World Academy of Safety & Health INTERNATIONAL

STCW Basic Safety Training Course Instructor Manual

1.20 Fire Prevention & Firefighting

v.2020

Purpose:

This *World Academy of Safety & Health (WASH) International STCW Fire Prevention and Firefighting Manual, v.2021* is exclusively intended to provide guidance and information on the delivery and administration of the World Academy of Safety & Health (WASH) International Maritime Training course(s). All information contained within this manual is subject to change at any time for any reason and without notice. All updates, changes, alterations, and new editions will be published on *www.lifeguardcertifications.com*.

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Published by Jefferson Marketing Group

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Each emergency situation is unique and, hence, warrants its own set of guidelines, principles, recommendations, information and/or emergency response protocols. Therefore, it is not possible for *World Academy of Safety & Health (WASH) International* to provide blanket emergency response recommendations.

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World Academy of Safety & Health (WASH) International utilizes an Advisory and Review Committee in the development of all programs, courses, manuals, resources, and other instructional materials.

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Module 1: FIRE Course – Introduction, Safety & Principles

Section 1 - Introduction

Aims of the course

- Know what to do if fire or smoke is detected
- Know what to do if the fire alarm is sounded
- Know how to raise the alarm
- Have a basic knowledge of the use of portable fire extinguishers
- Know how to isolate the fire and restrict air flow to it
- Know how to minimiZe the risk of fire & be ready to fight & extinguish a fire

Know what to do when fire or smoke is detected or the fire alarm is sounded
Before making a decision to fight even a small fire, there are several safety factors to consider:

- Accessibility to the fire
- Personnel at the fire
- Possible reactions with cargo
- Fire fighting agents & equipment available

Activate the alarm by pressing the MCP button (if available)

- Break the glass
- Press the button
- Contact the Officer of the Watch & pass on as much information as possible about the fire

Restrict

- Close the doors
- Shut off ventilation

Try to extinguish the fire

- If it is safe to do so, use a fire extinguisher, fire blanket or other device at hand to quickly extinguish a small fire

On hearing the fire alarm

- If you are a member of the fire team report to the fire station, don PPE and await instructions

Notes

Section 2 – Safety Rules

- Safety first at all times
- Wear clothing made of natural fibres during the practical training
- Woollen or cotton socks and closed toe shoes
- Long legged pants and long sleeved top

On joining a new ship

- Learn as much as you can from the ship's regular training and drills
- Locate the ship's fire fighting equipment and learn how to operate it
- Know what to do when you are called to a fire station
- Learn the location of the escape routes on board your vessel
- Know the hazardous areas onboard

Section 3 – Principles of survival in relation to shipboard fires

Drills & Training

- Required under AMSA's Marine Orders that empower STCW and SOLAS conventions regarding the frequency and types of drills to be conducted.
- Minimum 1 fire drill & 1 Abandon Ship drill every month & within 24 hours of leaving port if 25% of the crew have not participated in the drill in the previous month.
- Learn how to use the fire fighting equipment
- Learn your part in the fire team
- Knowledge of Emergency Escape Routes
- Check the proper operation of the fire fighting equipment

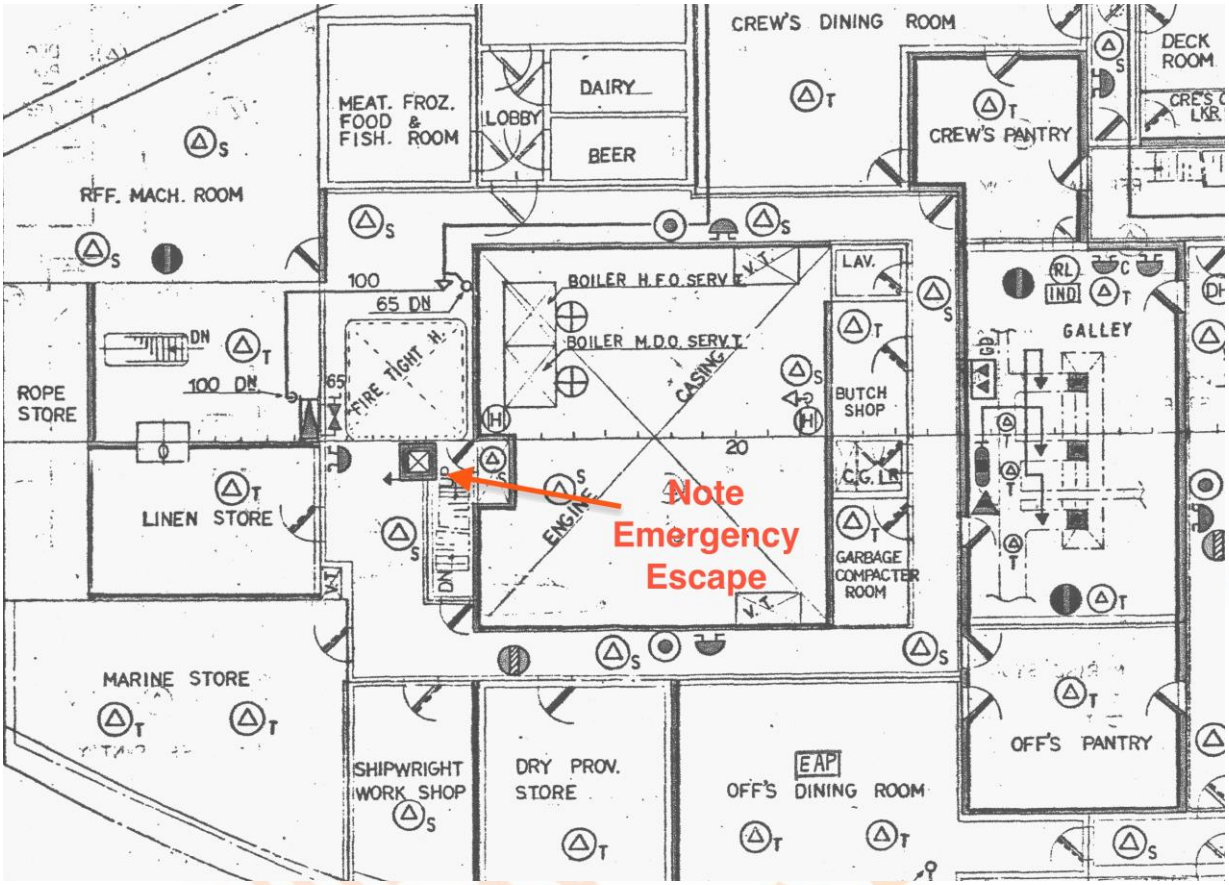
Escape Routes

- Fire Control Plans show the location of the escape routes
- Learn how to read the fire control plans
- Emergency escape routes can be used to access the seat of a fire if the normal entry if blocked
- Understand the use of EEBA to escape an engine room fire

Section 4 – Fire Control Plan

Fire control plans on board a ship provide

- Detailed schematic drawings of the spaces on the ship
- The location of fire fighting equipment
- The location of ventilation controls to each part of the ship
- The locations of the emergency exits
- The location and classes of bulkheads & doors within the ship



Classes of bulkheads and doors are rated with a suffix representing the duration of the fire protection provided:

- Class A-60 bulkheads and doors prevent the passage of flame and smoke for up to 60 minutes.
- Class B-30 bulkheads and doors prevent the passage of fire for up to 30 minutes.

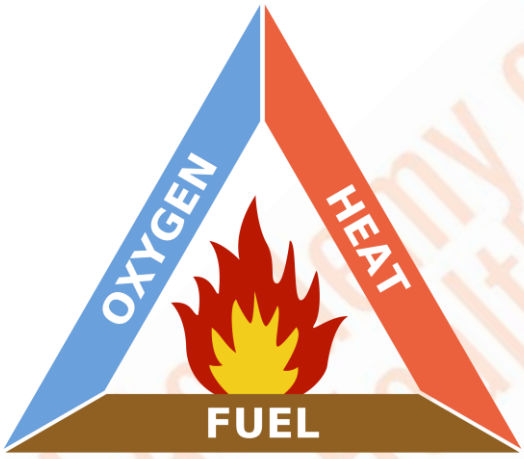
Module 2: FIRE Course – Understanding Fire

Section 1 – Concept & application of the fire triangle to fire & explosion

Conditions for fires

- Flammable vapour from a fuel mixes with Oxygen
- An ignition source ignites the vapour, a chemical action takes place & a flame is established
- The flame produces more heat and vapour
- The increased volume of vapour mixes with more oxygen
- The chemical action produces light & releases a cocktail of gases in the form of smoke
- The rate of spread depends upon the rate at which vaporised fuel mixes with

Oxygen The Fire Triangle



Upon the ignition of the three elements of heat, fuel and Oxygen, a fourth element, the Chemical Chain Reaction is created:

The fire will continue until one of these four elements is removed.

Facts

- A fire can double it's size every 30 seconds or less
- A room can reach a temperature of 700° or higher
- If a fire looks extinguished, there may still be sufficient heat or smouldering material that can catch alight at a later time.

Heat

The sources of heat and ignition include:

- Chemical reactions
- Biological action
- Physical actions

Heat starts and maintains a fire. The heat produced by fire can:

- Cause clothing to catch alight and melt synthetics
- Burn and damage skin through heat exposure or touching a heated item
- Heat the air causing irritation and possible damage to lungs
- Increase the spread of the fire by preheating objects

If clothing should catch alight, remember the catch phrase
"Stop – Drop – Roll"

Fuel

Fuel is the combustible material that is heated to produce the flammable vapour.
Fuel comes in 3 main forms:

- Solid
- Liquid
- Gas

Classification of Fires

Fires are classified according to the fuel type and presence of electricity. The classes of fire are listed in the following table:

Class	Fuel	Example
A	Combustible Solids	Wood / Paper / Plastic
B	Flammable Liquids	Petrol / Kerosene
C	Flammable Gases	LPG / Natural Gas
D	Combustible Metals	Magnesium
(E)	Electrically Involved	Navigation Equipment / Computer / TV / Photocopier / Electrical Switchboards
F	Fats & Oils	Chip Fryer

Electrical Fires

- Fire in which electricity is involved is a class (E) fire (electrical fire).
- Once the electrical power supply is isolated, the fire reverts to the primary class.

Finely Divided Fuels

- Finely divided fuels provide a greater surface area than the same mass of fuel which is not divided. An example is a log of wood.
- The finely divided fuel burns more quickly because it's surface area is greater. More vapour is emitted by it during the burning process and a greater supply of oxygen is available over it's surface area compared with the same mass of fuel which is not divided.

Oxygen

- Oxygen is required for fire to occur.
- The oxygen rapidly reacts with the vapourised fuel.
- Oxygen is in the atmosphere at 20.9% and has to be below 10% for a fire to be extinguished.

Properties of flammable materials

Definitions

Flash point

The lowest temperature at which a substance gives off sufficient flammable vapour to produce a momentary flash upon the application of a small flame (Ignition).

LPG / Propane	-104 ° C
Petrol	- 40 ° C
Diesel	+ 61 ° C
Kerosene	+ 38 ° C
Turpentine	+ 35 ° C
White Spirit	+ 38 ° C

Fire point

The point of temperature at which a substance gives off sufficient flammable vapour to produce a continuous flame upon the application of a small flame (Ignition). Generally 5% to 10% higher than flash point temperature.

Ignition point

The minimum temperature to which a substance must be heated before it will spontaneously burn.

Spontaneous Combustion

Spontaneous Combustion describes the bursting into flame of a flammable vapour with no external ignition source.

An example on a vessel is a 'scrunched up' (compacted by hand) oily rag being left lying around in an engine room and bursting into flame due to the heat of the chemical reaction between the oily substance(s) in the rag and the woven cloth which might comprise a combination of natural and synthetic fibres.

Flammability The ease with which a substance will ignite

Burning Temperature	The temperature that a fuel releases when
burning Burning speed	The speed at which a fuel burns
Thermal value	The amount of heat released from a fuel when it burns
Vapour Density	The density of a vapour in relation to that of hydrogen. (the mass of one molecule of a gas compared to that of a hydrogen atom.)
Lower flammable limit (LFL)	The lowest percentage of flammable gas and air that will ignite with an ignition source when a fuel is heated
Upper flammable limit (UFL)	The highest percentage of a flammable gas and air that will ignite with an ignition source when a fuel is heated
Flammable range (percentage)	The range between LFL and UFL

Section 2 – Ignition Sources

Ignition Sources

An ignition source is anything that can produce sufficient heat to ignite products around it.

Examples of Ignition Sources:

- Static Electricity
- Smoking
- Insulation removal (lagging around hot exhaust pipes)
- Faulty electrical appliances & equipment
- Use of electrical appliances that do not meet Australian standards
- Careless hot work
- Careless disposal of oily rags

Static charge in cargo tanks

The primary concern about static electricity is the possibility of generating an incendive spark within a flammable atmosphere. Inerting a tank can prevent the existence of a flammable gas mixture so that no hazard will exist.

Static electricity can be generated due to the passage of a liquid through a hose or pipeline and turbulence within a tank. In normal circumstances the charge generated is released instantaneously to earth (the ship's structure) because the liquid conducts it and design features of cargo tank internals will avoid its build up.

The problem is greater on very large tankers equipped with large individual tanks than it is on the smaller size of chemical carriers with extensive subdivision and multiple cargo tanks.

Oily rags should be discarded only in sealed metal containers.

Section 3 – Fire Spread

Fire spreads in four ways

1. Conduction - This is the transmission of heat through materials such as steel. This enables sufficient heat to ignite a fuel source through objects such as steel bulkheads, deck heads and floor plates.

2. Convection - This is the transmission of heat within a gas. Convection currents flow from an area of high density towards an area of lower density within the gas.

3. Radiation - This is the transmission of heat by waves travelling through space in straight lines in all directions until the heat is absorbed by other fuel sources. This enables heat to ignite a fuel source some distance away.

4. Direct Burning - The action of applying a naked flame to combustible material.

Temperature Equalization

The temperature difference between the fire and the area surrounding the fire is equalized through conduction, radiation and convection currents.

Examples of fire propagation as a result of temperature equalization:

- Conduction – Temperature equalization through conduction occurs when the fire and the surrounding fuel source are connected by a heat conducting material such as steel.

- Radiation – Temperature equalization through radiation occurs when heat radiated in all directions heats nearby combustible material to its ignition point.

- Convection Currents – As a gas is heated, it expands and becomes lighter, thus rising and being replaced by the heavier gas. In this way, fire draws in oxygen to further continue the chemical chain reactions and the hot gasses and smoke rise upwards.

There are four main phases which describe the commencement, growth, development and extinguishment of a fire:

Incipient

This first stage begins when heat, oxygen and a fuel source combine and have a chemical reaction resulting in fire. This is also known as “ignition” and is usually represented by a very small fire which often (and hopefully) goes out on its own, before the following stages are reached. Recognizing a fire in this stage provides your best chance at suppression or escape.

Growth
The growth stage is where the structures fire load and oxygen are used as fuel for the fire. There are numerous factors affecting the growth stage including where the fire started, what combustibles are near it, ceiling height and the potential for “thermal layering”. It is during this shortest of the 4 stages when a deadly “flashover” can occur; potentially trapping, injuring or killing firefighters.

Fully Developed
When the growth stage has reached its max and all combustible materials have been ignited, a fire is considered fully developed. This is the hottest phase of a fire and the most dangerous for anybody trapped within.

Decay
Usually the longest stage of a fire, the decay stage is characterized a significant decrease in oxygen or fuel, putting an end to the fire. Two common dangers during this stage are first – the existence of non-flaming combustibles, which can potentially start a new fire if not fully extinguished. Second, there is the danger of a backdraft when oxygen is reintroduced to a volatile, confined space.

Fire Temperatures

The temperature of a fire is dependent upon many factors including:

- An accommodation area fire on board a ship where Class A fuels are alight, can be from 100 degrees centigrade near the floor plate level up to 700 degrees centigrade at the deck head.
- A well established metal fire can range in temperature from 700 degrees Centigrade up to 1500 degrees Centigrade.

Normal temperatures of fires and flames

Fuel and Oxidizer type	Temperature (Celsius)
Fluorescent light	60-80
Incandescent light	100-300
Cigarettes - unventilated conditions	288
Cigarettes - ventilated	400-780
Cigarettes - insulated and smoldering	510-621
Stove element	>550
Match	600-800
Tungsten halogen light	600-900
Candle flame	600-1,400
Electrical spark	1,316
Bunsen burner	1,570
Methanol/air	1,910
Methane/air	1,920-1,949
Butane/air	1,977
Propane/air	1,977
Wood/air (most organics are about here))	~1977
MAPP Gas/air	
Hydrogen/air	2,210
Carbon monoxide/air	2,468
Acetylene/air	2,632
Acetylene/Oxygen	3,300
Hydrogen/Oxygen	
Electrical arcing	<3,750
Plasma torch	~4,700
Lightning	30,000

Temperatures of flames by appearance

Different flame colours depend on oxygen supply

On the left (flame 1) is a rich fuel, producing a yellow sooty diffusion flame;

On the right (flame 3) a leaner flame with a lower volume of flammable gas produces no soot and the flame colour is a bluer colour.

Flame 1 is burning at the lowest temperature and 2 and 3 are burning at progressively higher temperatures.

Flame	Typ	Temperature in	
		Centigrad	Fahrenhe
Re	Just	52	97
	Dull	70	129
	Cherry,	80	147
	Cherry,	90	165
	Cherry,	100	135
Orang	Dee	110	201
	Clea	120	219
	Whitish	1300	2370
	Bright	1400	2550
	Dazzling	1500	2730

The temperature of a fire is dependent upon many factors including:

- The environment, whether it is enclosed or in the open air
- The availability of fresh air to provide oxygen to it
- Air currents
- The type of fuel and the mix of fuels

Section 4 – Blocking the spread of fire

Structural & Thermal Protection Boundaries

The accommodation spaces on board a ship are isolated from machinery and cargo spaces by structural and thermal protection boundaries to prevent the spread of a fire originating in the machinery or cargo space to the accommodation spaces. These structural and thermal protection boundaries also prevent a fire originating in an accommodation space from spreading to the machinery or cargo spaces.

Class A Divisions prevent the spread of smoke & flame for up to 60 minutes:

- A-60 - 60 minutes
- A-30 - 30 minutes
- A-15 - 15 minutes

Class B Divisions prevent the spread of flame for the rated time:

- B-15 - 15 minutes
- B-0 - 0 minutes

Class C Divisions

- Constructed of approved non-combustible materials, without any particular requirements.

Shut Ventilation to a fire effected space

- Engine room
- Machinery Space
- Galley

This will reduce the volume of Oxygen in the fire effected space and slow down the spread of the fire. It could even burn up all the available oxygen and then be extinguished.

A fire effected space on a ship can have six or more boundaries

- Because steel structures are good conductors of heat, boundary cooling is of tremendous importance in delaying the spread of fire on a ship.
- Cooling the outside of a bulkhead can also reduce heat on the inside of the fire effected space.
- To perform boundary cooling a water hose nozzle is adjusted to provide a spray pattern of cooling water over all of the available boundary surface.

Section 5 – The need for constant vigilance

Fire Prevention is far better than Fighting a Fire!

The ability to recognise a potential fire hazard is an important part of any crew member's responsibility.

At all times on board crew members should -

- Maintain constant vigilance for potential hazards such as blocked exits and paths. Faulty fire detection, monitoring and fire fighting equipment.
- Be prepared for incidents and know how to deal with them;
- Conduct fire patrols when required;
- Apply proper watch keeping practices;
- Look for poorly maintained equipment. It is every seafarer's duty to report faulty equipment.

Patrol Systems

Patrols are mandatory on ships with 36 passengers or more and are recommended on all vessels. The duties of the patrol include:

- Conducting a patrol on a regular and scheduled basis. Frequent patrols are required to ensure early detection of a fire. Frequent patrols also provide an opportunity to correct fire hazards before a fire starts.
- Detecting cigarette smoking by crew or guests in areas where cigarette smoking is prohibited and considered to be a fire hazard.
- Monitoring electrical and mechanical equipment for overheating. Regular fire patrols provide the familiarity with the ship's equipment which is necessary to detect the difference between a normal and a high operating temperature for each item of equipment.
- Checking engine rooms and machinery spaces for good housekeeping practices and to ensure that potential ignition sources are removed.
- Visual observation of machinery for sparking which could be an ignition source and a fire hazard.
- Ensuring that electrical appliances are turned off when not in use.
- Removing any obstruction which could prevent an automated fire detector from operating
- Removing obstructions to emergency fire exits and checking the proper operation of watertight doors and hatches.

Module 3: FIRE Course – Shipboard fire hazards

Section 1 – Engine Room

The Engine room equipment includes

- The ship's engines
- Electricity generating equipment
- Air conditioning equipment
- Water making equipment
- Sewage treatment plant
- Pumps
- Hydraulic equipment
- Storage batteries

Internal combustion engines are fuelled by flammable and explosive fuel and create very hot exhaust gases. A continuous flow of air is required for this equipment to operate. Therefore all three of the basic elements of fire are continuously present in the engine room.

Potential causes of fire in the engine room include

- Oil fuel, hydraulic fluid or diesel leaking from a damaged fuel hose or pipe or failure of a fuel line flange. This could result in fuel being sprayed into the surrounding area and on to a hot surface.
- Unattended diesel and hydraulic fluid spills can be dangerous as they do not evaporate like petrol & can ignite when the auto-ignition temp is reached. (The *Courier* passenger hovercraft ferry in Port Phillip Bay is an example where a fuel line disconnected & the resultant fuel leak caught fire on a hot surface).
- Hot work such as welding, heating, chipping, cutting being performed in the engineer's workshop or the engine room;
- Faulty or missing insulation lagging around exhaust pipes;
- Fuel tank sounding pipes located in the engine room modified to remain open and left open during operations. When the ship is underway fuel can flow out of the sounding pipe and into the engine room bilges; Failure of electrical equipment can result in a great deal of heat being created which can become an ignition source;
- Failure of bearings can cause excessive heat from friction which can be an ignition source;
- Improper storage of oily rags, which can self-combust, can result in a serious engine room fire. All oily rags must be stowed in a steel container with a lid.

The engine room is an area of high fire risk

Drills

Masters and Chief Engineers therefore plan and carry out supplementary fire drills relating to fires in particular areas of the Engine Room, from likely causes. In particular, the following is practised:

- Shutting down ventilation systems to the engine room, bearing in mind that in a practice it may be necessary to keep some air inlets open to supply air to machinery that should not be shut down at the time of the drill;

- Operating remote shut off arrangements for fuel valves for tanks and fuel pumps. As far as possible, different remote shutoffs should be operated in rotation, so that all are operated between crew changes.

Proper Maintenance

- Failure of equipment in the engine room can result from improper or inadequate maintenance procedures and spare parts replacement.
- Regular maintenance and spare parts replacements must be according to the manufacturers' requirements.

Permit to perform Hot Work

A Permit to Work system must be followed to ensure that all possible precautions are followed during hot work in the engine room.

Good Housekeeping

A well run engine room will be free from litter at all times, kept spotlessly clean, bilges will always be maintained dry and clean and any fuel or oil leak detected will be immediately repaired.

Proper Watch keeping

Whenever the engine room equipment is operating it will be constantly monitored using remote status displays and frequent engine room patrols. In this way a fault in any item of equipment can be detected before a failure leads to a fire emergency.

Bunkering

When bunkering (refuelling) the quantity of fuel oil needed to be loaded into each tank should be carefully calculated and the tank levels monitored throughout the process to ensure that tanks are not overfilled, resulting in a spill of fuel.

Fire prevention in the Engine Room

- Conduct regular patrols of the engine room to detect any unusual operating condition that could lead to a fire such as a noise, smell, a higher temperature than normal & oil leaks;
- Equipment must be maintained to manufacturers' specifications;
- Good housekeeping includes maintaining bilges in a spotlessly clean state, attending to even the slightest oil leak immediately, keeping oily rags in a steel container with a lid, cleaning up and immediately putting tools and parts away after work is completed;
- Proper monitoring of unmanned machinery spaces alarms and reacting promptly to any alarm indicated;
- Checking that caps and cocks for fuel & oil tank sounding pipes are kept closed;
- Taking proper fire precautions when conducting any hot work in the Engine Room.

Emergency Escape Breathing Apparatus (EEBA)

is simple to don and provides a few minutes of breathable air to enable the wearer to escape from an engine room fire.

Ready availability of fire extinguishers -
Foam, CO2 and chemical dry powder are among the types of portable fire extinguishers which are provided for immediate use in the event of a small fire in the Engine Room.
Fixed fire extinguishing installations may be provided in the Engine Room including:

- Carbon Dioxide (CO2) gas bank with the capacity to replace oxygen in the engine room with CO2. A CO2 alarm will be sounded by the Master before the CO2 dump takes place;
- High Expansion Foam system with the capacity to completely fill the Engine Room with a foam which blankets a fire and prevents oxygen from feeding the fire.

Transportable fire extinguishing equipment
may also be available for immediate use in the Engine Room. This equipment has a greater volume of fire extinguishing medium compared to a portable fire extinguisher.

Fire rated Doors, Bulk Heads, Floor Plates and Deck Head

- The entire Engine Room space is surrounded by fire rated barriers. A class A-60 boundary will prevent the spread of flame and smoke for 60 minutes.
- If an effective CO2 dump is performed and ventilation has been shut down and all doors have been shut, then these boundaries can contain the fire to the engine room and prevent it's spread to other areas of the ship.
- However, the Engine Room on a large ship contains an enormous volume of air and therefore it can take a long time for the engine room to cool down to a temperature where it is safe to ventilate the space. It can take days in some cases.

Emergency Exits

- All Engine Rooms are equipped with emergency exits which can be used to escape a fire if the normal access route is blocked by fire or smoke.
- These emergency exits can also be used to gain access to fight the fire if the main access is blocked.

Training

- All engine room crew are trained in the use of fire fighting and suppression equipment & techniques.
- They are also trained in the use of EEBA and are familiar with the location of all emergency exits from the Engine Room.

Section 2 – Galley

Galley fire hazards include

- Use of combustible liquids in the cooking process such as fat and oil
- Hot cooking surfaces
- Defective electrical equipment
- Unattended galleys
- A build up of grease & dirt on extraction fans and filters
- A build up of fats & flammable residues in galley dampers
- Overheating of cooking surfaces
- Storing flammable materials near the cook top
- Not taking precautions to avoid spillage of flammable liquids when underway
- A careless attitude when using a Deep fat fryer

Fire Precautions include

- Maintaining a clean workspace and a dry clean floor space;
- Regular maintenance and testing of all equipment used in the galley;
- Procedures to ensure that flammable liquids are kept away from direct flame;
- Generally cooking stoves are electric ranges rather than LPG which is a common cooking fuel on small recreational vessels;
- Regular inspection and cleaning of exhaust ducts to remove any accumulation of vegetable and animal fats;
- The galley exhaust ducts might be equipped with a fire suppression system using an extinguishing agent such as CO2, Nitrogen or Argon;
- The galley exhaust ducts are equipped with a means of being closed in the event of a fire;
- The galley is equipped with fire fighting equipment including a fire blanket, portable fire extinguishers and fixed fire suppression systems;
- The galley space is completely surrounded by a fire rated boundary. For example, doors to the galley and the galley boundaries might be isolated from the rest of the ship with a class A-60 fire rating which will prevent the spread of fire and smoke for 60 minutes;
- All crew working in the galley are trained in the proper use of the fire fighting equipment;
- Emergency exits enable people to evacuate a fire effected galley if the main entrance is blocked by fire or smoke.

Section 3 – Accommodation Spaces

Accommodation spaces

- Cabins
- Lounge spaces
- Spaces used for eating meals
- The Gym, Swimming Pool or any other similar space

Hazards

- Combustible materials including furnishings and personal effects;
- Defective electrical equipment;
- Matches and cigarette smoking.

Precautions

- No smoking in bed;
- No unauthorised electrical fittings or appliances;
- No emptying of ash trays into wastepaper bins without first ensuring that all cigarette butts are extinguished and not capable of being an ignition source.

Fire fighting equipment includes:

- Fixed water sprinkler installation. In the event of a fire, the sprinkler head shatters and water is sprayed on that particular area such as a bed;
- Portable fire extinguishers. Commonly the fire extinguishing medium is water or Chemical Dry Powder;
- Manual call points to alert others to a fire.

Section 4 – Cargo Spaces

Material Safety Data Sheets (MSDS)

- Details of the characteristics of dangerous cargoes can be found in the Material Safety Data Sheet (MSDS) for the item.
- Requirements for safe handling are contained in the International Maritime Dangerous Goods Code (IMDG).
- Marine Orders Parts 34 & 41, the Bulk Cargoes Code and the Code of Safe Working Practice for Australian Seafarers should be complied with when handling dangerous cargoes.

Cargo space fire hazards include
Self heating cargo includes organic materials such as stock feed, maize, barley etc. These organic cargoes generate heat as they slowly decompose. Examples include coal and grain.

Pyrophoric cargoes include

- Ammonium Nitrate fertiliser - when mixed with hydraulic fluid can cause fire or explosion.
- Organic Peroxides when mixed with particular other agents such as Diesel, Chlorine & Brake fluid.

Oxidising cargoes which release Oxygen

- These cargoes release oxygen which increases the risk of a fire in a cargo hold.

Leakage of compressed flammable gas

During handling and carriage on bulk gas carriers, LNG and LPG can cause explosion and fire if there is a leak from pipelines, flanges, pumping equipment or cargo storage spaces. Refer ISGOTT (International Safety Guide for Oil Tankers and Terminals).

Pyrophoric cargoes (cargoes that can ignite spontaneously when exposed to air or water)

Rust formed by corrosion on the inner surfaces of oil tanks can react with Hydrogen Sulphide gas in the vapour above crude oil. This reaction produces mixtures of Iron Sulphides which are pyrophoric and they can cause explosions when they are exposed to air or water during the unloading of the cargo.

Explosives cargoes

Explosives require very special handling and storage to ensure that they do not come in contact with any other substance that might trigger an explosion or fire. The events which could lead to an explosion or fire on board include leaks in packaging resulting in exposure to air, water or other substances, poor handling and inappropriate use. A MSDS will be available for the explosive cargoes and this should be consulted to ensure that the handling and storage arrangements do not affect the stability of the explosive cargo. The procedures and regulations contained in the IMDG must also be followed at all times to ensure safe handling and storage.

Cargo hold lights and cargo cluster lights being left on and connected

If left on after cargo loading or unloading is completed, the heat generated by these lights can build up to a point where they are capable of igniting a fire in the space.

Fire

Precautions

General

- Ensure cargo spaces and cargo hatches are correctly cleaned after unloading cargo to remove traces of previous cargoes which act as fuel or react with other substances to generate heat;
- Be aware that cooling some cargoes, such as some coals, copra, swarf, charcoal and concentrates etc., with water can actually cause them to heat which could lead to spontaneous combustion;
- Sample the atmosphere in spaces which could be deficient in oxygen or subject to flammable gas accumulation prior to personnel entering to load or unload cargo;
- Stow packages where they are protected from accidental damage or heating;
- Be aware and warn others verbally and with warning signs of the fire risks from smoking and naked flames, static electricity and the use of faulty electrical equipment that could become an ignition source during loading and unloading as appropriate;
- Clean up spillages and leaks of flammable materials during loading and unloading immediately;
- Properly maintain all cargo handling equipment to ensure that it does not become a potential ignition source;
- An internal combustion engine or an electric motor must not be used in a cargo space in connection with loading or unloading unless suitable fire fighting equipment is at hand which can extinguish an electrical or liquid fire;
- An internal combustion engine of a mechanical stowing appliance or other vehicle used for loading and unloading cargo must not be refuelled in a cargo space unless the fuel has a flashpoint of 43 degrees Celsius or higher or the fuel is delivered by a system directly coupled to it's fuel system;
- Only refuel a petrol engined vehicle in a cargo space, being part of the cargo of the ship that is intended to be driven off the ship under it's own power, if the possibility of spillage is minimised and the amount of fuel being transferred is less than 5 litres and no more than 2 vehicles are being fuelled at the same time.

Hold/Cargo Compartment Lights

- Ensure that hold/cargo compartment lights are switched off and cargo clusters disconnected, removed and stored away after use and before closing of hatches;
- Cluster lights are a hazard because they might not be intrinsically safe;
- The light is lowered on a rope with the extension cord and it can swing around at sea and break if it is not put away after use;
- They should be stowed after use and before the ship is underway.

Dangerous Goods

- Check the coding of goods to be loaded and ensure that appropriate fire fighting equipment and PPE is at hand before loading cargo which carry a particular type of fire risk;

- Segregate dangerous goods from substances that could react with them to start or spread fires;
- Stow dangerous goods away from living quarters;

- Stow dangerous goods where they can be easily moved away from a fire if one occurs nearby;
- Test all fire detection systems before loading cargo;
- Have fire fighting appliances ready for use when loading and unloading;
- Ensure that no unauthorised personnel are present when loading and unloading cargo;
- A responsible person must always be present to supervise the loading or unloading of dangerous cargo;
- All packages must be tallied;
- Be aware particularly during cleaning after unloading that the residual dust from some bulk cargoes including grain and sugar can be explosive. (Smoking and static electricity are common ignition sources). Hosing down the cargo space after unloading can reduce the fire risk;
- No smoking when crew are working in a cargo space or loading or unloading cargo.

Ventilation

- Properly ventilate cargo spaces prior to loading and unloading operations;
- Ensure that cargo is securely stowed and continues to be adequately ventilated during the voyage;
- Ensure that exhaust gases from cargo ventilators are safely dispersed and pose no fire risk in another space on the vessel;
- Thoroughly ventilate cargo spaces after unloading;
- Do not allow potential ignition sources into a recently unloaded cargo space until the fire danger has been removed.

Gas Freeing & the Means of Inerting Cargo Spaces

An inert gas is used to reduce the oxygen content in a space where a flammable gas is present, the risk of fire is reduced.

However, considerable care must be applied during loading, unloading and transfer of flammable cargo to ensure that the correct oxygen level is maintained.

The inert gas system itself must be such design and construction that it does not increase the risk of explosion through it's operation.

Also, prior to the entry of personnel into a space where an inert gas system has been used to minimise the risk of fire, the air must be sampled to ensure that the atmosphere is safe to breathe.

The construction of these cargo spaces and the design and construction of the inert gas system must meet Australian Marine Orders and the Navigation Act 1904 as amended.

This Australian legislation is designed to enforce the SOLAS and other International Conventions to which Australia is a signatory.

The Navigation Act is expected to be amended soon to reflect the requirements of the SOLAS 74 Convention, Protocol 1978, Chapter II-2, Regulation 62, summarised in the following text.

Inert Gas System

- The Inert Gas System is capable of providing on demand a gas or mixture of gases to a cargo tank so deficient in oxygen that the atmosphere within a cargo tank may be rendered inert, i.e. incapable of propagating a flame.
- Personnel must not enter any cargo space which is equipped with an inert gas system unless specifically instructed to do so by the Master or a responsible Officer.

General requirements

A vessel's inert gas system shall be capable of inerting, purging and gas-freeing empty tanks and maintaining the atmosphere in cargo tanks with the required oxygen content. The inert gas system shall be designed, constructed and tested in accordance with the International Maritime Organization's Fire Safety Systems Code.

The need for constant vigilance

Fire Prevention is far better than Fighting a Fire. The ability to recognise a potential fire hazard is an important part of any crew member’s responsibility.

At all times on board crew members should:

- Maintain constant vigilance for potential hazards such as blocked exits and paths. Faulty fire detection, monitoring and fire fighting equipment;
- Be prepared for incidents and know how to deal with them;
- Conduct fire patrols when required;
- Apply proper watch keeping practices;
- Look for poorly maintained equipment. It is every seafarer's duty to report faulty equipment.

Section 5 – Cigarettes

Cigarette smoking fire hazards include

- The temperature of a burning cigarette which is about 500 degrees C;
- Carelessness with cigarettes and matches;
- Emptying ashtrays into wastepaper bins before ensuring that cigarettes are extinguished properly;
- Setting fire to bedclothes, bins and

furnishings. Precautions

- Many vessels do not permit smoking anywhere on board;
- Some vessels permit smoking in particular parts of the ship;
- Usually there is a ban on smoking in accommodation spaces.

Module 4: FIRE Course – Organisation of Shipboard Fire Fighting

Section 1 – Alarms & Actions

The first action upon discovering a fire of any size is to raise the alarm

A small fire:

1. Make sure that someone can hear you and call out loudly "Fire, Fire Fire!"
2. If you can safely put out the fire, extinguish it;
3. Call out "Fire is

out!" An established fire:

1. Find the nearest Manual Call Point (MCP) (if there is one) or notify the Officer of the Watch;
2. Break the glass;
3. Press the MCP button;
4. If you can safely extinguish the fire with an immediately available fire extinguisher, do so;
5. Isolate the fire effected area by blocking the flow of air to the space - close the doors, ventilation and any other openings;
6. If the fire is extinguished, notify the Officer of the Watch;
7. If you cannot safely extinguish the fire, contact the Officer of the Watch & convey everything you know about the fire.

Fire and Smoke Detection Systems

The construction of an automatic fire detection system

Requirements for passenger ships carrying more than 36 passengers include:

- Automatic Operation - A ship's automatic fire alarm and fire detection system will be capable of immediate operation at all times with no action on the part of the crew to operate it.

- Visual & Audible Alarms - Each section of detectors includes a means of giving a visual and an audible alarm signal automatically at one or more indicating units whenever any detector comes into operation. Such units give an indication of any fire and its location in any space served by the system. The alarm panels are located on the navigating bridge or in the main fire control station.

- Monitoring of the Fire Alarm Panel - The fire alarm panel provides alerts to responsible officers by way of a visual and audible alarm. The alarm system is also constructed to indicate if any fault occurs in the system.

- Detectors Grouped in Sections - Detectors are grouped into separate sections, each covering no more than 50 spaces served by the system and containing no more than 100 detectors. A section of detectors generally does not serve spaces on both the port and starboard sides of the ship nor on more than one deck and it is usually not situated in more than one main vertical zone.

- Examples of separate fire zones include passenger and crew accommodation spaces, cargo spaces, machinery spaces and the engine room.

- Detector Location - They are fitted in an overhead position and are suitably protected against impact and physical damage. They are suitable for use in a marine atmosphere. They are placed in an open position clear of beams and other objects likely to obstruct the flow of hot gases or smoke to the sensitive element. At least one detector is installed in each space where detection facilities are required and there is not less than one detector for each 37 square metres (400 square feet) of deck area. In large spaces the detectors are arranged in a regular pattern so that no detector is more than 9 metres (30 feet) from another detector or more than 4.5 metres (15 feet) from a bulkhead.

- Emergency Power Supply - There are not less than two sources of power supply for the electrical equipment used in the operation of the fire alarm and fire detection system, one of which is an emergency source. The supply is provided by separate feeders reserved solely for that purpose. These feeders run to a changeover switch situated in the control station for the fire detection system. The wiring system is arranged to avoid galleys, machinery spaces and other enclosed spaces which pose a high fire risk except when it is necessary to provide for fire detection in such spaces or to reach the appropriate switchboard.

- List of Fire Detector Locations - A list or plan is displayed adjacent to each indicating unit showing the spaces covered and the location of the zone in respect of each section. Suitable instructions for testing and maintenance are available.

- Periodic Testing of Detectors - Provision is made for testing the correct operation of the detectors and the indicating units by supplying a means for applying hot air or smoke at detector positions.

- Spare Parts - Spare detector heads are provided for each section of detectors.

Automatic Fire Alarm

The system is activated automatically by:

- Abnormal air temperature,
- Abnormal concentration of smoke or
- Other factors indicative of incipient fire in any one of the spaces to be protected.

Temperature Detectors
Generally the systems which are sensitive to air temperature are not operated at less than 57°C (135°F) and operate at a temperature not greater than 74°C (165°F) when the temperature increase to those levels is not more than 1°C (1.8°F) per minute.

Smoke Detectors
Usually systems which are sensitive to smoke concentration operate on the reduction of the intensity of a transmitted light beam.

The detection system is not be used for any purpose other than fire detection.

Detector operation

- The detectors may be arranged to operate the alarm by the opening or closing of contacts or by other appropriate methods.
- Detectors operated by the closing of contacts are of the sealed contact type and the circuit is continuously monitored to indicate fault conditions.

Manual Call Points

- Ships are fitted with manually operated fire alarms, called Manual Call Points (MCP's) which are fitted throughout the passenger spaces and crew spaces to enable a member of a fire patrol or any other person to give the alarm immediately upon the detection of fire.
- The fire alarm activates audible and visible fire indicators on the navigating bridge or fire control station.
- Ships are fitted with automatic fire detection and fire alarm systems capable of detecting the presence of fire in a part of the ship that is inaccessible to members of a fire patrol. The automatic fire alarms also activate audible and visible fire indicators on the navigating bridge or in the fire control station.
- Where a fire detection and fire alarm system depends on electricity for its operation, the system is connected to 2 sources of supply, one of which is an emergency source.
- Steps are taken in the construction of the fire alarm systems to avoid damage to them by a fire in an enclosed space or a high fire risk space on board the ship. These steps include:
- Routing the associated wiring so that it does not go through high fire risk spaces unless unavoidable;

- Fire protecting wiring by running it through a protective conduit formed by a fireproof material such as steel pipe.

Requirements for all other types of ships

- All fire detection systems are capable of automatically indicating the presence or indication of fire and also its location.
- Indicators are centralised either on the navigating bridge or in other control stations which are provided with a direct communication with the bridge.
- The indicators in some circumstances are distributed among several stations.
- The alarm system operates both audible and visible signals at the main fire control panel stations.
- Detection systems for cargo spaces might not have audible alarms.

The main types of automatic fire detectors

The main types of detectors include the following and sometimes a combination of these in one detector:

Type of Detector	Responsive To	Brief Summary of How it Works
Ionization	Smoke	The detector cell has a small electric current flowing across an air gap. Smoke interrupts this flow and triggers the fire alarm circuit.
Photoelectric	Smoke	When even a tiny amount of smoke enters the detecting cell, light from a small light in the cell is reflected by the smoke onto a light sensitive (photoelectric) plate which triggers the fire alarm circuit.
Air sampling	Incipient (smouldering), Smoke, Flame & Heat.	The air is constantly analysed for signs of fire at all stages. This is a sophisticated system which sucks air for sampling into a device which measures characteristics of the sample including pressure changes, particle density, temperature and temperature rise rates.
Infrared, narrow light band	Flame	Highly sensitive to the light of a flame. A camera specially designed to only see flame sets off the fire alarm when light from a flame of up to 200 metres away enters the camera lens.
Fusible link / quartzoid bulbs	Heat	An electric circuit is completed (closed) & the fire alarm is activated when a temperature increase melts a blocking device.
Bimetallic	Heat	2 strips of different types of metal bonded together expand at different rates with an increase in temperature. The strip then bends in a

		predictable way to complete an electric circuit and raise the alarm.
Rate of rise heat detector	Heat	Closes an electric circuit and raises the fire alarm when the temperature increases by a preset number of degrees over a particular minimum period of time.
Pneumatic spot or line detector	Heat	Metal inside the detector expands predictably as the temperature rises and makes an electrical contact when a precise temperature is reached, setting off the alarm.

Fire control Panel

Detectors, MCP's and automatic suppression systems activate an alarm through the Fire control panel. This panel is usually located on the Bridge. This panel indicates the location and type of the activation. With this information the Master directs the fire team to the location of the emergency.

Extension Alarm Panels

Extension alarm panels are panels that are linked to the main fire panel and are located in various locations around the vessel. They allow required personnel to view information on the alarm location and type without the need to respond to the main fire panel usually located on the Bridge.

Section 1 – Shipboard firefighting

Actions

- The responsible person monitoring the Fire Control Panel will take actions appropriate for the type of vessel. Differing watch keeping methods apply when a vessel is in port compared to those used when the vessel is at sea.

- An initial action might be to sound a special alarm signal to summon the Fire Response Team to investigate the location of the fire detector which has sent the initial alarm signal.

- On a passenger vessel a specially coded announcement might be given over the ship's public address system to summon the fire response team to a particular part of the ship where the detector has activated. This is done to avoid panic amongst the passengers.

- On a cargo ship - Unlike a passenger ship, there should be no risk of panic.

- The first priority of the Master is to alert all the crew that there is a fire on board and to do a headcount of the crew to make sure nobody is missing.

- The General Alarm might be sounded and details of the type of emergency could be given over the Public Address system.

- Crew who are members of the fire response team would go immediately to the fire station when alerted of the fire emergency. They would don Fire PPE and follow the Master's orders to fight & extinguish the fire.

- Other crew would report to their Muster Station.

- A special fire alarm determined by the Master and included in the ship's SMS might be sounded.

- This is usually the continuous sounding of the General Alarm system for at least 10 seconds.

Other possible alarms

Pump room

- Gas, temperature and bilge level monitoring and alarm devices - Gas monitors and alarms, hydrocarbon gas sampling points or detector heads must be located in suitable positions and audible and visual alarms set for not more than 10 per cent of the lower explosive limit (LEL) are required to be fitted in the pump room and cargo control room.

- Shaft glands, bearings and pump casings require temperature monitoring and alarm devices.

- Cargo pumps, ballast pumps and stripping pumps driven by shafts through bulkheads are to be monitored and continuous audible and visual alarms must be fitted in the cargo control room or pump control station in the event that any of these pumps fail to operate.

- All pump rooms have to be provided with bilge level monitoring devices and associated alarms fitted in appropriate locations.

Unmanned Machinery Space (UMS) fire detection system –

- Provides constant monitoring of unmanned machinery spaces on board the vessel including the engine room and some cargo spaces.

- The alarms can be found on the work station displays for the Engine Room, Cargo Spaces, Chief Engineer, Duty Engineer, Wheel House and the Master's Room.

If you hear any of the above alarms, immediately report the alarm to an appropriate officer.

CO2 Alarm – warns that a space such as an engine room is about to be flooded with CO2 gas to extinguish a fire.

Module 5: FIRE Course – Location of Fire Fighting Appliances & Emergency Escape Routes

Section 1 – Ship construction arrangements

Principles

- Constructed into divisions by vertical and horizontal thermal structural boundaries
- Separates various parts of the ship – accommodation space, machinery space, cargo space etc.
- Restricted us of Combustible materials
- Detection of any fire in the zone of origin
- Containment and extinction of any fire in the space of origin
- Protection of the means of escape or access for fire fighting
- Minimisation of the possibility of ignition of flammable cargo vapour
- The ability to shut down ventilation into specific areas

How these boundaries are constructed

- The hull, superstructure and deckhouses are subdivided into main vertical zones by “A” Class divisions.
- Steps and recesses are kept to a minimum but where they are necessary they are also “A” Class divisions.
- As far as practicable, the bulkheads forming the boundaries of the main vertical zones above the bulkhead deck are in line with watertight subdivision bulkheads situated immediately below the bulkhead deck.
- These bulkheads extend from deck to deck and to the shell or other boundaries.

Watertight Bulkheads	Location	Purpose	Relevance to Fire Fighting
Collision	Forepeak (Bow)	If the ship collides with another object at the bow, water will only flood a small compartment in the forward part of the ship.	A fire in the forepeak will be restricted to that area for a period of time before spreading to other parts of the ship.
Collision	Afterpeak (stern)	If the ship collides with another object at the stern or the *stern tube leaks, water will only flood a small compartment in the *after part of the ship.	A fire in the afterpeak will be restricted to that area for a period of time before spreading to other parts of the ship.
Division	Accommodation	To separate the accommodation areas from other parts of the ship which are considered to have a high fire risk such as the engine room and other machinery spaces	A fire in a machinery space or the engine room will be restricted to that area for a period of time before spreading to the accommodation spaces and other parts of the ship.

**Stern Tube – a tube passing through the hull of the ship inside of which the propeller shaft is accommodated. A watertight, oil lubricated, stern tube gland housed in a separate watertight compartment prevents water from flooding the ship's hull in the event that the stern tube gland develops a leak.*

**After Part – the part of the ship near the stern – the aft section of the vessel*

How fire rated divisions should be used to prevent fire spread

- Parts of the vessel are separated by Class A, B & C divisions in order to prevent the spread of a fire from the machinery and cargo spaces to the accommodation spaces and vice versa.
- All A-60 doors separating these spaces must be shut in the event of a fire in these spaces.
- All ventilation flaps must be shut in the event of a fire in the machinery or cargo spaces.
- The ship's design will contain all accommodation spaces in one part of the vessel.
- Fires originating in the galley, laundry, linen locker, common public spaces and living spaces must be prevented from spreading to other parts of the accommodation space by the use of thermal protection boundaries and by closing off ventilation to the fire effected area.
- Fire in any cargo hold must be contained in the effected space by shutting hatch covers, ventilator flaps and boundary cooling (spraying water onto the boundaries using hoses and nozzles).
- Fires in isolated spaces on the ship such as the wheel house, radio room, chart room, forepeak area,paint locker and steering flat must be contained in the space of origin by shutting doors, ventilator flaps, using fixed fire extinguishing installations and other fire fighting appliances.

Escape Routes – Location and Protection

Provided in and from all passenger and crew spaces and in spaces in which the crew is normally employed, other than machinery spaces, stairways and ladders are arranged to provide a readily available means of escape to the lifeboat and liferaft embarkation deck. In particular the following provisions are made:

- Below the bulkhead deck, two means of escape, at least one of which is independent of watertight doors, are provided from each watertight compartment;
- Above the bulkhead deck, there are at least two means of escape from each main vertical zone or similarly restricted space or group of spaces at least one of which gives access to a stairway forming a vertical escape.
- At least one of the means of escape will be a readily accessible enclosed stairway which provides a continuous fire shelter from the level of its origin to the appropriate lifeboat and liferaft embarkation decks and the highest level served by the stairway.
- Lifts are not considered as forming one of the required means of escape.
- If a radio station has no direct access to the weather deck, two means of escape are provided from the station.
- Deadend corridors do not exceed 13 metres (43 feet) in length.

Two means of escape are provided from each machinery space. Where the space is below the bulkhead deck the means of escape are either:

(1) two sets of steel ladders as widely separated as possible, leading to doors in the upper part of the space similarly separated and from which access is provided to the appropriate lifeboat and liferaft embarkation decks. One of these ladders provides continuous fire shelter from the lower part of the space to a safe position outside the space; or

(2) one steel ladder leading to a door in the upper part of the space from which access is provided to the embarkation deck and a steel door capable of being operated from each side and which provides a safe escape route to the embarkation deck.

Where the space is above the bulkhead deck, two means of escape are provided which are as widely separated as possible and the doors leading from such means of escape are in a position from which access is provided to the appropriate lifeboat and liferaft embarkation decks.

Where such escapes require the use of ladders these are constructed of steel. Provided that in a ship of less than 1,000 gross tons, there might only be one means of escape due to the large width of the upper part of the space.

In a ship of 1,000 gross tons and above, there might only be one means of escape from the space if either a door or a steel ladder provides a safe escape route to the embarkation deck. This is determined by the nature and location of the space and whether persons are normally employed in that space.

Escape routes from machinery space

- Exit signs are placed as appropriate to indicate a means of escape in the event of an emergency from any space on board.
- Two means of escape are provided from each machinery space.
- Where the space is below the bulkhead deck the two means of escape consist of either:
- Two sets of steel ladders as widely separated as possible, leading to doors in the upper part of the space similarly separated and from which access is provided to the appropriate lifeboat and liferaft embarkation decks. One of

these ladders provides a

continuous fire shelter from the lower part of the space to a safe position outside the space; or

- One steel ladder leading to a door in the upper part of the space from which access is provided to the embarkation deck and a steel door capable of being operated from each side which provides a safe escape route to the embarkation deck.
- Where the space is above the bulkhead deck, two means of escape are as widely separated as possible and the doors leading from such means of escape are in a position from which access is provided to the appropriate lifeboat and liferaft embarkation decks.
- Where such escapes require the use of ladders these are of steel.

Escape routes from accommodation space

Provided in and from all passenger and crew spaces and in spaces in which the crew is normally employed, other than machinery spaces, stairways and ladders are arranged to provide a readily accessible means of escape to the lifeboat and liferaft embarkation deck.

- Below the bulkhead deck, two means of escape, at least one of which has no watertight doors, is provided from each watertight compartment or other restricted space or spaces.
- Above the bulkhead deck, there are at least two means of escape from each main vertical zone or similarly restricted space or spaces. At least one of these leads to a stairway forming a vertical escape.
- At least one of the means of escape described above leads to an enclosed stairway, which provides a continuous fire shelter from the level of its origin to the lifeboat and liferaft embarkation decks or the highest level served by the stairway, whichever level is the highest.

Stairways serving only a space and a balcony in that space and lifts are not considered to be a means of escape.

Escape routes from cargo pump room to accommodation space, main deck & boat deck

- Stairways and ladders are arranged to provide two means of escape to the accommodation spaces, the main deck and lifeboat and liferaft embarkation deck from the cargo pump room.

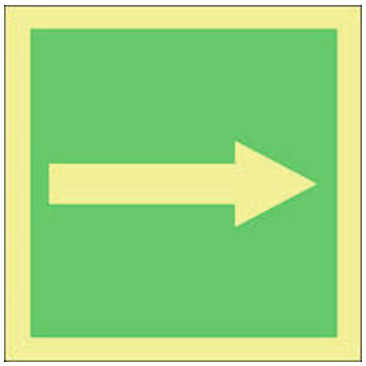
Escape routes from cargo spaces and main deck to boat deck

- Stairways and ladders are arranged to provide two means of escape to the main deck and lifeboat and liferaft embarkation deck.

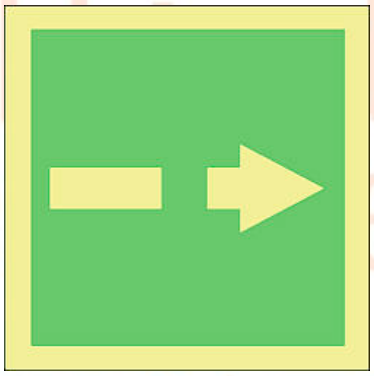
Identification of escape routes

Escape routes are clearly marked throughout the ship using internationally recognised signage pictograms and colours.

The following pictures illustrate various types of escape routes with signage:



Primary escape route symbol. If this route is not blocked, go this way in an emergency where the main entrance is blocked by damage, flames or smoke.



Secondary escape route symbol. Follow this route if the main entrance and the Primary escape route are both blocked.

Emergency lighting for escape routes

Emergency lighting is provided:

- at all muster and survival craft stations;
- in alleyways, stairways, emergency exits;
- in accesses to all muster and survival craft stations.

Should the main electrical power supply fail then an emergency lighting system is automatically activated in all parts of a ship where livestock is carried, passageways between pens and access routes to the pens.

The emergency lighting system is capable of giving a level of illumination of not less than 8 lux in all passageways and access routes for a continuous period of not less than 15 minutes.

The emergency power supply on a passenger carrying vessel is sufficient to supply all the services that are necessary for the safety of the passengers and crew in an emergency.

Special consideration is given to emergency lighting at every boat station on deck and oversides, in all alleyways, stairways and exits, in the machinery spaces and in the control stations, to the sprinkler pump, to navigation lights and to the daylight signalling lamp.

The power is generally adequate for a period of 36 hours.

Use of emergency escape routes to access a fire location

It is essential that fire fighting teams become familiar with the design, construction and layout of the interior of the vessel's hull. The emergency escape routes can be used in reverse direction for access to the fire spot by the fire team for the purpose of fighting the fire.

Section 2 – Emergency Fire Pump

Fire Pumps

- Fire pumps are provided to supply water to the fire system.
- Ships of 500 gross tons or more displacement are furnished with at least 2 self contained and power driven fire pumps.

Emergency Fire Pump

- The water pressure created by the fixed emergency pump is sufficient for the use of 2 fire hoses and nozzles.

Circumstances Under Which The Emergency Fire Pump Is Used

- The emergency fire pump is operated during alternate fire drills. This ensures that the crew are familiar with the equipment and at the same time the equipment is tested regularly for proper operation.
- The emergency fire pump will be available for use at all times in the event that there is a fire emergency and the main fire pump is not operational.

Location of the Emergency Fire Pump

- Where a fire in any one compartment in a ship might put out of action every fire pump provided, a self contained, fixed emergency power pump will be used to provide a supply of water for the fire fighting equipment.
- The emergency fire pump will be located in a separate compartment to the one housing the other fire pumps.

Section 3 – Chemical Powder Application

- On cargo ships Dry Chemical Powder fixed installation systems are installed in places where LPG or LNG or chemical cargo is loaded or unloaded and where these types of cargo are stored.
- Each container of Dry Chemical Powder holds 250Kg of extinguishing medium.
- Dry Chemical Powder can smother a fire instantly by blanketing the fuel with a fine powder and preventing oxygen from reaching the fuel.
- Dry Chemical powder also contains an inhibiting agent which breaks the Chain Reaction of the Fire Tetrahedron.
- The blanket of powder must cover the fire effected area including the source of the fuel and flame.
- This extinguishing medium is difficult to cleanup and will damage electrical equipment that comes in contact with it.

Section 4 – Fire & Smoke Detection Systems

The construction of an automatic fire detection system

Automatic Operation
A ship's automatic fire alarm and fire detection system will be capable of immediate operation at all times with no action on the part of the crew to operate it.

Visual & Audible Alarms

- Each section of detectors includes a means of giving a visual and an audible alarm signal automatically at one or more indicating units whenever any detector comes into operation.
- Such units give an indication of any fire and its location in any space served by the system.
- The alarm panels are located on the navigating bridge or in the main fire control station.

Monitoring of the Fire Alarm Panel

- The fire alarm panel provides alerts to responsible officers by way of a visual and audible alarm.
- The alarm system is also constructed to indicate if any fault occurs in the system.

Extension Alarm Panels

- Extension alarm panels are panels that are linked to the main fire panel.
- These are located in various locations around the vessel.
- They allow required personnel to view information on the alarm location and type without the need to respond to the main fire panel usually located on the Bridge.

Detectors Grouped in Sections

- Detectors are grouped into separate sections, each covering no more than 50 rooms served by the system and containing no more than 100 detectors.
- A section of detectors generally does not serve spaces on both the port and starboard sides of the ship nor on more than one deck and it is usually not situated in more than one main vertical zone.

Examples of separate fire zones include

- passenger and crew accommodation spaces,
- cargo spaces,
- machinery spaces and
- the engine room.

Detector Location

- They are fitted in an overhead position and are suitably protected against impact and physical damage.
- They are suitable for use in a marine atmosphere.
- They are placed in an open position clear of beams and other objects likely to obstruct the flow of hot gases or smoke to the sensitive element.
- At least one detector is installed in each space where detection facilities are required and there is not less than one detector for each 37 square metres (400 square feet) of deck area.

- In large spaces the detectors are arranged in a regular pattern so that no detector is more than 9 metres (30 feet) from another detector or more than 4.5 metres (15 feet) from a bulkhead.

Emergency Power Supply

- There are not less than two sources of power supply for the electrical equipment used in the operation of the fire alarm and fire detection system, one of which is an emergency source.
- The supply is provided by separate feeders reserved solely for that purpose.
- These feeders run to a changeover switch situated in the control station for the fire detection system.
- The wiring system is arranged to avoid galleys, machinery spaces and other enclosed spaces which pose a high fire risk except when it is necessary to provide for fire detection in such spaces or to reach the appropriate switchboard.

List of Fire Detector Locations

- A list or plan is displayed adjacent to each indicating unit showing the spaces covered and the location of the zone in respect of each section.
- Suitable instructions for testing and maintenance are available.

Periodic Testing of Detectors

- Provision is made for testing the correct operation of the detectors and the indicating units by supplying a means for applying hot air or smoke at detector positions.

Type of Detector	Responsive To	Brief Summary of How it Works
Ionization	Smoke	The detector cell has a small electric current flowing across an air gap. Smoke interrupts this flow and triggers the fire alarm circuit.
Photoelectric	Smoke	When even a tiny amount of smoke enters the detecting cell, light from a small light in the cell is reflected by the smoke onto a light sensitive (photoelectric) plate which triggers the fire alarm circuit.
Air sampling	Incipient (smouldering), Smoke, Flame & Heat.	The air is constantly analysed for signs of fire at all stages. This is a sophisticated system which sucks air for sampling into a device which measures characteristics of the sample including pressure changes, particle density, temperature and temperature rise rates.
Infrared, narrow light band	Flame	Highly sensitive to the light of a flame. A camera specially designed to only see flame sets off the fire alarm when light from a flame of up to 200 metres away enters the camera lens.
Fusible link / quartzoid bulbs	Heat	An electric circuit is completed (closed) & the fire alarm is activated when a temperature increase melts a blocking device.
Bimetallic	Heat	2 strips of different types of metal bonded together expand at different rates with an increase in temperature. The strip then bends in a predictable way to complete an electric circuit and raise the alarm.
Rate of rise heat detector	Heat	Closes an electric circuit and raises the fire alarm when the temperature increases by a preset number of degrees over a particular minimum period of time.
Pneumatic spot or line detector	Heat	Metal inside the detector expands predictably as the temperature rises and makes an electrical contact when a precise temperature is reached, setting off the alarm.

Spare Parts

- Spare detector heads are provided for each section of detectors.

Automatic Fire Alarm

Operation

Detector Activation
The system is activated automatically by:

- Abnormal air temperature,
- Abnormal concentration of smoke or
- Other factors indicative of incipient fire in any one of the spaces to be protected.

Temperature Detectors

Generally the systems which are sensitive to air temperature are not operated at less than 57°C (135°F) and operate at a temperature not greater than 74°C (165°F) when the temperature increase to those levels is not more than 1°C (1.8°F) per minute.

Smoke Detectors

- Usually systems which are sensitive to smoke concentration operate on the reduction of the intensity of a transmitted light beam.
- The detection system is not be used for any purpose other than fire detection.

Detector operation

- The detectors may be arranged to operate the alarm by the opening or closing of contacts or by other appropriate methods.
- Detectors operated by the closing of contacts are of the sealed contact type and the circuit is continuously monitored to indicate fault conditions.

Water sprinkler installations

- Heat breaks the glass bulb allowing the water to flow
- Water sprinkler installations in accommodation sleeping spaces offer the special feature of waking a sleeping crew member in the event of a fire.
- Only the water sprinkler in the fire effected space will operate

Manual Call Points

- Ships are fitted with manually operated fire alarms, called Manual Call Points (MCP's) which are fitted throughout the passenger spaces and crew spaces to enable a member of a fire patrol or any other person to give the alarm immediately upon the detection of fire.

Audible and Visible fire indicators on the navigating bridge or fire control station

- Ships are fitted with automatic fire detection and fire alarm systems capable of detecting the presence of fire in a part of the ship that is inaccessible to members of a fire patrol.
- The automatic fire alarms also activate audible and visible fire indicators on the navigating bridge or in the fire control station.

Where a fire detection and fire alarm system depends on electricity for its operation, the system is connected to 2 sources of supply, one of which is an emergency source.

Steps are taken in the construction of the fire alarm systems to avoid damage to them by a fire in an enclosed space or a high fire risk space on board the ship.

These steps include:

- Routing the associated wiring so that it does not go through high fire risk spaces unless unavoidable;
- Fire protecting wiring by running it through a protective conduit formed by a fireproof material such as steel pipe.

All fire detection systems

- are capable of automatically indicating the presence or indication of fire and also its location.
- Indicators are centralised either on the navigating bridge or in other control stations which are provided with a direct communication with the bridge.
- The indicators in some circumstances are distributed among several stations.
- The alarm system operates both audible and visible signals at the main fire control panel stations.
- Detection systems for cargo spaces might not have audible alarms.

Section 5 – Extinguishing Agents & Fire Extinguishers

Note:
In this section the information given applies to Australian standards for classification of fires and the identification of the types of extinguishing agents that are appropriate for extinguishing them. Some Flag States (foreign maritime regulators who are members of the IMO) have different standards for colour coding fire extinguishers.

General

- Extinguishing agents work by removing one of the three elements of a fire or inhibiting its chemical reaction, resulting in the fire being extinguished.

Fire Fighting Mediums

Water

- Identified with all red colour (no band)
- Water in the form of a solid jet, spray, fog or flooding is an agent that cools the fuel to a point that the fuel no longer changes into flammable vapour. This means the faster the cooling effect the quicker the fire will be extinguished.
- Direct stream of water at the base of the fire (at the fuel)
- Electrically conductive. Do not use on an electrically involved fire to avoid electric shock!
- Will cause liquid fuel to spread or splatter

Water is utilised in the following forms:

- Portable extinguishers
- Fixed systems (sprinkler, high pressure mist etc.)
- Hydrants and hoses

Foam

- Foam is an additive that is injected into a water flow or mixed directly into a water supply and it is designed to provide a film of foam between the surface of a fuel and the oxygen in the atmosphere.
- In chemical terms the combustion process is a fast running reaction between a flammable material and atmospheric oxygen induced by the ignition temperature.
- To extinguish a fire, the burning material must be separated from the atmospheric oxygen or cooled down to below the combustion temperature. This is exactly what fire extinguishing foam does.

The following fire extinguishing effects are utilised when using fire extinguishing foam:

Separating effect - The closed foam cover separates the combustion zone from the ambient air and prevents any further supply of oxygen to the flammable material.

Cooling effect - The water drained from the foam evaporates in the area of the flame front whereby heat is withdrawn and the reaction velocity between the flammable material and atmospheric oxygen is reduced significantly. The flammable material is cooled down by the water/foam solution discharged by the foam.

Cover effect - The closed foam cover stops any further gas evaporation from burning materials, i.e. flammable gases from the incendiary matter can no longer get into the combustion zone. Cooling the burning material at the same time reduces the vapour pressure whereby outbursts of gas and thus re-ignition are avoided. The preventive application of foam onto spilled volatile products prevents emissions harmful to the environment. This also significantly reduces the danger of fire.

Suppression effect - Flooding spaces, channels, plant parts, etc. with high or medium expansion foam suppresses the flammable vapours/gases from entering the atmospheric oxygen necessary for the combustion process.
Insulation effect - The low thermal conductivity of the foam insulates flammable material which has not yet caught fire or has already been extinguished against thermal radiation and ignition sources.

Film formation - Aqueous film (AFFF effect) - The foam produces a very thin aqueous film which floats ahead of the foam and provides for its excellent flowing, extinguishing and re- ignition inhibiting properties. The aqueous film also forms when using non-aspirated foam concentrate solutions, e. g. in sprinkler systems, water monitors, spray nozzles etc.

Different Types of Foam
Aqueous Film Forming Foam Extinguishing (AFFF) agents exhibit low expansion foam fire extinguishing properties which are adaptable for use in various low expansion foam generators.

The Aqueous Film Forming Foam Extinguishing Agent can be used in combination with powder extinguishing agents and can be used to extinguish large oil tank fires. It is widely used in fire protection and fire extinguishing in airports, oilfields, large chemical plants, chemical storerooms, oil depots and on ships.

High Expansion Foam Extinguishing Agents exhibit high and medium expansion properties and are adaptable to use in various high or medium expansion foam generators.

The Medium Expansion Foam Extinguishing Agent exhibits medium expansion properties and is adaptable for use in various expansion foam generators.

- Both the High Expansion Foam Extinguishing Agent and the Medium Expansion Foam Extinguishing Agents are useful for fire protection and fire extinguishing in limited spaces such as enclosed machinery spaces on ships.
- These extinguishing agents are most effective when they are used to cover large areas of drifting flammable liquids which do not mix with water.
- Two types of High and Medium Expansion Foam Extinguishing Agents are available - One may be used with both sea water as well as fresh water. The other may be used with fresh water only.

Foam is available with different expansion properties for different uses:

Low Expansion:

- Identified by a BLUE band
- Designed specifically to cover large areas quickly along a horizontal surface.
- Portable extinguishers containing a foam extinguishing agent would normally use low expansion foam.
- Electrically conductive. Do not use on an electrically involved fire to avoid electric shock!
- Ideal for oil fires (Class B) but also rated for Class A fires.
- For open oil spills lob foam high over spillage to cover fuel completely.
- Aim at corner of container or bulkhead & cover completely.
- Do not disturb foam blanket after application.

Medium Expansion:

- is utilised where some degree of in-depth coverage is necessary or where rapid vapour suppression is required. It is effective both indoors and outdoors and produces far more foam using less water than low expansion foam systems.
- Mobile extinguishers used to apply a foam extinguishing agent to small machinery spaces would normally use medium expansion foam to penetrate the bottom third of a cargo hold including difficult to reach places within the space.
- Medium expansion foam with an expansion rate of 12 to 1 would also be used in fixed installations involving a number of nozzles protecting a particular space.

High Expansion:

- Powerful fan driven foam generators expand the foam over 200 times.
- They are suitable for filling a large enclosed space rapidly.
- The foam displaces flammable vapour but provides an environment which is not harmful to crew remaining in the space.

Foam is utilised in the following forms:

- Portable extinguishers
- Mobile apparatus
- Fixed systems
- Injected into water from hydrants and hose reels

Carbon dioxide (CO2)

- Identified by a BLACK band.
- CO2 is an agent that creates a fire smothering gas layer between the fuel supply and the oxygen in the atmosphere.
- The fire is extinguished by removing oxygen from the surface of the fuel.
- Re-flash can occur when oxygen returns to the surface of a fuel that is hot enough to reignite itself. This is why CO2 has only a limited extinguishing action on solid fuels.
- Safe to use on electrical fires & CO2 is very effective if the ignition source is isolated by turning off the source of electrical power.
- Ideal for Class (E) fires but also rated for Class B

CO2 is utilised in the following forms:

- Fire extinguishers
- Mobile apparatus
- Fixed systems

Dry Chemical Powder (DCP)

- Identified by a WHITE band
- Dry chemical agent is a fine powder that interrupts the fire chemical reaction and smothers the fire. It quickly knocks down the flame of any fire.
- Fixed installations generally consist of 250KG pressurised cylinders and the extinguishing agent is delivered by either flexible hoses or static discharge ports.
- The dry powder is produced under great pressure and creates a very dense cloud of powder on application.
- Fixed Dry Chemical Powder systems should only be used after the fire affected space has been evacuated and sealed so that the extinguishing agent does not spread beyond the fire affected area and cause additional equipment damage.
- There are several different types of dry chemical powders including class D – special dry powders. However all dry chemical powder extinguishing agents act in the same basic way to extinguish a fire. The powder interrupts the chemical reaction at the fuel surface providing a rapid extinguishing action.
- Rated for use on Class B(E), A, B and safe to use on Class (E) but destroys electrical equipment.

Dry powder is utilised in the following forms:

- Portable extinguishers
- Mobile Apparatus
- Fixed installations
- Specific hoses attached to DCP systems

Wet Chemical

- Identified by an OATMEAL coloured band
- The Wet Chemical Extinguishing agent is commonly used to protect spaces such as a ship's galley from animal fat and oil fires.
- It is a potassium carbonate based solution which is discharged as fine droplets into a protected area. The fine spray discharge prevents the dangerous splash of hot grease.
- The fire is extinguished by saponification, a process in which the wet chemical agent combines with the grease to form a soapy layer at the surface of grease to seal off the fuel from the oxygen, allowing the grease to cool to below its auto-ignition temperature.
- The system provides a fine spray discharge lasting for a about 45 seconds.
- Unlike Dry Powder, Wet Chemical Agents may be quickly cleaned up following a discharge resulting in shorter down time in the galley.
- A Wet Chemical fixed installation system may be controlled manually or automatically using electrical detection equipment or mechanical fusible link devices.
- Do NOT USE on Class (E) fires to avoid electrocution.

Wet chemical is utilised in the following forms:

- Portable extinguishers
- Fixed installations on galley range hoods.

Steam

- Steam was one of the earliest extinguishing agents used aboard vessels.
- It was readily available for firefighting once the ship's boilers were lighted.
- Steam extinguishes fire by smothering, e.g., by forcing air away from the fire and by diluting the air around the fire.
- As long as the steam blanket is maintained, it will prevent re-ignition.

However, there are several disadvantages in using steam, especially in comparison with other extinguishing agents.

- Obviously steam is applied to the fire in the vapour state.
- Thus, most of its heat-absorbing ability is lost before it is applied and it does little cooling. (Water fog, on the other hand, cools as it turns to steam.)
- Additionally, steam condenses when the supply is shut off. Its volume decreases substantially and combustible vapours and air rush in to displace it.
- There is, then, a very good chance that the fire will reflash if it has not been completely extinguished and cooled.
- Finally, steam is hazardous to personnel because the heat it carries can inflict severe burns.

If a ship is equipped with a steam smothering system, the crew must, of course, use that system in case of fire. Some older ships may have fixed steam smothering systems for the protection of cargo; however, since January 1, 1962, such installations have not been allowed on new ships.

Steam is utilised in the following:

- Fixed installations

Waterless gas suppression agents

- The waterless gas suppression systems (EG FM200) use a rapid discharge of gas based agents that interfere with the chemical reaction.
- The agents are non conductive and do not remove oxygen to harmful levels thus are good for manned areas that require rapid extinguishment.
- Waterless suppression is only used in fixed installations.

Used fire extinguishers

- On land, an empty or partially empty fire extinguisher would be placed on it's side on the floor.
- It cannot be put back on it's stowage bracket because it would be mistaken for a fully charged extinguisher and that would be dangerous in the event of a fire.
- On a ship it is not practical to place an extinguisher on it's side because it will roll around when the ship moves.
- Therefore it should be placed on it's side and secured so that it will not roll around.
- A serviceable fire extinguisher should replace the used one as soon as possible.

Recharging Extinguishers

- On board a ship only some types of fire extinguishers can be refilled.
- Generally CO2 and Dry Chemical Powder extinguishers would be recharged at a shore facility.
- However, Water and Foam extinguishers can be recharged manually on board by crew who have been specially trained and approved to perform this work.
- When pressurising fire extinguishers, special safety precautions must be followed due to the high pressure of the contents of the fire extinguisher.

Under Australian standards and workplace practices only suitably qualified persons should refill any type of fire extinguisher and the workplace must be equipped with the safety equipment required to complete the work safely.

A pressurised cylinder can be extremely dangerous if accidentally perforated.

Module 6: FIRE Course – Fight & Extinguish Fires

Section 1 – Portable Fire Extinguishers

Type of extinguisher			Type of Fire, Class and Suitability						Comments (Refer Appendix B)
			A	B	C	E	F	D**	
Colour scheme AS/NZS1841 -1997	Colour scheme AS1841 -1992	Extinguishant	Wood, paper, plastics,etc	Flammable liquids	Flammable gases	Energized electrical equipment	Cooking oils and fats	Metal fires	
		Water							Dangerous if used on flammable liquid, energized electrical equipment and cooking oil/fat fires
		Wet Chemical							Dangerous if used on energized electrical equipment
		Foam***					LIMITED*		Dangerous if used on energized electrical equipment.
		Powder ABE							Special powders are available specifically for various types of metal fires (see **).
		Powder BE							
		Carbon Dioxide	LIMITED*	LIMITED*					Generally not suitable for outdoor use. Suitable only for small fires.
		Vaporizing Liquid		LIMITED*	LIMITED*				Check the characteristics of the specific extinguishant.
		Fire Blanket	Human torch						

* Limited indicates that the extinguishant is not the agent of choice for the class of fire, but that it will have a limited extinguishing capability.
** Class D fires (involving combustible metals). Use only special purpose extinguishers and seek expert advice.
*** Solvents which may mix with water, e.g. alcohol and acetone, are known as polar solvents and require special foam. These solvents break down conventional AFFF.

Australian Standard 2444-2001

- Each extinguisher is rated under Australian Standards to show the type of fire that it can extinguish.
- Green and red pictograms indicate the type of fires that the extinguisher should and should not be applied to.
- Pictograms overcome language and literacy barriers to convey the correct use of different types of fire extinguishers.
- The green pictograms shown here will be printed as appropriate on each type of portable fire extinguisher to indicate that the extinguisher is suitable for that type of fire. The Red coloured pictograms are prohibition pictograms, meaning "do not use on this type of fire".

PASS
P – Pull out the safety pin, test the extinguisher
A – Aim the director at the base of the fire
S – Squeeze the operating handle
S – Sweep the agent over the base of the fire

- In most cases, the extinguisher will have a plastic seal tag (anti-tamper seal) holding the safety pin to the handle.
- The tag shows that the extinguisher has not been activated since its last service.
- The tag is quite easy to remove and usually breaks as the safety pin is pulled out.

After Use

- Once an extinguisher has been operated, it must be replaced even though the extinguisher may feel full.
- Due to the discharge valve being dislodged, the pressure in the cylinder will most likely reduce to the point where the extinguisher will be unable to emit the extinguishing agent.
- Ensure that used extinguishers are laid down on their side, restrained so that they don't roll around and reported immediately.

Inspection & Maintenance

Inspection of fire equipment must be carried out on a regular basis. The following rules apply:

- Annual inspection and recertification by a qualified person
- Monthly inspection for corrosion and pressure by crew.
- A history log should be maintained which records inspections, usage, maintenance and recertification.
- Ensure that the extinguishers are accessible and serviceable and that the crew members know how to operate them.
- Water, AFFF and dry chemical with cartridge can be refilled by crew.
- Damaged, obsolete, or empty extinguishers must be replaced.

Section 2 – Mobile Apparatus

Mobile apparatus can be best described as large mobile extinguishers mounted on trolleys. The different types of mobile apparatus are:

Carbon dioxide cylinders

Powder containers with propellant gas

Foam making equipment

Uses of Mobile Apparatus

- Mobile equipment is found in areas such as machinery spaces where the potential fire may be too big for portable extinguishers and an agent other than water is preferred.

Section 3 – Fireman's Outfit

Personal protective equipment should be of a type and standard as approved by the Australian Standards Association or its equivalent.

A fireman's outfit includes the following personal equipment:

- Protective clothing of material to protect the skin from the heat radiating from the fire and from burns and scalding by steam. The outer surface is water resistant.
- Wearers must ensure that no bare skin is exposed and that they are wearing the correct size of clothing for their height and weight.
- Boots and gloves of rubber or other electrically nonconducting material. Socks must always be worn inside boots for skin protection and to prevent cross infection from other wearers.
- Clothing must be donned in the correct sequence to minimise the time taken to attack the fire - Trousers, Boots, Coat, Helmet, SCBA and Gloves in that order.
- A rigid helmet providing effective protection against impact
- An electric safety lamp (hand lantern) of an approved type with a minimum burning period of three hours.
- An axe.

Breathing Apparatus Types

There are two main types of air supplied systems

- CABA (Compressed Air Breathing Apparatus) open circuit
- Rebreathing type. (Closed circuit)

CABA systems are further broken down into two main types

SCBA (Self Contained Breathing Apparatus) and

Air Line. The Air Line type is not generally used on Australian ships.

The fireman's breathing apparatus is designed to protect the wearer from atmospheric hazards.

There are numerous brands and styles of breathing systems however air supplied systems are the only type used in fire fighting.

Breathing Apparatus Requirements for Australian registered ships:

- Are self contained breathing apparatus (SCBA)
- Are of the compressed air open circuit type
- Are designed, tested and maintained to the requirements of Australian Standards AS 1715 and AS 1716 or any other equivalent international standards
- Are fitted with a manually operated bypass valve
- The storage capacity of the air cylinder or cylinders attached to the apparatus is at least 1,200 litres of free air measured at a temperature of 16°C and at atmospheric pressure
- The pressure gauge is clearly marked to indicate (1.) when the cylinder capacity has been reduced by 80 per cent of its effective life and (2.) when the cylinder is full.
- Each SCBA is provided with fully charged spare cylinders, providing a storage capacity of at least 2,400 litres of free air. If the ship is carrying 5 or more SCBA's the total spare storage capacity of free air is 9,600 litres. If the ship is equipped with an approved means of recharging the air cylinders to full pressure with air, then the spare storage capacity of the fully charged cylinders for each SCBA will be at least 1,200 litres of free air and the total spare storage capacity of free air provided in the ship does not need to be more than 4,800 litres.
- A breathing apparatus is constructed of materials having adequate mechanical strength, durability and resistance to deterioration by heat or by contact with sea water and those materials are resistant to fire and do not allow the breathing circuit to be penetrated by smoke or chemical fumes likely to be encountered in service. The fabric used in the construction of any harness provided with that apparatus is resistant to shrinkage. Exposed metal parts of the apparatus, harness and fittings are of materials so far as practicable resistant to frictional sparking.

Relative Advantages & Disadvantages of Each Type of Breathing Apparatus

Self contained type (Cylinder is carried by the wearer)

- this type has the advantage of freedom of movement for the operator.
- However the key disadvantage is that the air supply and duration is limited to the amount of air the operator can carry.
- Generally maximum time is approximately 60 minutes depending on the cylinder size and the volume of air compressed into cylinder.

Air line type (A hose extends from the face mask to a supply of air outside the fire affected area.)

- These systems comprise a Smoke Helmet, Air Pump, Air Line & Fittings.
- This type has the advantage of air supply being constant and possibly unrestricted. Therefore there is no time restriction in its use.
- However, the disadvantage is that the wearer's agility and movements are restricted by the air line that is constantly attached.

Fireproof Lifeline with Fittings This

is used to –

- trace an exit path out of the fire zone
- to maintain contact between the team members at all times
- the lifeline can also be used as a means of communicating with other crew outside the fire zone

Signal	Meaning
By wearer of breathing apparatus 2 PULLS 3 PULLS	 SLACK OFF LIFELINE HELP ME OUT IMMEDIATELY
To wearer of breathing apparatus 3 PULLS	COME OUT IMMEDIATELY

Requirements of the Fireproof Lifeline

Fireproof lifelines including harness and connectors are used by fire teams when conducting search and rescue tasks.

The following equipment is provided for use with each breathing apparatus:

a) A fire proof life and signalling line with snap hook, at least 3 metres longer than is required to reach from the open deck in clean air well clear of a hatch or doorway to any part of the accommodation, service, cargo, or machinery spaces but not less than 30 metres in length. The line is made of copper or corrosion resistant steel wire rope with a breaking strength of at least 5kN and being overlaid at least 10 millimetres in diameter by hemp or other covering to provide a surface that can be firmly gripped when wet;

b) Where provision is not made on the breathing apparatus harness for attaching the lifeline, an adjustable safety belt or harness to which that line is capable of being securely attached and detached must be worn;

c) Operating instructions in clear and permanent lettering on a plate for attachment to the apparatus or for display in clearly visible position near the apparatus stowage position;

d) Plates of suitable material, that are not readily combustible, bearing the code of signals in the foregoing table to be used between the wearer and his or her attendant, one of which must be attached to the harness and another attached to the free end of the life and signalling line.

- A lifeline can be used for signalling purposes between members of the fire team.
- A series of pulls can be used to communicate vital instructions to operators.

Other equipment which could be used by fire teams to help ensure the safety of crews includes thermal imaging cameras. These allow the seat of a fire or a victim to be discovered very quickly in a smoke filled area. Remember that time is of the essence.

Section 4 – Fire hydrants, hoses & nozzles

Fire Mains & Hydrants

- Fire mains and hydrant systems are a series of pipes and connections that take pressurised water to areas on board the vessel.
- This allows the fire team to connect fire hoses to the hydrants positioned around the vessel using hose couplings.
- They should be installed with isolation valves, cross over valves and an individual shut off for each hose.
- This allows for extra pressure and water supply to be directed to certain areas as required.
- The quantities and locations of the hydrants are sufficient to provide at least two jets of water from more than one hydrant which can reach any part of the ship normally accessible to the passengers or crew while the ship is under way.
- One of the jets of water is able to be delivered by a single length of hose.

Pipes and Hydrants

- Materials which are easily damaged by heat are not used for fire mains and hydrants unless they are adequately protected.
- The pipes and hydrants positioned so the fire hoses can easily be coupled to them. In ships where deck cargo might be carried, the hydrants are positioned so they are always readily accessible.
- Pipes supplying water to the hydrants are positioned to minimise the chance of being damaged by the cargo.
- If each hydrant is not fitted with a hose and nozzle then all the hose couplings and nozzles on board the ship are completely interchangeable.
- A cock or valve is fitted to each fire hose so that any fire hose can be removed while the fire pumps are at work.

Passenger and cargo ships are furnished with:

- At least one fire hydrant on the port side of each machinery space
- At least one fire hydrant on the starboard side of each machinery space
- Additional hydrants if needed to deliver at least 2 jets of water directed at any part of the passenger space, crew space and coal bunker space (if any), cargo space or store room and the machinery spaces.

Additional fire hydrants

Some passenger ships or cargo ships of 500 tons or more might be fitted with additional hydrants outside the machinery space near the escape route entrance to the machinery space.

Requirements

- Only steel pipe and steel fittings are used for fire mains and hydrants.
- The pipes and hydrants are placed so that the fire hoses can be easily coupled to them.
- Unless one hose and nozzle is provided for each hydrant on the ship, the hose couplings and nozzles are completely interchangeable.
- A cock or valve is fitted to each fire hose so that any fire hose can be removed or a nozzle replaced while the fire pumps are working.

Hydrant Shut off valves

Shutoff valves are fitted to serve each hose connected to hydrants. Should one hose connected to a hydrant fail or to provide the ability to change the nozzle, the pressure to that hose can be shut off without affecting the operation of other hoses connected to the same hydrant.

Isolating and Crossover Valves on the Fire Main

Isolating and crossover valves are provided on the fire main to enable the water supply to the ship's hydrants to be switched from one main fire pump to another and from a main fire pump to the emergency fire pump.

These should be used and tested regularly for proper operation and for crew training purposes during fire drills.

Fire Hoses & Nozzles

Fire Hose

- One of the most basic pieces of fire fighting equipment.
- Used to move water to the fire.
- Able to expand and stretch with increased internal pressure
- Lay flat for storage. Either rolled or flaked.
- Durable, and resistant to abrasion and rough use.
- Resistant to chemicals and rotting.
- Variety of sizes 38, 64, 51 and 90 mm
- Each hose is no longer than 18 mtrs
- Up to 3 hoses can be joined together as long as the total length does not exceed 38 mtrs
- The combined hose length must be able to reach a 30 metre length of the ship
- The most common sizes are 38mm (one person) and 64mm (two person) Length & Construction of Fire Hoses
- The construction materials and the maximum length of fire hoses meet AMSA's requirements.
- The length of the hoses is sufficient to project a jet of water to any of the spaces in which they may be required to be used.
- Normally 18 metres is the maximum length of a fire hose provided on the ship.
- Three or more lengths of fire hose are not normally coupled together if the combined length exceeds 36 metres.

Kept Ready For Use

- Each hose is provided with a nozzle and the necessary couplings.
- Fire hoses and all necessary fittings and tools are kept ready for use in conspicuous positions near the water service hydrants or connections.
- Additionally in interior locations in passenger ships carrying more than 36 passengers, fire hoses are connected to the hydrants at all times.

Number of Fire Hoses

- A fire hose is provided for each hydrant in the machinery spaces.
- For each 30 metres of the length of the ship, one additional fire hose is provided.
- There are a minimum of 5 additional hoses in relation to a ship of 1,000 tons or over.
- Depending upon the type of trade the ship is involved in, additional fire hoses might be required.

Nozzles

- Branches or nozzles are a device fitted to the end of a delivery hose.
- A branch provides the firefighter with control over the pattern and pressure of the water or extinguishing agent delivered by the hose.
- The branch can provide a range of patterns from a straight jet through spray patterns to a very fine mist.
- Branches are available in various types including a straight branch, a control branch and a foam making branch.
- Standard nozzle sizes are 12 millimetres (1/2 inch), 16 millimetres (5/8 inch) and 19 millimetres (3/4 inch) or as near as possible to these sizes.
- Approved larger diameter nozzles might be provided.
- For accommodation and service spaces, the maximum nozzle size is usually no greater than 12 millimetres (1/2 inch).
- For machinery spaces and exterior locations, the nozzle size is selected to obtain the maximum discharge possible from two jets from the smallest fire pump.
- Usually the largest nozzle size is 19 millimetres (3/4 inch) for this application.

Nozzle Adjustment for and Use of Protective Screen, Concentrated Jet, Spray & Mist

Nozzles and branches can be adjusted to provide a range of water spray patterns from a jet or straight stream, a water spray and a mist.

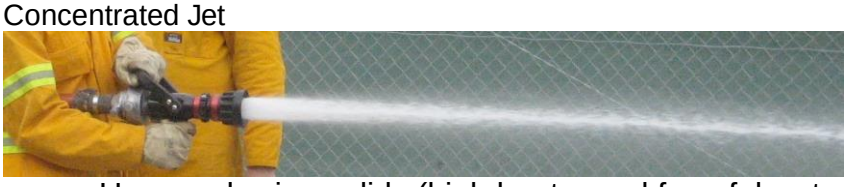
Protective Screen

This pattern provides a protective screen which allows the fire team to approach the fire safely.

Normally a second fire team would have another hose and nozzle with a straight stream alongside the first team.

In this way both teams are shielded from the heat from the fire and the straight stream begins to extinguish the fire as both teams approach it.

Concentrated Jet



- Use on glowing solids (high heat, need forceful water flow to cool).
- Better penetration.
- Longer range stream.
- Less steam.
- More water used.
- Less protection from heat.

Spray

- Use on solids with flames.
- More evaporation so maximum cooling for bulkheads etc.
- Protects from heat.
- Less water is used therefore there is less water damage.
- Less stream range.
- Minimal penetration.
- A wide spray pattern provides a protective wall of water for fire crew using a second hose and branch with a concentrated jet to extinguish a fire.
- Some branches can provide a wide spray pattern for protection at the same time as a concentrated jet of water to extinguish a fire.

Mist

- A finely atomised water at high pressure
- Very efficient at cooling flammable liquid fires so long as direct access to the fuel vapour is not blocked
- Minimal use of water
- The water droplets & vapour suspended in the air continue to provide an extinguishing effect after the water mist is turned off
- Not efficient at a frontal fire attack because of lack of ability of the fine droplets of water to penetrate flames
- Some branches might provide both a wide spray pattern and a straight jet in the one branch

Portable Foam Applicator for Water Hose Reels

- Water hose reels can be fitted with a foam induction pipe just behind the nozzle end of the hose.
- The induction pipe can be permanently fitted or clipped on when required.
- When the induction pipe is not fitted the nozzle is clipped directly to the end of the fire hose reel and the hose reel is then operated in the normal way.
- When the induction pipe is clipped into the end of the fire hose, the nozzle is connected after the induction pipe.
- The induction pipe is then inserted into a container of usually 20 litres of foam concentrate.
- When the water flows to the nozzle and the nozzle is open, the water pressure in the hose to the nozzle is lower than the pressure in the 20 litre of foam concentrate and the concentrate is sucked into the hose feed to the nozzle.
- Holes at the base of the nozzle allow air to be sucked in as the foam and water mixture rushes by, aerating the foam mixture.
- The aerated foam and water mixture discharges from the nozzle as a thick coating over the fire which suffocates the fire and extinguishes it by blocking the supply of oxygen.
- Foam is very effective in extinguishing a flammable liquid fire.

Nozzles for Fire Hoses in Machinery Spaces

- Each hose provided for a fire hydrant in the machinery spaces is fitted with a water spray nozzle.
- For machinery spaces or in similar spaces where the risk of spillage of oil exists, the nozzles are suitable for spraying water on oil or alternatively are of a dual purpose type.

Nozzles for Fire Hoses in Passenger Ships

- In addition to the requirements already listed above, a water spray nozzle or dual purpose nozzle is required for every four fire hoses provided on the ship.

Other Requirements of Nozzles

- Spray Nozzles must be capable of producing a spray pattern and intensity that will not disturb a film of oil on water.
- Nozzles, for deck hoses on tankers and other types of ships with similar fire hazards, must not be constructed of aluminium alloy (to avoid damage caused by the heat of a fire).

Interchangeability of hoses and nozzles

- Each fire hose provided is capable of being fitted to each hydrant in the ship and to every other fire hose in the ship.
- Each nozzle for a fire hose that is provided in a ship is capable of being fitted to each fire hose in the ship.

Duties of master in relation to fire hoses & associated equipment

- The master of a ship is required to ensure that each fire hose and associated tools and fittings are kept in a conspicuous position near a water hydrant or connection with which it is intended to be used.
- The master of a ship will not use, or permit the use of, any hose that is required to be provided on the ship, for any purpose other than extinguishing fire, testing fire appliances or fire drill.
- Penalties apply for noncompliance.

Maintenance and Storage of Hoses & Nozzles

- Lay flat hoses can be either rolled or flaked for storage
- Nozzles, couplings and all tools necessary to connect the fire hose to the nozzle and the hydrant must be stored together, ready for immediate use in the event of a fire emergency
- The condition of the equipment should be checked following regular drills
- Any defects must be reported immediately
- The equipment should be cleaned using soapy water but no harsh chemicals
- Repairs should be completed prior to returning the equipment to it's storage

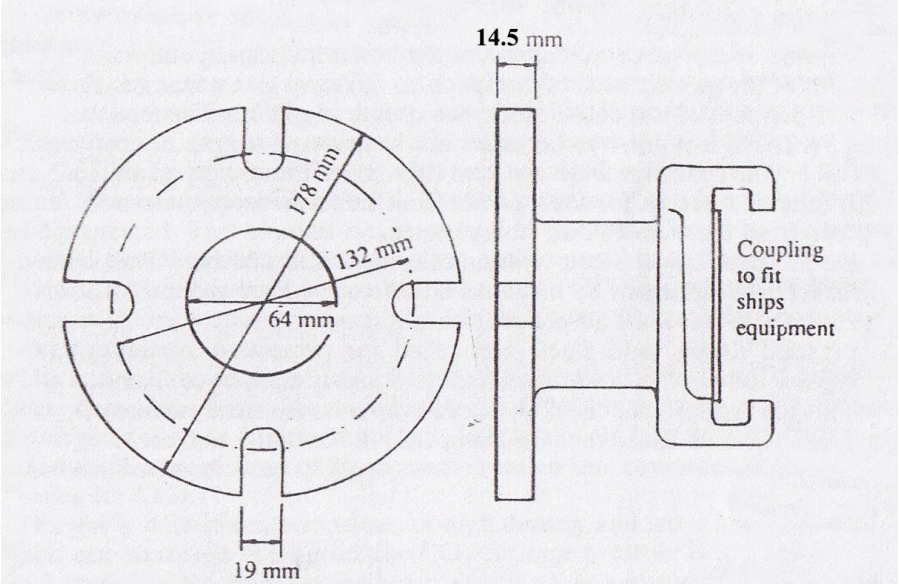
location Joining Fires Hoses Together & Connecting to Fire Hydrants

Couplings are used for connecting two lengths of hose or a piece of equipment to a length of hose.

The most common types used are British instantaneous (BIC) and screw or threaded.

British instantaneous	Screw threaded
Locking lugs hold the couplings together	Tools are required to tighten the couplings
No tools are required	Aligned so that the male coupling is towards the fire
Aligned so that the female coupling is towards the fire	These types take longer to join and often require a tool to tighten the join
These types “click” together and are generally faster to use than screw thread	

International Shore Connection



Courtesy: "General Engineering Knowledge" by H.D. McGeorge

- A ship of 1,000 tons or more is fitted with international shore connections on both sides of the ship.
- International Shore Connections allow the ship's fire main to be pressurised from a water supply external to the ship.

- They can be bolted on one face to the shore connection and coupled on the other face to the ship's hydrants.
- The connection is constructed of material suitable for 10.5 kilograms per square centimetre (150 pounds per square inch) service.
- The flange has a flat face on one side and the other has permanently attached to it a coupling that will fit the ship's hydrants and hoses.
- The connection is kept aboard the ship together with a gasket of any material suitable for 10.5 kilograms per square centimetre (150 pounds per square inch) service, together with four 16 millimetre (5/8 inch) bolts, 50 millimetres (2 inches) in length and eight washers.

Standard dimensions of flanges for the international shore connection comply with the following table:

Description	Dimension
Outside diameter	178 millimetres (7 inches)
Inner diameter	64 millimetres (21/2 inches)
Bolt circle diameter	132 millimetres (51/4 inches)
Slots in flange	4 holes 19 millimetres (3/4 inch) in diameter equidistantly placed on a bolt circle of the above diameter, slotted to the flange periphery
Flange thickness	14.5 millimetres (9/16 inch) minimum
Bolts and nuts	4, each of 16 millimetres (5/8 inch) diameter, 50 millimetres (2 inches) in length

Section 5 – Knowledge of fire safety arrangements

Crew Knowledge Required of Fire Fighting Equipment

- Immediately after joining a ship, seafarers should familiarise themselves with the location of the fire fighting appliances on board, the operation of such appliances and their effectiveness on different types of fires.
- In accordance with STCW Regulation VI/I section A VI/I of the Code, a responsible officer should verify this knowledge.
- The master of a ship must ensure that crew members are trained in the operation and application of all life saving, fire fighting and other emergency appliances and equipment provided in the ship.
- Training is an essential part of completing the job safely and expertly.
- Training allows you to gain the skills, knowledge and experience required using equipment, techniques and procedures in a safe and controlled environment.
- All crew must have knowledge of the ship's fire safety arrangements and evacuation procedures.

Important aspects are:

- Location and method of operation of fire alarms
- Location and method of operation of emergency controls
- Use of fire equipment
- Awareness of potential fire hazards and how to report them

Section 6 – Fire fighting administration

Access to the fire

- If the normal access route to the fire effected space is blocked by fire or smoke then emergency exits can be considered as a means of access.
- If the fire is in an inaccessible space then the first actions would involve the shutting down of air flow to the space followed by a selection of the most effective means of extinguishing the fire.
- Sometimes simply shutting down the flow of air to a space might be sufficient action to extinguish the fire.
- Machinery spaces on board a vessel are often equipped with a fixed fire extinguishing system such as a facility to fill the space with Carbon Dioxide gas, replacing the oxygen in the atmosphere and interrupting the Chain Reaction of fire.

Danger to Personnel

- The first consideration is always the safety of the ship's crew.
- Before conducting a dump of CO2 gas into a space to extinguish a fire, The Master will sound a special CO2 alarm to warn crew of the impending action and give them time to evacuate.
- Only after all crew have been accounted for will the Master initiate the CO2 dump.

Muster Stations

- The first step in any established fire emergency is to muster the crew and complete a head count.
- If anyone is missing then a search will be conducted.

The Master directs the fire fighting attack plan from the Bridge

- This necessitates the use of communications equipment usually in the form of hand held VHF transceivers. However, all available means of communications can be used.
- It is essential for the safety of the fire fighting team that the Master is aware of the exact location of all crew members.

Reactions with cargo/burning material

- The Master must also be aware of the location of any flammable material in the vicinity of the boundaries of the fire effected space.
- The Master might utilise Boundary Cooling, cooling the bulk heads, floor plates and deck heads surrounding the fire effected area with streams of water from fire hoses.
- In this way the spread of the fire through thermal conductivity to a neighbouring space containing flammable or explosive materials is reduced or prevented.
- If possible the Master will arrange for the removal of the flammable materials away from the fire effected space.

Appropriate fire fighting agents

The Master has at his/her disposal a range of fire extinguishing agents and equipment to dispense them:

- Water - in the form of solid Jet, spray, fog or flooding
- Foam - high, medium and low expansion
- Carbon Dioxide
- Steam
- Dry chemical powders

The Master's view of the fire emergency

The Master's view of the fire emergency should be complete and this is achieved from the Bridge by access to detailed Fire Control Plans of the ship.

Utilising the Fire Control Plans the Master identifies:

- each crew member's location
- the space(s) which are fire effected
- the fixed fire fighting installations
- the location of ventilation controls to the fire effected space(s)
- the mobile & portable fire fighting equipment
- the location of fire pumps, hydrants, hoses and

nozzles Reflash Watch

- A watch must be maintained after the fire has been extinguished to ensure that it does not reflash or reignite.
- If fuel and heat are still present then the restoration of fresh air containing oxygen can reignite the fire.
- In a large space such as the ship's engine room, it could take days before the space can be considered to be safe following an extensive fire.

In Port

- If the vessel is in port at the time of a fire emergency, the Master will immediately report the fire to the Port Authorities.
- Shore based fire fighting teams will always have a higher level of training and better equipment than what is found on board a ship.

Summary

When the fire alarm is given, fire procedures and emergency stations procedures are put into effect:

- crew assemble at the designated fire stations as given in the muster list
- fire parties assemble on orders from the Bridge and carry out their tasks aimed at containing the fire and extinguishing it
- pumps are started to supply extinguishing water
- the Master decides the most appropriate method for fighting the fire
- the Master controls the fire fighting operations from the Bridge
- when the fire is extinguished a fire watch is maintained
- the Master conducts an investigation into the cause(s) of the fire to prevent a recurrence
- if the fire occurs while the ship is in port the shore authorities are notified immediately

Module 7: FIRE Course – Fixed installations

Section 1 – General

General requirements

- The medium must not produce toxic gases
- The quantity of the medium must be adequate for the spaces which are to be protected
- the piping system must have control valves
- the release of a gas medium must not be automatic
- the order to release the medium must be given by the Master or a Senior Officer

Typical systems

- Carbon Dioxide (CO2)
- Sprinkler - can be kept charged with water (wet riser) or maintained dry but capable of being quickly charged with water supplied when needed from a pump and piping.
- Foam - Low expansion and High expansion
- Fire mains & hydrants
- Emergency generators, fire & bilge pumps
- Pressure water spray in special category spaces - Drainage must be adequate to prevent a free surface effect from the water sprayed by the extinguishing system
- Fixed installations which apply Chemical powder to a fire effected space

Section 2 – Smothering Effect Systems: CO2 & Foam

Carbon Dioxide (CO2)

How CO2 Smothers a Fire

- CO2 (Carbon Dioxide) is discharged as a "snow" like white cloud which smothers a fire by eliminating its oxygen.
- CO2 is a clean, non-contaminating, odourless gas, safe for use on clothing, equipment, valuable documents or food. However, it is toxic to human beings if breathed in.

Advantages of CO2

- No damage to electrical or other equipment.
- No mess

Disadvantages of CO2

- Can suffocate personnel in an enclosed space.

Actions to be taken when the CO2 Alarm Sounds

- There will be a short time delay from the time the alarm sounds until the CO2 is released.
- It is the Master's responsibility to ensure that no personnel are left in a fire affected space prior to flooding a space such as an engine room with CO2.
- If you are in a fire affected space and the CO2 alarm sounds, you must exit immediately to avoid being locked in and suffocated.

Spaces Where CO2 is used as an Extinguishing Agent

- CO2 fire extinguishing systems can be found in areas of the vessel where there is a high risk of fire due to the presence of heat, air ventilation and volatile fuel.
- Engine rooms and other machinery spaces where internal combustion engines are operating are typical spaces where CO2 extinguishing systems can be found.
- Cargo spaces containing a volatile cargo can also be protected with a manually operated CO2 extinguishing system.

Foam

- Foam creates a blanket over the fuel which prevents oxygen from reaching the fuel.
- The Chain Reaction of fire is broken and the fire is extinguished.
- It is necessary to leave the foam blanket undisturbed until the fuel has cooled down to avoid re-ignition.

High Expansion Foam

- Can cover a large area quickly
- Used in fixed installations where a high volume and pressure of water is available
- Commonly used in machinery spaces where there is a heightened risk of oil spill

Low & Medium Expansion Foam

- Used in portable and mobile extinguishers where there is a limited supply of water and insufficient water pressure to properly generate foam from the High Expansion product.

Advantages of Foam

- Ideal for extinguishing an oil fire.
- Fast acting.

Disadvantages of Foam

- Foam is mixed with water and therefore must not be used on electrically involved fires.
- Fire extinguishing foam also contains corrosive substances that can damage equipment and might be harmful to people if their skin comes in direct contact with the foam.
- Refer to the product's Material Safety Data Sheet (MSDS) for specifications and safety warnings.

Section 3 – Inhibitor Effect Systems

Dry Chemical Powder (DCP)

Dry chemical powder fire extinguishing systems protect:

- Decks
- Cargo manifolds on gas carriers
- Tanks on chemical tankers if required

The system extinguishes the fire using dry powder

- Ejected from monitors and hose stations
- Uses Nitrogen as the propellant
- The dry powder chemically breaks the combustion cycle

Dry chemical powder systems are

- Flexible in design

They come with

- Steel pressure vessels
- Cylinder banks with manifolds
- Gas release arrangements
- Pressure gauges
- Safety

valves Operation

- The central system is designed as a single or twin storage pressure vessel located inside the powder room.
- The system can be used to discharge powder across the whole cargo area at the required capacity, or the whole capacity can be combined and used on a single area.
- The central system feeds powder from the pressure vessels through piping systems on deck to the hose stations and monitors.
- The piping system is designed specifically for the vessel.
- Hose stations are located on deck so that every part of the deck area can be reached with two hose stations.
- The hose stations consist of a local release arrangement and 33 metres of hose with a powder pistol.
- Monitors are located at both cargo manifolds and can be released locally and remotely.

Section 4 – Cooling Effect Systems

Sprinklers

How water sprinklers work
Thanks to Hollywood most people believe that you could activate every sprinkler in an office building by pulling a fire alarm switch, shooting one sprinkler head or holding a cigarette lighter up to one sprinkler head. Fortunately, that is not how automatic fire sprinklers work.
Let's take a quick look at exactly how an automatic fire sprinkler is activated:

1. This is a sprinkler in it's normal state.
    - Unless a heat source is applied to the glass element (the red bulb in the centre), the sprinkler will remain like this for years.
    - The glass element is filled with fluid.
    - The size of the glass element and the type of fluid are dependent upon the temperature that a particular sprinkler is expected to operate.

2. This sprinkler has been exposed to enough heat to cause the fluid to expand and shatter the glass element.

- If you look closely, you can see the brass plug starting to drop now that the glass element is no longer in place.
- The purpose of the glass element is to hold the brass plug in place.
- When heat causes the glass element to break, the water pressure will force the brass plug out.

3. Here you can begin to see the brass plug being forced out by the water pressure in the Fire Sprinkler System.

- As the brass plug falls away this sprinkler will reach full flow and begin distributing water across a specific amount of floor area.

4. This sprinkler is at the beginning of full flow.
    - Water will now flow from this sprinkler head until the water source is depleted
    - The only way an automatic fire sprinkler can activate is when the glass element is broken and only the sprinkler head that is activated in this manner will operate
    - A well designed system can be in service for decades without having an activation

Water sprinklers are a simple and reliable way of not only detecting a fire but also commencing to extinguish or control the spread of the fire.

Generally the water based sprinkler or pressure spray systems cool the area to prevent the rapid spread of the fire and allow the fire team the time required to respond to the area.

This is especially important in accommodation areas.

Key advantages of sprinkler systems are the early detection, cooling and extinguishing of a fire.

The sprinkler heads operate individually and progressively activate as required.

Generally the heads are heat activated which makes the system very reliable.

Where are water sprinklers installed?

Water sprinkler systems are usually installed in accommodation spaces on board a ship, particularly where people sleep and rest.

Special category spaces

Manually operated pressure water spray systems are normally used in spaces such as the garage decks of a RoRo vessel and other special spaces.

In these large open spaces the extinguishing water is quickly drained away to prevent Free Surface Effect.

Module 8: FIRE Course – Breathing Apparatus

Section 1 – Self Contained Breathing Apparatus (SCBA)

Introduction

There are numerous brands of Self Contained compressed air Breathing Apparatus (SCBA).

They include Fenze, Drager, MSA, Sabre and Siebe Gorman which generally have the same features.

One safety feature fitted is a low pressure warning whistle which activates when the air pressure in the cylinder reaches the recommended pressure depending on the cylinder capacity, giving the operator approximately 10 minutes of compressed breathable air.

Today modern SCBA sets are positive pressure which assures a high degree of respiratory protection in hostile environments, by continually maintaining pressure within the facemask at a pressure above that of the surrounding atmosphere and therefore only outward leakage may occur.

Breathing Apparatus Types
There are two main types of air supplied systems –

- CABA (Compressed Air Breathing Apparatus) open circuit
- Rebreathing type. (Closed circuit)

CABA systems are further broken down into two main types

- SCBA (Self Contained Breathing Apparatus) and
- Air Line. The Air Line type is not generally used on Australian ships.

The fireman's breathing apparatus is designed to protect the wearer from atmospheric hazards. There are numerous brands and styles of breathing systems however air supplied systems are the only type used in fire fighting.

Breathing Apparatus Requirements for Australian registered ships
Are self contained breathing apparatus (SCBA)
Are of the compressed air Open Circuit type Are designed, tested and maintained to the requirements of Australian Standards AS 1715 and AS 1716 or any other equivalent international standards
Are fitted with a manually operated bypass valve
The storage capacity of the air cylinder or cylinders attached to the apparatus is at least 1,200 litres of free air measured at a temperature of 16°C and at atmospheric pressure
The pressure gauge is clearly marked to indicate: when the cylinder capacity has been reduced by 80 per cent of its effective life and when the cylinder is full.
Each SCBA is provided with fully charged spare cylinders, providing a storage capacity of at least 2,400 litres of free air.
If the ship is carrying 5 or more SCBA's the total spare storage capacity of free air is 9,600 litres.
If the ship is equipped with an approved means of recharging the air cylinders to full pressure with air then the spare storage capacity of the fully charged cylinders for each SCBA will be at least 1,200 litres of free air and the total spare storage capacity of free air provided in the ship does not need to be more than 4,800 litres
Breathing apparatus is constructed of materials having adequate mechanical strength, durability and resistance to deterioration by heat or by contact with sea water and those materials are resistant to fire and do not allow the breathing circuit to be penetrated by smoke or chemical fumes likely to be encountered in service. The fabric used in the construction of any harness provided with that apparatus is resistant to shrinkage.
Exposed metal parts of the apparatus, harness and fittings are of materials so far as practicable resistant to frictional sparking.

Relative Advantages & Disadvantages of Each Type of Breathing Apparatus

SCBA advantage

- Freedom of movement for the operator

SCBA disadvantage

- Air supply and duration is limited to the amount of air the operator can carry. Generally maximum time is approximately 60 minutes depending on the cylinder size and the volume of air compressed into cylinder.

Air line type
(A hose extends from the face mask to a supply of air outside the fire affected area.)

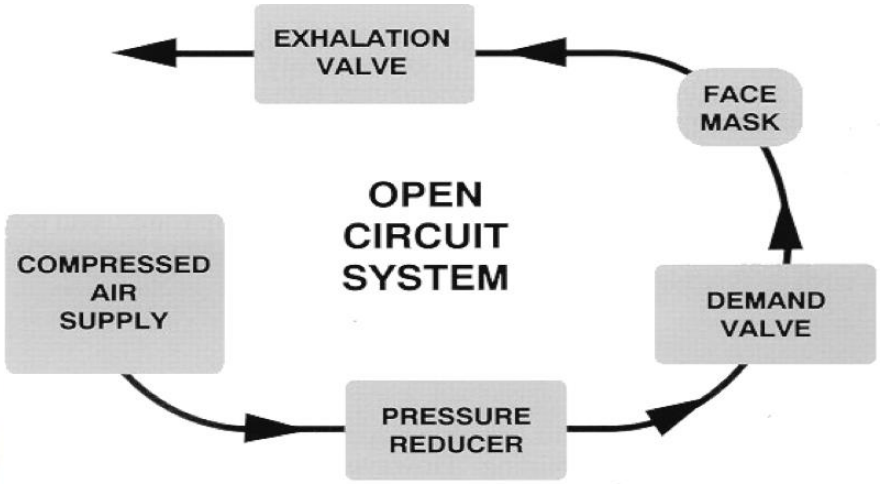
& Fittings.

This type has the advantage of

- Air supply being constant and possibly unrestricted. Therefore there is no time restriction in its use.
- However, the disadvantage is that the wearer's agility and movements are restricted by the air line that is constantly attached.

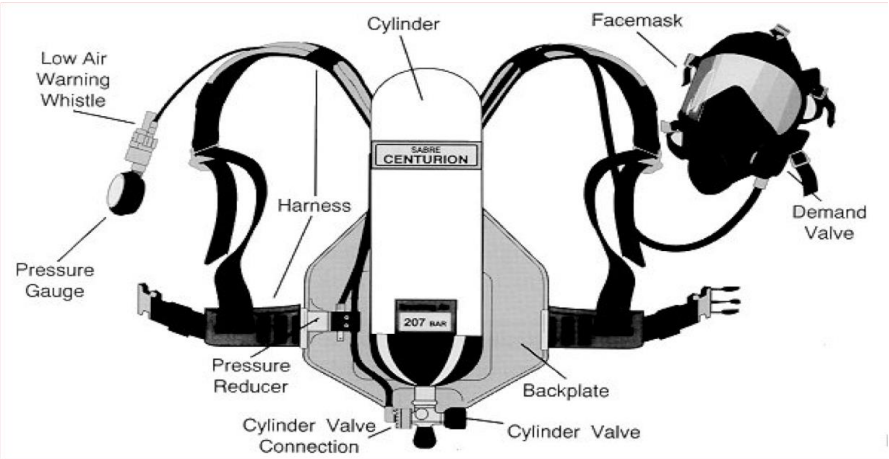
How SCBA's Work

Open Circuit System - The type of breathing apparatus set referred to here is a Self Contained Compressed Air Breathing Apparatus, Open Circuit, Positive Pressure system. In common with most compressed air sets, it has a two stage pressure reduction system. The Duration (how long you can use the set before running out of air) depends on the breathing rate of the wearer, physical fitness, the amount of work being performed and the amount of air in the cylinder.
The Open Circuit system supplies compressed air to the wearer at a breathable pressure. Exhaled air is discharged to the atmosphere and is not purified for reuse as is the case for Closed Circuit systems.



Closed Circuit System - In a Closed Circuit System the wearer's exhaled breath is recycled within the set. Oxygen is inhaled from a reservoir through a circuit that incorporates a system which removes carbon dioxide from the exhaled breath.
The key advantage of Closed Circuit systems over Open Circuit systems is that the Duration is much greater (the air lasts for a much greater time) compared to an Open Circuit system.
The disadvantages of a Closed Circuit breathing apparatus include increased complexity in checks prior to use and the requirement to fill the cylinder with pure medical oxygen.

The Component Parts of an Open Circuit System - Breathing Apparatus sets vary in their design and the location of certain component parts may differ between models but the basic parts listed below are common to most compressed air sets complying with Australian Standards.



Maintaining Breathing Apparatus

Breathing Apparatus must not be used unless the set has undergone the appropriate inspections and maintenance procedures, according to the following criteria:

- Major Service - Conducted by a qualified and currently competent SCBA service technician to the manufacturers specifications.
- Yearly Inspection & Test - Conducted by a qualified and currently competent SCBA service technician to the manufacturers specifications.
- Daily Inspection Before Use - Conducted by the wearer according to standard operating procedures.
- Daily Inspection After Use - Conducted by the wearer on completion of operational requirements according to standard operating procedures.

Checks Before Use

Visual inspection

A visual inspection is conducted to ensure that the set is complete and in good condition.
Particularly look for signs of deterioration or damage:

- Backplate
- Airlines
- Cylinder Straps
- Cylinder Valve Connection
- Harness and Buckles
- Facemask - Ensure that the ori-nasal (inner mask) and inlet valves are secured and not damaged
- Check that all connections are tight and secure
- Check the Demand Valve (DV) for condition and attachment to the face-mask

Cylinder contents, high pressure and warning whistle test
This test ensures:

- The set has adequate pressure in the cylinder
- The set will hold pressure within the manufacturer's specifications
- The warning whistle activates approximately 10 minutes before the cylinder is empty.

	Cylinder contents, high pressure & warning whistle test
1	Check that the first breath mechanism (In a set that has this mechanism) is closed on the Demand Valve
2	Slowly open the cylinder air supply valve until it is fully open
3	From the fully open position close the valve by ¼ of a turn
4	Check that the cylinder pressure gauge indicates at least 80% of the cylinder's full capacity
5	Listen for any audible leaks
6	Close the cylinder valve completely
7	Check that the pressure gauge does not indicate a fall of more than 10 bars in one minute or a different rate for this test Specified by the manufacturer
8	Slowly de-pressurise the system and observe the pressure gauge
9	At a pre-determined pressure, usually 50 bar + or – 5 bar, the low pressure warning whistle should operate
10	Check that the pressure gauge indicates zero when the system is fully depressurised

If the system fails any part of the high pressure and warning whistle test, close the cylinder valve, de-pressurise the system and check all pneumatic connections and repeat the high pressure test.

If the set fails again, inform the fire team leader or the appropriate officer that the set has failed the test. Any set which fails this test must be taken out of service.

Positive pressure and mask seal test
This test is done to ensure that:

- The positive pressure mechanism in the demand valve has activated correctly
- The mask seal is intact
- The mask is sealed on the wearers face. Common impediments include facial hair, spectacles and incorrect fitment.
- The test is performed prior to any operator entering a smoke affected area.

	Positive pressure and mask seal test
1	Check that the first breath mechanism (In a set that has this mechanism) is closed on the Demand Valve
2	Slowly open the cylinder air supply valve until it is fully open
3	From the fully open position close the valve by ¼ of a turn
4	Check that the cylinder pressure gauge indicates at least 80% of the cylinder's full capacity
5	Don the unit and place the mask neck strap over your head.
6	Place the mask over your face & secure the mask by tightening the lower straps first & then the upper straps
7	Inhale (Air will start to flow in all types of SCBA. This will activate the first breath mechanism if fitted)
8	Check that the demand valve operates satisfactorily by inhaling several times.
9	Insert a finger between the facemask seal and the face to allow an outward flow of air. This indicates the positive pressure mechanism is functioning correctly.
10	Inhale and hold your breath. Close the cylinder valve but keep your hand on the cylinder valve control knob.
11	Watch the pressure gauge and listen for any audible leaks
12	If there are no signs of a leak then the face mask seal is working properly
13	If the mask is leaking, open the cylinder valve and tighten the mask straps.
14	Repeat Step 13 until a satisfactory seal is achieved
15	Open the cylinder valve fully and then close it ¼ a turn. (This prevents the cylinder valve from sticking in the open position)

Positive pressure and mask seal test note:

An alternative to step 13 is:

- With the cylinder valve closed
- Inhale all the air from the mask to suck the mask onto your face whilst holding your breath.
- If the mask does not stay sucked onto your face then the mask straps need to be tightened.
- Open the cylinder valve, tighten the straps and repeat this procedure until a satisfactory seal is gained.
- Please note that this procedure removes all the air from the set and this may cause you some anxiety.

Maintenance, Breathing Rate & Safety

Cleaning and Storing the Set:

Immediately after use the set must be made serviceable. This includes:

- Cleaning the set as required (wipe with warm soapy water)
- Replacing the cylinder with a filled cylinder.
- Wash the facemask using an approved SCBA mask wipe or washing solution.

Operational sets should be stored in a clean dry environment and in a fashion that enables the quick donning of the set in an emergency.

Wall mounts are commonly installed for this purpose.

Correct Breathing Technique for Low Consumption

Our breathing rate and the quantity of air we suck in when using SCBA makes a very big difference to the consumption rate and therefore the length of time that an air cylinder will last before we have to exit the area and cease using the equipment or install a fully charged cylinder.

Good physical and mental health is the place to start.

When entering a fire zone in limited or no visibility our natural reaction is for our heart rate to increase and our breathing rate increases with it.

It takes a very conscious effort to reduce our breathing rate. It might be possible to prolong the Full Duration of our air cylinder by as much as 50% with familiarity and practice.

Everyone will use more air when performing heavy physical work.

However, we can calm ourselves and relax our breathing rate.

Some experienced firefighters recite nursery rhymes quietly to themselves to slow the rhythm of their breathing.

Others take a breath in, pause 5 seconds and then take another breath in and then breathe out slowly.

The breathing rate is therefore significantly reduced.

Other factors that affect our breathing rate are elevated temperatures, our lung capacity, our psychological stability, our experience in the use of SCBA and symptoms leading to heat exhaustion.

Reasons for not Remaining in a Toxic Atmosphere until the SCBA Air Cylinder is Empty

It is very important that personnel do not remain in the fire zone on their own for safety reasons.

Remaining in a toxic atmosphere until the air cylinder has run out could result in the wearer being overcome by toxic gases and this can result in long term brain damage or death.

Air Pressure Gauge Monitoring and Low Air Pressure Alarm

As mentioned in the foregoing, wearers of SCBA must regularly check the pressure gauge on his set to ensure that no unexpected drop in air pressure has occurred.

It is possible when entering areas of zero visibility the set can be damaged by rubbing up against sharp or hot objects.

The SCBA low air alarm will sound when 10 minutes of air remains in the cylinder (at an average consumption rate).

Upon hearing the alarm both members of the team must exit the area immediately.

The team support and protect each other.

If one member of the team suffers injury or equipment failure then the other team member is there to rescue that person.