Introduction and review of basic principles

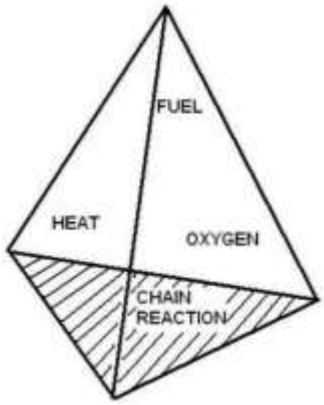
This course has been designed to meet the requirements of STCW Regulation VI/3, Section A-VI/3, Table A-VI/3 and is based on the guidelines of IMO Model Course 2.03.

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

- ### Theory of fire

To start a fire requires *fuel*, *oxygen* and a *source of ignition (heat)*. These requirements are often represented by the sides of the familiar fire triangle. Conversely, removal of any side of the triangle or breaking the chain reaction between the transient chemical species formed following ignition will extinguish a fire. It is therefore more appropriate to use a fire tetrahedron to represent the ways a fire can be extinguished. In the tetrahedron, the chain reaction is represented by its base.



Removal of oxygen

Except in those substances that contain their own oxygen, the removal of sufficient oxygen will extinguish a fire.

Small fires can be smothered with sand from a fire bucket, and a rug or blanket can be used to smother flames from a person's clothes. Ensure the door is properly closed when leaving a fire to burn in a compartment or room.

Fires in cargo holds can be starved of oxygen by closing hatches and blanking off ventilators. In all spaces affected by fire, ventilation fans should be shut down and doors and other openings closed.

Oxygen is also cut off during the operation of portable and semi portable carbon dioxide extinguishers and to some extent, during the operation of dry powder extinguishers. But for CO_2 and dry powder, the smothering action is temporary and there is a possibility for re-ignition.

In total flooding by fixed fire extinguishing systems on board ships, carbon dioxide displaces the air inside the compartment and fire is extinguished due to insufficient oxygen.

Removal of heat

A reduction in temperature is achieved by the use of a suitable cooling medium, normally water, at a sufficient rate. Cooling of boundary bulkheads will reduce the possibility of igniting material outside the affected compartment.
For a given quantity of water, about six times more heat will be removed if the water droplet size is small enough for it to be vaporized into steam. Heat can also be absorbed by decomposition of dry powder.

Removal of fuel

The removal of fuel is not always possible. However, in the case of liquid fuel fires caused by leaking pipes or fittings, the fuel supply should be closed. It may also be possible to drain the fuel from a burning tank.

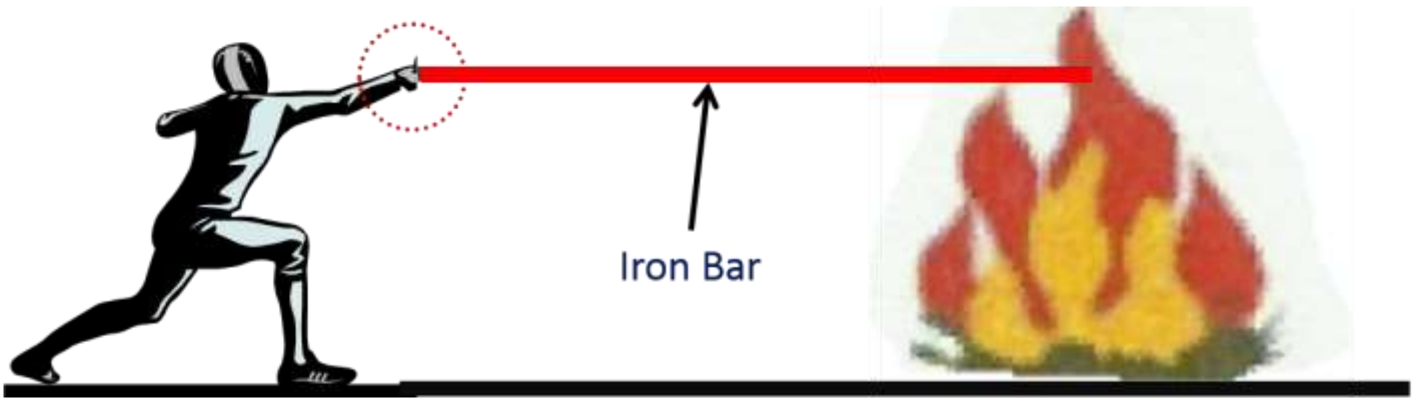
It is particularly important to shut off the supply in a gas fire. However, gas could also be left burning in a controlled manner to exhaust itself. In accommodation spaces, combustible materials should be removed from the vicinity of fire, including any adjacent compartment affected by the heat.

Breaking the chain reaction A fire may be extinguished by breaking the chain reaction between chemicals produced on ignition. For instance, halogenated hydrocarbons (halons) and dry powders attack the structure of the compounds and prevent their reaction by killing the flame, sometimes in less than one hundredth of a second. The extinction takes place without any appreciable removal of heat, fuel or oxygen. However, the remaining three sides of the tetrahedron will still be present and, unless the heat is removed, there is a danger of re-ignition if the concentration of extinguishing agent is not maintained.

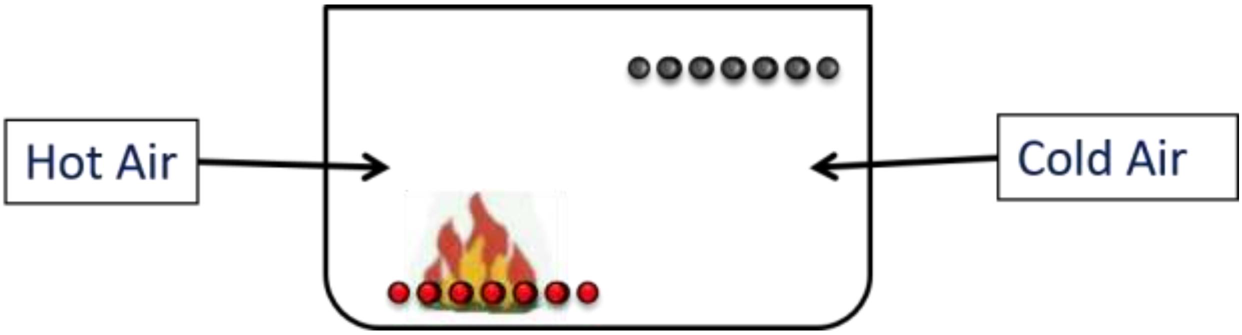
- How fire spreads

When a fire gets out of control, it will spread in many different directions unless stopped by cooling or other means. The fire will spread because materials in its vicinity are heated to their ignition temperature. HEAT is transferred in three ways:

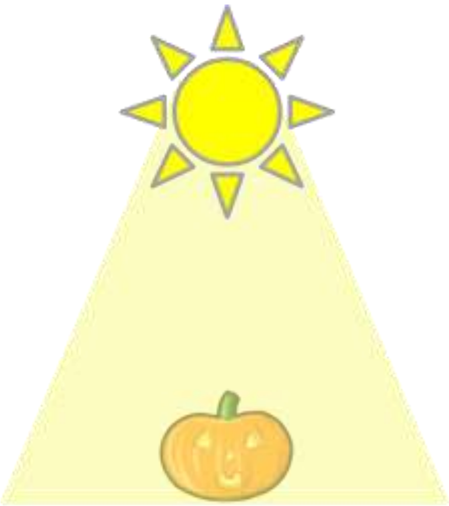
1. ***Conduction*** – the process of heat transfer by 'collision of molecules' in a substance. As temperature increases, molecules move faster and strike other molecules harder and more often. An example of this is when an iron bar is held at one end with the other end in a fire, the molecular motion at the hot end increases and the heat gradually travels along the bar by the increase in the motion and collision of molecules, until it can be felt by the hand.

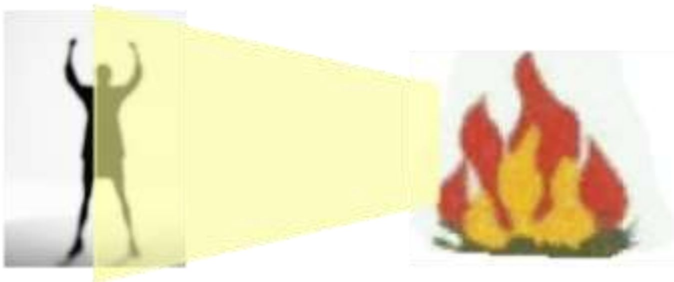


2. ***Convection*** – usually takes place in fluids. As a fluid is heated, the molecules increase in motion and the fluid begins to expand as molecules move further apart. This results in a decrease in density which causes the hotter fluid to rise and the cool fluid to fall, setting up a circulation within the fluid.



3. ***Radiation*** – Radiated heat is illustrated by the heat of the sun which reaches earth as 'rays' of heat energy which are invisible but similar to rays of light. Another example is heat from an open fire - when you are standing in front of the fire, the side facing the fire becomes warm while the other side remains cool.





- Properties of flammable materials

Flash point – The lowest temperature at which a heated liquid's vapor/air mixture can be ignited ("flashed") by a flame or spark, or other ignition source placed above the liquid surface.

Fire point – The lowest temperature at which a heated liquid's vapour/air mixture will burn continuously when combustion is supported by ignition sources.

Combustibility – This is a measure of how easily a substance will burn through fire or combustion.

Auto ignition temperature – The lowest temperature at which a heated liquid's vapours in air will self-ignite and burn, without exposure to any ignition source.

Flammability – This is how easily something will burn or ignite, causing fire or combustion.

Lower Flammability Limit (LFL) – Usually expressed in volume per cent, this is the lower end of the concentration range of a flammable solvent at a given temperature and pressure for which air/vapor mixtures can ignite.

Upper Explosive Limit (UEL) or Upper Flammability Limit (UFL) – The maximum concentration of gas in air that will produce combustion. Any higher percentage of combustible gas or lower amount of oxygen in the mixture of the two, and the mixture will be too "rich" to sustain combustion.

Flammable range or Explosive range – The range of a concentration of a gas or vapour that will burn (or explode) if an ignition source is introduced. Below the explosive or flammable range the mixture is too lean to burn and above the upper explosive or flammable limit the mixture is too rich to burn. The limits are commonly called the "Lower Explosive or Flammable Limit" (LEL/LFL) and the "Upper Explosive or Flammable Limit" (UEL/UFL).

Ignition Point - The minimum temperature at which a substance will continue to burn without additional application of external heat.

Thermal value – Heat produced by combustion, usually expressed in calories per gram or British thermal units per pound.

- Classification of fire

CLASS A Solid fire; fire involving ordinary combustible materials (wood, cotton, paper, rope, plastic rubber, etc.)
Characteristics: deep-seated, leaves embers and ashes
Extinguishing agents: Water; foam and powder are also used

CLASS B/C Liquid and gas fire; fire involving flammable liquids and gases (gasoline, diesel, paint, grease, LNG, LPG, acetylene, etc.)
Characteristics: surface-burning, explosion hazard
Extinguishing agents: Foam or powder; CO2 may also be used. Never use water on CLASS B fire!

Note: In US system "Class B" fires are fires whose fuel is flammable or combustible liquid or gas. In the European/Australian system, flammable liquids are designated "Class B", while burning gases are separately designated "Class C".

CLASS C/E Electrical fire; fire involving energized electrical equipment (generators, electrical motors, transmitter switches, fuses, etc.)
Characteristics: shock hazard
Extinguishing agents: CO2; dry powder may also be used

Note: The US system designates these "Class C" while the Australian system designates them "Class E".

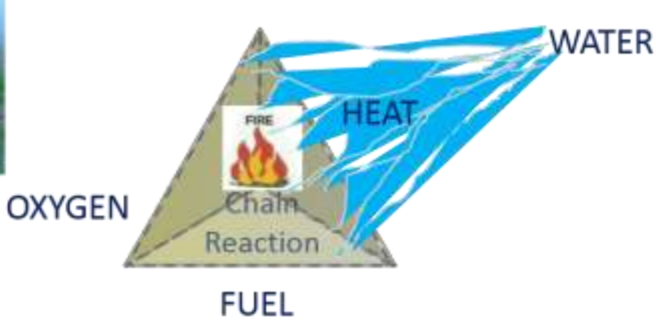
CLASS D Metal fire; fire involving combustible metals (Magnesium, potassium, Titanium, Aluminum, etc.)
Characteristics: explosion hazard
Extinguishing agent: Multi-purpose, dry powder, CO_2

CLASS K/F Fire involving combustible oils and grease commonly found in commercial kitchens.
Characteristics: Higher flash point
Extinguishing agent: Wet chemical fire extinguisher. The new cooking formulations used for commercial food preparation require a special wet chemical extinguishing agent that is especially suited for extinguishing these hot fires that have the ability to re-flash.

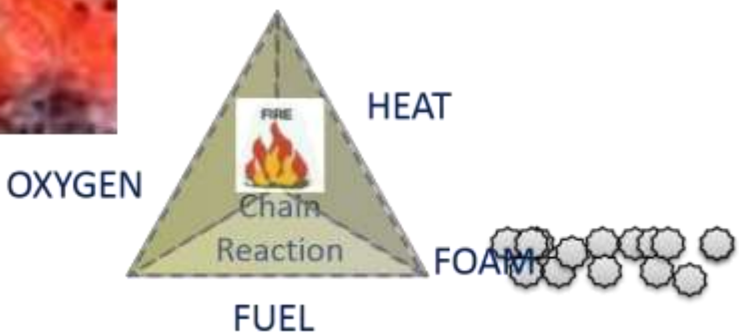
Note: It is designated "Class K" under the American system, and "Class F" under the European/Australian systems.

- Methods of extinguishment

Cooling – to reduce the temperature of a fuel below its ignition temperature. This is a direct attack on the heat side of the fire tetrahedron.



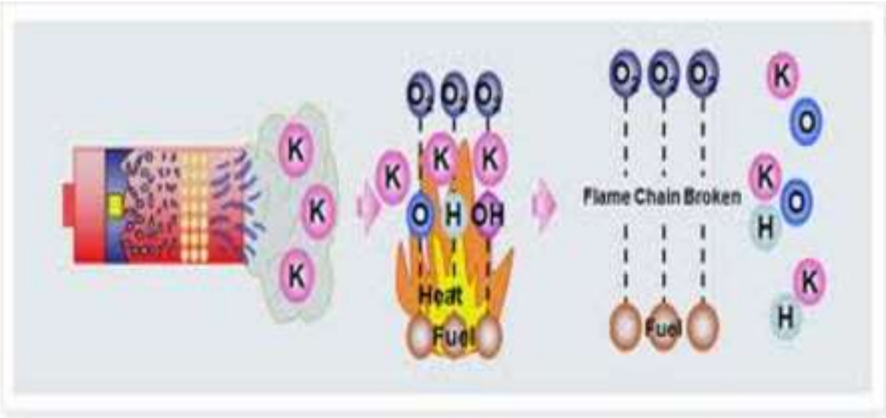
Starvation – the fire will not sustain combustion if the source of the fuel is removed. Eliminate any inflammable materials from the fire area; turn the valves off.

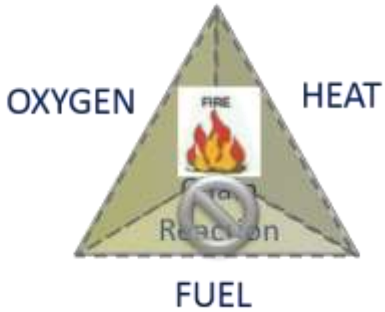


Smothering – to separate fuel from oxygen. This can be considered as an attack on the edge of the fire tetrahedron where the fuel and oxygen meet.

Oxygen Dilution – to reduce the amount of oxygen below the needed amount to sustain combustion.

Chain breaking – to disrupt the chemical process that sustains the fire.





COMPETENCE: CONTROL FIREFIGHTING OPERATIONS ABOARD SHIPS

1. Use of water for fire extinguishing

- **Fire extinguishing effect on ship stability**

As we all know, the ship is surrounded by large amount of water specifically when at sea. This water, which is the seawater, can be utilized to extinguish fire onboard ships. It can be through the use of the Emergency Fire Pump or by the Hyper Mist Pump. Water mist has been determined to be a preferred alternative to Halon 1301 total flooding to extinguish fires occurring in ship machinery spaces and pump rooms, because it is toxicologically and physiologically inert.

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 as free surface effect of water will come into effect thereby reducing the GM of the ship. Draining of particular cargo hold which is flooded to extinguish fire is absolutely important 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 in such cases is to be judicially monitored during the entire firefighting operation
- Firefighting, where water 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

○ *Dewatering*

The best defense is to plan for eventualities. When pre-fire planning, estimate the amount of water to be used for a given scenario and its potential effect on the vessel's stability. Then plan how to dewater, preferably during fire-fighting operations. This may be done by using existing drains and scuppers, using fixed and portable pumps or ejectors or by facilitating the flow either over side or to the lowest possible point in the ship.

When fire fighting in port, booms is usually rigged to minimize the environmental effect of runoff water. Upper sea intakes are used more in port to prevent silt and debris entering so care must be taken with runoff, especially if fuel or lubricating oils escape as they may be sucked into machinery and could precipitate an even more disastrous situation.

○ *Estimating quantities*

When planning emergency response to fire and damage control, stability must be considered. The volume of water required to extinguish a fire in a given compartment may be estimated by the formula:

$$(length \times height \times width) \div 100 = \text{gallons per minute required}$$

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 FSE of a given compartment may be estimated by calculating the moment. The formula for the moment is: $i = LB^3 \div 12$

2. 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. However, once a fire has started, a well-trained crew is the best defense for bringing the fire under control. Given the complexity of extinguishing a fire involving dangerous goods, it is essential that the advice in this Guide be incorporated into the ships training regime so that the crew will be able to respond to a fire casualty in a timely and effective manner.

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

COOL AND SUFFOCATE – In general, fires require heat (energy) and oxygen to start burning. Only a limited number of chemicals do not need oxygen from the air. Therefore, 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 – Expert advice should be sought irrespective of 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 – Depending on the type of ship and on the volume of dangerous goods allocated to this specific type of dangerous good, it may be necessary to consider abandoning the ship at an early stage. 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 maybe use 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

- Where possible, packages should be removed from the vicinity of the fire. In general, heated material will expand thus needing more volume and creating pressure in the package. This will affect the integrity of the package, which could lead to rupture, and dispersal of the contents. Effective cooling can lower the possibility of rupture
- It should be remembered that 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 firefighters 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

COMPETENCE: ORGANIZE AND TRAIN FIRE PARTIES

3. 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

4. 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.

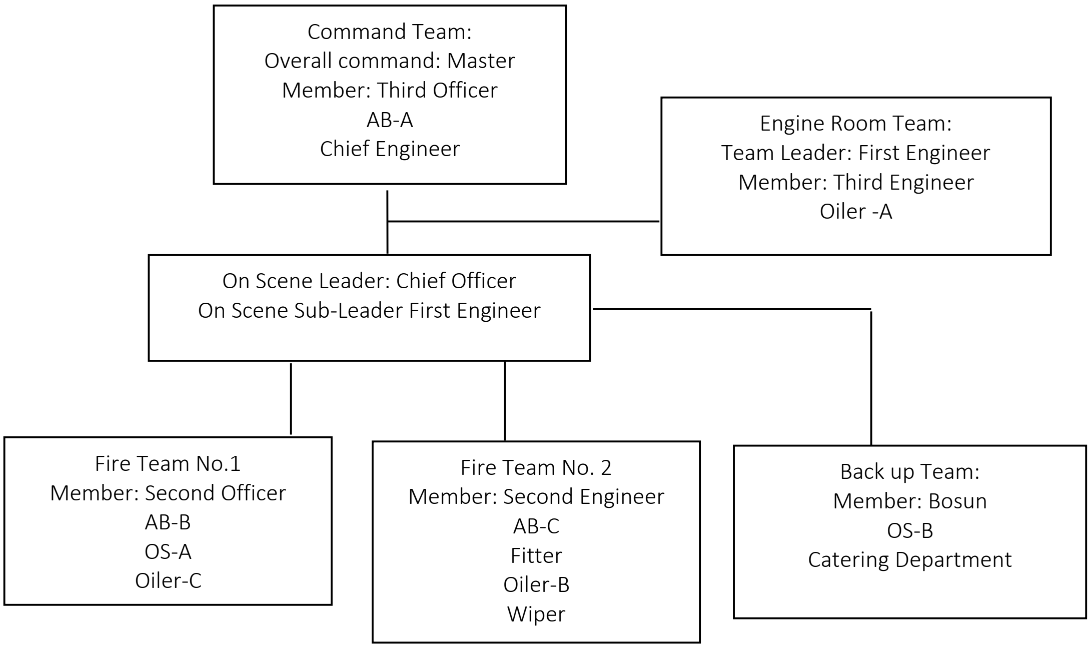
ENGINE ROOM TEAM

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:

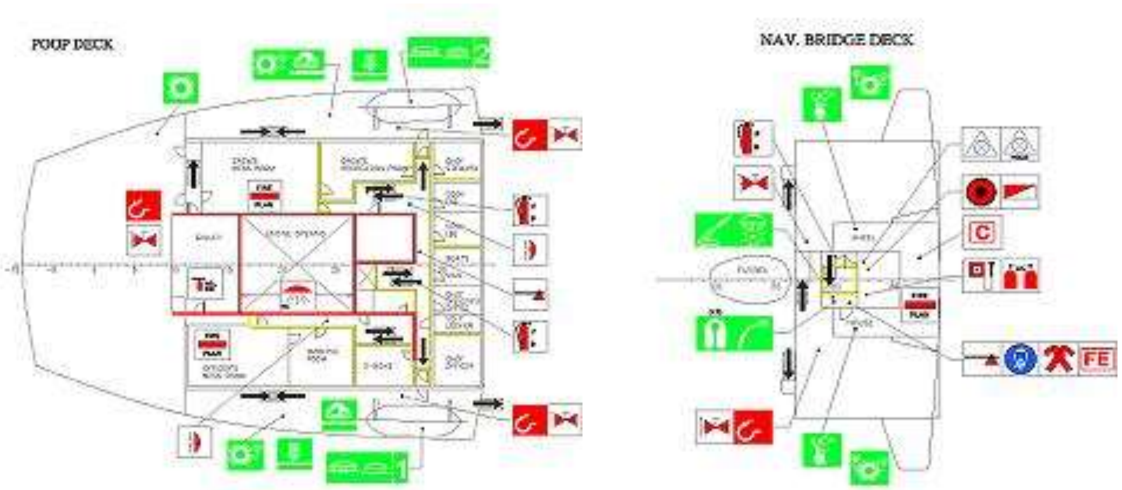
- Firefighting (all members)
- Enclosed space entry (all members using SCBA)
- Search and rescue techniques
- Observant and able to communicate

- 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

5. Strategies and tactics for control of fires



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.

1. 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.
2. Exit doors and passages
3. Emergency exits
4. Emergency stops of the ventilation (engine room, accommodation, pump rooms) – ventilation, flaps and fan switches either local or remote control.
5. Fire pumps
6. 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.
7. 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.
8. Positions and types of fire extinguisher
9. Position of International Shore Connection
10. Location of alarm apparatus
11. Location of the release arrangements for the fixed extinguishing installations
12. Location of fireman's outfit

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

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

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

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

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

6. FIRE DETECTION SYSTEMS

▪ Fire alarms

- 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
- 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.
- 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 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.

▪ 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 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.

3.2 Fire detection equipment

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.

- 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

- 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 70°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.

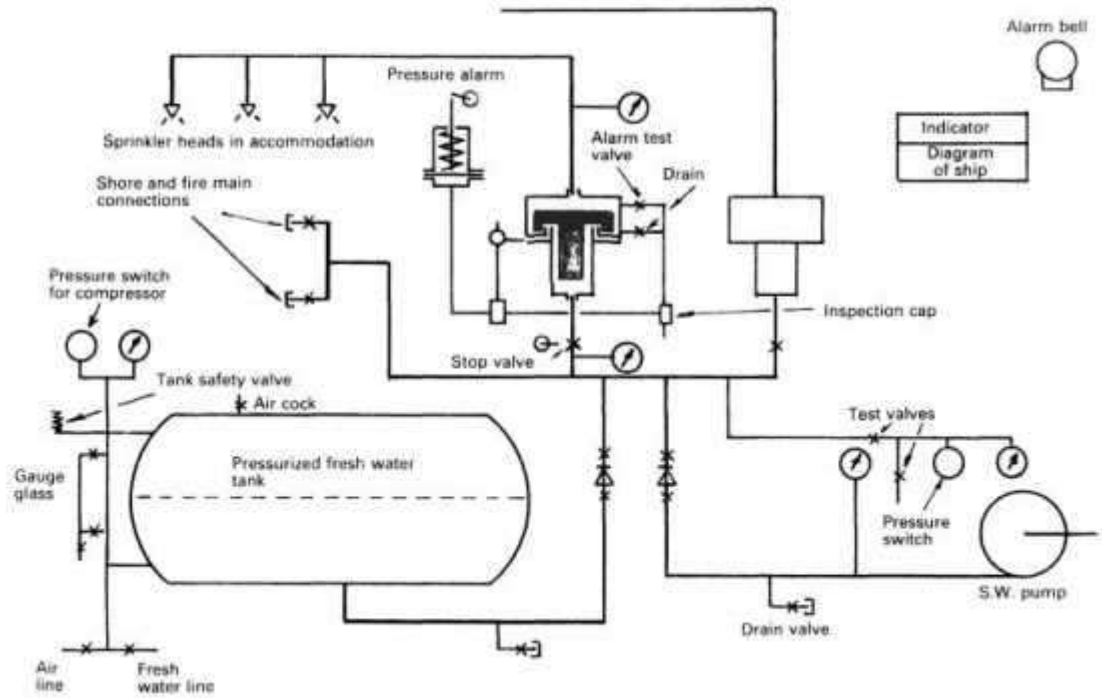
Vibrating bells – They are like the red lights on the control unit fire alarm signal, the operation of any automatic fire detection system (or manual fire alarm in a manual fire alarm system) must automatically cause sounding of vibrating bells.

Fixed fire extinguishing equipment

- Automatic sprinkler system

The sprinkler system is an automatic fire detecting, alarm and extinguishing system which is constantly on guard to deal quickly & effectively with the outbreak of fire that may occur in accommodations and other spaces.

This 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 least5 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**

This system is used mainly in fighting class B fires, although low expansion foam (with a high water content) can be used to extinguish class A fire. The foam extinguisher is 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

Deck foam system is required on all tanker vessels by the 1970 tanker vessel regulation. The foam system replaces the inert gas smothering system for improved fire protection. The deck foam system 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).

The capacity of any monitor shall be 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. The capacity of any applicator shall not be less than 400 liters/min and the applicator throw in still air condition shall not be less than 15 meters.

- CO2 fixed fire suppression systems

Fixed Carbon Dioxide Extinguishing Systems are the oldest and most common form of fixed fire protection on board vessels. CO_2 is a non-corrosive, non-conductive, odorless gas that will not leave any residue, and provides a cooling effect.

It extinguishes the fire by reducing the oxygen content in the space protected to the point where combustion is not possible. It doesn't 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. It is a relatively inexpensive agent compared to other fire extinguishing agents used in similar applications.

7. 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**

The term "inert gas" is used for 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 INCIDENT INVOLVING FIRE

8. Assessment and causes of incidents involving fire

- 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 usedfw
  - 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

9. Fire investigation and reporting

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.

(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 on board 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 stood by. 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 that light 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.