SOLENT
UNIVERSITY
SOUTHAMPTON

Updated Proficiency in Advanced Fire Fighting

Course Notes

WARSASH SCHOOL OF MARITIME SCIENCE
AND ENGINEERING

INTRODUCTION

This Advanced Fire Fighting course is intended for those who have completed the STCW Fire Prevention & Fire Fighting course which is part of the mandatory basic training for seafarers.

It deals with refreshing the theory of fire and how to prevent it, on-board safety in the event of a fire, use of portable and other fire fighting equipment and being an effective team member in fighting fire.

This course also covers a range of additional theory elements for those in areas of command and team leader roles. Each learner must take charge of a team and/or area of operations to safely demonstrate the relevant learning objectives.

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Aims & Outcomes

Aim

To give seafarers the essential education and training in fire prevention and fire fighting meeting the Knowledge, Understanding and Proficiency (KUP) requirements set out in the following:

Table A-VI/1-3 (STCW 2010)

Function: *Advanced Fire Fighting*
Competence: *Control fire fighting operations aboard ships*
Organise and train fire parties
Inspect and service fire detection and fire extinguishing systems and equipment
Investigate and compile reports on incidents involving fire

Outcomes

There are five outcomes to the training.

Outcome 1: The learner understands the principals involved in controlling fire fighting operations on board a vessel

Outcome 2: The learner is able to control fire fighting operations aboard ship

Outcome 3: The learner is able to organise and train fire parties

Outcome 4: The learner is able to inspect and service fire detection and extinguishing systems and equipment

Outcome 5: The learner is able to investigate and compile reports on incidents involving fire

Assessment Plan

Each student will be assessed by a variety of methods including a range of direct observation, oral questioning, simulation and role play. On completion of the course the student will:

- Understand fire fighting procedures at sea and in port, with particular emphasis on organization, tactics and command & procedures for coordination with shore-based fire fighters
- Understand the use of water for fire-extinguishing, the effect on ship stability, precautions and corrective procedures
- Practice good communication and coordination during fire-fighting operations
- Effectively control fuel, electrical and ventilation systems, including smoke extraction
- Knowledge of fire-fighting process hazards (dry distillation, chemical reactions, boiler uptake fires, etc.) and fire fighting involving dangerous goods including fire precautions and hazards associated with the storage and handling of materials (paints, etc.)
- Describe the management and control of injured persons
- Describe different strategies and tactics for control of fires in various parts of the ship
- Composition and allocation of personnel to fire parties
- Prepare contingency plans for fire incidents
- Understand and describe the use of fire-detection systems; fixed fire-extinguishing systems; portable and mobile fire-extinguishing equipment, including appliances, pumps and rescue, salvage, life-support, personal protective and communication equipment
- Understand requirements for statutory and classification surveys
- Make an assessment of causes of incidents involving fire

The above KUP objectives directly relate to Table A-V1/1-3

Where there is a deficiency in the performance of any task following debrief, remedial support/tuition will be provided to the student with opportunity to achieve the required learning objective.

Fire Prevention

Fire On board

Fires on board ships have to be fought by the crew in the first instance and very often there may be no outside assistance. It leaves the seafarer with little option when at sea, to deal with the situation or risk abandoning ship.

The construction of ships must include many areas that would not normally be located next to each other, engine rooms, cargo spaces, accommodation spaces for example. The different areas on board each have their own fire risk (means for a fire to start) and fire load (amount of fuel for the fire).

Nobody wants to be in a situation where they have to fight fires, but should the situation arise it is important that you are well prepared.

Recognising the different risks in these areas, as well as an understanding of the chemistry of fire, is key to the prevention of fires on board.

Recognising a fire risk and correcting the situation before there is a fire, shows that "**prevention is better than cure**".

Constant vigilance should be maintained at all times when working at sea utilising all the information from this course to enable you to work in a safe environment.

Causes of fire

There are many causes of fire on board ship in the different areas, below are a list of some of the more common examples.

All Areas

- Smoking – Carelessness and improper discarding of cigarettes.
- Smoking in bed.
- Hot Work – Any job involving heat will introduce a risk into that area and the potential of fire.

Accommodation

- Tumble dryers – Exhaust full of fluff/lint.
- Electrical – Overloaded sockets/faulty equipment.
- Rubbish – Accumulated rubbish can self-heat and also increases the fire load.

Engine Room

- Oily rags – Through spontaneous combustion.
- Oil leak/spray – Oil spraying onto a hot surface can easily ignite.
- Dirty burner tips – Oil accumulations at the bottom of the furnace may cause an explosion.

The Galley

- Ventilation Hoods – Layers of grease can build up meaning a fire would spread quickly.
- Hot Oil Fire – Overheated oil can auto ignite and cause a fire.
- Inattention – Ovens left on, cloths left on a hot plate are all dangers.

Cargo/Stores

- Cargo – Certain cargoes can be dangerous under different conditions. Strict attention must be paid to requirements.
- Packaging – Leaking or damaged packaging can allow cargo to leak or spill with potential to react with other cargoes.
- Paint – Static build up can cause ignition of solvents when pouring.

On Board Safety

There is a clear need on board ship for constant vigilance and awareness. There are distinct ways in which to prevent fire on board.

Good Housekeeping

When an area is kept clean and tidy, the fire risk lowers considerably. Ensuring waste paper bins are regularly emptied is fire prevention measure.
There are many areas where bad housekeeping results in fires:

- Galley extracts full of grease
- Tumble dryers, exhausts full of fluff, lint and dust
- Engine room drip trays and bilges which have collected oil
- Oil soaked lagging etc.

Equipment maintenance

Scheduled maintenance can ensure all equipment remains in good condition and reduce the risk of any defect or failure starting a fire. A program should consist of regular care, testing and inspection, repair or replacement and record keeping detailing checks and routines.

Safe Practice

Procedures can be safely regulated by "Permits to Work" which will ensure that all necessary precautions have been taken before maintenance is carried out. Personnel must not be allowed to take short cuts. Manufacturer's instructions coupled with the Company's Regulations and Code of Safe Working Practices are supplied to provide guidance on how to operate safely. Issues that arise:

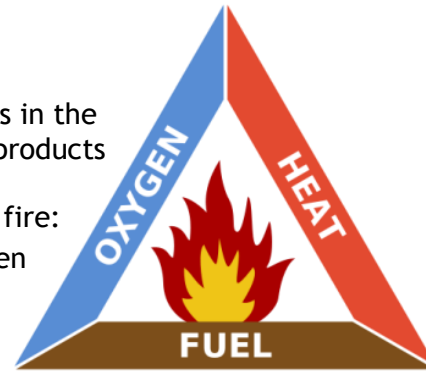
- No fire watch posted during hot work operations.
- Incorrect stowage of materials, dangerous goods etc.
- Poorly loaded or segregated cargoes.

Fire Patrol

On ships with greater than 36 passengers there is a requirement to make regular patrols of the vessel with special regard to fire by personnel familiar with and trained in the use of first aid fire fighting appliances/equipment found on board. They should have due regard to all of the above aspects.

Theory of combustion

The Fire Triangle



Fire is a chemical reaction which results in the production of heat, light and other by-products such as smoke and toxic fumes.
Three elements are needed to produce fire:

- Support for combustion - Oxygen
- A source of ignition - Heat
- Something that will burn - Fuel

All three elements must be present for combustion to occur, on many occasions two elements are present and it is important for us to recognise this so that we do not introduce the third.

Sources of ignition

There are various ways to start a fire:

- An open flame, spark or electrical arcing.
- Heating the fuel above its Self or Auto Ignition temperature (SIT or AIT) i.e. a fat pan can catch fire without the application of a naked flame, compression in a diesel engine raises the temperature of the fuel above its SIT/AIT.
- Some materials when damp or soaked with oil, or through a mixture of chemicals are likely to Spontaneously Combust without any external application of heat.

By Products

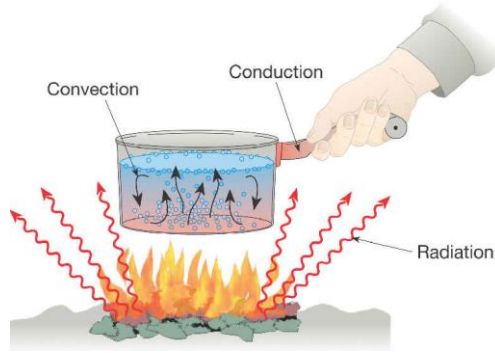
Fires in addition to generating heat and light also produce smoke/toxic products; these are responsible for the majority of deaths in fire cases. Smoke is essentially the incomplete (un-burnt) products of combustion; soot, liquid particles and gasses. It is generally toxic and may contain asphyxiants, irritants, flammable gasses, vapours and toxins. Carbon Monoxide is an example of a by-product of combustion found in smoke which is extremely dangerous to humans. Due to the inherent dangers of smoke any crew members operating in the environment must wear Self Contained Breathing Apparatus (SCBA).

Fire Growth and Spread

The flammability of a material is an indication of how easily something will burn or ignite.

When a material is labelled as flammable it indicates that it is readily combustible or liable to catch fire.

There are other important components in how things combust which will be discussed when we look at the different fuels in more detail.



When a material burns it releases energy in the form of heat. This heat is transferred in one of three ways as shown in the picture.

- **Conduction** - movement of heat through a material. As shown through the pan handle but could be through pipe work to another space. Air is a poor conductor of heat whereas most metals are very good conductors.
- **Convection** - upward movement of hotter less dense gases through the air or in a liquid as shown in the diagram. This can account for up to 75% of fire spread due to the movement of the hot fire gasses and smoke to other areas.
- **Radiation** - heat transfer by electromagnetic waves through the atmosphere. An example of radiation is the sun and how its heat reaches the earth. Radiation will vary as to the size and intensity of the fire, increasing as the fire gets hotter. The fire-fighter should wear fire protective clothing to insulate them against this heat.

Extinguishing Methods

The three primary extinguishing methods are achieved by removing one side of the fire triangle i.e. starvation, smothering, cooling.

Starvation

Removal of fuel which will be a combination of:

- Closing fuel oil or gas valves to stop the fuel supply.
- Boundary Starvation requires the removal of potential fuel from around the six sides of the fire which may be ignited by conductivity through bulkheads, decks or deck heads.

Smothering

Exclusion of oxygen (air):

- It is the flammable vapours given off from the fuel that burn so we can use a fire blanket, container lids, foam or sand which separate the fuel from the air.
- Carbon dioxide (CO^2) or other inert gas which displaces the air.
- Ventilation Control. Any system which is re-circulating air, (this is invariably the case with air conditioning) must be switched off. Selective extraction for short periods may be considered in some circumstances.

Smothering methods must be maintained until all the heat has dissipated otherwise re-ignition may occur.

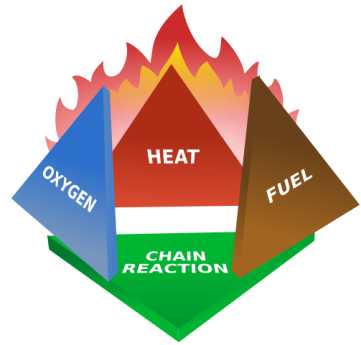
Cooling

Removing the heat energy from the fire:

- Typically achieved with water or foam (because of its high water content), directly into the fire to remove heat energy.
- Water can be applied to the boundaries of a fire as a spray in order to reduce the temperature inside, this is called boundary cooling.
- Isolating any equipment such as a galley hot plate can cool the fire area.

Flame Inhibition

In addition to the fire triangle, another method of extinguishment is flame inhibition – which breaks the chain reaction of fire. The triangle is sometimes expanded to four elements and referred to as the fire tetrahedron. Use of a flame inhibitor (e.g. a dry powder extinguisher) can result in a re-ignition hazard.



Dry powder effectively absorbs the energy in a flame and breaks the chain reaction so the fire goes out. However as no smothering, cooling or starving has occurred (e.g. if a flammable liquid fire is extinguished using dry powder the exposed liquid and hence vapours remain) additional steps must be taken to prevent re-ignition.

Extinguishers

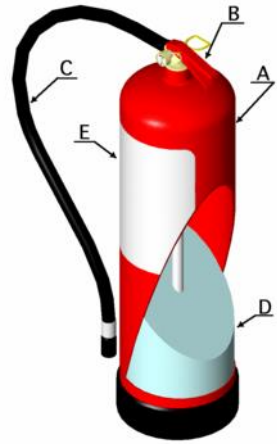
Different methods are utilised by the different extinguishers that we have available to us on board and are highlighted below in the table.

Type	Colour Code British Standard	Method
Water		Cooling
Foam		Cooling/Smothering
CO^2		Smothering
Dry Powder		Flame Inhibition
Wet Chemical		Smothering
Fire Blanket	N/A	Smothering

We will consider why each extinguishing method is the most appropriate under the classification of fuels.

Extinguishers come in two main types:

- **Stored Pressure** – These extinguishers are filled and then pressurised. They will have a gauge on them indicating the pressure and limits above and below.
- **Cartridge Operated** – These extinguishers are not under pressure until the extinguisher lever is operated for the first time. This introduces pressure into the extinguisher to operate as before.



A. Cylinder made from mild steel

B. Activation Lever & Safety Pin/tamper tag

C. PVC reinforced hose

D. Extinguishing Medium with siphon tube.

E. Labelling and colour coding

The fire extinguisher is operated by releasing the pin, breaking the anti-tamper seal and squeezing together the fire extinguisher handles. This will either pierce the co^2 cartridge and pressurise the extinguisher/open the valve or with stored pressure simply open the hose valve. The media is then forced up the syphon tube within the fire extinguisher, through the head cap and hose onto the fire.

Extinguishers (except CO^2) can be recharged on-board if facilities are available. When empty and all pressure released, the units can be washed and dried and then refilled with the appropriate medium. Stored pressure extinguishers are then pressurised to the required pressure by a pump. Cartridge type extinguishers have the spent cartridge replaced for a new fresh cartridge. Extinguishers should be inspected once a year by a competent person (see below) and be provided with signed label indicating that it has been examined.

Maintenance requirements

The following contains information from SOLAS, IMO Resolution A.951(23), Instructions to Surveyors UK and the good practices contained in BS 5306-3:2009* for rechargeable extinguishers.

- The BS EN 3-7:2004+A1:2007 Standard requires all new extinguishers to be coloured red regardless of contents to align with Europe. It states that National regulations may require a zone of colour. BS 7863:2009 states that between 3% and 10% of the extinguisher body may be colour coded. Depending on the vessel's flag state, all extinguishers may be red.
- At each fire drill at least one fire extinguisher should be discharged by a different crew member (MGN 71 M). At least one fire extinguisher of each type manufactured in the same year should be discharged at 5 yearly intervals as part of a fire drill, IMO A23/Res.951.
- Always test the extinguisher at the stowage position before use. Keep clear of the head cap as the extinguisher is pressurised.
- Instructions for recharging should be kept on board. Records must be maintained and should show the date of inspection, the type of maintenance carried out and whether a pressure test was performed.
- When opening any extinguisher for maintenance, first ensure that all pressure has been released by depressing the handle. Next unscrew the head or valve assembly several turns carefully to allow any residual pressure to escape via the venting arrangement and do not unscrew it further until all pressure has escaped.
- Propellant cartridges are supplied in varying sizes and types for different extinguishers. Always use the correct size/type.
- A person with the necessary training and experience, with access to the relevant tools, equipment and information, manuals and knowledge of any procedures recommended by the manufacturer of the portable extinguisher, to carry out the necessary procedures. A Merchant Shipping STCW 2/2 or 3/2 unlimited certificate of competency and an Advanced Fire Fighting Certificate must be held. MGN 276 (M+F)

*This British Standard has now been updated by the new version BS 5306-3:2017, however the MGN 276 refers to the old version as quoted.

Table from MGN 276 Maintenance of portable fire extinguishers

Type of portable extinguisher	Basic service	Extended service (test discharge)	Overhaul (hydraulic test)
Water, foam, & water based	Every year	Every 5 years	Every 10 years[c]
Powder	Every year	Every 5 years	Every 10 years[c]
Powder – primary sealed	Every year	Every 10 years[a]	Every 10 years[c]
CO2	Every year	Every 5 years[b]	Every 10 years

[a] Primary sealed portable fire extinguishers should be returned to the manufacturer/supplier for recharge.
[b] This service is only necessary for cylinders which have been previously hydraulically tested.
[c] IMO Resolution A.951 (23).

ANNUAL INSPECTION	
Safety clip and indicating devices	Check to see if the extinguisher may have been operated.
Pressure indicating device	Where fitted, check to see that the pressure is within limits. Check that dust covers on pressure indicating devices and relief valves are in place.
External examination	Inspect for corrosion, dents or damage which may affect the safe operation of the extinguisher.
Weight	Weigh the extinguisher and check the mass compared to the fully charged extinguisher.
Hose and nozzle	Check that hoses and nozzles are clear and undamaged.
Operating instructions	Check that they are in place and legible.
INSPECTION AT RECHARGE	
Water and foam charges	Remove the charge to a clean container if to be reused and check if it is still suitable for further use. Check any charge container.
Powder charges	Examine the powder for reuse. Ensure that it is free flowing and that there is no evidence of caking lumps or foreign bodies.
Gas cartridge	Examine for damage and corrosion.
INSPECTION AT FIVE AND TEN YEAR INTERVALS	
INSPECTION AFTER DISCHARGE TEST	
Air passages and operating mechanism	Prove clear passage by blowing through vent holes and vent devices in the cap. Check hose, nozzle strainer, discharge tube and breather valve, as applicable. Check the operating and discharge control. Clean and lubricate as required.
Operating mechanism	Check that the safety pin is removable and that the lever is undamaged.
Gas cartridge	Examine for damage and corrosion. Weigh the cartridge to ascertain that it is within prescribed limits.
O-rings washers and hose diaphragms	Check O-rings and replace hose diaphragms if fitted.
Water and foam bodies	Inspect the interior. Check for corrosion and lining deterioration. Check separate containers for leakage or damage.
Powder body	Examine the body and check internally for corrosion and lining deterioration.
INSPECTION AFTER RECHARGE	
Water and foam	Replace the charge in accordance with the manufacturers instructions.
Reassemble	Reassemble the extinguisher in accordance with the manufacturers instructions.
Maintenance label	Fill in entry on maintenance label, including full weight.
Mounting of extinguishers	Check the mounting bracket or stand.
Report	Complete a report on the state of maintenance of the extinguisher.

Table from Resolution.951 (23)

Media Water

Suitability: Wood, paper, textiles.

Technique: Attack from upright position utilising full throw if possible. Keep low if required to avoid heat and steam. Sweep the jet rapidly to break it up into water droplets to enhance the cooling effect and move around the fire. Once the fire is knocked down use the full force of the jet to help the water cool completely and break up the fuel.

Media Foam

Suitability: Liquid spill or contained liquid fires.

Technique: Stay back from the fire and use the full throw of the extinguisher. On a contained fire, spray the foam on the inside edge of the container and let the foam blanket spread undisturbed. On an open spill fire direct the foam jet upwards and sweep side to side to allow the foam to drop gently on to the fire. Fully discharge the foam extinguisher for maximum blanket thickness. Never direct the foam into the oil. If the foam boils away there is a danger of re-ignition. In any fire ensure there are back up extinguishers.

Media CO^2

Suitability: Liquids and inside electrical equipment or under engines where access is difficult. It is electrically non-conductive.

Technique: The gas comes out with some force and may scatter any fuel if the discharge horn is placed too close to loose material or burning liquid. The gas must be directed above the fuel so as to exclude the oxygen from its surface and smother the fire. On an open fire use the same sweeping action as described for dry powder- sweep rapidly from side to side and work from the front to the back. As the CO^2 changes state from a liquid to a gas before it leaves the extinguisher, the discharge horn becomes very cold. There is a danger of a frost burn if anything other than the handle or grip is touched by the operator.

Media Dry Powder

Suitability: Ideal for low flashpoint liquids (e.g. petrol) and gases (propane, butane); as was noted before heavier oils such as cooking or lubricating oils may well be already above their auto ignition temperature (AIT) and re-ignite once the dry powder extinguisher is empty.

Technique: Keep low to avoid flare up when you start extinguishing. Sweep rapidly from side to side and work from the front to the back. Do not walk into the fuel. Although dry powder gives rapid knockdown it has no cooling or smothering effect on oils and vapours may remain to be re-ignited. Beware of a significant reduction in visibility when using.

Media Wet Chemical

Suitability: Designed specifically to fight fires resulting from cooking oils and fats up to 75 litres in size.

Technique: This fire extinguisher contains a specially formulated wet chemical which, when applied to the burning liquid, cools and emulsifies the oil, extinguishing the flame, sealing the surface and preventing re-ignition. It is essential when fighting this class of fire that the extinguisher is used from a minimum of 1 metre (from nozzle to the fire). Ensure entire contents are fully discharged, even after the flames have been extinguished, in order to cool the fat or oil effectively to prevent re-ignition.

They can only be used on animal fats, vegetable oils and Class A fires.

Media **Fire Blanket**

Suitability: Fat pan fires, contained liquid fires. Smothering any small fire.

Technique: Fold back the top edge over hands to protect them, hold the hands up with the arms widespread to allow the blanket to hang in front of you to protect your body and face from radiant heat and flames. Advance and drape over the fire stretching towards the back to prevent the blanket dipping in the liquid. Fire blankets are made in different sizes. Have a look at the one on board and practise with it on a simulated fat pan fire.

Stay calm and do not throw the blanket on to the fire; if you do you may force air into the container and cause an eruption of flame. Turn off any heat underneath and leave to cool. If the blanket is removed prematurely the oil may be hot enough to re-ignite.

A person with burning clothing should be laid on the floor as heat rises. Use the blanket to pat out the flames but do not leave him in a rolled up blanket which may trap the hot smouldering clothing next to the skin.

Classification of Fuels

Fires are classified depending on the type of fuel; this allows us to select the most appropriate medium for the fire.

Class A – Solids

Woods, paper, plastics are some example of solids (usually organic in nature) that combust. These are heated to their ignition point where they will break down and release combustible gases. This fire will release heat and this will continue to heat other materials which can lead to the growth of the fire. They will typically leave behind smouldering, glowing embers which can retain a lot of heat. For this reason water, a good coolant, is effective at removing that heat energy. Foam which also contains water is a good coolant as well.

Class B – Liquids & Liquefiable Solids

When a flammable liquid burns it is the vapour that combusts, not the liquid itself. Flammable liquids release these vapours at different temperatures; this is called the flash point. Liquids that have a low flashpoint of below 60°c (so more likely to release flammable vapour) like petrol are termed as volatile.

Smothering will help prevent the vapours, cutting them off at the surface and therefore is a good method of extinguishing liquid fires. Some liquids will ignite when heated without the application of a flame or spark; this is called their auto ignition temperature.

Class C – Gasses

Fires involving flammable gases can be extremely hazardous; these are best extinguished by isolating the fuel. It is important to cool around the area and cylinder (if involved) with water to prevent further hazards such as a BLEVE (Boiling Liquid Expanding Vapour Explosion) from occurring. Gas fires may be extinguished by dry powder.

Class D – Metals

Metal fires such as magnesium, lithium or aluminium typically burn with an intense heat and using a common extinguishing medium can cause an adverse reaction. There is a special Class D dry powder extinguisher designed for metals and works by smothering the fire, sand can also be used to smother small fires.

For larger fires involving metals copious amounts of water can be used from an open ended hose in order to attempt to cool.

Class F – Cooking Oils

Because of the high temperatures that cooking oils can reach they can be difficult to extinguish using ordinary foams. Specially formulated wet chemicals when applied to the burning liquid cools and emulsifies the oil, extinguishes the flame, seals the surface and prevents re-ignition.

Note: Electrical Risks

Electricity, is not a class of fuel, but is considered to be a risk or complication in all types of fire.

To protect the fire fighter and reduce the risk of sparking or heat energy sources whenever possible, the power supply should be isolated in the fire area. In cases where it is unclear if power has been isolated the fire fighter should use only non-conductive media such as dry powder or carbon dioxide.

Initial Response

Providing the following actions are taken in order most emergencies are dealt with effectively. It is invariably the failure to inform that allows the incident to get out of control.

Find - detect - using all senses, sight, smell, hearing.

Inform - raise the alarm - by all available means

Restrict - close doors, isolate electrics, switch off fuel, stop ventilation etc.

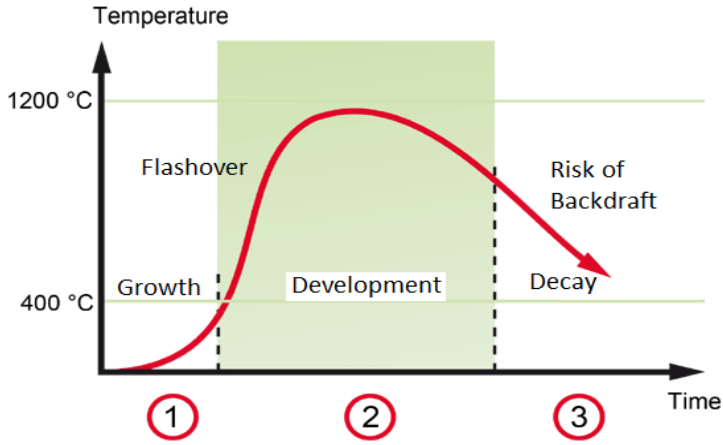
Extinguish if it safe to do so or Escape and/or Evacuate.

Fires can start small and quickly grow in intensity. For this reason a rapid response can be an effective tool in combat against fire.

Growth is due to the process of combustion in which the heat given off will spread (through conduction, convection and radiation) and heat other items nearby. These will then start to release flammable vapour and ignite further items causing a **Chain Reaction** and increase in intensity.

There are a numbers of factors that will have an influence on fires such as the amount of fuel, air, location of fire and combustibility of the fuels involved.

Typically fires involved in a compartment such as a cabin will follow the same curve of development as shown in the diagram.



1. Ignition is the start of our fire and we see a steady increase in temperature as it grows incorporating more materials. Smoke and hot gasses start to be produced, rising in the compartment, forming a hot layer at the top of the space. In addition to the heat from the fire this layer of smoke radiates heat downwards also.
2. The heat levels inside the space increase to the extent where, along with a possible re combustion of hot gasses, all the items begin to break down and release combustible gasses. This sees a rapid conflagration known as ‘Flashover’ in which the temperature very rapidly increases and all the items in the space ignite. The temperature now reaches its maximum as now all the items are on fire.
3. We now see a reduction in the heat as the fuel is used up inside the space. The other reason for a possible reduction in intensity is a lack of oxygen, this can be dangerous to fire fighters if when entering the space oxygen is re-introduced causing a re-ignition which can often be violent. This is known as a backdraft. In order to prevent this care should be taken utilising the correct door opening procedures.

Team Organisation and Equipment

SOLAS Ch 3/Reg 19 and MGN 71 gives guidance on Musters, drills, on-board training and instructions to be carried out onboard:

- It is recommended that a fire or other emergency drill should be held simultaneously with the first stage of the abandon ship drill.
- A mock attack in varying spaces, e.g.
  - cargo holds
  - engine & boiler rooms
  - accommodation
  - galleys
  - pump rooms
  - enclosed spaces, etc.
- Fire and emergency pumps started. Hoses should be laid out and where practicable water should be played through them first with the machinery space pump and secondly with the emergency pump with the isolation valve closed.
- Instruction and discharge of extinguishers
- Closing of openings and operation of remote controls
- Operation of fixed installations
- Exercises in BA and other emergency appliances
- Examination of appliances not used at that drill
- Sprinkler installations tested monthly
- At least one extinguisher let off by a different member of crew
- Instruction in fire prevention and other emergency subjects

Once the alarm has sounded the crew muster at their emergency station. Provision must be made for alternative muster points where fire or smoke makes it impossible to assemble. The regular ritual of mechanically performing these duties will contain little training benefit therefore drills must be as realistic as possible.

It is excellent practice in drills to occasionally take the leader out of the emergency structure so the second in command can have an opportunity in taking on this difficult task.

A different officer devises a scenario for each drill, either:

- The exercise is performed in slow time with full instruction accompanying the equipment being used , or;
- A proper emergency response.

The drill must be followed by a full debrief as there will always be mistakes and misunderstandings. Never surprise your crew with a drill, always give some forewarning even if it is not too precise. Where a public address system is installed, a message must be prefaced “This is a drill”.

Most fires and enclosed space incidents will require the efficient and confident use of BA, therefore

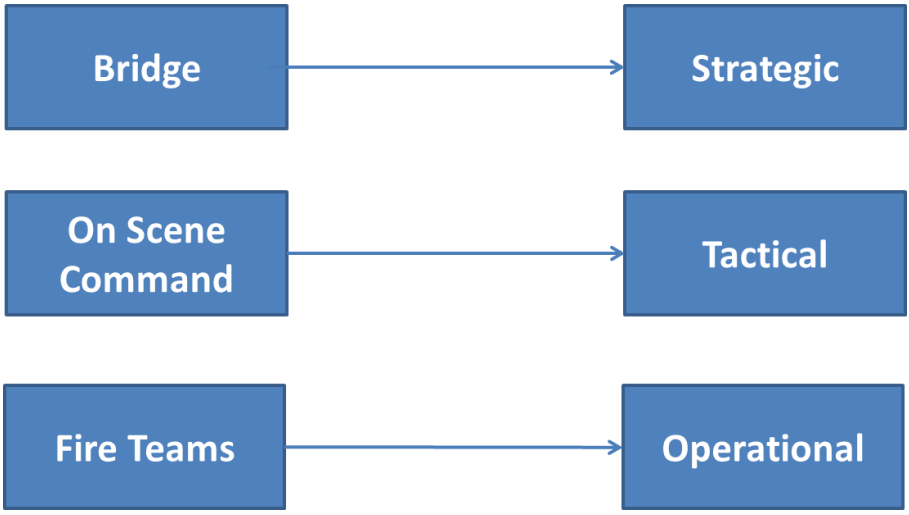
- Train crewmembers to don and perform search and rescue (SAR), i.e. in accommodations with full visibility especially if they are not confident.
- SAR can be developed by partially reducing the lighting or using cosmetic smoke
- Specific breathing apparatus (BA) teams can be exercised whilst the rest of the ship is working normally, constant gauge checks are essential for a proper emergency response.
- Cargo ships and passenger ships carrying not more than 36 passengers will require either
    (a) an on-board means of recharging breathing apparatus cylinder used during drills; or
    (b) a suitable number of spare cylinders to replace those used during drills.

It is possible that, on smaller vessels the BA Controller may also be the officer in charge. The BAC is essential and they must be in clear air adjacent to every entry point. They are responsible for:

- assistance in donning, giving confidence
- briefing (SAR, fire fighting, or both)
- gauge checks
- two relief BA wearers are ready to enter and relieve or rescue five minutes before the whistle time of the first entry team.
- debrief and undress (doff) first entry team

Command & Control

Command and control can be broken down into three areas on-board alongside relevant levels of responsibility in the incident.



Strategy An overall plan for incident attack and control.

Tactics Specific tasks and duties to be completed in order to meet overall strategy.

Operational Implementation of the strategy and tactics as decided utilising safe operational procedures.

The following is an introduction to each area and some of the considerations to be taken. Due regard should be taken to your company procedures on-board for emergency organisation as this will vary from vessel to vessel.

Bridge

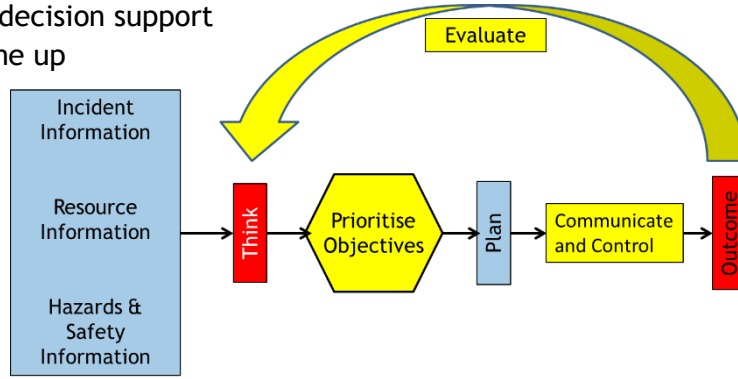
Strategy is the undetailed plan of action to achieve a (complicated) goal.

The Captain of the vessel during a fire incident or other emergency has overall command and responsibility for any fire/emergency situation, the safe navigation and the operation of the vessel, the safety of those on board and the protection of the environment.

Resources and factors affecting strategy will include but are not limited to:

- Alarms / Resources / Location
- Missing persons/Incomplete Muster/Verbal reports/Information
- Fire Spread / Fire screen doors/ W/T doors
- Ventilation / Isolations / Fire plans
- Internal Communications /External Communication / GMDSS

The bridge team will use this information along any contingency plans and any other decision support systems to come up with a suitable strategy for the situation, prioritising safety of life.



The Captain should give the On Scene Commander (OSC) freedom to act locally but should monitor actions and be prepared to prompt him/her using information from his resources as required. It is not intended that the Captain will direct or take charge of operations at the incident location.

On Scene Command

Tactics can be summarised as the deployment of personnel and equipment at an incident within set objectives and priorities to achieve the overall aims. Factors affecting may include:

- Missing Persons / Safety of life / Search and rescue
- Hazards / Chemicals / Boundary cooling/ Starvation
- Fire Location / Type / Fire Fighting Media
- Fire Teams Entry / Exit / BA entry control
- Team briefings / Communication

The OSC directs and coordinates operational activities based on approved Company procedures to meet the strategic aims as set by the Captain (Bridge). The OSC determines the disposition and resources required locally to resolve the incident. The OSC should be supported by the Captain whilst being allowed to act independently to achieve these aims.

Tactical decisions made at this level should as a priority avoid

- **Fighting a fire from opposite directions**
- **Changing conditions inside the fire area without the fire fighters knowledge.**
- **Changing the cylinder and sending a fire fighter back in**.

The OSC position should be at or near to the scene of operations which should be a suitable safe position and a short travel distance from the incident, with the intention to control the incident response by briefing and debriefing team leaders.

It is imperative that the OSC does not become engaged in operational activities during the event, this can cause a lack of focus and appreciation of the overall situation.

Fire Teams

Operations can best be described as tasks that are carried out in the vicinity of an incident to achieve desired objectives. This will be achieved using Company procedures in accordance with the tactical plan to achieve the strategic aims. This is the level at which direction of immediate "hands-on" or task level work is undertaken at the scene of an incident.

The team leaders are responsible for carrying out the tasks as detailed in the tactical plan set by the OSC.

The responsibilities of those undertaking this level of work should be kept to a minimum to due to the increased risk of operations in these areas. Their focus should be on:

- Standard Operating Procedures
- Team Safety
- Communications
- Debrief OSC

Standard operating procedures should be practiced on-board during training, recommended procedures for fire fighting on-board can be found in the further on in these notes.

It can be seen that radio communications are essential. There is now a requirement for new ships to carry radios for this purpose, SOLAS Chapter II-2, Regulation 10.10.4 and their use is important and can be very effective. The officer in charge can monitor their progress and assist as required. The confidence of a BA wearer will increase where there is communication to the outside.

Equipment

Each team member will be equipped with a firefighter's outfit which will consist of the following as a minimum:

- Protective clothing (Fire suit) to protect from heat and steam, must also be water resistant.
- Non-conducting boots (usually rubber).
- Rigid helmet.
- Electric lamp.
- Axe with insulated handle.

Each fire fighter will also be provided with a self-contained breathing apparatus capable of functioning for at least 30 minutes.

As a minimum all SOLAS applicable ships should carry two fire fighters outfits (typically ships will have more) and there are further requirements for ships carrying passengers or dangerous cargo.

All kit should be stored in the lockers ready to go in the event of an emergency. This includes trousers and boots together, tunics hanging up, all other equipment, lamps, SCBA sets etc. tested regularly so they are ready to use.

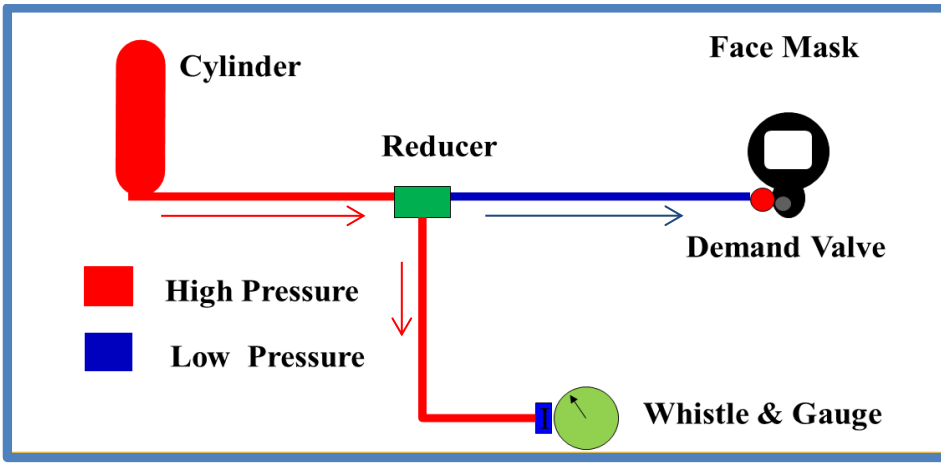
Fully dressed fire fighter wearing SCBA.

Note trousers outside boots to prevent water run-off into boots.

Breathing Apparatus

During the course of any fire, toxic products and poisonous gases are produced as a result of combustion. In order to protect fire-fighters, breathing apparatus (BA) is required. The self-contained breathing apparatus (SCBA) set, which is carried like a rucksack and provides the wearer with fresh air, has been developed. The requirements are set out in the FSS code Res. MSC.98(73).

There are a variety of sets available and most are positive pressure type of which will be described here.



This schematic diagram represents the component parts of a SCBA.

Cylinder

All cylinders are grey in colour, with black and white quartered shoulders denoting the contents as medical air (i.e. dried and filtered air). It has minimum contents of 30 minutes of air, which for an average person is a charged capacity of 1200 litres (This is based on the assumption that an average person breathes 40 litres of air per minute.)

Reducer

Passes un-restricted air from the cylinder to the Pressure Gauge and Low Air Warning Whistle, and supplies low pressure air, to the Demand Valve.

Pressure gauge & Whistle

A gauge gives the wearer a constant indication of the cylinder pressure. The gauge face is calibrated in 10 bar intervals and may be numbered every 30 or 50 bar. The whistle is designed to operate automatically when the cylinder pressure falls to 40-45 bar, allowing a safety margin for emergency purposes. The team should plan ahead and aim to be clear of the danger area before the whistle sounds.

WARNING - Hard work may reduce duration.

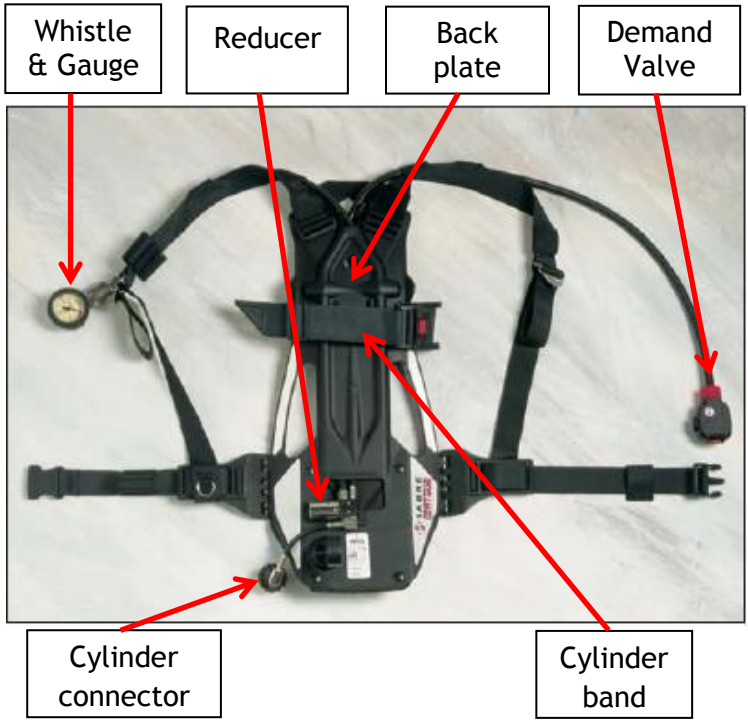
Demand valve

The air delivered by the demand valve depends upon the requirements of the wearer. Demand valves are capable of delivering up to 5 times the average volume of air. The demand valve is attached to the facemask.

Face Mask

The mask is constructed of non-dermatitic rubber and has a high-density polycarbonate shatterproof visor, providing maximum vision to the wearer. The mask is fitted with the following:

a) Speech Diaphragm – This is a thin mica disc situated opposite the mouth, allowing the wearer to converse normally.
b) Ori-Nasal Mask – This inner mask avoids the build-up of exhaled carbon dioxide (CO^2) within the face mask by the use of one-way mushroom valves. These valves open on inhalation and allow air into the ori-nasal mask. On exhalation these valves close which means that the air is directed out through the one-way exhalation valve to atmosphere.



Typical BA Set with cylinder and facemask removed.

Cylinder with black And white collar

The cylinder air is joined with the cylinder connector valve. The cylinder is attached to the back plate and secured with the cylinder band. The mask attached to the demand valve. There are various designs of mask available.

BA Mask, Internal view showing oral nasal mask

Donning

- Press demand valve reset button and check bypass valve is in the off position.
- Open main cylinder valve fully – check that the warning whistle momentarily operates.
- Check gauge reading – ensuring sufficient cylinder contents. A minimum of 80% of the cylinders maximum capacity is required (e.g. for a cylinder with a maximum charging capacity of 200 bar, the minimum pressure reading before entry will be 160 bar i.e. 80% of 200 bar).
- Stand BA set upright, making sure the back plate is facing you and the facemask is released from the top of the cylinder.
- Grasp the right hand shoulder strap and face mask harness in the left hand and swing the set onto the right shoulder. Next slip the left arm through the left shoulder strap.
- Place the face mask neck strap over the head.
- Adjust the shoulder straps so that the set is comfortable and tighten the waist strap. (Do not over tighten as this can restrict deep breathing)
- Inspect the face mask ensuring that the head harness straps are fully extended.
- Check that the gauge is in a readable position.

Starting Up/Pre Entry Checks

- This must be carried out in “safe” air (an environment where the air is breathable and will not be harmful without the use of respiratory equipment).
- Don the facemask, adjust to ensure good fit and tighten the straps (bottom to top, two at a time)
- Breathe in sharply to operate the first breath mechanism, and then breathe in and out 2 or 3 times to ensure the air is flowing in through the demand valve and out through the exhalation valve.
- Carry out the following safety checks:
    - Check that positive pressure is functioning by inserting a finger between the face mask and the face, this should cause an audible flow of air.

- Operate the bypass valve – This will cause a free flow of air into the mask (bypassing the demand valve) so proving air can be supplied to the wearer in event of a demand valve failure.
- Take a breath and hold it, move your head vigorously from side to side, stop and listen for leaks. If there are any leaks, adjust the head harness.
- N.B. Facial hair may affect the ability of the wearer to get a face seal so causing an air leak.

Doffing

- Remove helmet, gloves, pull back flash hood. Helmet must be removed with gloves on to prevent any burn injuries to the hands.
- Take a deep breath, press the reset button, loosen straps and remove mask.
- Switch off cylinder.
- Drain BA set and ensure whistle activates.
- Ensure all straps are fully extended (loosened off)
- Hang mask from neck.

It is recommended that the manufacturer's guidelines are followed in all instances as SCBA sets will vary from vessel to vessel.

The Department for Communities & Local Government (UK) publication 'Operational Guidance for Breathing Apparatus" also provides guidance on best practice for start-up procedures.

Equipment

Fire teams will have a variety of equipment available to them and this will partly depend on the type of vessel and area of operations.

Hose

Fire hose enables us to move water to where it is required for fire fighting efforts. Modern hoses are made out of synthetic materials and are not prone to rot however they may be damaged by shock or abrasion.

- Where a hose leads over sharp edges protect it with a mat.
- Where a hose is led through a doorway make sure the door is held ajar with wooden blocks or wedges.
- Open and close nozzles or hydrants gently.

The diameter of hoses may vary but is often 45mm in accommodations and engine rooms and 64mm elsewhere. They should be long enough to project a jet of water into any space they are required to be used. They shall be at least 10m long but not more than 15m in machinery spaces, 20m in other spaces and open decks and 25m for open decks on ships with a maximum breadth in excess of 30 m.

Hoses are stored typically either in a "Dutch roll" on a bight or a coiled roll. Either method can be used but the same one should be used throughout the ship.

The "Dutch roll" has the advantage that both coupling remain in hand when the hose in rolled out.

After use the hose should be drained out by walking along it and lifting it to shoulder level (under running), any contaminates washed off and the couplings rinsed in fresh water.

Couplings

Whichever type of coupling is found on board they will be uniform throughout the whole vessel.

Some of the more common are:

Instantaneous Couplings

These couplings push together and two spring loaded lugs hold the two together. To release, the lugs are pulled outward simultaneously. Each hose has a male and female coupling.

Storz type coupling

These couplings twist together locking into place, they will often come with a 'C' type spanner in order to facilitate this. Both ends of the hose are the same enabling more adaptability

International Shore Connection

Because of the non-standardisation of couplings every vessel over 500 gross tonnes must be fitted with an International Shore Connection.

It permits connection of the shipboard fire main with another ship or shore facility when the hose couplings are different to allow the damaged ship's fire main to be pressurized.

Nozzles

Nozzles on board must have the ability to offer a jet, a spray and shut off option. These may be facilitated in a number of ways but this must be a minimum.

Common types include:

Unifire V-12 Nozzle

Akron Turbo jet Nozzle

The fact that all nozzles can be shut off means that the amount of water used can be reduced to:

- Limit the amount of water damage.
- Limit the effect that excess water may have on the ship's stability.
- Preserve water pressure in the fire main for use elsewhere in the ship.
- Control the humidity in the space by turning the nozzle off for a moment to allow the steam to dissipate.

The nozzle can be adjusted to a jet so that:

- Water can be thrown a long way if necessary
- The force of the jet can be used to assist water penetration when damping down after a fire.

It can be adjusted to a spray so that:

- The nozzle is being used in the most effective way provided the water is sprayed on the fuel and not just on hot smoke.
- The cooling effect of water will be most effective if it is applied in the form of a spray rather than a jet.
- If water is turned to steam the maximum amount of heat is taken out of a fire.
- When fighting an internal Class A fire, control the amount of water applied by using short (2 – 4 second) bursts to limit the steam production.
- The hollow cone of water spray will protect the fire fighter from radiant heat and flame.
- A 60° arc of spray is the ideal fire fighting mode.
- It can be adjusted to a 'water wall' so that it allows close approach to a fire e.g. to close a valve or to use another hose through the wall.
- Foam or dry powder can be directed through the water curtain.

'Waterwall' in use to protect fire fighters

Precautions

Most adjustable jet/spray nozzles operate from shut-off through jet to spray. The hose should always be pointed down to the deck when it is opened or closed otherwise a jet may be inadvertently put into the fire. Possible hazards are:

- If the jet hits a red-hot steel bulkhead it may splash back as boiling water, or may cause local cooling. Unequal thermal expansion could crack open the bulkhead.
- If the jet strikes another person unseen in the smoke, it could injure them, or knock their BA mask off.
- If the jet strikes live electrics, it could provide the shortest path to earth. Water as a jet or spray must never be used near high voltage switch-boards.
- If the jet enters a hot liquid, it may flash to steam and expand about 1700 times, atomise to produce a boilover. A jet directed into a dusty cargo may throw the dust in the air and cause a dust explosion.

Remember water can easily spread fire because oil fuels will float on water.

Fog Lance

A fog applicator or fog lance can be inserted into the end of the nozzle or be standalone kit. It can be used in places which are difficult to access e.g. under vehicles, engine compartments, but steam production will be considerably higher than that produced by a normal spray. The fog lance is found on all types of car carrier and ro-ro ships where it can be particularly useful in extinguishing fires underneath lorries or cars where the drencher system cannot reach. They can also be found in the engine rooms of passenger vessels.

Foam Making Equipment

Additional foam making equipment is carried on board vessels in the engine room and may be required for other areas including helidecks or cargo areas. There are a number of different foam types available.

Foam Types

- Protein Foam
  This is based on hoof and horn meal from a slaughterhouse and has a good resistance to higher oil temperatures. It is mainly used in the fixed foam systems on tankers. Manufacturers will recommend in which temperature range it must be stored because it may deteriorate and lose its properties in very hot or cold conditions. Tankers require a sample of their foam compound used for pump rooms and deck fires to be tested annually.
- Aqueous Film Forming Foam (AFFF)
  This foam is detergent based. Because of its film forming properties it is particularly good on low flash point liquids as it resists re-ignition. On hotter fires (high flash point) there may be a tendency for the thin aqueous (water) film to boil away. It is very commonly used in extinguishers and can be found in some tanker fixed systems.
- Film Forming Fluoro Protein Foam (FFFP)
  This foam has the film forming properties of AFFF and the heat resistance of protein foam.

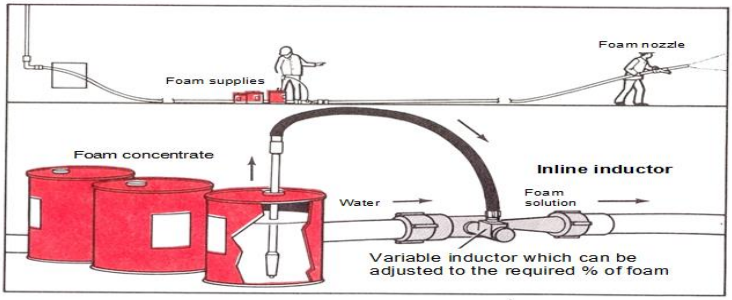
Low expansion foam (LX) is the usual type found aboard ship.
Foam is normally supplied as a 6% or 3% concentrate, this means that:

- 6% foam concentrate + 94% water and air = Finished Foam
- 3% foam concentrate + 97% water and air = Finished Foam

The percentage will be written on the side of the drum.

The Inline Inductor

This allows the foam to be injected into the fire hose two lengths back from the fire front, in a safe area where foam supplies can be maintained by deck crew.



A foam nozzle will be required to aspirate the foam liquid.

Ensure that your equipment is compatible or adjusted to the foam percentage carried

Foam Nozzle

These come in a variety of types and will aspirate (add air) to the foam as it leaves the nozzle. The nozzle can be used with an inline inductor as shown above or often in a standalone mode where the pickup tube comes from the nozzle and is added to the foam concentrate.

A foam nozzle with a pickup tube.

This can be operated with or without an inline inductor, with the pickup tube being removable.

Typically these can throw foam up to 20m.

Larger wheeled units

Larger foam, dry powder and carbon dioxide wheeled units are usually found in engine rooms and often placed near manifolds during tanker loading or discharge. They are operated on the same principle as hand held extinguishers.

Because of their larger capacity and higher application rates they are able to control larger fires. Do not place them too close to high fire risk areas where a fire may limit access.

CO 2 Unit

Foam Unit

Dry Powder Unit

Techniques

Door Opening

When opening doors inside a structure involved in fire, the temperature of the surface of the door and its fitting should be tested. Look around the edges of the door for signs of heat and smoke. Apply water on door to ascertain its temperature. If a fire or potential backdraught condition is suspected then certain precautions must be taken to prevent injury:

- Ensure that suitable fire fighting equipment is available and in position.
- Determine the type and the direction of opening of the door. Which side are the hinges? Are the door stops on your side?

If the door opens towards the team:

- The team should be positioned on the hinge side of the door.
- Use door as shield, brace leg against door.
- Keep low, pass nozzle to second in team.
- Warn the team, open no more than 10cm for 10sec.
- Look into the compartment at low level to assess the conditions.
- If it is safe, proceed through the door.

If the door opens away from the team:

- The team should be positioned on the handle side of the door.
- Use the wall on the opposite side to the door's hinges as protection. This may not always be practicable.
- Keep low.
- Keep hold of the handle, maintain control of the door.
- Pass nozzle to second in team.
- Warn the team, open no more than 10cm for 10sec.
- Look into the compartment at low level to assess conditions.
- If it is safe, proceed through the door.

In any event doors should be left in the closed position after exiting to stop the spread of fire and smoke products.

Search Procedures

BA wearers must balance the need for making progress and taking safety measures to avoid the numerous potential hazards found at all incidents. The following safety measures must always be adopted to reduce the possibility of accidents:

- A fire fighter should always shuffle not walk.
- The weight of the body should be placed on the rear foot until the advancing foot has tested that it is safe to move forwards.
- The feet should not be lifted from the ground; the foot should slide forward to detect obstructions or openings and other dangers such as a buckling deck.
- As you move forward, you should raise the free hand in front of you, lightly clenched with the back outermost to feel for obstructions. If the back of the hand touches a live electrical wire the shock will throw you clear and will not cause the hand to grasp the wire.

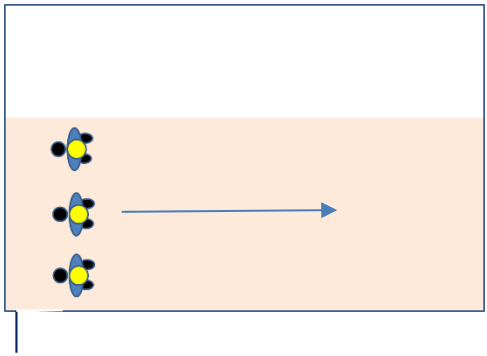
Searches should be carried out methodically to a pre-planned route detailed by the OSC/Team Leader before the search has begun. There are two directions in which a search can be carried out:

- Left hand search (maintaining contact with a bulkhead using the left hand on the way into the incident).
- Right hand search (maintaining contact with a bulkhead using the right hand on the way into the incident).

These searches can be carried out using two different methods of search pattern depending on the circumstances of the task.

Search Procedures

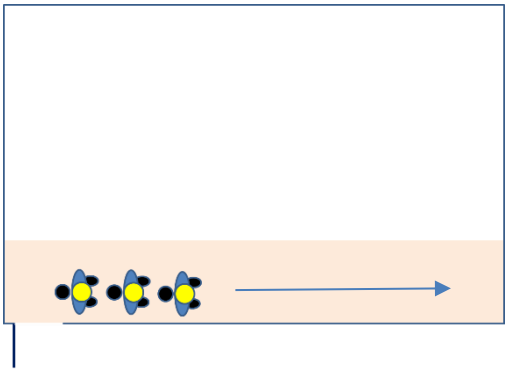
Indirect Search



When teams are briefed to search and locate a casualty or the seat of a fire, then team members must spread out to cover the maximum area possible whilst maintaining physical contact. The team leader is responsible for maintaining the designated search pattern and wherever possible, the team must remain at right angles to the bulkhead. Any hatches or doors that are found on the opposite side to the search should be briefly assessed and if they cannot be searched without leaving the designated search pattern, the team should make note of it and inform the team leader/ OSC.

Direct Search

When teams are briefed to go to a specific area of a structure on either a left or right hand search pattern to carry out a search for casualties, locate a fire, or relieve a team then there is no requirement to search the areas of the structure prior to the arrival at the designated area. Therefore teams will proceed one behind the other with the team leader as the pathfinder, remaining team members must still carry out personal search procedures. Also direct search patterns can be used by teams withdrawing from an incident.



Heat / Condition Monitoring

Burns through heat transmission can cause serious injury. In a fire situation heat will be transferred to the BA wearers by:

- Conduction through direct contact with hot surfaces.
- Convection through high atmosphere temperatures caused by the fire.
- Radiant heat.
- Excessive steam production.

When working in BA regular sampling of the temperature to prevent contact burns can be achieved by rolling back the cuff of the glove and testing the air temperature at or above head level. This technique is designed to prevent BA wearers, who by the nature of their protective clothing are isolated from the environment, entering into potentially hazardous conditions of high radiant heat and atmospheric temperatures. A count of 5 seconds should be able to be sustained before rising from a low position or when entering a compartment.

When fire fighting in the accommodation, always do so in the standing position and use water in short sharp bursts. Monitor the steam/heat barrier, stop applying water and crouch down into the cooler conditions when necessary. When the steam/heat barrier rises and it is safe to do so, stand and continue to fire fight, repeating this process as necessary until the fire is extinguished.

If a BA wearer starts to experience burns through their fire kit they should withdraw immediately and remove it ASAP. Usually the first signs of heat transmission through the PPE are felt at the shoulder straps and other places where the material of the PPE is in contact with the body. Note: Radiant heat is directional and unless the wrist is exposed in line with the direction of transmission BA wearers will not detect its presence.

Communications

Radio communications in all its forms is vital to the efficiency and safety within operations; this is particularly true during fire incidents. Even the best radio system can suffer from interference, because of this it is possible that others cannot hear anything or everything that is said. Therefore it is of utmost importance that proper procedures and simple clear language are used to save time.

All teams are to follow the following procedures when communicating on the radio,

- Radio messages and traffic should be kept short.
- Do not interrupt other users – except for priority messages prefix with “Urgent, Urgent, Urgent”.
- Always yield to more important messages.
- Speak slowly and clearly.
- Use easily understood words.
- Avoid ambiguity.

Radio discipline is the responsibility of every operator, and should adhere to the following:

- Listen before you speak.
- Use correct procedure (call station to, station from).
- Maintain constant radio watch.
- Answer all calls promptly.
- Keep the airways free of unnecessary talk.
- Be brief and to the point.

Liaison with Shore Based Fire-fighters

This liaison is vital when a ship is in harbour for any length of time and especially when the ship's company is depleted by shore leave.

As a general rule the owners of a ship have a legal right to control access to their property, the ship, and to decide what assistance the ship may require. They may also dispense with assistance already accepted, for any reason, but in doing so may incur legal liability. The Authority to exercise these property rights is usually delegated to the ship's Master (Captain). Shore based fire brigades and other persons invited to assist ships in difficulty must respect the ultimate control of the owners as exercised through the Master. However the Master of a ship, in exercising this control is subject to various legal duties to take all reasonable care to secure the safety of personnel and/or ship. In most cases where a ship in port is threatened by fire, the concept of 'reasonable care' would require the Master to accept the services of the local fire brigade and recognise their expertise and resources, delegating control of the operations to the Fire Chief concerned. The decision to do so or not must always be with the Master who will be fully accountable in law for the consequences of such a decision.

There are exceptions to the above general rule where the ship fire also threatens the safety of the wider public and/or the property interests of others, e.g. harbour installations including protection of the environment. In such cases national laws often provide statutory rights of intervention which override the above property rights. Power is granted to various national and local authorities, in defined circumstances and for specified reasons, to take control of all such actions as may be required to contain or minimise such dangers. Those likely to be involved should be familiar with their nature and extent as any abuse or misuse of such powers, no matter how well intentioned, can be subject to legal redress in the courts.

The following indicates areas for consideration alongside:

- How emergency services are summoned (VHF, telephone)?
- Invite fire crews aboard to familiarise themselves with the layout and other peculiarities of the ship
- Invite suggestions on cutting down fire risks
- Arrange training exercises with the Brigade and ship's crew working together
- Learn how the local Brigade works and what its plans are for a ship fire
- Have a fire wallet available at all times containing: stability data, fire plans, ventilation & bilge plans, cargo manifest
- Does the port have a local disaster plan? If so obtain a copy and determine what support can be expected from Port Authorities
- Is there a language barrier? If so, know where an interpreter can be contacted 24 hours a day

Additional considerations will be:

- Are Brigade hose couplings compatible with the ship's fire main?
- Ensure quaysides are clear at all times allowing access for emergency vehicles
- Always arrange to have a responsible officer to meet the Brigade at the top of the gangway
- Introduce a plan of laying a guideline or guide tape from the fire area to the gangway
- What arrangements are there for obtaining additional supplies of carbon dioxide: bulk supplies, cylinders?
- What arrangements are there for extra foam supplies?
- What arrangements are there to make available fire tugs/boats if ship is anchored offshore?

The question of stability is one that can only be dealt with by the ship's officers. Fire officers, although they may understand the basic principles of stability, can only assist in supplying data regarding the tonnage of water put in and taken out during fire-fighting operations.

In the event of a fire on board your vessel a fire officer will require a brief and ask you some of the following questions. This question will be first:

Is there anyone missing?

Other questions that may be asked, in no particular order, will include:

- Where is the fire?
- What sort of fire is it?
- Is there any danger of electricity in the compartment? (i.e. high voltage)
- How long has the fire been burning?
- How did the fire start?
- What has been or is being done about it?
- What is the state of the fire main?
- What is the state of the fire party?
- How much water has been pumped into the ship?
- How critical is stability at present?
- How many access points are there?
- Are there dangerous goods on board?

When a ship is under repair, the responsibility for fire prevention and fire fighting must be clearly defined. The repair yard often takes responsibility for this, if so, there must be a clear agreement in writing to this effect. Divided responsibility must always be avoided as it can only lead to confusion and has been the main cause of the disastrous loss of certain ships.

Outside the UK standards of fire-cover vary tremendously. There may or may not be a disaster plan. An IMO resolution, Dangerous Goods in port areas Annex to Marpol III, has been ratified. This requires that there should be one, however masters should make themselves aware of standards of fire cover and disaster plans in any port they visit.

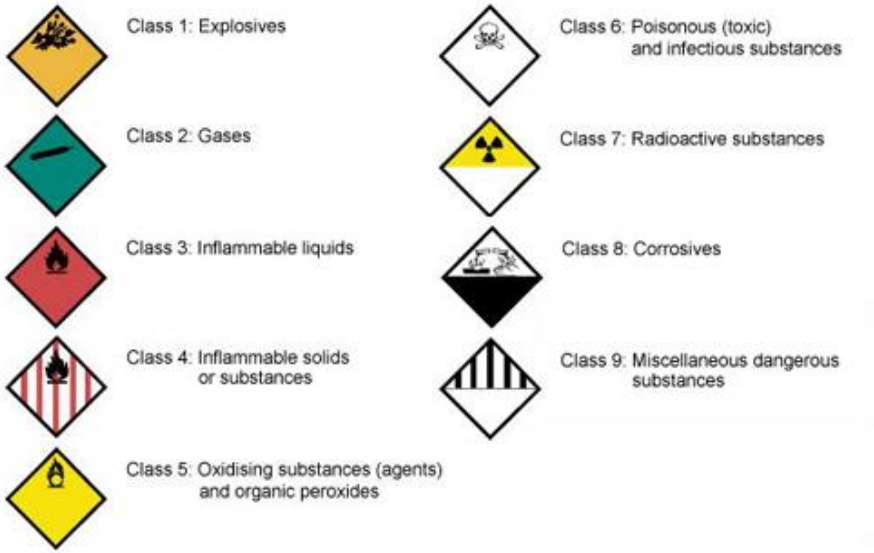
Dangerous Goods

The International Maritime Dangerous Goods Code (IMDG) gives specific details on the carriage of Dangerous Goods in packaged form, solid or bulk. In short safe carriage can be achieved by:

- good packaging
- correct marking, labelling and placarding
- appropriate segregation
- complete documentation

The IMDG Code specifically states that it does not apply to ship's stores and equipment, however many dangerous or potentially dangerous chemicals are carried. These will vary according to the type of ship. If dangerous ship's stores are stowed according to the IMDG Code this would show that all precautions had been taken in the event of an accident.

Classification in the IMDG Code is as follows:



The segregation table provided in IMDG Code 7.2.4 (see below) identifies general requirements for separation between hazard classes and divisions.

CLASS		1.1 1.2 1.5	1.3 1.6	1.4	2.1	2.2	2.3	3	4.1	4.2	4.3	5.1	5.2	6.1	6.2	7	8	9
Explosives	1.1, 1.2, 1.5	*	*	*	4	2	2	4	4	4	4	4	4	2	4	2	4	X
Explosives	1.3, 1.6	*	*	*	4	2	2	4	3	3	4	4	4	2	4	2	2	X
Explosives	1.4	*	*	*	2	1	1	2	2	2	2	2	2	X	4	2	2	X
Flammable gases	2.1	4	4	2	X	X	X	2	1	2	X	2	2	X	4	2	1	X
Non-toxic, non-flammable gases	2.2	2	2	1	X	X	X	1	X	1	X	X	1	X	2	1	X	X
Toxic gases	2.3	2	2	1	X	X	X	2	X	2	X	X	2	X	2	1	X	X
Flammable liquids	3	4	4	2	2	1	2	X	X	2	1	2	2	X	3	2	X	X
Flammable solids (including self-reactive substances and solid desensitized explosives)	4.1	4	3	2	1	X	X	X	X	1	X	1	2	X	3	2	1	X
Substances liable to spontaneous combustion	4.2	4	3	2	2	1	2	2	1	X	1	2	2	1	3	2	1	X
Substances which, in contact with water, emit flammable gases	4.3	4	4	2	X	X	X	1	X	1	X	2	2	X	2	2	1	X
Oxidizing substances (agents)	5.1	4	4	2	2	X	X	2	1	2	2	X	2	1	3	1	2	X
Organic peroxides	5.2	4	4	2	2	1	2	2	2	2	2	2	X	1	3	2	2	X
Toxic substances	6.1	2	2	X	X	X	X	X	X	1	X	1	1	X	1	X	X	X
Infectious substances	6.2	4	4	4	4	2	2	3	3	3	2	3	3	1	X	3	3	X
Radioactive material	7	2	2	2	2	1	1	2	2	2	2	1	2	X	3	X	2	X
Corrosive substances	8	4	2	2	1	X	X	X	1	1	1	2	2	X	3	2	X	X
Miscellaneous dangerous substances and articles	9	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

The numbers in the segregation table represent:

1. away from
2. separated from
3. separated by a complete compartment or hold
4. separated longitudinally by an intervening complete compartment or hold

X Consult the Dangerous Goods List (DGL) to identify any specific segregation provisions

* See IMDG Code 7.2.7.1 for segregation provisions between Class 1 substances and articles

The IMDG code consists of two volumes and one supplement.

Volume 1 contains sections on:

- General provisions, definitions, training
- classification
- packing and tank provisions
- consignment procedures
- construction and testing of packaging
- transport operations

Volume 2 contains:

- Dangerous Goods List, presented in tabular format
- limited quantities exceptions
- the Index
- appendices

The Supplement contains the following texts related to the IMDG Code:

- EMS Guide
- Medical First Aid Guide
- Reporting Procedures
- Packing Cargo Transport Units
- Safe Use of Pesticides
- INF Code

The Emergency Schedules (EmS) Guide contains guidance on Emergency Response Procedures for Ships Carrying Dangerous Goods including the EmS to be followed in case of incidents involving dangerous substances, materials or articles, or harmful substances (marine pollutants), regulated under the International Maritime Dangerous Goods Code(IMDG Code).

The Emergency Schedules for FIRE contains specific guidance for ten groups of dangerous goods and gives general guidelines for dealing with fires onboard.

Management & Control of Injured Persons

The main risks from fire involve the both the effects of smoke and heat.

Smoke Inhalation

Smoke inhalation refers to injury due to inhalation or exposure to hot gaseous products of combustion. This can cause serious respiratory complications.

The hot smoke injures or kills by a combination of thermal damage, poisoning and pulmonary irritation and swelling, caused by carbon monoxide, cyanide and other combustion products.

Burns

The severity of a burn is defined as the depth in relation to the area of burn. The complexity of a burn relates to where it occurs on the body. The depth is classed as:

- Superficial red, tender, no blisters
- Partial red, tender, blisters
- Deep all layers, appearance varies(eg white, charred)

The area is considered as the palm being 1% of their body surface. Its size can be used as a template to measure the total body area burnt.

Management of burns

- remove from source of heat
- cool for at least 20 to 30 minutes
- remove constrictions, eg rings, watches, necklace
- lightly cover with non-fluffy dressing

Special Considerations

- Cooling is most effective in the first 30 minutes but still effective up to 3 hours later
- don't remove burnt on clothing this may cause further damage
- monitor airway, it can swell very quickly and stop breathing
- rinse with cold water for mouth burns

Heat and Humidity

The body core has to be kept within a few degrees of 37°C (98.6°F) as it contains important organs. Heat production is increased by exercise and is lost by

- ***Radiation*** – 50% under normal resting conditions. If the surrounding atmosphere is hotter than the body then it will tend to absorb heat. This is called hyperthermia. Clothing interferes with radiation and will naturally reduce heat loss from the body but equally it will protect the body from absorbing heat radiated towards it.
- ***Convection*** – 25%, rising hot gases are replaced by cooler ones.
- ***Vaporisation*** - 25% from skin and lungs. The evaporation of sweat cools the blood below the surface of the skin, unfortunately excessive sweating over a short period leads to salt loss and heat exhaustion. Fire fighters must replace these body fluids with as much fresh water as they require. Conditions of high humidity are a feature of shipboard fires so the sweat cannot evaporate. The last line of defence to lose heat is to pant, further reducing the duration of the BA set.

Symptoms of heat disorders include

- a feeling of being unwell, including tiredness, headaches, dizziness, nausea, and vomiting
- breathing difficulties/shallow rapid respiration
- rapid pulse, which may be bounding or weak
- extreme thirst and mouth dryness
- muscle cramps
- poor control over movements/stumbling/weakness
- irritability.

Individuals should dress down and drink cool water. If possible warm, not cold, water should be sprayed onto the affected individuals and they should, where possible, be fanned to aid in the process of cooling by evaporation. Wrists may be placed in cool water to help the core temperature reduce.

Emergency Escape Breathing Devices (EEBDs)

An EEBD is a supplied air or oxygen device only used for escape from a compartment that has a hazardous atmosphere and shall not be used for fighting fires or entering oxygen deficient voids. It shall have a service duration of at least 10 minutes and when inactivated shall be capable of being carried hands free. Brief instructions or diagrams clearly illustrating their use shall be clearly printed on each EEBD. The donning procedures shall be quick and easy to allow for situations where there is little time to seek safety from a hazardous atmosphere. All EEBD training units shall be clearly marked.

Spare EEBDs shall be kept on board. All ships shall carry at least two EEBDs within the accommodation spaces. In all passenger ships, at least two EEBDs shall be carried in each main vertical zone. In all passenger ships carrying more than 36 passengers, two EEBDs, shall be carried in addition i.e. four per main vertical zone.

Note: A very important sentence was unfortunately missed from the regulations insofar as;
'EEBDs should be placed in the emergency (fire) lockers for BA wearers to take in if a passenger or crew member were trapped in their cabins'. B.A. teams will take an EEBD through a hazardous atmosphere to a trapped person who will then be able to breathe safely until reaching fresh air. Because of the number of EEBD's required i.e. two in the accommodation on cargo ships they cannot possibly be supplied for all personnel to escape. Because of this lack of guidance, accommodation EEBD's can be found in galleys, cross alleyways, bridge indeed every where except for the fire locker which is their proper stowage.

Engine rooms

On all ships, within machinery spaces, EEBDs shall be situated ready for use at easily visible spaces, which can be reached quickly and easily at any time in the event of a fire.Their location shall take into account the number of people normally working in the space and its layout. The number required is not specified. It is evident that placing them adjacent to an escape door or hatch would be of little use. These are for personal escape.

Fire Detection and Alarm

Fire detection systems are designed to detect the fire in the space of origin and to provide alarm for safe escape or fire fighting activity. They shall be suitable for the nature of the space, fire growth potential and potential generation of smoke and gasses.

Audible and visible warning of a fire must be given in some central control point usually the bridge and engine control room. If not acknowledged after 2 minutes this will then sound throughout the ship.

Heat Detectors

These come in two common types;

Fixed temperature

Operate when the sensing mechanism reaches its specific temperature threshold. Usually there is a fusible metal element which melts and causes a short on the initiating circuit.

Rate of Rise

Identify an abnormally fast temperature climb over a short time period. Rate of rise detectors also have a fixed temperature backstop to ensure that even very slow increases in temperature will eventually raise an alarm, if the increase continues for a sufficiently long period.

Smoke Detectors

These also come in two common types;

Ionisation

In a chamber a radioactive source, usually alpha particle, which ionizes the air passing through the chamber where a current flows between two electrodes. When even invisible smoke enters the chamber and it disrupts the flow of current and generates an alarm

Photoelectric

Light is projected into a smoke sensing chamber inside the detector assembly. The light hits a black background of the chamber and is absorbed. When enough smoke enters the chamber it reflects the light on to a sensor inside the chamber.

Flame detector

The Optical detector "sees" the fire by detecting the electromagnetic radiation emitted by the combustion products. They are line of sight devices that operate on either an infrared, ultraviolet (UV) or combination principle.
I.R. responds to the flicker in a flame and may give false alarms from sunlight, faulty fluorescent lights, etc. Many modern detectors have now reduced these false alarms considerably by further comparing the flame with the light spectrum. UV is not affected by sunlight or artificial light but is sensitive to electrical arcs.

CCTV systems can also be used to monitor spaces looking for particular patterns for smoke or oil mist. Some passenger ships have these sytems throughout the engine room areas.

Hold Sampling

The most usual type of fire-detection equipment to be found in cargo holds is a smoke-detector system where a sample of air is taken from each protected space and passed through a smoke detector. This system has the advantage that the same sampling pipes may be used to deliver the fire extinguishing medium to the space.

The sampling pipes terminate at a cabinet in which the labelled ends of the pipes can be seen. A propeller or other device indicates that a stream of air is in fact being drawn through the pipe. Indirect lighting will illuminate any smoke particles entering the cabinet. One disadvantage of this type of detection system is that one detector is sampling air from a very large volume. To overcome this disadvantage more recent types have a miniaturised detector on each sampling pipe.

The air then passes through a photo-electric detector that will set off an audible and visible alarm. Air may be discharged into the wheelhouse to give the officer of the watch an opportunity of nasal detection if all else fails.

Every vessel shall develop a regular routine for testing detectors. They must be tested to the phenomena in which they are designed to respond.

SOLAS II-2 Part C Suppression of Fire - Regulation 7

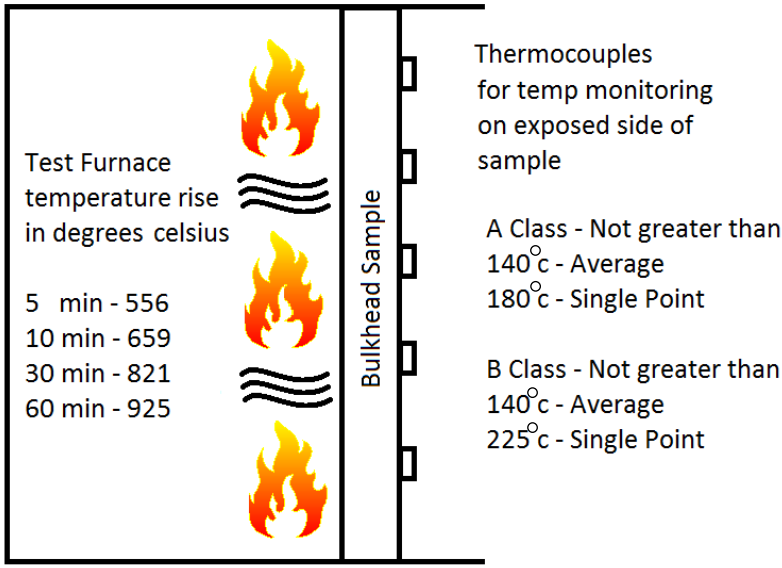
Containment

A fire is to be contained within the point of origin as follows:

1. The ship shall be subdivided by thermal and structural boundaries;
2. Thermal insulation of boundaries shall take into account the fire risk of the space and adjacent spaces; and
3. The fire integrity of the divisions shall be maintained at openings and penetrations.

A, B and C class divisions are used to maintain thermal barriers depending on the associated risk. Fire dampers are also provided in ventilation ducting to limit the spread of heat and smoke.

A and B class divisions should meet certain requirements when subjected to a standard fire test. In this test, a bulkhead sample is exposed to a test furnace with temperatures as follows:



A Class Division

1. Constructed of steel (or equivalent) and stiffened.
2. Prevent passage of smoke and flame for 60 minutes during the standard fire test.
3. Not rise above specified temperature for required period.
    - A60 – 60 Minutes
    - A30 – 30 Minutes
    - A15 – 15 Minutes
    - A0 – No temp requirements

B Class Division

1. Prevent the passage of flame for the first 30 minutes of the standard fire test. Smoke may pass through the ventilation panel on a door.
2. Not rise above specified temperature for required period.
    - B15 – 15 Minutes
    - B0 – No temp requirements

The numbers clearly represent the time and therefore the amount of insulation required in the sample to meet the requirements.

C Class Division

This is constructed of non-combustible materials but there are no requirements relative to the passage of smoke and flame nor limitations relative to the temperature rise.

Tables in SOLAS detail the appropriate class of bulkhead or deck to be used between spaces on all ships. An accommodation space on a cargo ship adjacent to an engine room would require an A60 bulkhead whereas an accommodation space next to a cargo space would require an A0. These are fire resistive bulkheads and must not be breached by ship's staff or contractors to allow pipe work, cables etc. to lead from one compartment to another. This can be done but only with the permission and advice from the company, ship's class surveyor, Lloyds, DNV, RINA etc.

Passenger Ships

A Class Divisions

In general, main vertical zones bounded by A Class divisions should not exceed 40 metres. A Class divisions are also used as boundaries protecting spaces that provide vertical access (stairways etc.), the boundaries of machinery spaces and those separating accommodation from cargo and service spaces and others.

B Class Division

All corridor bulkheads, which are not required to be A Class, must be B Class.

C Class Division

C Class divisions are used for inter-cabin bulkheads and inter-sanitary accommodation must be constructed of approved non-combustible materials.

Cargo Ships

The fire resistance will vary depending on the degree of fire detection or whether a sprinkler system is fitted. There are various methods in SOLAS to achieve the required protection, dependent on other measures, Method IC is common where a fire detection and fire alarm system provide smoke detection and manually operated call points in all corridors, stairways and escape routes within accommodation spaces.

Tankers

A60 materials must be used for those areas of superstructure and deckhouses facing the cargo deck and for 3 metres aft on either side, engine casing, uptake and cargo pump rooms.

Ventilation of Shipboard Fires

Due to the fire resistive divisions required aboard ships, a fire should be able to be contained within the space by:

- Boundary cooling
- Boundary starvation
- Isolation of recirculated air
- Patrols, especially above

Smoke extraction systems have been incorporated into buildings for many years. However, no international attention was paid to ship design until 158 people died from toxic products and smoke inhalation aboard the Ro-Ro vessel Scandinavian Star in April 1990.

Accommodation

Many passenger and commercial vessels are able to slightly over-pressurise their stairwell escape routes which prevents smoke in accommodation entering the stairwell where other passengers or personnel are escaping from different levels. The only problem is that the deck where the fire has started remains smoke-logged which may lead to fatalities. Other newer passenger vessels do have smoke detectors in the cabin exhaust. When a fire is detected, all recirculated and fresh air being supplied is stopped, with only the toilet extraction left on to allow smoke and other products to escape.

If the muster is complete, all ventilation systems can be shut down and the fire attacked by the fire team. Once they have covered or extinguished the fire, they may well request ventilation by whatever means. Tactical ventilation of a space may generally be very successful if employed, but if there are fire-fighters inside they must decide or approve how this is achieved.

Engine room

When initial fire fighting attempts are unsuccessful, early use of fixed installations into engine rooms is generally recommended. There may, however, be circumstances where an entry is required prior to the use of these systems. Entry must be made at the lowest level possible and a funnel flap may be opened to allow the steam and hot gases to escape. There is always a concern that the fire will be fed with more oxygen but, providing there is a limited opening at the entry point, a chimney effect will not be created.

The benefits of ventilation are:

- increased visibility and therefore greater mobility
- lower heat and humidity levels
- casualties will survive longer

There can be no blue print in what action to take in every event. Simply if there is no-one missing, box in the six sides of the fire. Thoughts must be given to smoke extraction in those early minutes if a rescue team is required.

Understand the natural or mechanical ventilation systems on your own ship; they vary immensely and may be easy or very difficult to use.

At present the only requirement for smoke extraction applies to public spaces i.e. atria on passenger vessels that span three or more open decks. They must have an automatic smoke extraction system activated by smoke detector or manual control so that the space can be exhausted in 10 minutes or less.

Fixed Fire Extinguishing Systems

SOLAS sets out the requirements for the protection of certain spaces with the appropriate fixed fire system, guidance can be found in Chapter II-2 *Part C Suppression of Fire*. This includes systems for engine rooms of various types and sizes, fixed local application systems of various types, accommodation and cargo spaces.

Sprinkler System

A sprinkler system is a wet pipe fire detection system with the added advantage that it immediately sprays water on to the fire. A charged system of pipes kept pressurised with fresh water has outlets which are sealed by a glass bulb containing a liquid of a known coefficient of expansion.

Glass bulb nozzles		Fusible element nozzles	
Nominal release temperature (°C)	Liquid colour code	Nominal release temperature (°C)	Frame colour code[1]
57	orange	57 to 77	uncoioured
68	red	80 to 107	white
79	yellow	121 to 149	blue
93 to 100	green	163 to 191	red
121 to 141	blue	204 to 246	green
163 to 182	mauve	260 to 343	orange
204 to 343	black		

In accommodation and service spaces the sprinklers should have a nominal temperature rating of 57°C to 79°C, except that in locations such as drying rooms, where high ambient temperatures might be expected, the nominal temperature may be increased by not more than 30°C above the maximum deckhead temperature. (FSS Code Resolution A.800(19) Revised guidelines for approval of sprinkler systems).

At a certain temperature (above) this coloured liquid will expand and break the glass, this breaks the seal on the assembly and the water released hits the diffuser and sprays on the fire. The flow of water activates an alarm and indicates the section activated. When the pressurised freshwater reserve falls (about 1½ ton tank) a dedicated seawater pump cuts in and maintains the flow.

Where there are high ambient temperatures, e.g. laundry, drying rooms and galley blue bulbs may be used provided the operating temperature is not more than 30ºC above the maximum deckhead temperature.

Other heads will not be activated unless they are affected by heat; if too many heads are activated, the pressure will not be maintained. The delivery from one head can range from about three to five tons an hour dependant on the system. This may affect stability in a prolonged fire but the system should not be shut off until it is certain that the fire out.

The system is grouped into sections, each of no more than 200 heads, each section having its own isolating and detection valve and no section should (normally) cover more than two decks nor penetrate a Class A bulkhead.

Visual and audible alarm systems shall be centralised on the bridge or a main fire control station indicating in which zone the sprinkler head has been activated.

Deluge System

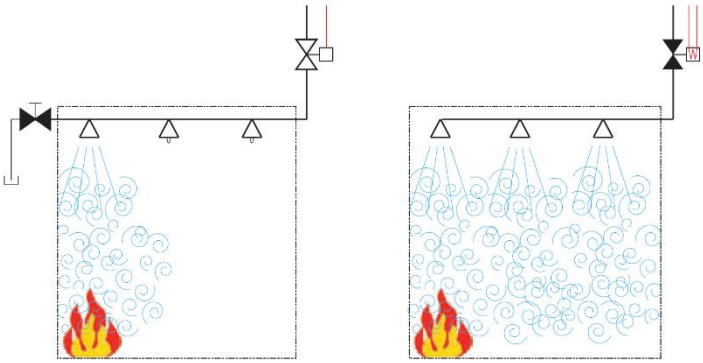
Deluge is a system employing open nozzles attached to a piping system connected to a water supply through a valve that can be opened by signals from a fire detection system and by manual operation. When this valve is opened, water flows into the piping system and discharges from all nozzles attached thereto.

These systems can be found on cargo & car decks (MSC/Circ.1430) and areas where large and immediate quantities of water are required. By the nature of operation the volume of water delivered is significantly more than the wet pipe sprinkler system.

Water Mist Systems

Water mist systems utilise higher pressures to create a fine spray which has a number of positive effects on the fire. These include a smaller droplet size which encourages more rapid cooling and the production of steam around the fire which gives a smothering effect. Due to these features water mist is suitable for use on Class B and Class F fires also, MSC/Circ's.668/728 or MSC/Circ.1165 give further guidance on the systems

These systems can be in a wet pipe (*above*) or deluge type (*left*) configuration dependent on their situation. There are a number of areas where these systems are utilised, it may be the only system in the Engine Room (MSC/Circ. 1165) however it must cover the entire area, and the systems with the largest approved volumes currently quite small.



Wet pipe system

Deluge system

Engine room

A fixed *local* application fire extinguishing system (MSC/Circ. 1387) is only required for machinery spaces of Category A above 500m^3 on ships with keels laid after 1st July 2002, and for all existing passenger ships of 2000 GT and above built before 1st July 2002.
These systems in the case of periodically unattended spaces should have both automatic and manual release capability.
The systems are designed to protect certain areas of the engine room without the need to shut down the engine, evacuate personnel or seal the space for at least 20 minutes.

Areas protected include:

- Fire hazard portions on internal combustion machinery
- Boiler fronts
- Incinerators
- Purifiers of heated oil

Water mist systems are typically more complex than standard pressure systems but when operated correctly can provide excellent protection. It is essential that all crew are aware of the system, where it is located, areas protected and how to operate it. The fact that this system can be used with people in the vicinity is one of its key features and there should be no delay in releasing it.

MSC/Circ 1432 was amended by MSC/Circ.1516 to deal with a number of issues related to water quality and clogging of systems. These amendments deal with testing the quality of water in wet pipe systems and additionally procedures should any number of heads fail to operate as expected.

Foam Fire Extinguishing Systems

Guidance for the following systems can be found in more details in the following Marine Safety Circulars,

- Fixed Systems MSC/Circ. 1432
- Low ex MSC/Circ. 1312
- Med ex MSC/Circ.798
- Hi ex MSC/Circ.670 – Inside air foam MSC/Circ.1271

Fixed Deck Foam Systems

Solas Ch.2 Regulation 10.8.1 essentially requires tankers of 4,000 tonnes deadweight and above to be fitted with protection of the cargo tank deck area and cargo tanks by a deck foam system, in tankers over 20,000 tonnes an equivalent system may be used as long as meets the requirements. Almost all oil carriers are required to be fitted with a deck foam system.

It must be capable of simple operation with the control station located outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected. This system will normally consist of fixed monitors, as well as required hand line applicators.
In any chemical tanker, the type of foam concentrate should be appropriate for the chemicals listed on the Certificate of Fitness, i.e. either a regular foam or an alcohol resistant foam. In cases where a foam concentrate of each type is required, an all-purpose foam should be used.

Sufficient foam concentrate shall be supplied for 20 minutes of foam generation in ships fitted with inert gas or 30 minutes where there is no inert gas. Guidance for the positioning of monitors and the distance that they reach are included in the Fire Safety Systems Code, there are a number of additional requirements such as there must be a minimum of 4 portable applicators and the system should be fitted with an isolation valve in the foam main to isolate any damaged sections.

Fixed Deck Foam System Diagram

High Expansion Foam for Engine Room/Pump Room

These systems (MSC/Circ.1384) are an alternative to a fixed CO^2 system for an engine room. Basically Hi-Ex foam is composed of a mass of bubbles having an expansion ratio of approximately 650 -1000 volumes of foam for each volume of liquid foam concentrate

This can be produced by hi-ex foam generators using air from outside the space or by generators using air from inside the engine/pump room.

When foam with an expansion ratio of 1000:1 is driven onto a fire, the one volume of liquid is flashed to steam. The resulting expansion rate creates a mixture of some 1700 volumes of steam to reduce the oxygen content to 7.5% or well below what is required for active burning. Conversion of water to steam absorbs a great deal of heat, thus cooling the burning material.

Principal requirements for the system are

- System source of power supply, foam concentrate supply and means of controlling the system should be readily accessible and simple to operate.
- Should be adequate to completely fill the largest protected space in 10 min or less.
- The quantity of foam concentrate available should be sufficient to produce a volume of foam equal to at least five times the volume of the largest protected space, min 30 min of full operation for the largest protected space.
- All sections of piping should be provided with connections for flushing, draining and purging with air.
- Audible and visual alarms should operate for at least 20 seconds to warn of imminent release.
- If the space is greater than $500m^3$ it must be capable of being ventilated as the foam flows in otherwise a back pressure could curtail the formation of foam.

In particular when using inside air foam,

- On-board procedures should be established to require personnel re-entering the protected space after a system discharge to wear BA to protect them from oxygen deficient air and products of combustion entrained in the foam blanket.

Hazards of High Expansion Foam

- There is a general loss in effectiveness of vision, hearing and sense of direction, i.e. disorientation, difficult to find casualties.
- Penetration of light from torches is severely affected, cannot see dangers, i.e. missing floor plates.
- Audibility of speech and the sound of low-pressure warning whistles are severely restricted.
- Thermal imaging cameras are ineffective.

Clearing away the foam.

BA must be worn when entering a space where hi-ex has been released as toxic gases may be entrained in the foam bubbles. Entering hi-ex before it has been broken down should be avoided. This can be achieved by using water sprays or dry powder but with the disadvantage of causing further damage. The foam will break down the longer it is left but this is no help to the Master who may require power back sooner rather than later.

Low expansion foam systems for engine rooms.

Low expansion foam systems are no longer permitted to be installed as the sole fixed fire fighting system for machinery spaces.

The system where installed shall be capable of discharging through fixed discharge outlets in not more than 5 minutes a quantity of foam sufficient to cover to a depth of 150mm the largest single area that over which oil fuel is liable to spread. The expansion ratio shall not exceed 12:1.

There must be effective distribution and for means to direct the foam by fixed sprayers onto other main hazards in the protected space.

Foam Concentrate used in Portable Applicators- Annual testing and inspections

Verify all portable containers remain factory sealed and the manufacturer's service life has not been exceeded. Foam concentrates, excluding protein foam, less than 10 year's old that remain factory sealed can normally be accepted without the periodical foam control tests required by MSC.1/Circ.1312.

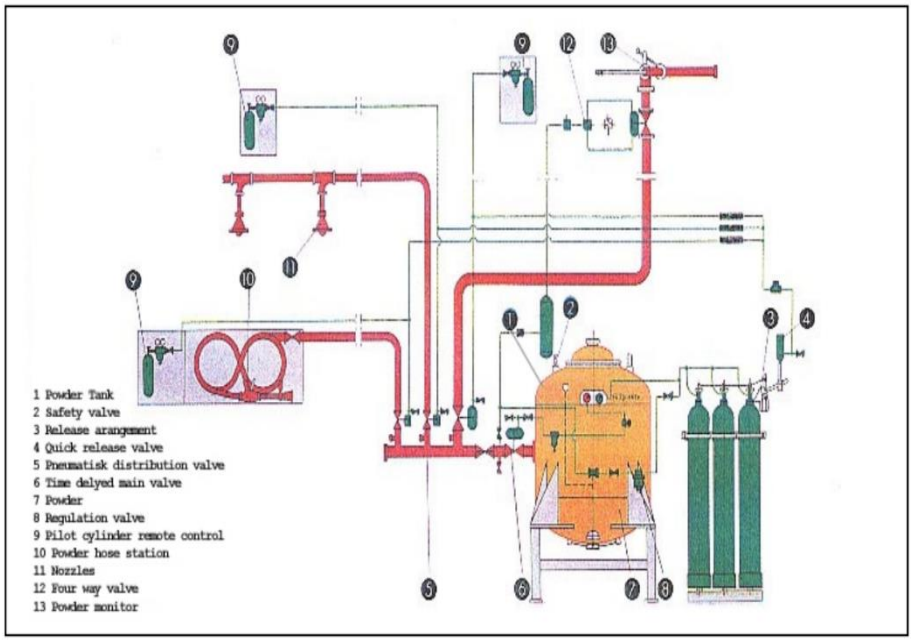
Protein based concentrates, if more than 5 year's old, should be subjected to the tests required in MSC.1/Circ.1312 or renewed. Take samples of all foam concentrates carried on board for testing. The first test shall be carried out 3 years after being supplied to the ship then every year thereafter.

During re-surveys, foam monitors should be tested with water to ensure the pipes are clear and the throw from the monitors has not been impaired. Foam proportioning devices and measuring pumps should be tested, preferably by the discharge of foam from one of the monitors. The foam compound test certificates should be inspected.

Fixed Dry Powder Installations

Ships in which the carriage of flammable products is intended (see SOLAS in Ch.2 Regulation 1.6.2) should be fitted with fixed dry chemical powder type extinguishing systems for the purpose of fighting fire on the deck in the cargo area and bow or stern cargo handling areas if applicable.

The specification for fixed dry powder systems are contained in the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code), as amplified by MSC Circular 1315.



The system is to be capable of delivering powder from at least two hand hose lines or a combination monitor/hand hose line(s) to any part of the above-deck exposed cargo area including above-deck product piping. The system shall be activated by an inert gas, such as nitrogen, used exclusively for this purpose and stored in pressure vessels adjacent to the powder containers.

A sufficient quantity of dry chemical powder should be stored in each container to provide a minimum 45 seconds discharge time for all monitors and hand hose lines attached to each powder unit. The capacity of a monitor should be not less than 10 kg/s. Hand hose lines should be non-kinkable and be fitted with a nozzle capable of on/off operation and discharge at a rate not less than 3.5 kg/s. The maximum discharge rate should be such as to allow operation by one man.

Hand hose lines should be considered to have a maximum effective distance of coverage equal to the length of hose. Special consideration should be given where areas to be protected are substantially higher than the monitor or hand hose reel locations.

The IGF Code (MSC.391(95)) for ships using low flashpoint fuels states that,

"A permanently installed dry chemical powder fire-extinguishing system shall be installed in the bunkering station area to cover all possible leak points. The capacity shall be at least 3.5 kg/s for a minimum of 45 s. The system shall be arranged for easy manual release from a safe location outside the protected area."

Water Spray systems

On ships carrying flammable of toxic products or both, a water spray system for cooling, fire prevention and crew protection are to be installed to cover:

- exposed cargo tank domes and any exposed parts of cargo tanks;
- exposed on-deck storage vessels for flammable or toxic products;
- cargo liquid and vapour discharge and loading and any other areas where essential control valves are situated which shall be at least equal to the area of the drip trays provided;
- boundaries of superstructures, deckhouses normally manned, cargo compressor rooms, store-rooms containing high fire risk items and cargo control rooms all facing the cargo area.

Boundaries of unmanned forecastle structures not containing high fire risk items do not require water spray protection.
Additionally water sprays may be utilised to protect survival craft embarkation areas from the tank deck or other high risk areas.

Remote starting of pumps supplying the water spray system and remote operation of any normally closed valves in the system shall be arranged in suitable locations outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected.

Fixed System Pump Room

In addition to SOLAS requirements for engine room spaces there are additional requirements for cargo compressor and pump room spaces.

These areas should be protected by those systems that would be applicable for engine rooms namely;

Co2 System
High Ex foam System
Fixed pressure water spraying system

Under no circumstances should a Co2 system be used for inerting purposes due to the risk of static discharge causing a spark and igniting a flammable atmosphere.

Carbon Dioxide (CO^2) Systems

CO^2 systems can be used in engine room or cargo spaces on-board ship, key features of these systems are,

- When protecting more than one space the required amount on-board need only be enough for the largest space.
- Pipe work should be arranged for even distribution throughout the space.
- Instructions for operating the installation must be displayed near the remote operating controls, distribution control valves and also near the gas cylinders in accordance with MGN 389.
- Means shall be provided of giving an audible alarm in the space protected if personnel have access, this is often accompanied by a visual signal as required by the Code on Alerts and Indicators, 2009.
- Engineers must recognise this warning when it sounds and evacuate immediately.
- Notices should be posted on the entrances to every space protected by CO^2, indicating that the space is so protected and that personnel should evacuate the space immediately on hearing the CO^2 alarm.
- Two separate controls are required to prevent inadvertent operation. They should be positioned inside a control box clearly identified for releasing CO^2 into the protected space.

For further information refer to the FSS Code Ch.5, MGN 354 & the comprehensive instructions provided in the guidelines for the maintenance and inspections of fixed carbon dioxide fire-extinguishing systems (MSC/Circ.1318) for fixed CO^2 systems.

NOTE: CO^2 and other fire extinguishing gases should not be used for inerting purposes in spaces which may contain an explosive mixture of flammable gases or vapours where there is no fire, as there is evidence to show that the action has resulted in an explosion caused by electrostatic sparks generated by the CO^2 discharge.

Engine Room Systems

In the event of a fire in the engine room (ER) assuming that it cannot be immediately extinguished by portable equipment or any local application appliances the CO^2 system should be activated ASAP and ideally within 20 minutes.

Instruction for release

Masters, skippers and crew should be fully competent with the remote and local operation of the fixed CO^2 fire extinguishing system.

Before discharge the Master has to ensure that all personnel are out of the engine room and all doors and openings are closed.

Before a space is filled with CO^2 it is essential that the compartment ventilation flaps are properly closed and sealed, ventilation fan emergency stops and all fuel and hydraulic oil remote quick closing valves are operated.

In the event of navigational constraints consideration should be given to the effects of a loss of propulsion and consequent effects on the vessel.

For an ER the required amount is 35% of the gross volume of the largest space including the casing, 85 per cent of this required concentration should be achieved within two minutes. However the arrangements should additionally provide for a discharge of at least 50 per cent of the required amount of gas in the first minute of operation.

Release cabinet with detached hose for positive action release

Immediately after activation of the CO^2 system checks should be carried out to ensure that the gas has been correctly released from the cylinders. (Before entering the CO^2 room at this stage appropriate precautions should be taken such as donning breathing apparatus). This can be achieved by feeling the CO^2 cylinders which should be cold to the touch and visually checking the individual cylinder release valves to ensure they are in the open position.

Remember that although CO^2 has the great advantage that it causes no further damage than that already caused by the fire, it has no cooling effect and re-ignition will occur if the ER is opened up before the steelwork has cooled below the AIT/ SIT of any vapours or liquids remaining. This will vary depending on the size and duration of the fire before the gas was injected.

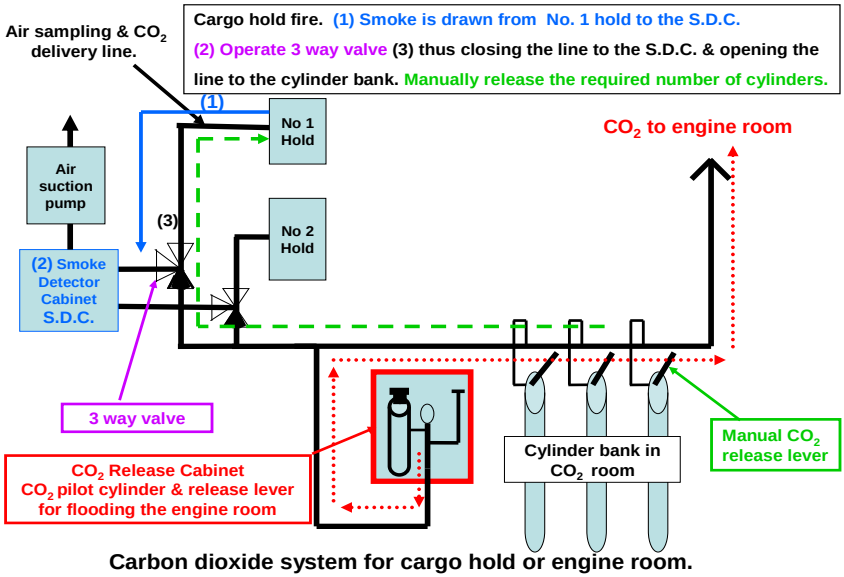
Applying controlled amounts of water to the boundaries, by whatever means, will continue to cool and protect, if any steam is given off this can also be good indicator of the temperature inside the space.

MGN 354 Safe Operation of Fixed CO2 Gas Fire Extinguishing Systems gives guidance including,

"It is strongly recommended that expert advice should be obtained from ashore before ventilation of the space or any attempt at re-entry is made. The nearest Coastguard to your position may be contacted who will assist in trying to obtain this advice. Unless specifically requested, this will not be interpreted by the Coastguard as a request for on-scene fire-fighting assistance."

Even when the fire is extinguished a fully equipped fire team in BA must inspect the ER before the gas can be ventilated and auxiliary machinery can be started.

Temperature checks can be achieved by water sprays on the entry door. If steam is given off it is too hot to enter. Infra-red thermometers or thermal imaging cameras are most useful and where temperatures of 70^{o}c to 80^{o}c are obtained a careful entry can be undertaken. If the vessel is not in any danger there may be no urgency to re-enter.



Carbon dioxide system for cargo hold or engine room.

For a ship using a smoke sampling system, the same pipe work can be utilised to introduce the CO^2 into the space. In the CO^2 room or in the detector cabinet there will be a manifold with each space labelled on each lever, 2 lower hold, 3 lower hold etc. The appropriate three-way valve is operated which closes the line to the detector cabinet but allows delivery of CO^2 to the space on fire.

In the control room there will be instructions as to how many cylinders should be released initially and how many at set intervals until arrival in port or all CO^2 is used up. In a hatch filled with cargo it cannot be certain that the CO^2 would flush out all the air trapped in amongst the cargo, so control is aimed for.

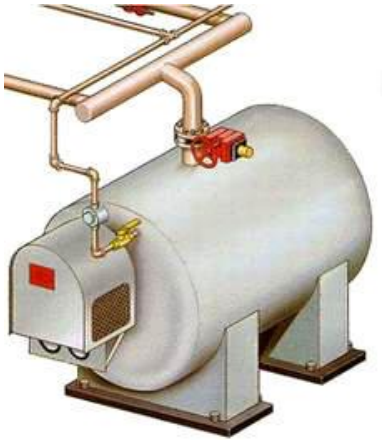
The number of cylinders initially released will depend on the amount of cargo in the hatch, e.g. where a space is full 4 cylinders would be manually released into the space whereas 10 cylinders maybe released into the same partially filled space.

Liquid Level Indicator

The Liquid Level Indicator enables the extinguishing content to be checked without dismantling the manifold or common release wires so that the system remains fully operational. The Liquid Level Indicator consists of a small low power radioactive source and receiver displaced on a yoke by the width of the container being measured. Simply moving the sensor assembly over the height of the container and observing the indicator on the control box, quickly identifies the liquid level. The tables provided convert the liquid level into the weight of extinguishing gas.

CO^2 rooms can contain any number of cylinders for the required spaces dependent on the size.

Occasionally CO^2 is stored in large low-pressure refrigerated tanks instead of the customary high-pressure 48kg cylinders.



Bulk low pressure CO^2 utilizes a central storage tank that keeps the CO^2 at a lower pressure through the use of a refrigeration unit.

Other Fixed Systems requirements

Deep Fat Fryer

Deep fat cooking equipment must be fitted with a fixed system under SOLAS Ch II-2/10.6.4.1. This can be a variety of systems including CO^2, water mist or wet chemical.

Spaces containing flammable liquid

Paint lockers shall be protected by one of the following,

- CO^2 System
- Dry Powder system
- Water spraying/sprinkler system

In all cases operable outside the space.

Galley Exhausts

On passenger ships and where passing through accommodation exhaust systems shall be fitted with a grease trap and a fixed means of extinguishing a fire within the duct.

Gas carriers

Ships intending to carry flammable products are to be fitted with a fixed dry chemical powder type extinguishing systems for the purpose of fighting fire on the deck in the cargo area and bow or stern cargo handling areas if applicable in accordance with SOLAS Ch II-2/1.6.2 and chapter 11 of the International Code for the construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code).

Equivalent fixed gas fire-extinguishing systems engine rooms and pump rooms

Under the guidelines for the approval of equivalent fixed gas fire fighting systems MSC/circ.848 as amended* they should have the same reliability as previously approved systems.

Halocarbon clean agents are 'active' gases and break down the chemical reaction in the fire and typically only need 5 – 12% concentration to work. They include:

- FM 200 – *CF^3CHFCF^3*
- NOVEC 1230 – *$CF^3CF^2C(O)CF(CF^3)^2$*
- Halotron IIB – *HFC 3-4-9 C^2 (FS 49 C2 or R866)*
- NAF S227 – *CF^3C H F^2 (Pentafluoroethane or HFC 227)*
- FE 13 - *CHF^3*

Where halocarbon clean agents are used, 95% of the design concentration should be discharged in 10 seconds or less.

Inert gases work by reducing oxygen levels and typically require concentrations of 35 – 50% to work. They include:

- Argonite – Nitrogen (50%) + Argon (50%)
- Inergen - Nitrogen (52%) + Argon (40%) + Carbon dioxide (8%)

Note: these gases have been engineered to allow personnel to survive in atmospheres at design concentrations

Aerosols systems usually comprise a fine potassium powder, which is held inside a container or 'generator' until activation causes the powder to be dispersed as an aerosol around the protected space. The potassium molecules attack the fire physically and chemically, inhibiting the chemical chain reaction present in combustion.

- Pyrogen - Aerosol (inert solid producing gas like extinguishant)
- FirePro Aerosol Potassium compounds KOH reacts & forms K2CO3

**MSC/Circular 1267, MSC/Circular 1316 and MSC/Circular 1317*

Novec 1230

It has a low toxicity and has a boiling point of 48°c and therefore exists as a liquid at room temperature. It is super-pressurised with nitrogen to 25 bar and it rapidly extinguishes fire through a combination of heat absorption (its main action) and an element of chemical interference with the flame. Novec 1230 will require approximately twice as much agent by weight as the equivalent halon system although end use design concentrations will be similar.

It contains neither bromine nor chlorine, has a zero ozone depleting potential and an atmospheric lifetime of 3 – 5 days.

FM 200

This extinguishes fires quickly through a combination of chemical interaction and physical heat removal. It does not smother. Stored as a liquid in pressurised cylinders, FM 200 flows to a discharge nozzle where it is deployed as a gas. In most systems about 7% of gas is required. It has zero ozone depleting potential, a low global warming potential and a short atmospheric lifetime.

Halotron

It is discharged as a liquid which rapidly evaporates. The primary extinguishing is the absorption and removal of heat and to a lesser extent by the displacement of oxygen. Approximately 6% to 7% by volume needs to be discharged into the space. Its atmospheric lifetime is 3 to 11 years and low ozone depletion potential. The heat of the fire may release hydrochloric and hydrofluoric acids.

Pyrogen

Pyrogen arose out of the development, in the former Soviet Union, of a solid rocket fuel. When activated, the solid generating chemical undergoes a combustion reaction producing potassium carbonates, carbon dioxide, nitrogen and water vapour. It chemically inhibits the flame and lowers the fire temperature.

MGN 71 (further guidance MSC.1/Circ 1432)

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

Monthly testing and inspection should be carried out to ensure that:

1. all firefighters outfits, fire extinguishers, fire hydrants, hose and nozzles are in place and in serviceable condition;
2. all escape routes including stairways and corridors are free of obstructions and properly maintained;
3. public address system and ship's alarms are serviceable;
4. all fixed fire fighting installation valves are set in the correct operational position;
5. dry pipe sprinkler systems are pressurised, where appropriate, and gauges indicate correctly;
6. sprinkler system pressure tank water levels are correct as indicated by glass gauges;
7. all sprinkler system pumps operate automatically on pressure loss in the systems;
8. all fire pumps are operational; and
9. all fixed gas fire extinguishing installations are free from leakage.

The coloured liquid in the bulb of the sprinkler or hi fog nozzle has been known to leak. If there is no liquid in the glass bulb there is nothing to expand, break the glass and hence release the water from the pressurised system.
Establishing a routine to visually check that no leakage has occurred is important.

Quarterly testing and inspection should be carried out to ensure that:

1. all fire extinguishers are at correct pressure and are not due for servicing;
2. all automatic alarms for sprinkler systems activate using the section test valves;
3. the international shore connection is serviceable;
4. fire fighting equipment lockers contain their full inventory and the equipment they contain is in serviceable condition; and
5. all fire doors, fire dampers and closing devices can be operated locally.

Annual testing and inspection should be carried out to ensure that:

1. all fire doors, and ventilation dampers where appropriate, operate remotely;
2. where practicable all aqueous foam and water spray fixed fire fighting installations operate correctly;
3. all accessible components of fixed fire fighting systems, typically nozzles, are free from damage or obstruction on visual inspection;
4. all fire pumps, including sprinkler system pumps, develop correct pressures and flow rates;
5. all hydrants operate;
6. all antifreeze solutions are correctly maintained and cross connection between fire main and sprinkler system operates correctly; and
7. fixed fire detection systems operate correctly, according to manufacturers test instructions.

Fire Investigation and Reporting

Procedures are governed mainly by the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 (SI 1743) which replaced the regulations of 2005. They define the accidents to which they apply, set out the purpose of investigation and make provisions for the ordering and conduct of investigations.

An accident is defined as any marine casualty (including very serious marine casualties and serious marine casualties) or any marine incident. An accident also includes serious injuries as defined by the Regulations. A full list of descriptions can be found in MGN 564.

A marine incident incorporates the 2005 Regulation's definition of hazardous incidents. Marine incidents include 'near misses', stemming from failure of procedures in shipboard operations, material defects, fatigue and human failures. Marine incidents are now required to be reported to the Marine Accident Investigation Board (MAIB). Many incidents occur which do not cause injury or damage, but have the potential to be hazardous or to have serious consequences.

Reporting marine incidents can lead to important safety lessons being learned.

A fire is categorised as a serious marine casualty or higher depending on the extent of the incident.

After the initial report the master or senior surviving officer, the ship's owner and where appropriate harbour authorities and inland waterway authorities must, so far as is reasonably practical, ensure that the circumstances of every accident are examined. A single report giving the findings of such an examination, stating any measures taken or proposed to prevent a recurrence, must be provided to the Chief Inspector as soon as is practicable, irrespective of any investigation that may be conducted by the MAIB.

The Code of Safe Working Practices for Merchant Seamen, Chapter 3 gives information on how to investigate accidents. The Code must be made available to all on board and the number of copies held will be determined by the crew complement.

As much evidence as possible must be recorded so the accident can be investigated thoroughly. This will be especially important should there be injury or loss of life.

This report should include the following factors:

Synopsis of the incident	Date, Time, Place
Reasons	Faulty storage, carelessness or neglect
	Poor maintenance
	Malicious
On Board Organisation	Command
	Coordination
	Control
	Assistance from outside organisations
	Effects of this assistance

Additional elements will include

- The extent and spread of the fire:
- Statements from participants or witnesses
- First indications of fire
- Actions taken by those first at the scene
- History of previous failures
- Housekeeping standards
- Ability and knowledge of those involved
- Repair work undertaken
- Conclusion
- Recommendations

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