lighting
  - Report on persons present or trapped in compartments or unaccounted for

- The information which should be available on the bridge includes:
  - Arrangement drawings, in a convenient size, of ship, engine room and accommodation
  - Details of accesses and escapes from the different zones of the ship
  - Details of fire-extinguishing equipment, both fixed and portable, for the entire ship, including storage position of refills
  - Stability information
  - Details of survival equipment and where it is stored
  - Stowage plans
  - Information on dangerous goods

- Communication co-ordination methods available include:
  - Telephones
  - Loud hailers
  - Direct speech, e.g. bridge to machinery control room
  - Radio telephones, hand-held radios
  - Messengers

- Methods of damage control and containment of fires:
  - Bridge operated closing of watertight doors and release of fire doors to their shut position
  - Stopping of ventilation fans and closing of dampers on funnel and other places
  - Closing of all windows and portholes in accommodation, galley and other spaces
  - Turning ship to give best position relative to wind direction for fighting the fire
  - Cooling boundary bulkheads
  - Using fire blankets as necessary
  - Maintaining fire watch after fire is extinguished

- Monitoring and controlling the stability of ship during fire

Due to the use of water for extinguishing fire, control and stability of ship will be affected. The following action should be taken to avoid further problems:

- Calculating the change in GM (Metacentric height) caused by the weight of the extinguishing water as free surface effect. Note, that the metacentric height (GM) is a measurement of the initial static stability of a floating body. It is the distance between the center of gravity of a ship and its metacenter.
- Arranging pumping or draining of firefighting water from affected spaces, including cutting holes in ship's side
- For cargo fires, calculating the effect of having to move cargo to attack a fire.

- Assessing the effect of any damage which causes spaces to be flooded by seawater
- Considering possibilities of moving vessel to shallow water or even allowing it to ground.

13. Composition and allocation of personnel to fire parties

TEAM LEADERS

All team leaders must be capable of carrying out tasks that would be assigned to members of their team. The team leader must never become so involved in actual operation that control of his team action is lost such that they jeopardize their lives. To be able to achieve this, a leader must ensure that his team is efficiently trained and that they have confidence in the leader and in each responsibility.

BRIDGE TEAM

This 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 immediate external communication, establish internal communication between the bridge, engine room, and emergency and support teams, maintain the safe navigation of the vessels and keep detailed timed record and log event.

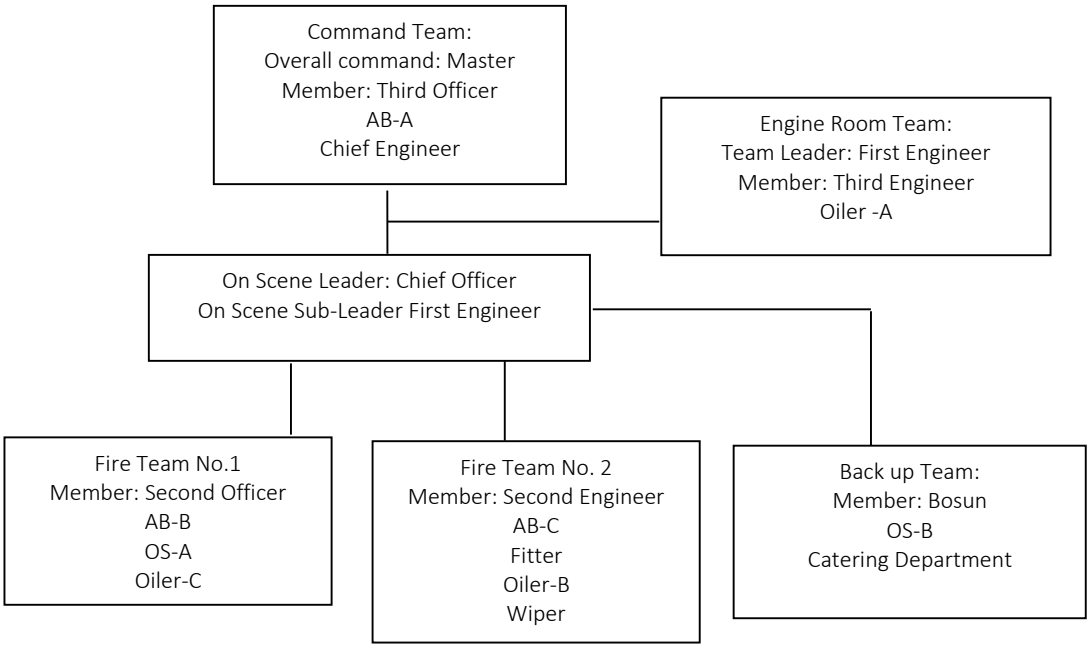
ENGINE ROOM TEAM

The engine room team must advise the bridge of the state of readiness of the engine room. This advice must indicate the status of plant and emergency systems, which must be placed in state of maximum readiness. The team must also establish whether the emergency had any adverse effect on the operation of the plant and then determine what actions, if any, need to be taken to remedy any deficiencies to the plant and emergency systems. The team should be able to maintain essential emergency services.

EMERGENCY TEAM 1 AND 2

The emergency teams first muster and report to the bridge. They then make ready equipment and report their readiness to the bridge, and be ready to take action as directed by the Master or Officer in Command.

Sample formation of Emergency Response Team:



SUPPORT TEAM

The support team advises its readiness to the bridge and provides support to emergency team as and when instructed by the Master or Officer in Command. Below are some examples:

- Hospital and first aid
- Prepare lifeboats and life rafts
- Prepare to provide breathing apparatus support to emergency team
- Provide logistical support to emergency teams, such as recharging self-contained breathing apparatus cylinder
- Provide additional firefighting equipment
- Maintain security patrols
- Provide boundary cooling

The success of this team is measured by the effective support it can provide the emergency team. To provide this service, individual team members will need similar skills and attributes so far for an emergency team.

RESERVED TEAMS

In cases where vessel complement exceeds 26 people, additional suitable personnel may be designated to each team as deemed prudent, however it is strongly recommended that no team ever exceeds eight people.

- Team effectiveness

The success of each team is dependent upon the varying skills and attributes of individual team members as well as upon the degree of effectiveness in harnessing such skills through realistic simulation of all forms of emergency.

The following skills must be sought for the members of emergency team:

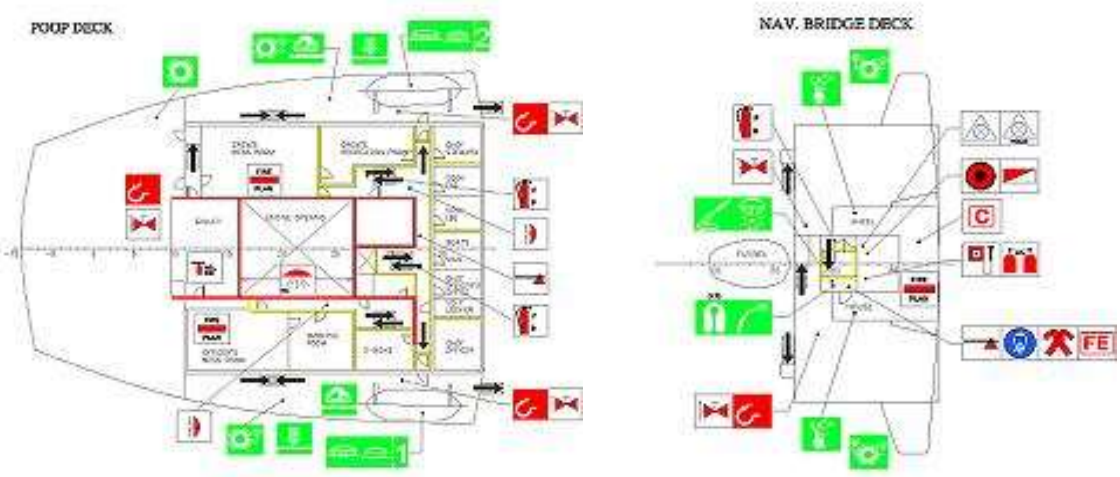
- Firefighting (all members)
- Enclosed space entry (all members using SCBA)
- Search and rescue techniques
- Observant and able to communicate
- Electrical skill
- Mechanical skill
- Seamanship skill
- First Aid skill
- Survival skill
- Knowledge of ship and its equipment
- Damage control
- Physical fitness (age may be a consideration)
- Self-discipline / respect for authority
- Team spirit

Regular drill must always be done to ensure the team's effectiveness in the following:

- Ship's crew must be familiar with the following:
    - Starting the emergency generator
    - Starting the emergency fire and bilge pump
    - Selecting the appropriate valves for providing water for firefighting, flooding holds or pumping out bilges
    - Identifying the emergency controls and their functions
- Improving personal safety by practice
- Moving and finding the way in spaces with restricted visibility
- Moving through small apertures
- Finding and removing casualties
- Using compressed air breathing apparatus and the fireproof lifeline in these conditions

14. Strategies and tactics for control of fires

Fire control plans



A Fire Control and Safety Plan shows all safety facilities and equipment onboard. It also indicates fire precaution and extinction aboard ship.

The fire control plan is posted onboard in distinct locations accessible to everyone. For the effective use of all fire technical facilities it is necessary to have knowledge of the different fire systems and how these can be used in various situations.

- **Information in the Fire Control Plan**

The following information is mostly given by means of symbols. The meaning of each symbol is shown on the plan. All crew in a vessel should study the plan in order to become familiar with the fire-fighting installations on board (e.g. knowledge of escape routes, location of extinguishers, etc.). This is because the crew has to act quickly and accurately in case of emergency.

a) Position of water-tight door (as applicable)
   In case of fire or fire drills, water tight doors must be closed. This is of utmost importance, because a fire always needs oxygen, which can each via the accesses.
b) Exit doors and passages
c) Emergency exits
d) Emergency stops of the ventilation (engine room, accommodation, pump rooms) – ventilation, flaps and fan switches either local or remote control.
e) Fire pumps
f) Emergency fire pumps
   Fire pumps are normally located in the engine room. The number and capacity of the pumps must be as prescribe in the regulations. Emergency fire pumps must always be located far from the fire pumps.
g) Connection for fire hoses

Number, size and length of the hoses are prescribed in the regulations. Fire hoses on the open deck have at least of 2 inches. In the accommodation smaller hoses are permitted.

h) Positions and types of fire extinguisher
i) Position of International Shore Connection
j) Location of alarm apparatus
k) Location of the release arrangements for the fixed extinguishing installations
l) Location of fireman's outfit

COMPETENCE: INSPECT AND SERVICE FIRE DETECTION AND FIRE EXTINGUISHING SYSTEMS AND EQUIPMENT

15. Inspection, maintenance and testing

- Fire alarms
  - A fire alarm system on board a vessel can be a hand-operated fire alarm box, equipped with a button to be pushed by the person reporting the fire. Automatic fire alarm systems are also found onboard. This system consists of a series of detectors placed in different areas of the vessel, connected to the central fire alarm located on the bridge.
  - Manual fire alarm systems may be combined with an automatic fire detection and alarm system and should be so arranged that a fire alarm can be raised, even though a zone or zones in the automatic detection system have been disconnected for maintenance or repair.
  - A fixed fire detection and fire alarm system shall be installed and arranged as to provide smoke detection in service spaces, control stations and accommodation spaces, including corridors, stairways and escape routes within accommodation spaces.
  - A plan should be available during the activation of fire alarms to show the location of fire.
  - A schedule should be prepared that shows date when surveys, inspection, maintenance and testing should be carried out.
  - The manufacturers instruction manual should be used as basis for the schedule which should include at least:
    - inspection for damage or omission in wiring and equipment
    - cleaning electrical contacts and switches
    - testing of the system and proving that all equipment operates correctly

- Manually Operated Call Points

Manually operated call points complying with the Fire Safety Systems Code 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 meters from a manually operated call point.

- Fire patrols

For ships carrying more than 36 passengers an efficient patrol system shall be maintained so that an outbreak of fire may be promptly detected. Each member of the fire patrol shall be trained to be familiar with the arrangements of the ship as well as the location and operation of any equipment he may be called upon to use.

- Fire zone

The system is divided into sections called fire zones. These display a light on the central fire-alarm panel pin-pointing the fire location. Aboard cargo ships, the alarm will go off automatically as soon as a fire is detected. On passenger ships, the officer on duty on the bridge will first pull a fire alarm in the crew quarters.

- General Emergency Alarm

The signal consists of seven short blasts followed by one long blast on the ship's whistle and bells or klaxons or equivalent sounding elsewhere in the ship. There are other special alarms operated from the navigating bridge to summon the crew to fire stations. Other possible fire alarms include: CO_2; pump room alarm; manually operated alarm system; UMS fire-detection system. All these alarms could sound like a siren. When the CO_2 alarm is sounded, leave the room quickly closing the doors behind you. Make sure all crew members are out of the area. CO_2 or carbon dioxide is non-toxic however on the discharge of CO_2 in fire extinguishing concentration, serious hazards such as suffocation which leads to death and reduced visibility may occur.

- Fire detection equipment

These are the devices found onboard which are used to detect fire and give an alarm signal indication. The following should be considered:

- A plan should be available to show their position and schedule should be prepared that shows date when surveys, inspection, maintenance and testing should be carried out
- Additional maintenance is needed such as:
- Cleaning and checking of contacts and other component in the control box and ensuring that connection to fire alarm system operates correctly.
- Testing the correct operation of each head probe as appropriate

SOLAS Chapter II-2, 2002, Regulation 7
Part C - Suppression of fire
The purpose of this regulation is to detect a fire in the space of origin and to provide for alarm for safe escape and firefighting activity. For this purpose, the following functional requirements shall be met:

- Fixed fire detection and fire alarm system installations shall be suitable for the nature of the space, fire growth potential and potential generation of smoke and gases;
- Manually operated call points shall be placed effectively to ensure a readily accessible means of notification; and
- Fire patrols shall provide an effective means of detecting and locating fires and alerting the navigation bridge and fire teams.

- Types of fire detectors:

A fire detector is a sensor to detect the presence of a flame or fire. Responses to a detected flame depend on the installation.

Smoke detector – All fire emits smoke and gases, often long before open flames are visible. The smoke detector can therefore be activated before the actual outbreak of a fire.

Flame detector –This is activated when it is "hit" by varying infrared or ultraviolet rays from the flames.

Heat detector – As the name indicates, this is affected by heat. The alarm is usually triggered when the room temperature rise to about 700°C. Such detectors are also available for activation at other temperatures.

- Components of fire detectors

Normal power supply – The normal power supply may be supplied either by a separate branch circuit from the ship's switchboard or by storage batteries. When the power is supplied by storage batteries, they must be used only for the fire alarm and fire detection systems.

Emergency power supply – Emergency power may be supplied by a separate branch circuit taken from the temporary emergency lighting and power system switchboard or by storage batteries. If duplicate storage batteries supply the normal power, the battery being charged may serve as the emergency power source.

Fire detection control unit – The fire detection control unit consists of a drip-proof enclosed panel containing the fire alarm signaling, trouble-alarm and power failure alarm devices. These devises must register both a visual and an audible signal. The visible signals are lights:

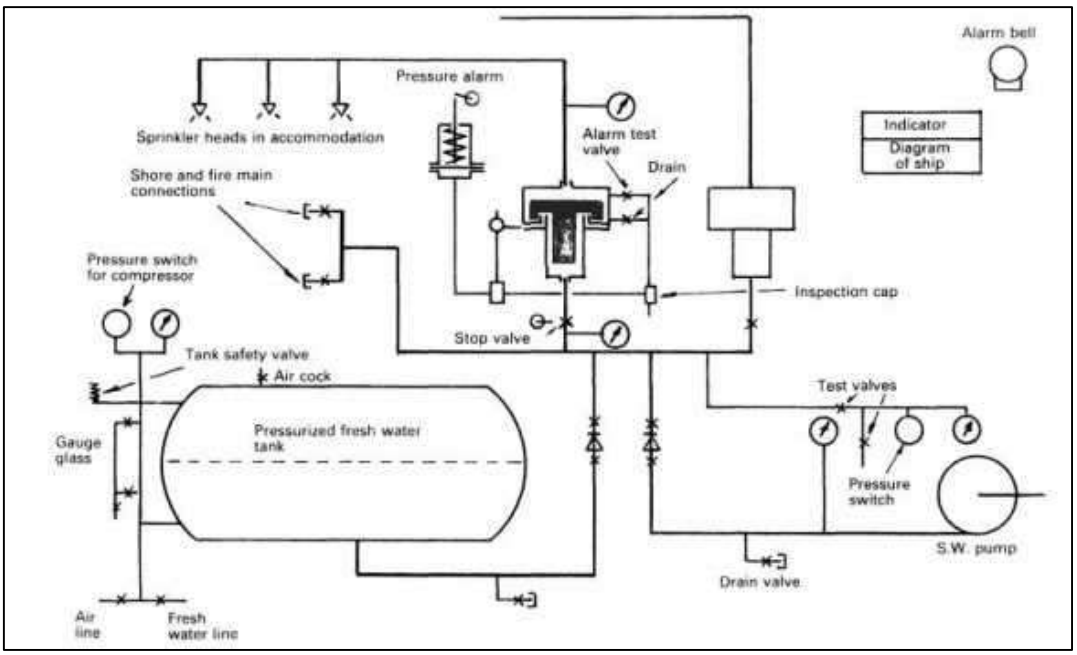
A red light indicates fire or smoke
A blue light indicates trouble in the system
A white light indicates that the power is on in the system

The control unit also contains a power supply transfer switch to engage the emergency power supply if the normal power supply fails.

Vibrating bells – They are like the red lights on the control unit fire alarm signal, the operation of any automatic fire detection system (or manual fire alarm in a manual fire alarm system) must automatically cause sounding of vibrating bells.

Fixed fire extinguishing equipment

- Automatic sprinkler system
  - automatic fire detecting, alarm and extinguishing system
  - consists of a pressure water tank with water pipes leading to various places in the compartments. These water pipes consist of sprinkler head which comes in operation when there is an outbreak of fire.



The pressure in the tank is such that it would be able to deliver pressure at highest sprinkler head in the system and is not less than 4.8 bars.

The sprinkler heads are grouped into different sections with not more than 200 sprinkler head in each section. Moreover, each section has its own alarm system which gives alarm on operation.

The sprinkler head consists of a quartzoid bulb which bursts when the temperature increases beyond the limit and the water starts flowing from the sprinkler head. These quartzoid bulbs are color coded in red, yellow and green. The rating of red bulb is 68 ˚C, yellow is 80 ˚C and green is 93 ˚C.

Each sprinkler head covers a deck area of 16 m2 and the flow of water in each one of them should be at least 5 liters/minute as per the regulation of SOLAS. When the sprinkler head bursts and comes into operation, the non-return valve in the line opens and water starts flowing. Due to this flow there is a

drop of pressure in the line and the alarm activates for the particular section, indicating fire in the section.

This system is also connected to sea water pump which can supply water to the system in case the water in the pressure tank is used up. Various alarms and pressure switches are provided in the system for maintenance and check of alarms and activation of sea water pump by isolating the system.

The sprinkler system is generally used in accommodation, paint room and other places on the ship.

- Foam system
  - used mainly in fighting class B fires, although low expansion foam (with a high water content) can be used to extinguish class A fire
  - mainly used for smothering, with some cooling action
  - Foam can be generated chemically or mechanically. Chemical foam is produced by first mixing air with the foam solution. The bubbles are then filled with air.

The arrangement for providing foam shall be capable of delivering foam to the entire cargo tank deck area as well as into any cargo tank deck of which has been ruptured.

The foam system shall be capable of simple and rapid operation. Operation of the foam system at its required output shall permit the simultaneous use of the minimum required number of jets of water at the required pressure from the fire main.

- Deck foam system
  - required on all tanker vessels by the 1970 tanker vessel regulation
  - The foam system replaces the inert gas smothering system for improved fire protection
  - Is intended to protect any deck area with foam applied from stations (monitors or hose stations) located aft of the area. At least 50% of the required rate of application must come from mounted devices (deck foam monitors).
  - capacity of any monitor: at least 3 liters/min of foam solution per square meter of deck area protected by the monitor, such area being entirely forward of the monitor. Such capacity shall not be less than 1250 liters/min.
  - capacity of any applicator: not be less than 400 liters/min and the applicator throw in still air condition shall not be less than 15 meters

- CO_2 fixed fire suppression systems
  - the oldest and most common form of fixed fire protection on board vessels
  - CO_2 - a non-corrosive, non-conductive, odorless gas that will not leave any residue, and provides a cooling effect
  - extinguishes the fire by reducing the oxygen content in the space protected to the point where combustion is not possible
  - does not support human life, therefore presenting a threat to personnel in the space protected, so necessary precautions should be taken to install pre-discharge alarms to allow the space to be vacated prior to discharge.

- A relatively inexpensive agent compared to other fire extinguishing agents used in similar applications

- Halon fixed fire extinguishing system
  - use a superior fire extinguishing reaction
  - will not leave any residue or harm equipment
  - has been considered to be a safe and expected to be available for several more years
  - does not deplete oxygen from the environment and is life supportive
  - Fixed fire suppression systems are available in Halon replacement agents, including FE241 and FM200 and HFC227Ea.

Fire main, hydrants, hoses and nozzles and pumps

- Fire main system
  - A fixed pipeline running throughout the ship with hydrants at suitable points to cover all the areas
  - is fed by big fire pumps sized by regulations
  - There must be at least two fire pumps and an emergency fire pump in a cargo ship
  - emergency fire pump must be at a remote location from the engine room on the ship
  - Isolating valves to isolate sections of the pipe line in the event of pipe failure are located in accessible places and clearly marked.
  - Fire hoses and nozzles are kept coiled and ready near the hydrants.

Single fire main system
- makes use of one main pipe running fore and aft, usually at the main deck level. The vertical and horizontal branch line extends the piping system through the ship. On tankers, the main pipe usually runs the length of the vessel, down its centerline.
- Disadvantage: its inability to provide water beyond a point where a serious break has occurred

Looped fire main system – Consists of two parallel pipes, connected together at their furthest points fore and aft to form a complete loop. The branch line extends the system to the fire station. In the horizontal loop system a ruptured section main pipe may be isolated. The system then can be used to deliver water to all other parts of the system. Isolation valves are sometimes located on the main pipe line, forward of each hydrant location. They are used to control water flow when break occurs in the system.

- Fire pumps
  - the only means for moving water through the fire main system when the vessel is at the sea
  - On vessels that are required to carry two fire pumps, the fire pumps must be located in separate spaces. The fire pumps, sea suction and power supply must be arranged so that fire in one space will not remove all the pumps from operation and leave the vessel unprotected. Engineering personnel are usually charged with responsibility for maintaining and testing the ship's fire pumps to ensure their reliability during an emergency.

- Hydrants and piping

The piping system consists of a large main pipe and smaller branch lines leading to the hydrants. The main pipe is usually 102 – 105mm (4 – 6 inches) in diameter while the branch lines are generally 37 –

64mm (1 ½ - 2 ½ inches) in diameter. The piping directs firefighting water from the pumps or hydrants at the fire stations. The piping must be large enough in diameter to distribute the maximum required discharge from two fire pumps operating simultaneously.

Water pressure in the system must be approximately 345 kilopascals (50 psi) at the two hydrants that are highest or farthest (whichever result in the greater pressure drop) for cargo and other vessels. For tanker vessels, pressure must approximately be 517 kilopascals (75 psi).

Portable and mobile fire extinguishing equipment including appliances

Portable fire extinguishers are those which can be carried to the fire location for a fast attack, but contain a limited amount or supply of extinguishing agent. Typically, a fire extinguisher consists of a hand-held cylindrical pressure vessel containing an agent which can be discharged to extinguish a fire.

- Main types of fire extinguishers

Stored pressure type – In stored pressure units, the expellant is stored in the same chamber as the firefighting agent itself. Depending on the agent used, different propellants are used. With dry chemical extinguishers, nitrogen is typically used; water and foam extinguishers typically use air. Stored pressure fire extinguishers are the most common type.

Cartridge-operated type –the expellant gas is contained in a separate cartridge that is punctured prior to discharge, exposing the propellant to the extinguishing agent. Unlike stored pressure types, these extinguishers utilize compressed carbon dioxide instead of nitrogen.

- Portable fire extinguishers
  - The type of extinguisher used must be appropriate for the type of fire
  - E.g. water sprayed on grease fire will cause the grease to splatter and the fire may spread
  - Another example: dowsing electrical equipment with water causes electrical shock

There are many kinds of portable fire extinguishers on board ships. Depending on their intended use, fire extinguishers use a variety of "fire extinguishing agents"– the water or the chemicals(s) that put out the fire.

Water extinguishers – contain water and compressed gas and should only be used on Class A (ordinary combustibles) fires.

Carbon dioxide (CO2) extinguishers – are most effective on Class B and C (liquids and electrical) fires. Since the gas disperses quickly, these extinguishers are only effective from 3 to 8 feet. The carbon dioxide is stored as a compressed liquid in the extinguisher; as it expands, it cools the surrounding air. The cooling will often cause ice to form around the "horn" where the gas is expelled from the extinguisher. Since the fire could re-ignite, continue to apply the agent even after the fire appears to be out.

Dry chemical extinguishers – are usually rated for multiple purpose use. They contain an extinguishing agent and use a compressed, non-flammable gas as a propellant.

Halon extinguishers – contain a gas that interrupts the chemical reaction that takes place when fuels burn. These types of extinguishers are often used to protect valuable electrical equipment since

they leave no residue to clean up. Halon extinguishers have a limited range, usually 4 to 6 feet. The application of Halon should be made at the base of the fire, even after the flames have been extinguished.

Foam fire extinguisher – when sprayed onto a fire, foam extinguishes and smothers the flames, then seals in any harmful vapors under the outer film of foam. The foam also penetrates absorbent materials and cools the fire as the water in the foam evaporates. Foam is extremely effective on Class A fires and Class B (flammable liquids such as petrol, spirits, and diesel).

- Mobile / Semi-portable fire extinguishers

Semi-portable fire extinguishers provide a way of getting a sizable amount system of extinguishing agent to a fire quickly. Usually bigger than portable fire extinguishers and mounted on a wheel for easy transport.

CO2 reel extinguisher – usually found in engine rooms and spaces containing electrical equipment. The system is activated manually by the use of a control lever mounted on the top of the CO_2 cylinder. Only one needs to be operated, pressure from the first cylinder opens the valve of the second, so both will be used.

Dry chemical hose system – consists of a storage tank containing the agent, a rubber hose and a nozzle valve. The nitrogen is used as a propellant for dry chemical systems that employs sodium bicarbonate or potassium chloride. It can be located where Class B and C fires may be expected. Systems employing mono-ammonium-phosphate may be approved for any location on the ship. However, they should not be used to protect the electrical gear, because of the sticky residue this dry chemical leaves behind.

Halon hose-reel system – the semi-portable halon hose reel system is very similar to the CO_2 system and is employed to combat Class B and Class C fires. Most semi-portable systems use Halon 1301. The system consists of one or two pressurized cylinders containing the extinguishing agent, a hose line and a nozzle with an on-off control valve.

Portable foam system – a foam system using in-line proportioner or a mechanical foam nozzle with a pick-up tube. The foam system can be carried to various parts of the ship and is used with the ship's fire main system. It is an efficient method for producing foam, but it requires more manpower than the semi-portable system employing their extinguishing agents.

Mechanical foam nozzle with pick-up tube – the mechanical foam nozzle is attached to a standard hose line from the fire main system, the nozzle is screwed into the fire hose, and the pick-up tube is screwed into the side part in the base of the nozzle. When water pressure is applied to the hose, foam concentrate is drawn up to the nozzle where it mixes with the air and water. The resulting foam is applied in a usual manner.

Portable in-line proportioner – the portable in-line proportioner or educator allows the nozzle more freedom of movement than the nozzle with pick-up tube. The proportioner may be installed anywhere in the hose line, between the fire main and the nozzle.

How to Operate a Portable Fire Extinguisher

There are four basic steps to operating a portable fire extinguisher. An easy way to remember the procedure is to think of the word "P.A.S.S."

Pull the Pin: Holding the extinguisher with the nozzle pointing away from you, release the locking mechanism. In most cases, this means pulling out the pin located below the trigger.

Aim low: Standing 6 to 8 feet away from the fire, point the extinguisher nozzle at the base of the fire – the lowest point of the fire nearest you. Extinguishers are designed to be operated in an upright position. Always hold the extinguisher vertically. Never cradle it horizontally or at an angle in your arms.

Squeeze the trigger: Squeeze the trigger slowly and evenly. This will release the extinguishing agent and expel it through the nozzle.

Sweep side to side: As the extinguishing agent is expelled, sweep the nozzle from side to side. As the fire closest to you goes out, you may move closer to the fire and continue the sweeping motion until the fire is extinguished.

Communication Equipment

The following are the methods of communication used during fire emergency:

- Messenger
- Telephone
- Radios or walkie - talkie
- Ship-to-shore VHF
- Public address system

Personal Protective Equipment (PPE)

- Fireman's outfit

The fire fighter outfit is mandatory on every ship. The outfit consists of the following:

- Breathing apparatus
- Water resistant clothing
- Safety shoes
- Hand Gloves
- Rigid helmet
- Electric intrinsically safe hand lamp that lasts for about 3 hours duration -Fire Axe
- A strong fire proof line
- A belt for carrying auxiliary equipment

As per SOLAS, the minimum numbers of fire fighter outfit required on board are as follows:

- For ships between 500-2500 tons – minimum two (2) sets are required
- For ships between 2500-4000 tons – minimum three (3) sets are required
- For ships 4000 tons and above – minimum four (4) sets are required

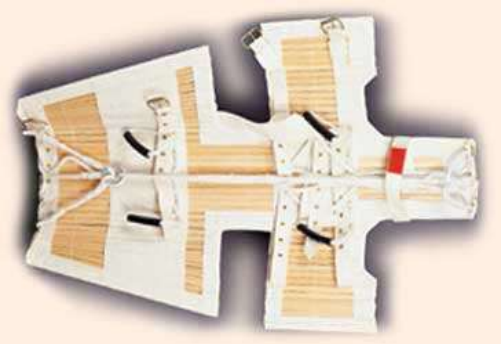
The firefighter's outfit is stored in the fire control room and in places that are easily accessible during emergencies.

- ***Requirement for Self-Contained Breathing Apparatus (SCBA) used in firefighter's outfit***
  - Capacity of air bottle should be at least 1200 liters

- Should be capable of working 30 minutes & provided with one face mask
- Fire proof line with snap hook of at least 3 meters should be present and must have enough length to reach any part of the space to be entered. Line should have breaking strength of 500 kg.
- Adjustable safety belt or harness made of fabric
- Must have a by- pass valve
- Should have a pressure gauge with anti-bursting orifice in high pressure air supply system
- Maximum weight should not increase above 19 kg including lifeline, safety belt and harness
- Spare cylinders should be available fully of 2400 liters of free air
- For ships carrying 5 sets or more, the total spare capacity of free air is 9600 liters or if charging facility is available, free air is 4800 liters
- Must give audible warning when 20% of air is left in the bottle
- Operating instructions should be present near the apparatus
- Marking of maker & year of manufacturer
- Maximum pressure should be about 180-200 bars

- *Inspection of fireman's outfits*
  - A scheme similar to inspection of fire alarms must be prepared and operated.
  - The inspection and maintenance schedule should include checking the following:
    - that all outfits are in their correct stowage positions;
    - that the personal equipment is undamaged and complete;
    - that the battery of the electric safety lamp (hand lantern) is fully charged;
    - that the breathing apparatus is ready for use;
    - that the compressed air bottles, including all spares, are kept fully charged;
    - that after any use, the breathing apparatus is dismantled to ensure that all parts are clean and all valves are operating correctly; and
    - that the fireproof lifeline is undamaged.

Rescue and life support equipment



Neil Robertson stretcher –This is the most common type of stretcher used on ship. It is designed for removing an injured person from engine-room spaces, holds, and other compartments where access hatches are too small to permit the use of regular stretchers. The Neil Robertson stretcher is made of semi rigid canvas. When firmly wrapped around the victim in mummy-fashion, it gives sufficient support so the victim may be lifted vertically. To keep the injured person from swaying against bulkheads and hatchways while being lifted, tie a guideline to the victim's ankles.

Self-Contained Breathing Apparatus (SCBA)– This is a device worn by rescuers, firefighters, and others to provide breathable air in an "Immediately Dangerous to Life or Health" atmosphere (IDLH).

- *Operation method of Open Circuit/Positive Pressure SCBA*
  1. Compressed air from cylinder is supplied to wearer.
     a. Inhalation opens valve in regulator.
     b. Regulator allows air to flow to face piece.
     c. Exhalation closes valve in regulator, stopping flow and opens exhalation valve in face piece to atmosphere.

  2. Air from cylinder is allowed to pass through regulator. Upon inhalation, pressure is reduced in face piece. Regulator supplies more air to compensate for pressure drops. Exhalation valve forced closed by spring tension causing slight pressure buildup inside face piece.
     a. Maintains slightly higher than atmosphere pressure
     b. Prevents leaks from outside into face piece

- *Maintenance and inspection after use:*

  1. Recharge/replace cylinder if at 90% capacity or less
  2. Inspect "O" ring and gasket
  3. Inspect face piece
  4. Clean face piece
     a. Submerge in approved cleaner/disinfectant with warm water
     b. Rinse in warm water
     c. Air dry; do not connect to regulator when low pressure hose is wet
  5. Inspect and clean harness
  6. Check operation of all gauges and valve

Hand-operated resuscitator – Hand-operated resuscitators are used to maintain or restore respiration in an emergency situation; therefore, as a matter of principle, they must function independently of external sources of power especially in disaster situations.

VORTRAN Automatic Resuscitator (VAR) – This is a unique single patient use, disposable resuscitator. It provides consistent, reliable, hands-free ventilator support via a mask or endotracheal tube using a continuous gas flow source. VARs are to be used by properly trained personnel for the delivery of short term, constant flow pressure-cycled ventilator support in emergency and hospital environments. They are cost competitive and provide more consistent ventilation than manual resuscitators.

Intrinsically-safe portable lights – These are designed to eliminate "sparking" which can cause explosions in and around flammable conditions. Intrinsically safe lights are rated by Class, Division and Group. These ratings tell prospective users under what conditions the light will NOT cause explosions.

Salvage equipment

Salvage equipment are used to assist the ship during fire especially while in port/near port.

Fireboat – a specialized watercraft with pumps and nozzles designed for fighting shoreline and shipboard fires. They are frequently used for fighting fires on docks and shoreside warehouses as they can directly attack fires in the supporting underpinnings of these structures. They also have an effectively unlimited supply of water available, pumping directly from below the hull. Fireboats can be used to assist shore-based firefighters when other water is in low supply or is unavailable.

Fire truck / Fire engine – a vehicle designed primarily for firefighting operations. In addition, many fire departments often employ their vehicles for various other uses including emergency medical services and rescue purposes. The terms "fire engine" and "fire truck" are often used interchangeably.

16. Requirements for statutory and classification survey

- The statutory requirements for fire prevention are contained in SOLAS 74 Chapter II/2. It includes fire prevention, protection and fire extinction.
- The specialized firefighting systems, equipment and procedure while carrying dangerous goods are described in emergency procedure of the IMDG Codes.
- The specialized firefighting systems, equipment and procedure while carrying cargoes in bulk are described in BC Codes.
- The specialized firefighting systems, equipment and procedure while carrying liquid chemicals in bulk are described in IBC/BCH Codes.
- The specialized firefighting systems, equipment and procedure while carrying liquefied gasses in bulk are described in the IGC/GC Codes.
- The fire protection bulkhead such as A-60 and B-30 class materials, fireproof materials and low flame spread material are tested per fire test procedure code.
- Ships Administration are required to follow the minimum requirements of the IMO and shall also make national rules.
- The classification societies are based on IMO requirements and their own practical requirements.

▪ Structural fire-protection prevention

The ship is divided into main vertical zones by thermal and structural boundaries. A standard fire test is one in which the specimens of the relevant bulkheads and decks are exposed in a test furnace to temperatures corresponding approximately to the standard time-temperature curve. The test methods shall be in accordance with the Fire Test Procedures Code.

"A" Class Divisions – are those divisions formed by bulkheads and decks which comply with the following:

- They shall be constructed of steel or other equivalent material.
- They shall be suitably stiffened.

- They shall be so constructed as to be capable of preventing the passage of smoke and flame to the end of the one-hour standard fire test.
- They shall be insulated with approved non-combustible materials such that the average temperature of the unexposed side will not rise more than 140˚C above the original temperature, nor will the temperature, at any one point, including any joint, rise more than 180˚C above the original temperature, within the time listed below:

  Class "A-60" – 60 min
  Class "A-30" – 30 min
  Class "A-15" – 15 min
  Class "A-0" – 0 min

"B" Class Divisions – are those divisions formed by bulkheads, decks, ceiling or linings which comply with the following:

- 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.
- They shall have an insulation value such that the average temperature of the unexposed side will not rise more than 140˚C above the original temperature, nor will the temperature at any one point, including any joint, rise more than 225˚C above the original temperature, within the time listed below:

  Class "B-15" – 15 min
  Class "B-0" – 0 min

- They shall be constructed of approved non-combustible materials and all materials entering into the construction and erection of "b" class divisions shall be non-combustible.

Other structural fire-protection provisions include:

- Lockers for combustible materials
- Use of flame-retardant materials
- Flame screens and other devices for preventing the passage of flames
- Use of steel / aluminum construction

- Inert Gas protection on tankers

Inert gas - gases with a low content of oxygen that are used to fill void spaces in and around tanks for explosion protection.

L.S. Regulation 30(1) and SOLAS Ch. II-2 Regulation 4.5.5 require tankers of 20,000 tons or over carrying flammable bulk liquid cargoes (i.e. Crude oil and petroleum products having a flashpoint not exceeding 60˚C), to be provided with an inert gas system complying with the requirements contained in Schedule 9 of MSN 1666(M) or the FSS Code, dependent on date of build.

COMPETENCE: INVESTIGATE AND COMPILE REPORTS ON INCIDENTS INVOLVING FIRE

17. Assessment and causes of incidents involving fire

Ships are at high risk of fire in the same manner as civil or industrial land structures. Ships carry tons of liquid fuel, electrical equipment, air-conditioning plants, engines, boilers, stores of flammable material and crew accommodation areas (kitchens, mess rooms, lounges, cabins, WCs). Added to these are the load which different types of ships carry. Cargo vessels carry a high percentage of solid and liquid goods that are flammable or at least combustible, and often of a dangerous nature. Passenger ships consists of accommodation and entertainment facilities for the passengers and, in ferries, of a large garage for motor vehicles. Offshore rigs and tanker storage ships are essentially oil plants.

What are the most common causes of fires aboard ships?

Fires on ships usually start in either the accommodation area or the engine room.

Some of the most common reasons why accidental fires can start on board ships include:

Leakage in high pressure pipes

In older ships, fire can start due oil leakage from a high-pressure pipe resulting from improper fitting. The leaking oil falling on an indicator cock or exhaust manifold can cause spontaneous combustion, which can quickly spread through the entire generator and engine room.

Electrical failure or overload

Technical reasons like overloading of switches, use of open or loose wires, battery failures, overheated appliances, unattended circuits that can lead to a spark, etc. can start fire even under strict supervision of electrical equipment usage on ships.

Damage during maintenance operations

Another cause of fire onboard ships are maintenance operations like a spot of welding or gas cutting. Welding is a routine part of ship maintenance but needs to be performed under careful observation to avoid mishaps due to sparks, hot metal welds, or improper fitting of equipment like non-return valves or flame arresters, etc.

Human fault

Despite the extensive trainings that seafarers receive, careless human behavior have resulted in fire on board ships. This could include smoking cigarettes while lying on the bed or throwing live ends into dust bins, unattended appliances during ironing, cooking, charging, overloading switches by using multiple gadgets at once, etc.

Control of fire in various parts of the ship

Fire in the machinery spaces

- *Causes:*
  - Combustible liquids and flammable fuel leaking through faulty or damaged connections
  - Oil-soaked insulation
  - Hot surfaces (exhaust pipes, engine parts over heating in close proximity to oil lines)
  - Lagging defects

- Hot works (welding, cutting by oxy-acetylene)
- High voltage electrical equipment
- Internal combustion engines

○ *Methods of containment:*
- Watertight doors
- Fire doors
- Dampers (ventilation)
- Water spray and screens with remote control system

○ *Methods of detection:*
- Fire / flame detectors
- Smoke detectors
- Heat detectors
- High temperature probes
- Patrol / Alarm system

○ *Firefighting equipment:*
- Fixed fire-fighting system (fire main, CO2, sprinkler system, high expansion foam system)
- Portable fire extinguishers
- Semi-portable / Mobile fire extinguishers

Fire in the galley

○ *Causes:*
- Overheating of combustible liquids and fats
- Overheating of deep-fat fryers
- Hot surfaces
- Defective electrical connections
- Greasy flues

○ *Methods of containment:*
- Fire doors, ventilation and flue dampers
- Fire blankets

○ *Methods of detection:*
- Smoke detector
- Patrols

○ *Fire-fighting equipment:*
- Fixed system
- Portable fire extinguishers

Fires in radio / battery rooms

○ *Causes:*
- Overloading and short circuits
- Defective insulation

- Fractures and loose connections
- In battery room, buildup of hydrogen (due to lack of ventilation) and its ignition

o *Methods of containment:*
- Fire doors, ventilation dampers

o *Methods of detectors:*
- Routine check / observation

o *Fire-fighting equipment:*
- Portable fire extinguishers

Fire in hold and containers

o *Causes:*
- Cargoes liable to self-heating and spontaneous combustion, and bulk cargoes that can possibly emit flammable gas
- Loss of packages containing explosives, flammable or reactive substances
- Collection of oily materials as a result of insufficient cleaning and of leakage from tanks

o *Methods of containment:*
- Hatch covers, tween-decks and hull structure
- Use of dampers
- Remote control of extinguishing media

o *Methods of detection:*
- Smoke detectors
- Temperature probes

o *Fire-fighting equipment:*
- Fixed systems
- Portable fire extinguishers
- Mobile fire extinguishers

Fire in accommodation

o *Causes:*
- Combustible materials
- Matches and cigarettes
- Textile adjacent to hot objects such as radiators and lamps
- Defective and overloaded electrical systems
- Laundry equipment (dryers, washing machines etc.)

o *Methods of containment:*
- Fire doors and dampers
- Sprinkler system
- Fire retardant materials in construction
- Fire retardant deck coverings
- Fire retardant furnishing

- *Methods of detection:*
  - Smoke detectors
  - Temperature probes
  - Sprinkler system
  - Patrols

- *Fire-fighting equipment:*
  - Fixed system
  - Portable fire extinguishers

Safe Practices to Prevent Fire

- *Some general safety procedures to prevent fires onboard:*
  - No smoking in hazardous areas
  - Cleanliness
  - Good housekeeping
  - Ability to recognize fire hazards and to take the necessary steps to prevent fires

- *For the engine-room:*
  - Ensuring insulation and lagging are kept in good condition
  - Eliminating oil leaks and preventing accumulation of oil
  - Taking proper fire precautions when welding or burning is being carried out
  - Checking that caps and cocks for sounding pipes to oil tanks are closed
  - Maintaining a clean engine-room, removing oil-soaked rags

- *For the galley:*
  - Keeping extraction fan and flue-gas duct clean
  - Ensuring cooking oils do not spill on top of the stove or overheat in electrical cooking pans
  - Keeping electrical installations well maintained

- *For the accommodation areas:*
  - No smoking in bed
  - No unauthorized electrical fittings
  - No emptying of ashtrays into wastepaper bins without ensuring all cigarette ends are extinguished

- *For cargo spaces:*
  - Ensuring hatches are correctly cleaned
  - Ensuring cargo is stowed and ventilated in accordance with the rules
  - Prohibition of smoking during cargo-working periods
  - Securing of cargo
  - Inerting the atmosphere in cargo compartments when required
  - Ensuring hold/cargo compartment lights are switched off and cargo clusters disconnected, removed and stored away after use and before closing of hatches

Safety precautions everyone should follow

To ensure the safety of every seafarer, SOLAS has decreed that all ships and sailors comply with the International Fire Safety Systems code. Some of the mandatory requirements of the FSS code include carrying pumps sufficiently strong to direct two powerful streams of water at the fire, fire-fighting equipment and personal life-safety appliances, design specifications for appropriate ventilation, and personnel training. Apart from these, some of the basic rules seafarers can follow to prevent accidental fires on ships include:

- Prohibition of open flame on ships or in cabins, such as candles, cigarettes, or incense sticks, unless they are lit in the presence of people and extinguished before leaving
- Ensuring that circuit overloading is avoided at all costs
- Avoiding carrying of oil rags into cabins or accommodation areas where the possibility of accidental flames is higher
- Not leaving oil pans unattended in the open
- Following all safety procedures while performing maintenance operations like welding or gas cutting where flammable material is involved
- Complete understanding of fire-fighting equipment and basic training in its operation

18. Fire investigation and reporting

- Fundamental purpose
  - To determine the circumstances and causes of the incident with the aim of improving the safety of life at sea and the avoidance of accidents in the future
  - To identify the different factors contributing to the incident based on the conclusions drawn in the reports

- Investigation into the fire should record the following:
  - Discovery of the fire (HOW)
  - When and how the fire alarm was given
  - Time at which the Master or other officers were informed
  - Conclusions on the cause of fire and recommendations to avoid re-occurrence
  - Position and nature of the fire
  - Persons in the fire outbreak
  - Initial firefighting procedures used
  - Number of fireman's outfit and SCBAs (CABA) used
  - Appliances used (fixed / portable)
  - Manpower used
  - Time of fire extinguishment
  - Number of casualties/injuries and nature or degree of injuries
  - Damages caused to ship's structure, fittings and machinery
  - Duration of fire watch maintained after fire was extinguished
  - Extent of ship's immobility because of the fire
  - Analysis of the fire, materials burning and the known probable sources and causes of ignition

- The report on the investigation will include the following:
  - The occurrence and the time table of the fire
  - The actions taken and the time for each action
  - The facts concerning the fire, including its site, materials and ignition
  - The fire-extinguishing appliances required for firefighting and the numbers of each type used
  - The number of crew and shore fireman (if appropriate) engaged in fire fighting
  - The number of fireman's outfit and CABAs used
  - The damage caused by fire
  - The damage caused by the fire extinguishing media
  - The extent to which the ship or its services were immobilized by the fire

- Conclusion from the facts established:
  - An analysis and discussion of the facts
  - The conclusions reached from this analysis and discussion
  - Recommendations on the actions required to avoid a recurrence
  - Recommendations, if any, to improve fire prevention and firefighting procedures

Nature of Fire Investigations

A fire or explosion investigation is a complex endeavor involving skill, technology, knowledge, and science. The compilation of factual data, as well as an analysis of those facts, should be accomplished objectively, truthfully and without expectation bias, preconception or prejudice.

Basic Procedure for Fire Investigations

The basic methodology of the fire investigation should rely on the use of a **systematic approach** and attention to all relevant details. The use of a systematic approach often will uncover new factual data for analysis, which may require previous conclusions to be reevaluated. With few exceptions, the proper methodology for a fire or explosion investigation is to first determine and establish the origin(s), then investigate the cause: circumstances, conditions, or agencies that brought the ignition source, fuel, and oxidant together.

4.1 Case studies

(Reports taken from IMO Model Course 2.03)

INTERNATIONAL CHAMBER OF SHIPPING
CASE STUDY No. 1

1. Situation

A cargo ship of 26,000 tons DWT built in 1970 was on passage from Canada's western seaboard to Europe with a cargo of timber products and a full deck cargo of timber. The vessel had been on passage for 24 days when the fire was discovered.

Two days before the discovery hurricane weather conditions had been experienced in which the deck cargo had shifted. The wind had moderated but fairly heavy sea conditions were prevailing at the time of discovery.

2. Initial Action

The bridge smoke detection cabinet gave first indications of a fire in No. 2 hold. The audible alarm did not function. However, at 1222 hours smoke was observed in the vicinity of No. 2 hatchway.

The Officer of the Watch immediately sounded the fire alarm; engines were put on 'standby' and tie ship's speed reduced.

3. Tactical Fire Fighting Procedures

No. 2 hold was sealed and carbon dioxide injected by the ship's fixed installation. Six fire hoses were used for cooling decks and timber in the vicinity of the hold.
At 1406 hours, the ship resumed full speed.

At 17.03 hours smoke was again seen in the vicinity of No. 2 hatch. More carbon dioxide was injected. At 19.00 hours No. 1 and No. 3 holds were examined and found normal.

From then onwards, carbon dioxide was injected into No. 2 hold at hourly intervals, and decks and the timber cargo in the vicinity were cooled continuously. Examinations of No. 1 and No. 2 holds were made at regular intervals.

On the twenty-sixth day of passage when smothering and cooling procedures had been in progress for 44 hours, the vessel altered course for Falmouth. The Owners made arrangements with the Falmouth Fire Service for equipment and firemen to be available when the ship arrived.
Thirteen hours after altering course a small explosion was heard in No. 2 hold. Eight hours later, the supply of carbon dioxide ran out. By this time the vessel was within two hours steaming from Falmouth. Since the discovery of the fire a south-westerly wind between 5-8 force had been experienced. Two hours after picking up the Falmouth Pilot and Harbor Master the local fire service boarded the ship moored in the harbor and commenced arrangements to control the fire.

It was decided to inject high expansion foam into No. 2 hold through ventilator trunks at the aft end. To accomplish this, a portable foam generator was shipped and timber shifted to give access. Foam

was fed through a large diameter polyethylene pipe and vents forward were opened to allow the extinguishing agent to spread through the hold. The ship's carbon dioxide supply was replenished and a 30-cwt. tank of carbon dioxide shipped on deck to supplement the fixed installation. Two days after arrival at Falmouth the vessel sailed for its first scheduled discharge port, Cardiff, with six firemen on board.

On the twenty-one-hour passage from Falmouth to Cardiff, smoke and steam were observed. During' this period the level of high expansion foam in the hold was maintained.

At Cardiff the local fire service relieved the firemen onboard and stood by while timber, destined for the port, was discharged. Further foam was injected into the hold. After removing timber from No. 2 hatch, it was found that water had entered the hold causing cargo to swell, as a result of which the hatch covers had lifted and become distorted. It was decided not to open up No. 2 hatch as it was felt that further ingress of air would increase the fire risk.

Temporary repairs were carried out and the vessel sailed for its second scheduled discharge port, Antwerp, with two firemen on board.

On the fifty-one-hour passage from Cardiff to Antwerp, bad weather conditions prevented the inspection of No. 2 hold but it was then discovered that the hatch covers had lifted further due to the ingress of sea spray swelling the cargo. On entry, the hold was found to be cool although traces of item were being emitted. Hold temperatures were taken throughout and the high expansion foam topped up as necessary. The condition of other holds was found to be normal.

On arrival at Antwerp the local fire service attended. It was decided that they need not remain aboard but should attend when No. 2 hatch covers were removed to discharge cargo.

When the hatch covers were eventually removed, traces of steam were observed. During discharge, which took place with little difficulty, the cargo was found to be cooling rapidly and no further outbreak of fire occurred. It was evident that the high expansion foam had penetrated the entire cargo.

4. Damage and Personal Injuries

There was considerable charring and water damage to cargo in No. 2 hold and to the deck cargo above this hold. Structural damage had occurred to hatches, hatch comings, deck plating and associated stiffeners due to the ingress of water swelling the cargo. No personal injuries were sustained.

5. Cause of Fire

The seat of the fire in No. 2 hold was located in sulphite paper rolls. The cause was not determined.

The suggestion that steel wrapping bands on the cargo rubbing adjacent steel structure could generate sufficient heat to cause the fire was discounted, as was the suggestion that breakage of a wrapping band caused a spark. There is no evidence that this product ignites through spontaneous combustion. The most logical explanation is a carelessly discarded cigarette or cigar. Experiments have shown that sulphite paper will smolder and burn very slowly without generating much smoke or heat if in contact with a lighted cigarette.

6. Tactical Fire Fighting Appraisal

The smothering and cooling procedures used kept the fire under control. Had the vessel been further from a port of refuge, with depleted supplies of carbon dioxide, the situation would have been far more serious.
Foam penetration in the hold was probably a major factor in extinguishing the fire.

7. Remedial Action Taken by Company

High expansion foam generators have been supplied to vessels as well as operating and testing instructions for smoke detectors. Testing of detectors is now being regularly carried out.

8. Conclusions

Regular inspection of the hold spaces may well have detected this fire at an earlier stage, It is considered that some damage had already occurred to the hatch which allowed the escape of smoke when the fire was discovered.

The use of water in fighting the fire in the hold would have caused swelling of the cargo and may have caused more structural as well as cargo damage.

INTERNATIONAL CHAMBER OF SHIPPING
CASE STUDY No. 2

1. Situation

This report concerns an engine room fire on an ore carrier of 18,300 DWT, built in 1960, proceeding on a short coastwise passage in United Kingdom waters. The main propulsion machinery was a five cylinder turbo-charged unit, which at the time of the incident was operating on diesel fuel.

Before the start of the voyage, the fuel valves of No. 4 and No. 5 cylinders had been replaced by overhaul spares. During the passage, the Third Engineer was rectifying minor leaks in the fuel lines to these replacement valves and while attempting to tighten a connection, the stud coupling sheared. Escaping fuel ignited on contact with the exhaust manifold.

2. Initial Action

The Third Engineer informed the Second Engineer who was at the main engine controls. He then returned to tackle the fire with a two-gallon foam extinguisher. The Second Engineer sounded the general alarm and instructed a Junior Engineer to advise the bridge. The main engine was stopped and the fuel oil booster pump shut down. The Second Engineer then went to the outbreak where the Third Engineer and fireman greaser were attacking the fire with portable foam extinguishers. The fire was getting out of hand and all three, two Apprentices and the Junior Engineer evacuated the engine room. At this time, the Chief Engineer who had been off duty arrived and assumed command of the fire-fighting operation.

3. Tactical Fire Fighting Procedures

Meanwhile, the Electrician had activated the CO_2 discharge system alarm but had not operated the release valves. He was told not to do so by the Chief Engineer so that the situation could be assessed and a check made that all personnel had evacuated the engine room. The electrical shutdown switches were operated and engine room skylights, vent flaps and funnel dampers closed. Deck personnel were

set to rigging hoses and smoke masks, catering staff and other Junior Engineer collected five extinguishers in readiness for use.

The fire appeared to be seated at the exhaust trunking system in a way of No. 5 cylinder. The Chief Engineer and storekeeper used foam and soda acid extinguishers but were unable to get close enough because of thickening fumes and smoke. An attempt to clear the atmosphere by opening the skylight caused a flare up. All the quick-release valve gears were operated except the fuel supply to the generators which was clear of the fire.

By this time, the fire had begun to subside but flared up as spilled fuel on the cylinder head footplates dripped to the exhaust system. The Second Engineer and the Electrician, both wearing smoke helmets and the Chief Engineer, without a smoke helmet so he could move more freely to direct operations, applied water from hoses fitted with spray jets to the exhaust manifold and the adjacent floor plates. A rescue party stationed outside helped to maneuver the hoses. The Chief Engineer was of the opinion that the situation was coming under control but at the same time a glow was noticed in the area of the workshop aft and purifier flat at the upper platform level. It was thought that the fire had spread to these parts where lubricating oil and kerosene tanks were located, and it was decided to close the fuel supply to the generators, vacate the engine room and discharge CO_2 into it. This decision had been delayed for some forty minutes as the ship was in a buoyed channel and hitherto the apparent seat of the fire had not endangered these tanks.

As soon as the fumes had cleared, the Chief and Second Engineers checked the engine room casing for hot spots but found none. By 1400 hours, thirty minutes after discharging the CO_2, the Chief Engineer was convinced that the fire was extinguished but decided to allow further time for the exhaust manifold to cool down to avoid the possibility of re-ignition when the engine room was opened up for inspection.

At 1500 hours, the Chief Engineer entered the engine room wearing a smoke helmet and safety line. A hose party stoodby. The fire was out and unlikely to restart. Skylights were eased up to ventilate the space and as soon as power had been restored, the engine room forced ventilation fans were started.

4. Damage and Personal Injuries

The main engine turbo-blower was seriously damaged, in particular the circular frame, inner and outer suction nozzles and the air inlet filter elements.

Exhaust gas by-pass trunking was fitted and after repairs had been made to the fuel piping and the whole tested, the voyage was resumed on reduced revolutions.

5. Cause of Fire

The fire was caused by ignition of leaking fuel from a sheared fuel pipe coupling.

6. Tactical Fire Fighting Appraisal

The prompt actions of the Second Engineer confined the fire so that the only serious damage was to the turbocharger.

Allowing for the fact that the ship's position made immediate use of the engine room CO_2 system undesirable, the Chief Engineer's control of the situation resulted in speedy resumption of normal conditions in the engine room.

After operating the CO_2 system, smoke in the alleyway prevented a check being made that all the bottles had discharged. It was found afterwards that nine bottles out of the total of sixty had not operated because their pull-cord was not properly connected to the operating piston.
In addition to the fifty-one bottles of CO_2 discharged, a total of six two-gallon foam extinguishers and two-gallon soda-acid extinguishers were used.

7. Remedial Action Taken by Company

Firefighting personnel reported that smoke helmets restricted movement and sets of self-contained breathing apparatus were subsequently supplied.

A thirty-gallon foam extinguisher located at the forward end of the boiler flat could not be used due to insufficient length of the hose. This was re-sited at the forward end of the boiler flat could not be used due to insufficient length of the hose. This was re-sited in a position approved by a surveyor of the national administration.

8. Conclusions

This incident demonstrates the need to replace compressible olives in couplings whenever fuel valves are changed – to prevent over-tightening of couplings. Such work should not be undertaken while the engine is running or still hot.

It was reported that too many personnel were attempting to assist fire-fighting and in so doing generally hampering operations. Instructions should be given that all personnel, apart from fire-fighting and back up teams, should muster at an approved position for ease of counting and to facilitate giving of assistance when required.

INTERNATIONAL CHAMBER OF SHIPPING
CASE STUDY No. 3

1. Situation

An 11,000 DWT cargo liner loaded with general cargo and cotton was enroute to the west coast of the U.S.A. when fire broke out in No. 4 hold. Weather at the time was fine with a force 3 wind.

2. Initial Action

At 0105 hours, smoke was seen coming from ventilators at No. 4 hold. The fire alarm was sounded and ventilation fans to the cargo compartments were stopped. The main engines were ordered to “stand by” and the ship was turned off wind.

3. Tactical Fire Fighting Procedures

At 0114 hours, the Engineer of the Watch reported that the bulkhead between the engine room and the No. 4 hold was extremely hot. Shortly afterwards, flames were seen in the after part of the engine room. The main engines were stopped, the skylight and ventilators were closed and the engine room was evacuated.

Meanwhile, the ship's firefighting team led by the Chief Officer had been organized. The emergency fire pump located in the poop section was brought into operation and an attempt was made to gain entry into No. 4 hold but was not possible because of the heat and smoke.

It was decided to tackle both fires with CO_2. Greater priority was given to the engine room fire which was threatening the whole of the mid-ship superstructure. Furthermore, it was hoped this action would enable the main fire pumps to be brought into use to tackle the fire in No. 4 hold but shortly afterwards it was reported that the fire had spread to the store room above and adjacent to the engine room.

The officers and crew's quarters are located on the deck above the store room and the danger of fire spreading throughout the accommodation was imminent. Due to the main fire pumps still being inoperable, the only fire-fighting resources available were the emergency fire pump and portable extinguishers.

Access to the storeroom was through a narrow, smoke-filled passage but two seamen wearing fire suits and compressed air breathing apparatus succeeded in controlling the fire there, while others tackled fires which had broken out in the accommodation above.

At 0230, the fire in the engine room appeared to be extinguished and the storeroom fire brought under control. In No. 4 hold however, the temperature was again rising and it was clear that the CO_2 had only temporary subdued the fire. It was decided to flood the hold using the emergency fire pump. Meanwhile, fires continued to break out in the storeroom and these were tackled with portable extinguishers.

During the firefighting operations, radio contact was established with the ship's agent and with the authorities at the nearest port. Details of cargo composition, draught, weather conditions and the fire situation were given and the assistance of a fire-fighting boat was requested. In addition, lifeboats and rafts were prepared for launching and other precautions taken to abandon the vessel should this become necessary.

At 0650, a fire-fighting tug arrived and increased the rate of flooding of No. 4 hold using three jets.

A second tug arrived at 1215. The jets from the first tug were stopped and the ship was taken in tow; flooding of No. 4 continued, using the ship's emergency fire pump.

At 1940, the vessel arrived in port and the tugs resumed flooding. A further supply of CO_2 was provided and discharged into the hold.

At 0820, the following day, flooding of No. 4 was ceased and at 0900, crew members were able to gain entry to the tween deck. The ship had listed 10 degrees to port and while the portside of the lower hold was filled with water, the starboard side was dry. Hot plating in this area indicated that a renewed outbreak of fire could be expected. The local fire brigade which had been in attendance since the ship berthed cut six holes through the plating and further water was applied by one of the tugs,

At 1500, there were no signs of fire in the hold and at 1640, the hatch cover was opened.

At 1920, the auxiliary engines and pumps were started and the water was removed from No. 4 discharge of damaged cargo began at 1945.

4. Damage and Personal Injuries

Considerable structural and cargo damage was sustained but further details were not given. There were no personal injuries.

5. Cause of Fire

Investigations showed that the fire originated in the middle of the cotton cargo in No. 4 lower hold. The most probable cause was thought to be smoking by dockers during loading. Spontaneous combustion, put forward as an alternate theory, was considered to be less likely.

6. Tactical Fire-fighting Appraisal

The fire broke out at night while the ship was at sea. After the initial outbreak, it spread quickly to the engine room and midships accommodation. Even after the fire in the engine room appeared to be extinguished, the main fire pumps could not be used because of the concentration of CO_2 remaining in the engine room.

The most critical phases of what was a difficult incident to control were successfully tackled by the ship's personnel who acted with determination and skill.

7. Remedial Action Taken by the Company

The incident was studied by the company's safety committee. All senior deck and engine officers undergo compulsory training courses in firefighting. The company also operates monthly safety conferences which officers on shore leave can attend. On all ships, great attention is given to training and fire-fighting drills.

8. Conclusions

This incident demonstrates the value of well-trained personnel on board and an active company policy towards education and training in all safety matters.

INTERNATIONAL CHAMBER OF SHIPPING
CASE STUDY No. 4

1. Situation

A 14000 DWT tanker built in 1970, was undergoing shell-plating and engine room repairs involving welding at a repair berth. The ship was partially manned and, with fire-fighting equipment out of commission while certain items were undergoing inspection ashore, the repair yard had assumed responsibility for fire protection on board.

A shore laborer, engaged in laying alleyway flooring in the aft accommodation, observed smoke coming from a cabin.

2. Initial Action

Finding that there was no fire-fighting equipment at hand, he went on deck and procured a fire hose, only to find that it was not connected to the shore hydrant.

During the time taken to connect the hose, the fire spread from the cabin to the adjacent corridor and dense smoke made it impossible to enter the area.

3. Tactical Fire-Fighting Procedures

The municipal fire brigade was called in but no further details are available beyond the fact that water and foam were used.

4. Damage and Personal Injuries

The entire after part of the ship was damaged. In particular, the accommodation was gutted.
A man working in the engine room perished, although the cause of death is not known.

5. Cause of Fire

As a result of an asbestos fire screen becoming dislodged, cabin furniture and bedding were ignited by heat from exterior welding work.

6. Tactical Fire-Fighting Appraisal

Nothing can be said about the fire fighting procedures adopted, because of the absence of detailed information. However, it is probable that if a watchman had been stationed in the accommodation area and portable extinguishers provided as required by the regulations of the repair yard, the outbreak of fire might have been contained.

Yard regulations also required the following measures: the siting of extinguishers in the vicinity of the gangway, and a fire hose-connected to a shore hydrant at all times on deck.

Non-compliance with these regulations allowed the fire to assume the proportions of a major outbreak. The situation was further aggravated by the fact that free circulation of air could not be eliminated as it was not possible to close doors in the area, due to the presence of cables carrying services for repairs in the engine room.

7. Remedial Action taken by Company

All ships' officers were instructed to make sure, regardless of whoever is responsible for safety when repair work is being carried out, that fire-fighting equipment is available, ready for use, and that the necessary surveillance is carried out, particularly when welding operations are in progress.

8. Conclusion

When a vessel is undergoing repairs, the risk of fire is increased. Shipowners and personnel should satisfy themselves that all the safety precautions are observed especially where the responsibility for ship safety is shared.

INTERNATIONAL CHAMBER OF SHIPPING
CASE STUDY No. 5

1. Situation

An 11000 DWT cargo ship was berthed in an Indian port when fire started in an engineer's storeroom, in which cotton waste had been stowed earlier in the day.

2. Initial Action

At about 1900 hours, smoke was observed coming from the poop deck ventilator and a check was made of the store rooms in the area. The fire was found to be in the engineers' store on the lower deck starboard side.

3. Tactical Fire Fighting Procedures

The poop accommodation was cleared of personnel and at 1930 hour, carbon dioxide was discharged into the store-room from the ship's fixed installation. At the same time the engine room fire pump was started and water was used to cool the ship's starboard side, in way of the storeroom.

The Port fire brigade was summoned and arrived on the scene at 1940 hours to supervise firefighting.

Between 1930 and 2230 hours, 8 cylinders of carbon dioxide (in all about 240 Kgs.) were discharged into the storeroom but the door was not kept properly closed and the gas concentration was too low to be effective.

Hoses were used to flood the storeroom and the fire was eventually extinguished by 0500 hours the following morning.

4. Damage and Personal Injuries

No structural damage of injuries to personnel was sustained.

Fire damage was confined to electrical circuits, fittings and stores in the compartment; engine spares were damaged by water. Flooding also caused drums of paint to float about, spilling their contents.

5. Cause of Fire

Cotton waste, stowed in the storeroom earlier in the day, had been placed in contact with a bare electric light bulb.

At the time the ship's after electric lighting was turned off so that repairs could be carried out to a defective flood light. However, the circuit serving the storeroom light had been left with the switch in the "on" position.

Repairs were completed at 1700 hours and the electricity supply restored. Heat from the storeroom light bulb which, of course, lit automatically, caused the cotton waste to ignite,

6. Tactical Fire Fighting Appraisal

The fact that the door to the storeroom had not been properly closed and that this door was repeatedly opened to observe results, reduced the effectiveness of the carbon dioxide. The compartment had to be flooded to extinguish the fire, causing water damage.

7. Remedial Action Taken by Company

The following instructions were issued by the Company:

- Cotton waste should be stowed to spaces provided for the purpose.
- Paint and cotton waste should not be stowed together.
- All electric light bulbs should have protective guards in place at all times.
- When leaving a compartment, personnel should ensure thatlight switches are in the "off" position.

8. Conclusions

The importance of checking that electrical fittings are in good order and that, when not in use, electric lights are switched off cannot he over-stressed. If proper care had been taken in stowing the cotton waste, there would have been no fire.

INTERNATIONAL CHAMBER OF SHIPPING
CASE STUDY No. 6

1. Situation

This report concerns a fire in the accommodation space of a passenger ship of 25,000 tons which, at the time of the incident was in port, alongside.

2. Initial Action

At 2300, an outbreak of fire occurred in a locker in the Smoke Room. Attempts to extinguish it by means of fire extinguishers were unsuccessful and the general alarm was sounded, the port fire brigade was summoned and the Port Captain's office was also informed. The fire spread rapidly from the locker in to the cavity between the Smoke Room ceiling paneling and the steel deck above. Shortly afterwards, the interior of the ship filled with smoke and instructions were given to evacuate all passengers ashore. The public address system and the general alarm system could no longer be used because the wiring of these systems passed through the locker where the fire originated and had been damaged. Instructions to evacuate were passed orally by members of the crew and the evacuation proceeded in a very orderly manner, being completed by 2345 hours.

3. Tactical Fire Fighting Procedures

At this time four Grinnel sprinkler heads were operating in the Smoke Room, but it soon became clear, from the rapid increase in deck temperatures of the Sun Deck cabins overhead, that the fire was above the deckhead paneling in the Smoke Room. As the continued use of sprinklers was having little effect and was causing unnecessary flooding, the sprinkler system was shut down. The fire brigade produced a smoke extracting pump which was partly effective in clearing smoke in the vicinity of the door into the Smoke Room. With the assistance of breathing apparatus and strong lighting, it was possible to uses hoses on the Smoke Room locker which was still extremely hot.

To check the spread of fire above the deck head paneling, part of the paneling was removed and water was sprayed into the area where the fire was still burning fiercely in the trunkings and ceiling reduced the concentration of smoke. Further deck head panels were removed to release trapped heat and the deck head plating was cooled with water.

The fire was eventually extinguished ad 0030 the following morning.

4. Damage and Personal Injuries

All electrical cables passing through the locker had been badly charred and, in addition to the side paneling in the immediate vicinity of the fire, there was extensive damage to the deck head paneling over a fairly large area.

The steel deck over the area was buckled and a cabin on this deck had been badly affected. There was minor fire and water damage to furniture in the Smoke Room and water damage to some cabins on the deck below, where water had penetrated by way of the stairways.

No personal injuries were reported.

5. Cause of Fire

The fire appears to have been caused by the ignition of waste paper in a refuse bag in one of the Smoke Room lockers. The contents of ashtrays had been emptied into this bag.

6. Tactical Fire Fighting Appraisal

It is possible that the fire had already spread from the locker into the space over the Smoke Room deck head paneling by the time it was detected.

The use of fire extinguishers was not effective but prompt application of water, which had the added benefit of cooling the deck plating above, prevented still greater spread of fire and consequent damage.

7. Conclusions

Despite the obvious risks of putting the contents of ash trays into receptacles containing combustible material, reports of many incidents where fire appears to have been caused by smoking show that human carelessness is all too common.

Although fitted with a sprinkler system, the construction of the deck head paneling was such that a fire, which started at a lower level, was able to spread into the space between the paneling and the steel deck head and affect a wide area of this space.