Home Office (Fire Department)

Manual of Firemanship

Incidents involving Aircraft, Shipping and Railways

[Bo]ok 4

Issued under the authority of the Home Office (Fire Department)

Manual of Firemanship

A survey of the science of fire fighting

Book 4

Incidents involving Aircraft, Shipping and Railways

London
HMSO

First published 1985
Third impression 1990

The structure and publishing history of the *Manual* is shown on pages 263–266

ISBN 0 11 340584 7

Preface

Firemen have to effect rescues, fight fires and carry out special services at a wide range of transport incidents. This Book looks at three particular categories: incidents involving aircraft, shipping and railways. (Road traffic accidents, which may likewise be classed as transport incidents, do not normally make the same major demands on emergency services and do not involve the same degree of complexity or the same special considerations. They are dealt with in the *Manual,* Book 12.)

Part 1 deals with incidents involving aircraft. Serious aircraft accidents are relatively rare but when they do occur can raise severe problems. The degree of severity depends to some extent on the size of the aircraft, the number of passengers and the location of the incident: in a town, in remote countryside or at an airport. There will, however, always be the danger of serious fires and major risks to life, problems in gaining access and possibly dangers from the aircraft's components, its contents or materials used in its construction. This Part looks at the general features of aircraft and airports, and considers general operational principles.

Part 2 deals with shipping incidents. Although few Brigades now maintain fireboats and it is only rarely that a Brigade might attend an incident at sea, the likelihood of firemen having to deal with shipping is greater than might be expected. Occurrences just off shore, in ports, harbours, or docks, in shipyards and on inland waterways could affect many Brigades. The amount of shipping, its variety, the size and complexity of some vessels, the presence of widely differing numbers of crew and passengers, and the carriage of large and often hazardous cargoes can present serious problems. This Part of the book looks at these factors, reviews the situations firemen might face, and discusses the operational tactics they might employ and the considerations they must bear in mind.

Part 3 deals with incidents on railways. These usually arise from collisions or derailments and can again present a wide range of problems. Access to the scene may be difficult; the incident may be spread over a wide area and cause extensive disruption; there may be dangers from electrified track and installations or dangerous goods on the train, and adjacent lines still in use; and there may be many passengers injured or trapped. Firemen need a knowledge of the construction of trains, track and installations, of how the railway system works and of the special procedures adopted on railways. This Part aims to give some basic information which firemen must supplement by local reconnaissance and liaison.

Reference in this Book to the male person should be construed as applying, where appropriate, to the female person also. The ranks of junior firewoman, firewoman and leading firewoman have been introduced by the *Fire Service (Appointments and Promotion) (Amendment) Regulations 1976* to equate with ranks of junior fireman, fireman and leading fireman. References to the latter should, where appropriate, be construed as references to the former also.

The Home Office is indebted to all those who have helped in the preparation of this work.

HOME OFFICE
1985

Metrication

List of SI units for use in the Fire Service

Quantity and basic or derived SI unit and symbol	Approved unit of measurement	Conversion factor
Length metre (m)	kilometre (km) metre (m) millimetre (mm)	1 km = 0.621 mile 1 m = 1.093 yards = 3.279 feet 1 mm = 0.039 inch
Area square metre (m^2)	square kilometre (km^2) square metre (m^2) square millimetre (mm^2)	1 km^2 = 0.386 $mile^2$ 1 m^2 = 1.196 $yards^2$ = 10.764 $feet^2$ 1 mm^2 = 0.002 $inch^2$
Volume cubic metre (m^3)	cubic metre (m^3) litre (l) $(= 10^{-3} m^3)$	1 m^3 = 35.7 $feet^3$ 1 litre = 0.22 gallon
Volume, flow cubic metre per second (m^3/s)	cubic metre per second (m^3/s) litre per minute (l/min)	1 m^3/s = 35.7 $feet^3/s$ 1 1/min = 0.22 gall/min
Mass kilogram (kg)	kilogram (kg) tonne (t)	1 kg = 2.205 lbs 1 t = 0.984 ton
Velocity metre per second (m/s)	metre per second (m/s) international knot (kn) (= 1.852 km/h) kilometre per hour (km/h)	1 m/s = 3.281 feet/second 1 km/h = 0.621 mile/hour
Acceleration metre per second^2 (m/s^2)	metre/second^2 (m/s^2)	1 m/s^2 = 3.281 feet/second^2 = 0.102 'g'

Quantity and basic or derived SI unit and symbol	Approved unit of measurement	Conversion factor
Force newton (N)	kilonewton (kN) newton (n)	1 kN = 0.1 ton force 1 N = 0.225 lb force
Energy, work joule (J) (= 1 Nm)	joule (J) Kilojoule (kJ) Kilowatt/hour (kW/h)	1 kJ = 0.953 British Thermal Unit 1 J = 0.738 foot lb force
Power watt (W) (= 1 J/s = 1 Nm/s)	kilowatt (kW) watt (W)	1 kW = 1.34 horsepower 1 W = 0.735 foot lb force/second
Pressure newton/metre^2 (N/m^2)	bar (= $10^5 N/m^2$) millibar (mbar) (= $10^2 N/m^2$) metrehead (= 0.0981 bar)	1 bar = 0.991 atmosphere = 14.5 lb force/in^2 1 mbar = 0.0288 inch Hg 1 metrehead = 3.28 foot head
Heat, quantity of heat joule (J)	joule (J) kilojoule (kJ)	1 kJ = 0.953 British Thermal Unit
Heat flow rate watt	watt (W) kilowatt (kW)	1 W = 3.41 British Thermal Unit/hour 1 kW = 0.953 British Thermal Unit/second
Specific energy, calorific value, specific latent heat joule/kilogram (J/kg) joule/m^3 (J/m^3)	kilojoule/kilogram (kJ/kg) kilojoule/m^3 (kJ/m^3) megajoule/m^3 (MJ/m^3)	1 kJ/kg = 0.43 British Thermal Unit/lb 1 kJ/m^3 = 0.0268 British Thermal Unit/ft^3
Temperature degree Celsius (°C)	degree Celsius (°C)	1 degree Celsius = 1 degree Centigrade

Contents

Part 1
Incidents involving aircraft

Part 2
Incidents involving shipping

Chapter 11 Factors relevant to incidents on ships

Chapter 12 Stability

Chapter 13 Fighting ship fires in port

Chapter 14 Incidents at sea

Chapter 15 Dangerous substances on ships and in port areas

Chapter 16 Inland waterways

Part 3
Incidents involving railways

Chapter 17 Features of railways

List of Plates

Aircraft Incidents

A.10 The Chinook which can be compared with its civil version in Plate A.9. Note the break-in panel and escape hatch.
Photo: Ministry of Defence.

A.11 Mk 4 Sea King helicopter of the Royal Navy. Various delineated panels and doors can be seen.
Photo: Royal Navy.

A.12 Royal Navy Lynx helicopter. The means of access is clearly marked. The tail rotor of this aircraft would be very low.
Photo: Royal Navy.

A.13 Defective nose-undercarriage landing where airport fire service has laid protective foam to forestall any ignition. Illustrates type of crew door which could be encountered.
Photo: British Airports Authority.

A.14 Typical tyre failure on multi-wheel undercarriage. The massive suspension can be clearly seen.
Photo: British Airports Authority.

A.15 Good example of DC-10 deployment of an escape chute. The sheer height of the aircraft doors from ground level is worth noting.
Photo: British Airports Authority.

A.16 A Boeing 707 of Egyptair crashed at Geneva airport. All exits have been used on the port side plus the forward chute. The engine in the foreground looks to have been the port inner.
Photo: Commandant du Service Sécurité, Aéroport de Genève.

A.17 The result of a flashover within an aircraft, showing an internal view of its construction and the type of cladding and seating material.
Photo: British Airports Authority.

A.18 An impact crash with no fire, showing examples of sheared metal.

A.19 A Sikorsky S61N helicopter operating the Gatwick-Heathrow air-link.
Photo: British Airports Authority.

A.20 Hawk 2-seat attack aircraft with Sidewinder missile and cannon. Compare with Plate A.23.
Photo: British Aerospace.

A.21 Boeing 747 with 3 engines running. The height of the aircrew position above ground and the overall size of this aircraft is noteworthy.
Photo: British Airports Authority.

A.22 A Boeing 757 on approach.
Photo: British Airports Authority.

A.23 An overturned Hawk. This was a difficult rescue as both ejection seats were 'live'. The pilot had to be supported whilst the seats were made safe.
Photo: Ministry of Defence.

A.24 Heavy landing of a helicopter. The lightness of construction can be easily seen.
Photo: Royal Air Force.

A.25 Single-seat Harrier following a low-level crash and fire. It was difficult to reach the pilot.
Photo: Royal Air Force.

A.26 The front cockpit of a Hawk aircraft. Note the MDC, aircrew equipment, ejector seat and, behind the seat, the pin-rack. The stencilled and visual instructions on the fuselage are self-explanatory.
Photo: British Aerospace.

Shipping Incidents

S.1 A typical shaft tunnel leading to an engine room amidships.
Photo: Essex Fire Brigade.

S.2 Modern LASH ship, 35,800 gross tonne, USSR 'Tibor Szamuely'.
Photo: Skyfotos Ltd.

S.3 21,000 dwt 'Eleo Maersk' multi-purpose ship. Can be used as Ro-Ro, Sto-ro, container carrier or bulk cargo carrier.
Photo: Marine Publications International.

S.4 An example of a hard-arm facility at a refinery marine terminal. The vessel discharging is the 250,000 dwt 'Esso Northumbria'.
Photo: Esso Petroleum Co Ltd.

S.5 An LPG carrier, the 37,000 dwt SS 'Isomeria', gas capacity 58,950m^3, fitted with self-supporting pressurised and refrigerated tanks.
Photo: Harland and Wolff Ltd.

S.6 A general bulk carrier of 8000 gross tonne.
Photo: Marine Publications International.

S.7 A car and passenger ferry of 8600 gross tonne.
Photo: Marine Publications International.

S.8 An International shore connection in use.
Photo: Hants Fire Brigade.

S.9 An interesting photograph illustrating the deck and corridor layout of a typical cruise ship. This vessel was cut in half and lengthened by having a section inserted.
Photo: Marine Publications International.

S.10 An example of an offshore jetty leading to a marine refinery terminal. Compare with Plate S.11.
Photo: Humberside Fire Brigade.

S.11 This is the type of narrow, unlit, partially obstructed floating jetty which could be, and was, used for transporting equipment. Compare with Plate S.10.
Photo: Essex Fire Brigade.

S.12 A fire tug equipped with three monitors capable of a water or foam attack.
Photo: Alexandra Towing Co Ltd.

S.13 At this incident the small tug 'Fenland' was used for the initial boarding and remained as a pumping platform. The police vessel acted as the ferry for equipment, reliefs etc. Note the narrow companionway.
Photo: Essex Fire Brigade.

S.14 BA entry point on board a bulk carrier with a fire in the engine room and accommodation.
Photo: C P Nelson.

S.15 Fire in the hold of a cargo ship of an older type. Note the examples of hatches, ventilators and fire main (in the scupper). There is a distinct listing of the vessel.
Photo: County of Avon Fire Brigade.

S.16 A diagram of a fixed firefighting installation aboard the car ferry 'Norwave'.
Photo: Humberside Fire Brigade.

S.17 Fixed firefighting monitors covering the deck of a tanker.
Photo: Stewart Bale Ltd.

S.18 A gas carrier with a capacity of 12,000 m^3. Note the firefighting platforms at intervals along the centre of the deck.
Photo: Marine Publications International.

S.19 The engine room of the car-ferry 'Norwave' following a fire. A horn nozzle of the CO_2 system can be seen above the valve group. The engine room was evacuated, the CO_2 system operated, and the ferry towed back into dock to enable the Brigade to tackle the fire.
Photo: Humberside Fire Brigade.

S.20 A turntable ladder being used as a crane to load gear onto a tug.
Photo: Kent Fire Brigade.

S.21 Personnel being lowered from a helicopter. This Plate ties in with Plate S.14.
Photo: C P Nelson.

S.22 Firemen and RAF aircrew preparing to lower a high expansion foam unit onto a ship's deck. The very restricted space is obvious as is the safety harness.
Photo: C P Nelson.

S.23 A lightweight pump lashed to a companionway suspended some 3-4 metres above the surface of the sea.
Photo: Kent Fire Brigade.

S.24 A push-tow formation. Depending on the size of the waterway either a maximum of 3 barges or 6 barges can make up the load.
Photo: British Waterways Board.

S.25 A pleasure craft fire which has had time to develop involving fuel, furnishings and, probably, LPG.

S.26 Illustrating the height, steepness and narrowness of access to this ship's main deck. In this case all gear had to be either hauled aboard or manhandled up this companionway.
Photo: Essex Fire Brigade.

S.27 A fire in a tightly packed cargo of building board. When the cargo was eventually unstowed the cause was found to be a fixed lighting installation which had been left permanently switched on.
Photo: Kent Fire Brigade.

S.28 Fixed foam monitors covering a marine refinery jetty. Operation of the fire alarm automatically brings in pumps supplying water to the jetty. The tanker also has fixed monitors.
Photo: Humberside Fire Brigade.

Railway incidents

R.1 Points, point operating mechanism, point heaters, rodding and LPG cylinders. Access to this particular place looks difficult.
Photo: British Rail.

R.2 A typical accumulation of railway equipment. Note which sections of line are movable.
Photo: British Rail.

R.3 Multiple overhead line equipment with 25 kV lines, tensioning devices etc.
Photo: London Fire Brigade.

R.4 Typical pantograph which is retractable.
Photo: London Fire Brigade.

R.5 An illustration of the difficulties at an incident in a steep-sided cutting. Positioning of lighting here is essential to all services.
Photo: Evening Argus, Brighton.

R.6 The height of a carriage lying on its side is obvious. An attempt is being made to extricate a body partly pinned under the train.
Photo: London Fire Brigade.

R.7 Passenger coach on embankment secured by Tirfor equipment during rescue operations.
Photo: Daily Record, Glasgow.

R.8 An unsuccessful attempt to cut into the floor of a sleeping car. Even if the next section can be penetrated there could still be berths and other equipment to circumvent.
Photo: Northumberland County Fire Brigade.

R.9 An illustration of cutting into the roof of a carriage, showing the insulation, parts of the carlines, trunking and the ceiling of the compartment.
Photo: Northumberland County Fire Brigade.

R.10 A casualty being removed via the connecting sleeves between coaches. The girders support the OLE and, fortunately, this was not brought down as a result of the accident.
Photo: London Fire Brigade.

R.11 View along the corridor of an overturned sleeping car showing the restricted access to the compartments. The roof is to the right.
Photo: Northumberland County Fire Brigade.

R.12 This carriage struck the side of a house and crumpled. This could cause doors to jam, impeding rescue.
Photo: Northumberland County Fire Brigade.

R.13 Looking down into adjacent sleeping compartments of an overturned sleeping car.
Photo: Northumberland County Fire Brigade..

R.14 A typical LPG tank wagon with a white barrel and horizontal orange stripe.
Photo: Standard Railway Wagon Co.

R.15 Tank wagon used to carry AVTUR aviation fuel.
Photo: Standard Railway Wagon Co.

R.16 Combined efforts of Brigade, BR and medical team (right) in the extrication of trapped passengers (see also Plates R.5 and R.17).
Photo: Evening Argus, Brighton.

R.17 Raising a casualty up the steep side of a railway cutting using a 135 ladder as a slide (see also Plates R.5 and R.16).
Photo: Evening Argus, Brighton.

R.18 Aerial view of incident shown in Plate R.7. This train was being pushed by the locomotive. The two isolated coaches were the first and second and both have turned completely through 180 degrees.
Photo: D C Thomson and Co Ltd.

R.19 High-speed derailment involving sleeping cars. Note alternate coupling of cars—those with five single windows are corridor uppermost. See also Plates R.8, R.9, R.11, R.12 and R.13.
Photo: Northumberland County Fire Brigade.

R.20 Two passenger coaches destroyed following a collision between a diesel locomotive and a tanker-train carrying gas-oil. The resulting fireball engulfed the locomotive and these coaches.
Photo: Greater Manchester Fire Brigade.

Part 1
Incidents involving aircraft

Introduction

The Preface to this Book has already pointed out the serious problems which aircraft incidents can cause. These problems can only increase as aircraft construction develops and the number of aeroplanes of different types in service for different purposes grows. Accidents remain relatively rare, but for the Fire Service this aggravates the situation since it makes it difficult for ordinary Local Authority firemen to accumulate experience. Nevertheless these occasional accidents can happen anywhere, so any fireman might have to cope with an incident.

To do this successfully his first need will be a basic knowledge of aircraft construction and design. Aircraft types, whether civil or military, are numerous and in each category there are many varieties. This Part of Book 4 cannot describe in detail each individual type that firemen might encounter, but it describes the basic principles of aircraft construction and design and the main features that are commonly found, and it gives some examples. It discusses fixed firefighting and escape provisions and the special features of military aircraft.

Aircraft can crash anywhere. The severity and difficulty of the incident will depend to a considerable degree on the location. Crashes off the airport give rise to problems of notification, of locating the aircraft, of efficient mobilisation and of access. The accumulation of manpower and equipment, particularly in bad weather over difficult terrain, can be painfully slow. Accidents at airports may not be as severe or difficult since there should be a prompt attendance and rapid build-up of personnel and equipment. They are, however, more likely. It is important for firemen to be familiar with airports, their lay-out, facilities, equipment organisation and methods of operation. This Part of Book 4 gives a brief general description of these and of the controlling authorities. Firemen must supplement this information by reconnaissance of their own areas and must up-date it as necessary in the light of continuing developments. They must bear in mind the variety of airfields.

It must be stressed that wherever an accident occurs it will present the Fire Service with special problems. Preplanning and liaison will be especially important, particularly where an incident amounts to a major disaster (see the *Manual*, Book 12, Chapter

4). The remaining concern of this Part is with these factors, with firefighting and rescue techniques on and off airports and with the many special considerations firemen will have to bear in mind during operations: the problems, mentioned above, of crashes off an airport; the problem of aircraft entry; the handling of the crew and numerous passengers who might be involved; the risks inherent in the components of some aircraft; dangerous cargoes; and the special risks, e.g. weaponry, associated with military aircraft.

Chapter 1 Design and construction of fixed-wing civil aircraft

1 General

Aircraft vary greatly in size and design, ranging from the ultra-light single and two seaters to the four-engined 'stretched' passenger aircraft seating up to 600 people. A fuel load of 200,000 litres is quite possible and speeds up to 1000 kph are usual for large civil aircraft. The construction of aircraft varies, obviously, with their projected use. It is not intended to describe the older type of medium-sized aircraft in this Part because, by virtue of their design, they do not represent so great a problem to firemen in their passenger capacities, fuel loads and access following an accident.

2. Body construction

a. Fuselage

The main design construction is the stressed skin type. The tapering shape of the fuselage is formed by a series of vertical metal frames placed transversely from nose to tail (Fig. 1.1). Metal stringers, running horizontally along the length of the fuselage, are spaced around the circumference of the frames. Internally placed stringers made of stronger and thicker metal, which are called longerons, are continuous along the length of the fuselage, and serve as the attachment points for the cabin floors, cargo holds etc. The skin is not merely a sheet metal covering but is stressed according to the load it must take and contributes to the total rigidity of the airframe. The skin panels may be either riveted or bonded to a number of stringers to form a separate assembly which is then riveted to the frames. When the skin is bonded there is no external indication of the underlying framework. Due to pressurisation, the fuselage of most modern aircraft consists of a double skin with a suitable insulating material interposed.

b. Wings

Tapering metal spars run from the centre section to the wingtips, or from wingtip to wingtip, i.e. through the fuselage. Their vertical

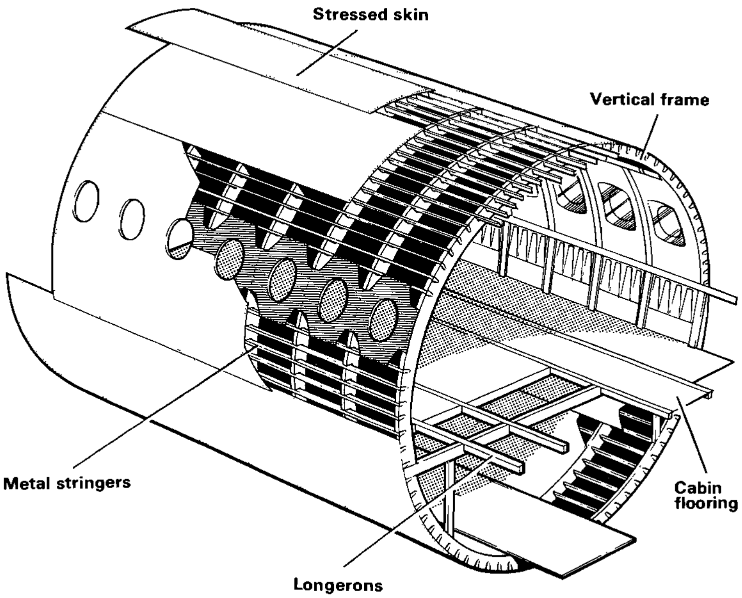


Fig. 1.1 The basic design of a stressed skin construction in the fuselage of an aircraft.

height forms the thickness of the wings. Some aircraft have only two spars but many have several which vary in length according to the wing plan (swept, crescent, delta etc). Short metal struts known as ribs are closely spaced at right-angles to the spars, and form the profile of the aerofoil of the wings. The whole construction is covered by the skin, which, again, forms part of the structure and is either riveted or bonded to the spars.

c. Metals used in aircraft construction

Firemen should try to obtain knowledge of the types of metals used in aircraft structures and their likely locations, because their reaction to impact, fire and cutting will have a pronounced effect upon rescue and firefighting.

The type of metal most used in construction is an aluminium alloy. The exact composition of the alloy differs in different aircraft, but the following examples are typical:

(i) **Duralumin** Aluminium with about four per cent copper and one per cent each of magnesium, manganese and silicon.

(ii) **Alclad** Duralumin with a surface finish of pure aluminium.

(iii) **Magnalium** Aluminium with about two per cent copper and two to ten per cent magnesium.

These alloys are used for skin surfaces and as pressed sectional members, channels for framework, spars and stiffeners. The sheets

are readily pierced and severed and heavy sections can be cut with an axe, hack saw or power-operated cutting tool.

(iv) **Magnesium (and its alloys)** Magnesium alloy castings and sheets are used to minimise weight in areas where bulkiness is no object, such as engine mounting brackets, crankcase sections and other engine parts. Magnesium will rarely be found in areas where forcible entry might be necessary.

(v) **Stainless steel and titanium alloys** Where greater strength or resistance to heat is required, stainless steel and titanium alloys are necessary. Some engine parts and reinforcing to the skin surfaces of mainplane leading edges on high speed aircraft, propellers and some structural tubing are the usual areas where these will be found.

A general indication of the different metal areas is shown in Fig. 1.2.

3. Aircraft engines

a. Piston engines

Piston engines are rare on large aircraft and the hazards they present are relatively slight, although one potential danger is the presence of a propeller. Broken fuel or oil lines (especially if close to hot exhausts) or damaged electrical wiring are the most likely causes of fire. Provided that the fire has not penetrated the fire-resisting bulkhead which separates the engine from the adjoining parts of the aircraft, the application of CO_2, halon or water-fog will usually be sufficient to extinguish it.

b. Turbine engines

These are basically of three types—turbojets, turbofans and turboprops, the latter having the drive shaft extended forward to drive a propeller. Kerosene, of a special grade, is used as fuel (see section 4 below), and the main problems for LAFB firemen can be fuel spilling from broken pipes etc. in a fine spray, or an internal fire in the engine combustion chamber following a crash. Most 'jet' engines are designed fairly low down on the aircraft (underwing or undertail) but a few aircraft have an additional engine high up on top of the fuselage near the tail (Plate A.1). This can make application of foam or halons difficult, especially at the head of a ladder (Plate A.2). Firemen must bear in mind that, due to their weight and momentum, compressors and other rotary parts of the engine will continue to run for a considerable time after the engine has been shut down.

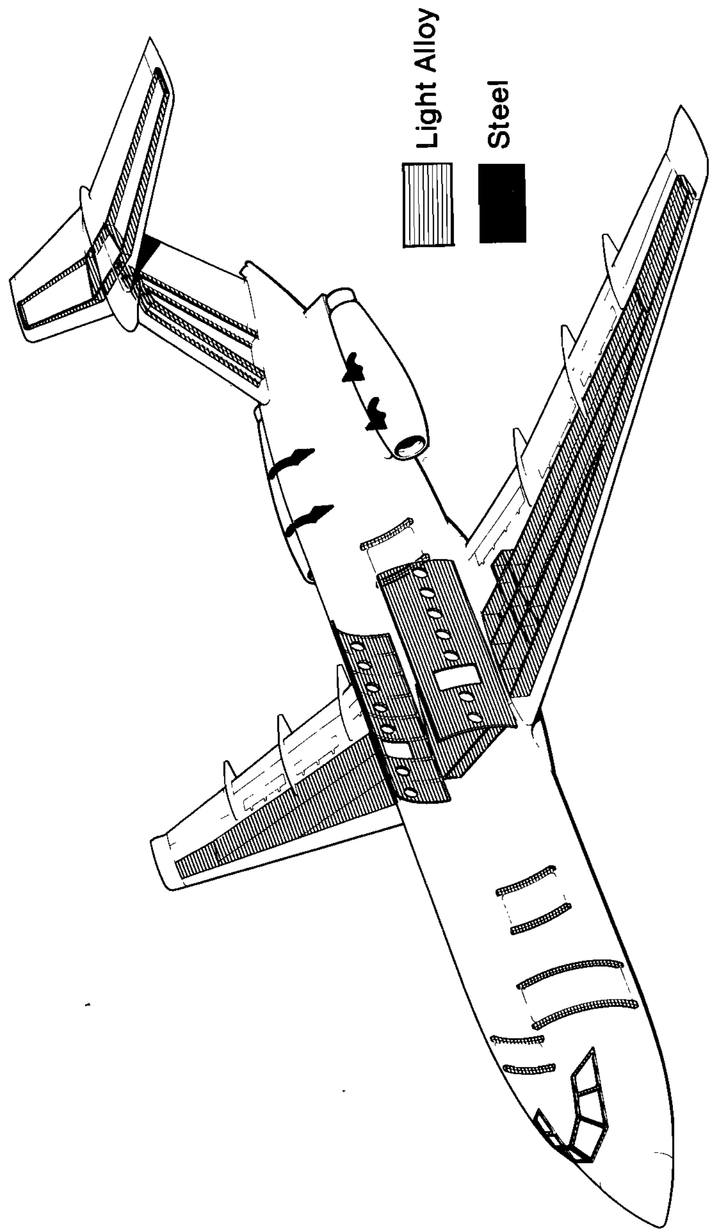


Fig. 1.2 Diagram of a BA 111 showing the use of light alloys and steel.

4. Fuel and fuel tanks

a. Types of fuel

Aircraft, broadly, use two different types of fuel: petrol (gasoline) and kerosene.

(1) Petrol or gasoline

Petrol (also known as gasoline) is basically of one standard type, but is supplied in three grades—Avgas 115/145 (dyed purple), Avgas 100/130 (dyed green), and Avgas 73 (not dyed). The grades are characterised by their octane rating, i.e. they are of slightly differing composition to suit the different engine compression ratios. The octane rating does not, however, have any bearing on the flammability of the fuel. Each grade has a flashpoint of about −40°C.

(2) Kerosene

There are three kerosene fuels in use for turbine engines:

(i) Avtur (also known as JP1 and ATK), flashpoint above 37.8°C. There are two grades: Avtur 40 and Avtur 50.

(ii) Avtag (also known as JP4 and ATG), flashpoint of −20°C and is more akin to gasoline.

(iii) Avcat (also known as JP5 and ATC), flashpoint above 65°C. This is specially distilled for use in naval aircraft.

Kerosene with an anti-misting additive, designed to reduce the risk of ignition in the event of an accident, has recently been developed, and is currently (1985) undergoing tests. It is expected to come into use in the aircraft industry in a few years' time.

b. Physical properties of fuels

It is obvious that, within certain limits, Avgas and Avtag will ignite readily at normal temperature and pressure (NTP). Avtur will not ignite under these conditions, but it may do so if it gets sprayed on to hot engine parts in the event of a crash. Once ignited, Avtur will burn as readily, and produce as much heat, as a fire involving Avgas or Avtag. There is a difference, however, in the rate of flame spread. Controlled experiments have shown the following:—

Fuel	*Rate of flame spread*
Avgas, Avtag	215–245 m/min
Avtur	30 m/min or less

Obviously flame propagation will be much faster if the fuel is in mist form.

c. Fuel tanks

Fuel is carried in a number of structurally separate but interconnected tanks, usually in the wings but also, in some cases, in the fuselage (see Fig. 1.3). The principal types are:—

(i) Rigid tanks
These are usually made of aluminium or duralumin sheet with internal baffles which brace the tanks and reduce swirling. They are often covered with fabric and have a vent pipe, an overflow, a base sump and a fuelling orifice. They are also provided with a bonding point to prevent the formation of static electricity sparks.

(ii) Integral tanks
These are compartments formed by the airframe structure itself, and made fuel-tight. They are generally found in the wings but can also be located in the fuselage. An accident can distort the supports, split the joints and cause a fuel spillage.

(iii) Flexible tanks
These are flexible bags made of plastic or other man-made materials fitted in wing or fuselage positions and secured by press studs. Their advantage is that the shock of an accident may not necessarily damage them unless they are cut by jagged metal. They have the disadvantage, however, of being combustible, and can emit toxic vapours.

(iv) Auxiliary tanks
Many aircraft can be fitted with additional fuel tanks, either under the wings or fuselage or at the wingtips and, occasionally, in the fuselage. Wingtip tanks are likely to be made of fibreglass, but larger tanks may be built of metal, using the stressed skin construction similarly to the fuselage. Any additional fuel adds to the fire hazard although, often, the fuel in auxiliary tanks is used first in flight. In some cases these tanks can be jettisoned as an emergency measure.

5. Powered and pressurised systems

The internal spaces in an airframe are closely packed with components, pipework, cables, and ducts for various different systems. In large aircraft most of these are run through the cargo holds but pressurised containers and pipework can be found in many different places. They can have the effect of aggravating a fire and impeding the penetration of extinguishing agents.

a. Hydraulic and de-icing systems

Hydraulic (i.e. pressurised liquid) systems are normally used to operate the undercarriage, flaps, and brakes; they may employ a

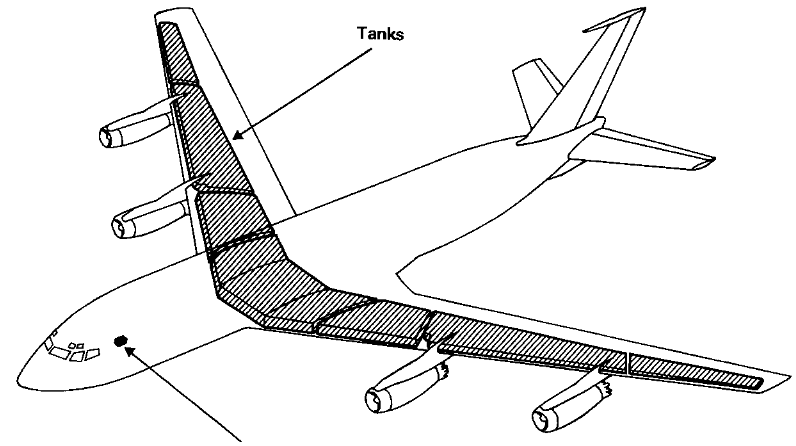


Fig. 1.3 Illustrating a type of fuel tank layout in a modern aircraft.

castor oil/alcohol mixture, certain mineral oils, or synthetic liquids. De-icing systems use a non-pressurised alcohol mixture. The liquids are contained in tanks which may have from 5-225 litres capacity and, in the case of the hydraulic systems, may be pressurised to about 70 bar.

b. Electrical systems

Electrical systems are used to operate numerous devices, including special equipment like radar and navigational aids. They are powered either by batteries or engine-driven alternators with rectification to direct current. Engines may each have their own battery or there will be a central battery position to give reserve, peak or starting loads. There are main switches usually in the pilot's or engineer's areas but firemen should take great care before deciding to operate them. If any cables are severed or damaged, the operation of a switch could cause a spark of sufficient power to ignite any flammable vapour present.

c. Auxiliary power unit (APU)

Many modern aircraft are equipped with an auxiliary generator powered by a small turbine engine. It is often found in the tail cone area and, though normally used only on the ground to run various services whilst the main engines are off, it may be operating to restore battery levels.

d. Pressurisation and air conditioning

The fuselage of a pressurised aircraft is specially strengthened and each door is pneumatically sealed. The pressurisation and air-conditioning is done by engine-driven compressors. The pressure inside an aircraft is maintained at a value of 1 bar (approximately equivalent to normal sea-level atmospheric pressure) throughout the flight until the aircraft nears the ground. Automatic vents then come into operation, so as to provide a gradual equalisation of any difference between the inside and outside pressure due to local weather conditions.

e. Compressed gases

There can be various containers of compressed gases on board an aircraft, e.g.:—

Compressed air—for emergency use if the hydraulic system fails;

Nitrogen —for pressurising fuel tanks;

Oxygen —for emergency breathing purposes. Stored in containers of between 400 and 2250 litres each, at pressure of 125 bar. Up to 12 containers may be carried.

The identification markings on compressed gas containers are referred to in Chapter 2, Section 3b.

6. Seating

Civil aircraft seats and seat belts are of particular importance to firemen in rescue operations. Passenger seats are easily adjustable, and the seats of the crew can usually also be adjusted to some extent (see Chapter 7, Section 2b(2)). All seats are fitted with seat belts; those for passengers are of a simpler design than those of the crew, but both types are easy to operate and are unlikely to cause any serious problems in a rescue. Firemen should familiarise themselves with the different types of seat and seat belt if they get the opportunity to do so.

Modern large passenger aircraft, to run economically, must have variable seating arrangements. An airline must be able to vary its passenger carrying capability from class to class or mix it. Examples of seating arrangements are shown in Fig. 1.4 but are not standard. The distance between corresponding points of adjacent seats (fore and aft), known as the 'pitch', can be as little as 740 mm, and the width of the aisles (see Fig. 1.5), both fore-and-aft and across the aircraft, can vary even in the same aircraft, especially if it is one of the 'wide-body' type.

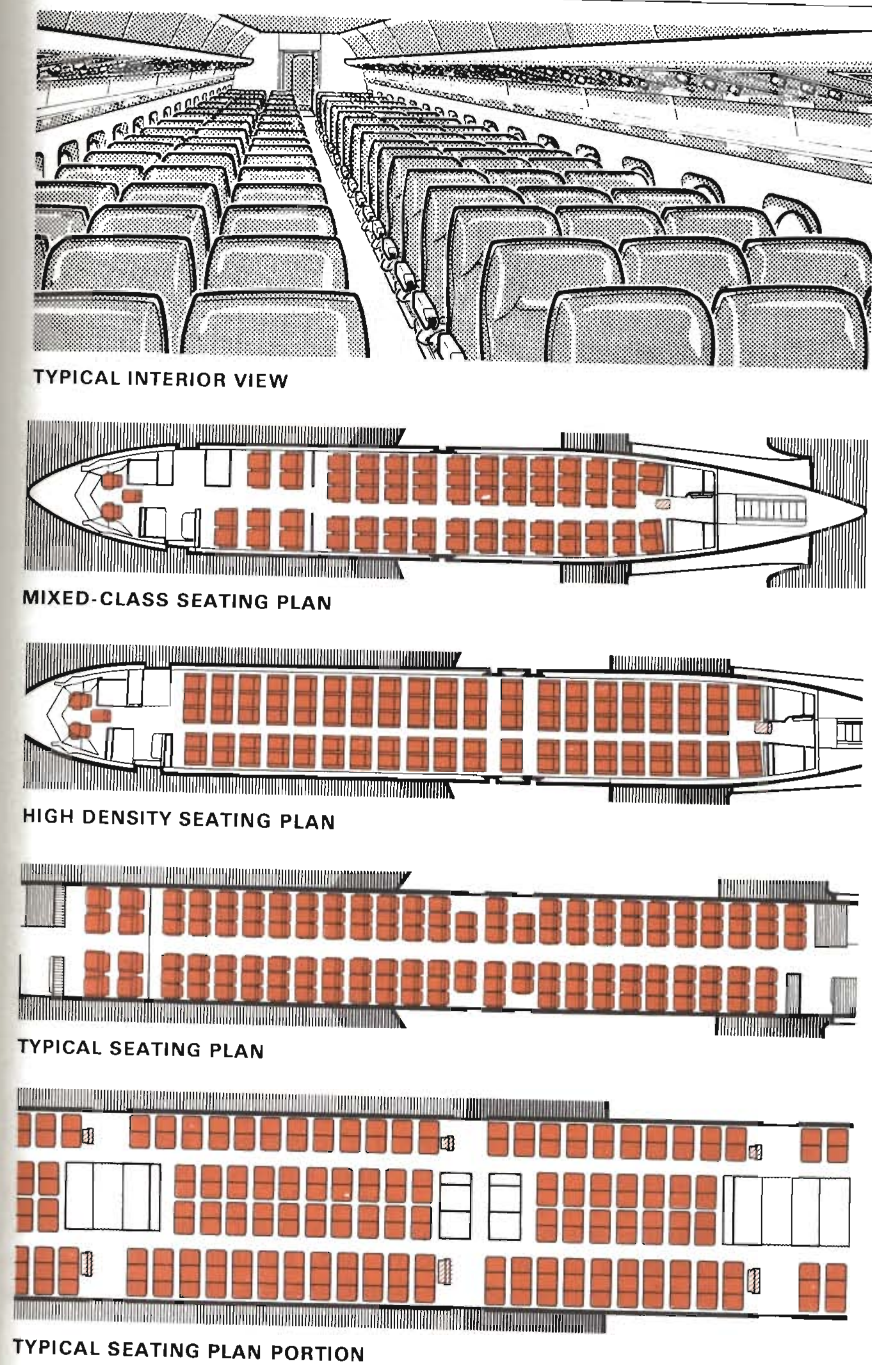


Fig. 1.4 Example of various seat configurations which may be found in civil aircraft.

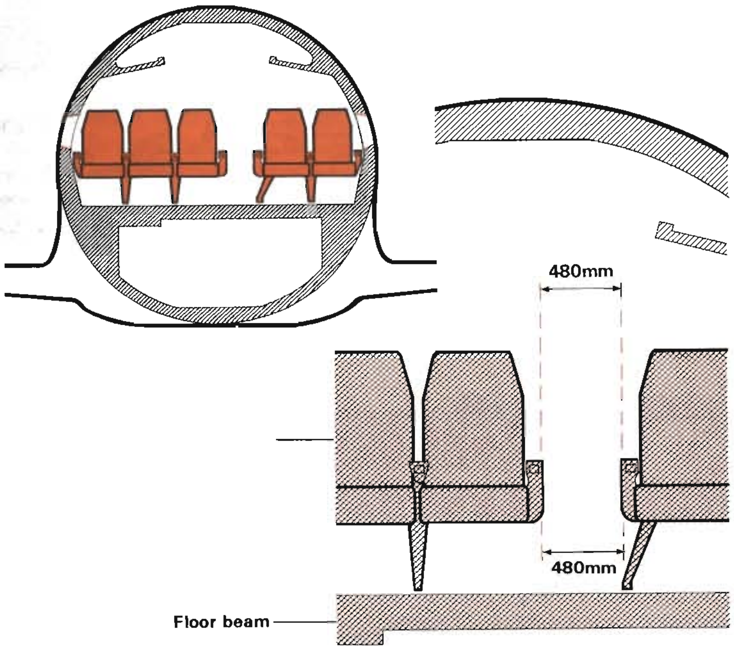


Fig. 1.5 A typical cross-section of a civil passenger aircraft showing the width restrictions in a gangway.

7. Aircraft access and exits

a. Doors

The normal means of entrance into an aircraft is through a door. The number and position of doors differs a great deal, even in the same type of aircraft, due to individual airline preferences. Aircraft are provided with at least one normal entrance, or exit, in the form of a main door, and most large passenger aircraft have a number of additional doors to help the rapid escape of the occupants in an emergency (see Fig. 1.6). The doors are generally of a size and number related to the carrying capacity of the aircraft, and provide easy access for passengers even in conditions of darkness. Normally, on large aircraft, the main door is forward on the port side, bearing the number 'one port', and the others are numbered consecutively aft. The same arrangement is found on the starboard side, numbering from forward to aft. The doors are readily identifiable, e.g. outlined in a contrasting colour. Where cabins are divided into two or more compartments, there will be at least one exit door in each compartment unless there is easy access from one compartment to the next. How doors are designed to open varies greatly, e.g. some

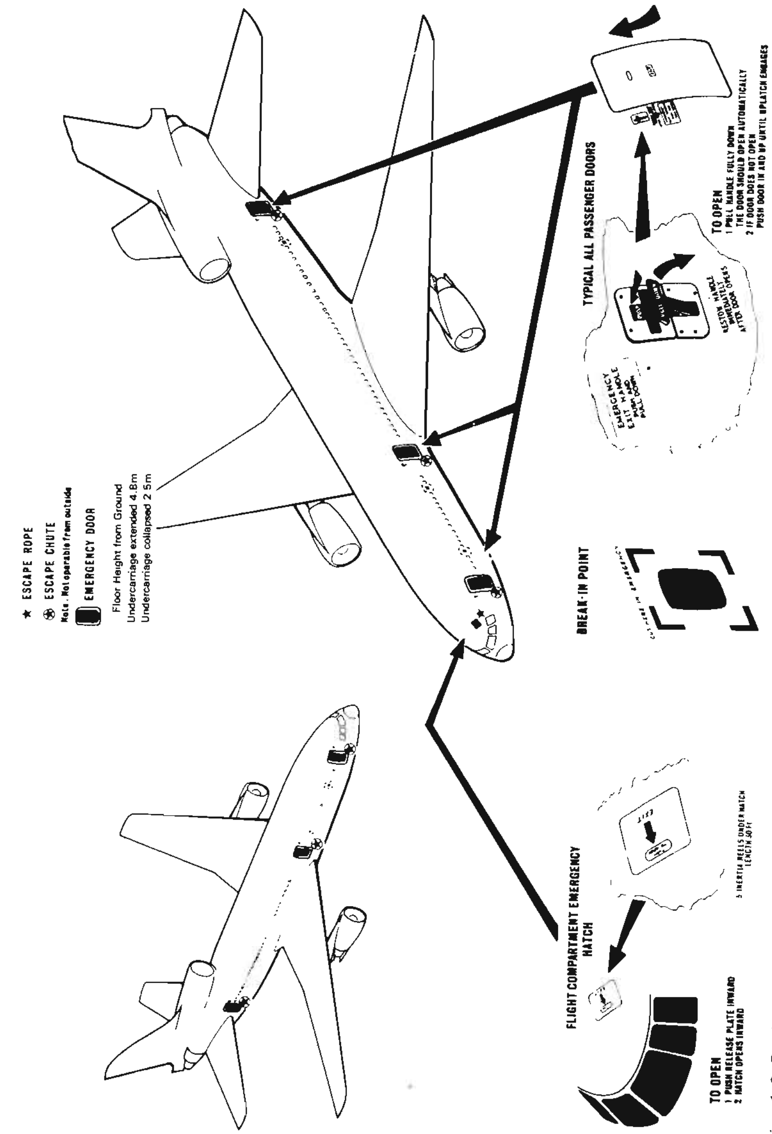


Fig. 1.6 Position of doors, hatches, break-in points etc. in a Tri-Star 500 civil passenger aircraft. Also illustrates door-operation and where the chutes and escape ropes are located.

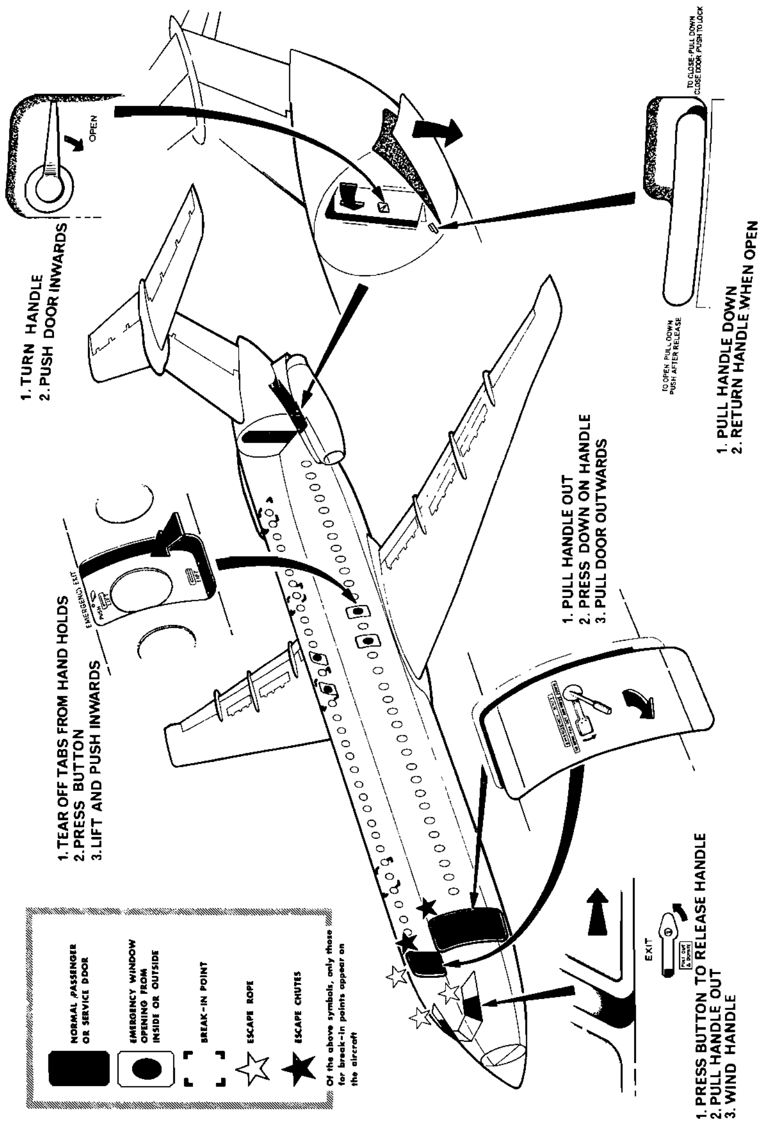


Fig. 1.7 Diagram similar to Fig. 1.6 showing escape facilities and door operation on a BA Super 111 510/539.

are hinged on the forward side and open outwards; some push in and slide up and over or to one side; others pull out and move sideways (see Fig. 1.7). Operation of door control handles or switches is clearly marked on both the outside and inside of the aircraft and usually allows rapid movement.

b. Emergency stairs

Some passenger aircraft which have a rear entrance are fitted with stairs which are used for normal embarking and disembarking, e.g. DC9, BA 111. These are usually lowered by hydraulics but can be hand-pumped down in an emergency and also operated externally for the same reason. External controls with instructions are clearly indicated on the fuselage (Fig. 1.8).

c. Escape slides or chutes

Escape slides are normally provided at doors and emergency exits to help rapid evacuation of passengers and crew in emergency (Fig. 1.9).

They are generally of two types: (i) inflatable, self-supporting, made from rubber and nylon and inflated by nitrogen or CO_2, and (ii) non-inflatable, constructed of synthetic materials, requiring support when in use, hand-holds being provided. In most modern aircraft the slides are deployed automatically when the door is opened from inside in an emergency. To prevent injury this system is normally disarmed automatically when the door is opened from the outside. However, technology changes, and firemen should still exercise a degree of caution when gaining entry.

In certain circumstances, an escape slide may accidentally inflate while still inside the aircraft (see Chapter 7, Section 2a(4)).

d. Windows

These are usually completely fixed, often double-glazed and made of transparent plastic. In modern pressurised aircraft they are kept as small as possible, are extremely strong and in very tough frames. Unless expressly constructed as emergency hatches (see below), they should, for rescue purposes, be avoided as far as possible.

e. Emergency hatches

Emergency hatches are fitted on most large civil aircraft, in the form of window panels which are designed to fall inwards or outwards on the operation of a release mechanism. Design requirements for pressurisation mean that almost all large pressurised civil aircraft also have certain inward-opening window panels which are normally located over the wing. These are intended primarily as escape routes in case of ditching. Other emergency hatches may be found on top of the fuselage.

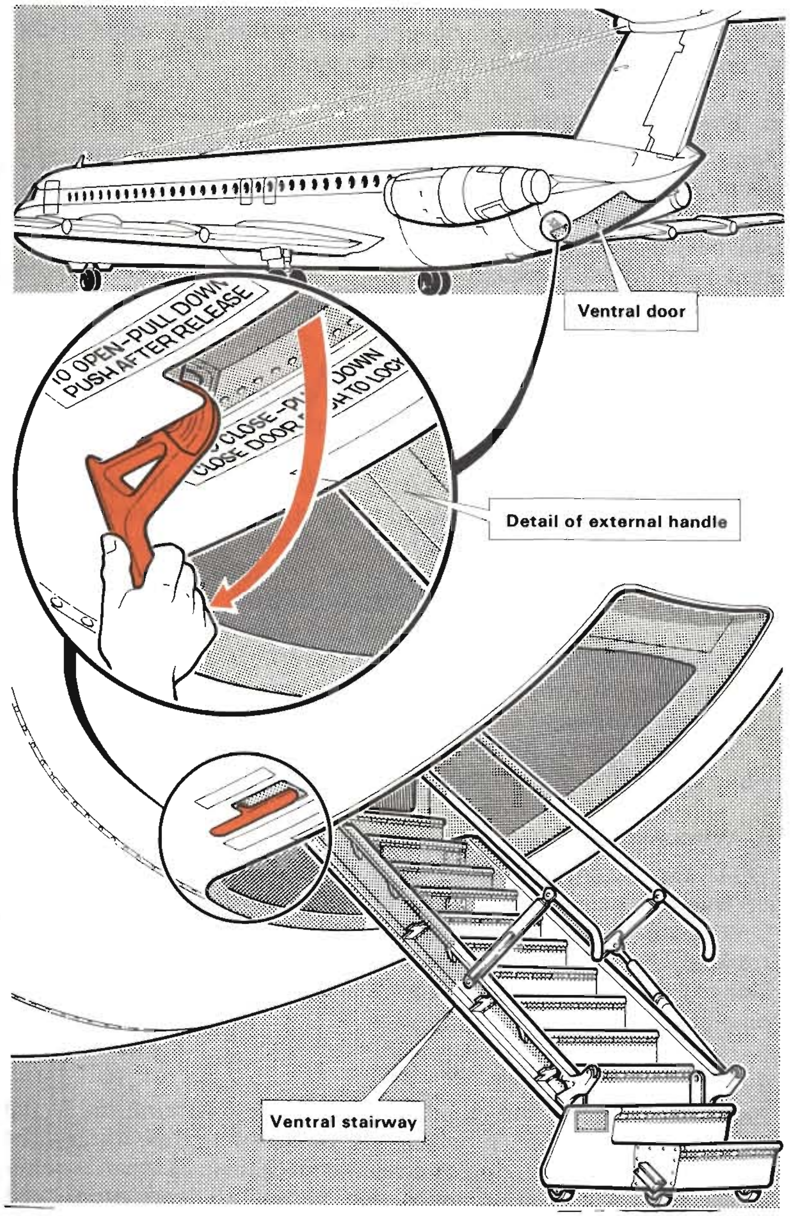


Fig. 1.8 A method of releasing a rear staircase on an aircraft in an emergency.

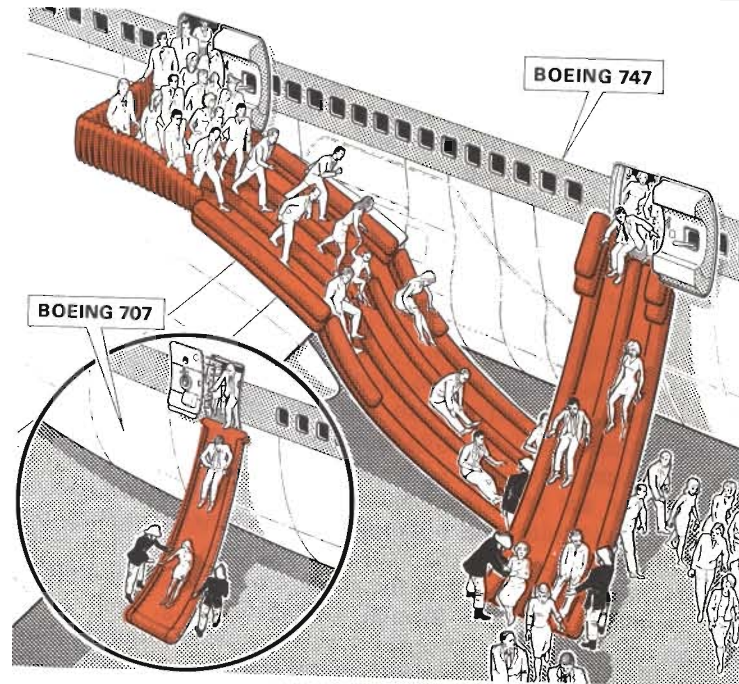


Fig. 1.9 Illustrating the use of various types of escape slides on large civil aircraft.

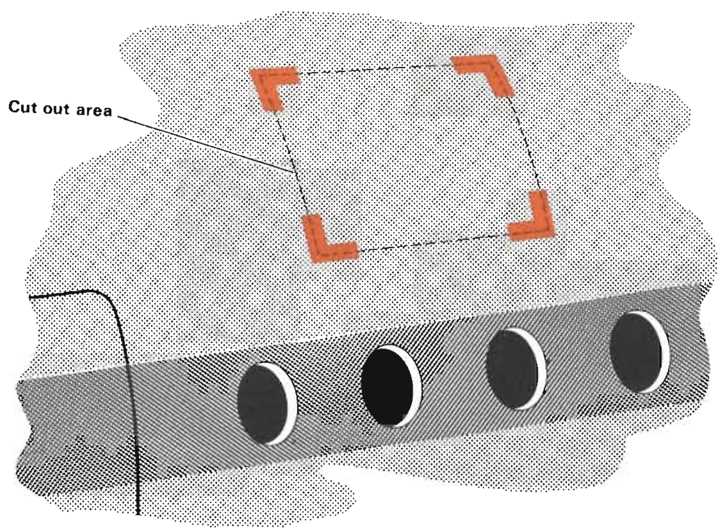


Fig. 1.10 Typical 'break-in' marking on a fuselage where it is possible to cut through the airframe clear of internal obstructions.

With very few exceptions, emergency hatches are openable from both inside and outside the aircraft. Their location can be recognised by outline bands of contrasting colour on the fuselage and by the marking of the release devices (Fig. 1.7). The use of overwing exits can be hazardous if the aircraft has stopped with its undercarriage in the normal down position, and these exits are sometimes fitted with an escape line secured above the exit. Aircrew are also provided with means of escape, usually by roof hatches or removable glazing on the flight deck, and lines. (Figs. 1.6 and 1.7).

f. Break-in points

These are areas marked on the fuselage where it should be possible to cut through the airframe to force an entry (Fig. 1.10). They are usually indicated by broken lines, and may have stencilled instructions on them. They are not weak points in the airframe structure but are areas between frames and are usually located where there is no internal obstruction e.g. electrical wiring, pipework, furnishings. Only the skin and stringers should therefore require cutting, but, owing to the arrangement of internal fittings, these points are usually located awkwardly, e.g. well up the fuselage and well above floor level on the inside. Firemen should attempt other points of access before resorting to any cutting away.

The precautions to be observed when cutting through the airframe are dealt with in Chapter 7, Section 2a(6).

g. Other factors

(1) Cargo aircraft

Although firemen are principally concerned with the rescue of aircraft passengers, they may have to tackle an incident involving a cargo aircraft. Obviously the number of people involved will be relatively few but means of access will differ. A point to remember is that cargo doors on any aircraft are not good access unless the APU or engines are running because these doors are often fitted with pressure-equalising panels which require power to operate them. There may, however, be enough power in the batteries for this purpose, but firemen should first attempt access elsewhere.

(2) Depressurisation

Aircraft are equipped with means of pressurising and de-pressurising the fuselage (see Section 5d above). If the automatic depressurising vents should fail to operate, there may be a difference between the inside and outside pressure when the aircraft reaches the ground. If the pressure inside the aircraft is less than that outside, firemen may find it impossible to open doors because they are held shut by the force of the air outside. In this case,

the fuselage skin obviously has to be penetrated to equalise the pressure, and an attack should be made with an axe at the corner of one of the windows.

8. Fire protection systems

Most aircraft have fire extinguishing systems, and a large number also have fire detection systems. They are usually independent of one another in that detection is automatic but an extinguishing system operates only when the pilot switches it on. The extinguishing agents used are BCF, BTM or a combination of Freon and nitrogen, contained in pressurised cylinders located in various parts of the aircraft. The discharge from the cylinders is usually very brief—between one and five seconds.

These systems are only intended to cope with a wholly enclosed fire in a particular compartment, e.g. engine, luggage, fuel, and have no effect outside that compartment. In an accident, the extinguishant may disperse through damage holes or be over-

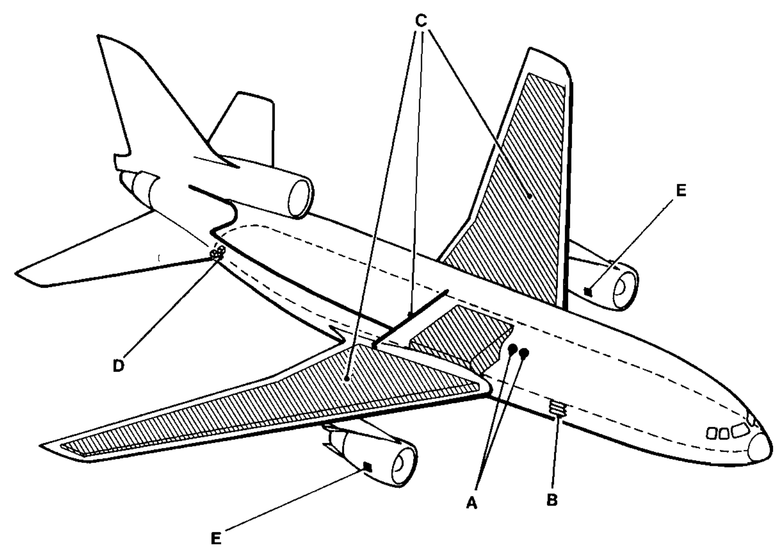


Fig. 1.11 Position of flight recorder, fire extinguishers etc. on a Tri-Star 500.

whelmed by a large free-flowing fuel fire. If the cylinders are not discharged and are involved in fire, they may burst at a comparatively early stage.

9. Flight recorders

Flight recorders are carried on all civil passenger aircraft and will also be found on many aircraft used for freight or for private or business purposes. Although referred to in the media as *black boxes* they are more often a brilliant fluorescent red colour, and are specially designed to resist shock and fire. Usually found in the rear fuselage section often adjacent to a rear exit door (Fig. 1.11), they record details of all the aircraft functions through all stages of operation and are, therefore, invaluable to the AIB in the event of an accident (see Chapter 6 Section 8).

Chapter 2
Design and construction of fixed-wing military aircraft

1. General

Fixed-wing military aircraft range from very large four-engined transports to single-seat fighters through supersonic attack types and VTOLs. They can, and often do, crash a long way from airfields, and the initial rescue and firefighting operations will have to be carried out by local authority firemen. Some knowledge of the design, construction and special features of military aircraft is therefore essential for firemen. They should take every opportunity to liaise with RAF, RN and USAF fire departments and visit any military airfields in their area. It is obviously impossible to cover the many different types of aircraft either based in, or visiting, the UK but examples of some of the more common types are included.

The basic points made in Chapter 1 on the construction of civil aircraft apply equally to similar aircraft in service used for air freight or troop transport roles, and indeed to military aircraft in general. Some features of military aircraft, however, are seldom or never seen on civil aircraft, e.g. side-seating, loading ramps, reinforced floors, weaponry. The features of most interest to firemen are set out below, with the exception of weaponry which is dealt with in Chapter 8.

2. Fuel and fuel tanks

a. Types of fuel

In addition to the aviation fuels listed in Chapter 1 Section 4, some military aircraft use AVPIN (isopropyl nitrate) in liquid-fuel engine-starter systems. This unusual fuel produces its own oxygen, allowing it to burn fiercely without an air supply. Its principal physical properties are:—

(i) It has a flashpoint of 10°C;

(ii) Its vapour is heavier than air;

(iii) It is lighter than water and non-miscible;

(iv) It has very wide limits of flammability;

(v) It generates toxic fumes when burning.

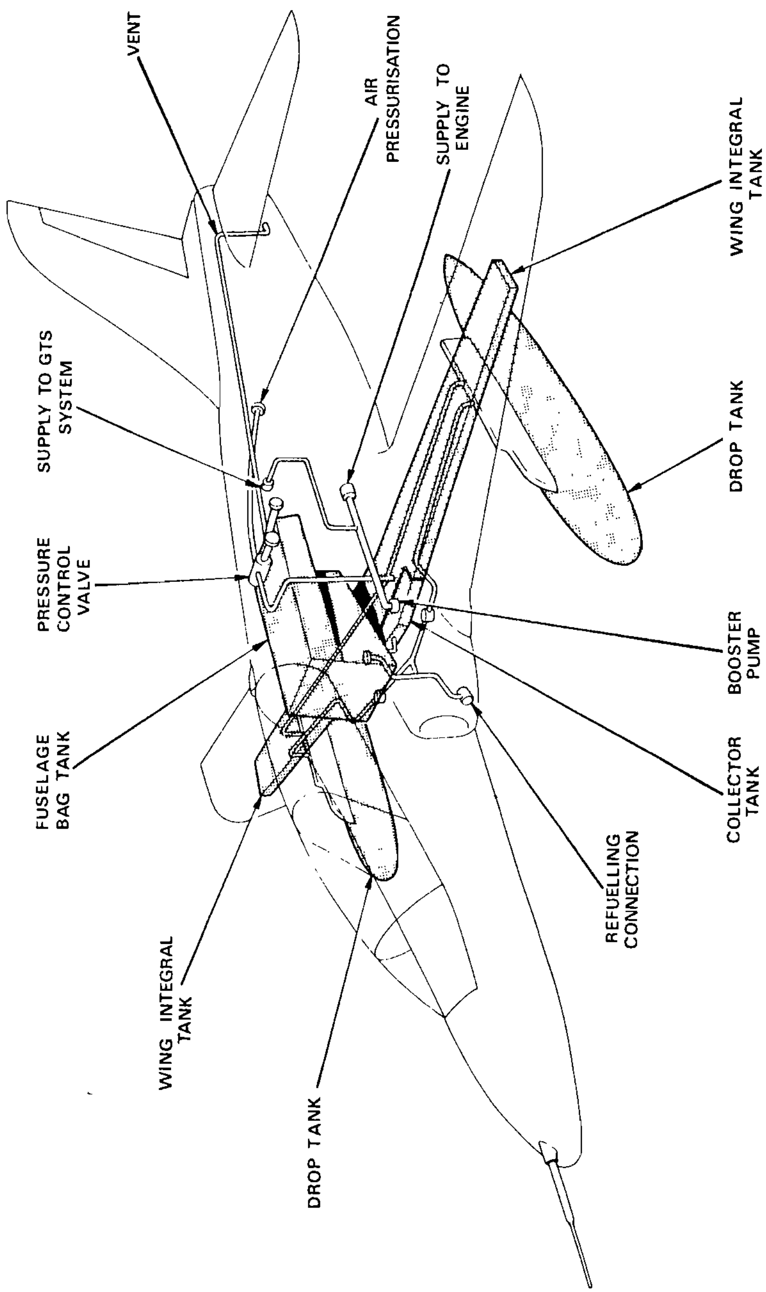


Fig. 2.1 Main fuel system in a Hawk attack trainer aircraft.

b. Fuel tanks

An example of the main fuel system in a Hawk attack-trainer aircraft is shown in Fig. 2.1. The fuel tank layout for a Harrier aircraft is illustrated in Fig. 2.2.

Where military aircraft are required to fly longer-range sorties, they can be equipped with either internal or external additional fuel tanks. Wingtip tanks, ventral fuselage tanks, and wing drop tanks are standard types. Larger aircraft may have a large temporary tank fitted within the fuselage. Victor aircraft, used for in-flight refuelling, are specially designed internally to carry several tonne of fuel. (Plate A.3.)

3. Powered and pressurised systems

a. Auxiliary power unit

An auxiliary power unit (see Chapter 1 Section 5c) is installed in most military aircraft. It is not used for propulsion but to provide a supplementary source of electrical or pneumatic power, e.g. to drive an additional alternator, to pressurise pneumatic turbo-starters to the main engines, or to supply pressurised air for a nuclear weapon. It normally has its own compartment close to the main engines with its own air intake and exhaust, and uses various types of aviation fuel.

b. Liquid oxygen and gases

Military aircraft carry quantities of liquefied oxygen (LOX). This supplies, via converters and other equipment, oxygen to personnel on board. The systems are usually located near the cockpit, but additional containers on transport aircraft may be located at the sides or rear of passenger compartments.

Systems using containers of gaseous oxygen or other gases may also be found, and these containers can be identified by their colour, and by lettering along the side and the chemical formula round the neck. Most common in use are oxygen (black), air (light grey), CO_2 (white), and nitrogen (light grey with black neck).

All liquid oxygen and gas containers are pressurised and may burst violently in the event of a fire (see Chapter 8 Section 3b(4)).

c. Systems identification symbols

Pipeline systems and components are identified by the symbols shown in Fig. 2.3. The pipework of each system is marked at the sides of every union, cock, or other connection with printed slips bearing the identifying symbol and general title of the system, i.e. fuel, hydraulic, pneumatic etc.

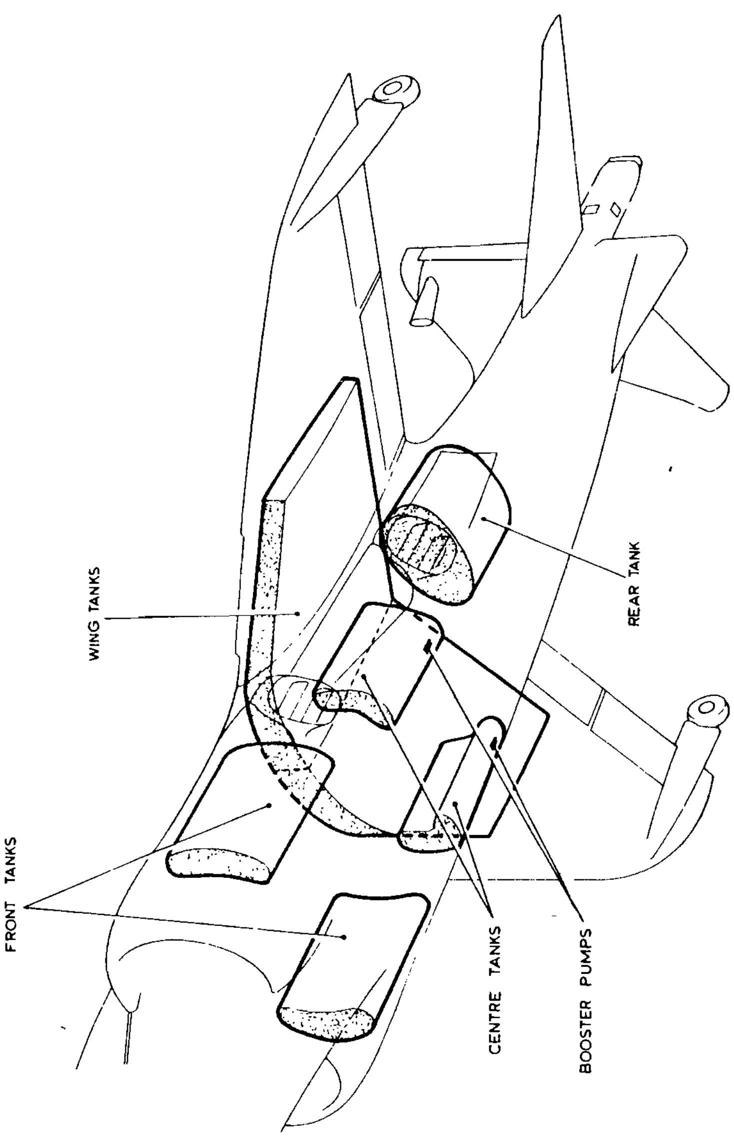


Fig. 2.2 Distribution of fuel tanks on a Harrier aircraft.

SYSTEMS FILLED WITH POL OR PRESSURISED GASES		
Fuel	Hydraulic fluid	Oxygen
Rocket fuel	De-icing	Power boosting
Rocket oxydisers	Coolant	Air-conditioning
Lubricating oil	Pneumatic	Inert gas
		Fire extinguishant

ELECTRICAL SYSTEMS		
External electrical connection	Ground earthing receptacle	Batteries

Fig. 2.3 Some symbols used in military aircraft to identify systems (NB POL means petrol, oil and lubricants).

4. Seating

a. Passenger seats

In fixed-wing military transport aircraft (not light versions) the passenger seating faces rearward and is grouped similarly to that of civilian airliners although usually with a narrower aisle. The seating is easily removable for conversion to freight carrying. Seating in mixed freight and passenger loads can be found either in the front or rear fuselage.

Paratroop seating is very basic, consisting of tubular frames with straps of webbing or synthetic material. These are set in rows along the sides of the aircraft and, in some cases, also back-to-back down the centre. The maximum number of paratroopers which can be carried is greater than the number of ordinary seated passengers.

b. Ejection seats

All types of high-speed attack aircraft are fitted with ejection seats which are designed to 'fire' the crew from the aircraft in an emergency (see Fig. 2.4 and Plate A.26).

The types of seat used in the RAF, RN and USAF are similar in that they all have an explosive charge or rocket pack to eject the crew member upwards. They do, however, differ in a number

Fig. 2.4 Sign on side of fuselage denoting ejection seat.

of details, and these differences are important to the safety of firemen and aircrew. There is, moreover, the possibility of frequent visits by military aircraft from other NATO countries.

Martin-Baker ejection seats are used on all British, most French and some USAF fighter and attack aircraft. (Fig. 2.5 and Plate A.26 show an occupied Martin-Baker seat in a Hawk aircraft). However, there are quite a number of types of USAF aircraft which have US-type ejection seats and one, the F111, where the whole crew capsule is ejected. It is beyond the scope of this Manual to describe all the types now in use, and in any case these could change in the future. Officers-in-charge should take every opportunity of familiarising their men with as many types as possible. The information is available, and liaison between the military authorities and the fire service is such that there should be no difficulty in finding out the necessary facts.

The actual procedures for releasing a crew member will be found in Chapter 7 Section 3, together with instructions on precautions to follow.

5. Aircraft access and exits

a. Doors

On large aircraft there is usually at least one main door with operating instructions stencilled on it, and this is usually on the port side but may be found under the nose. Doors may open inwards or outwards, slide, lift up or down on hinges etc, and all are finely balanced so that, unless there is extreme distortion, one man should be able to open most doors. Some aircraft have doors that can be entirely jettisoned. Instructions on the fuselage are usually sufficiently explicit. Occasionally, large military transport aircraft have freight doors like those of civil cargo-carrying air-

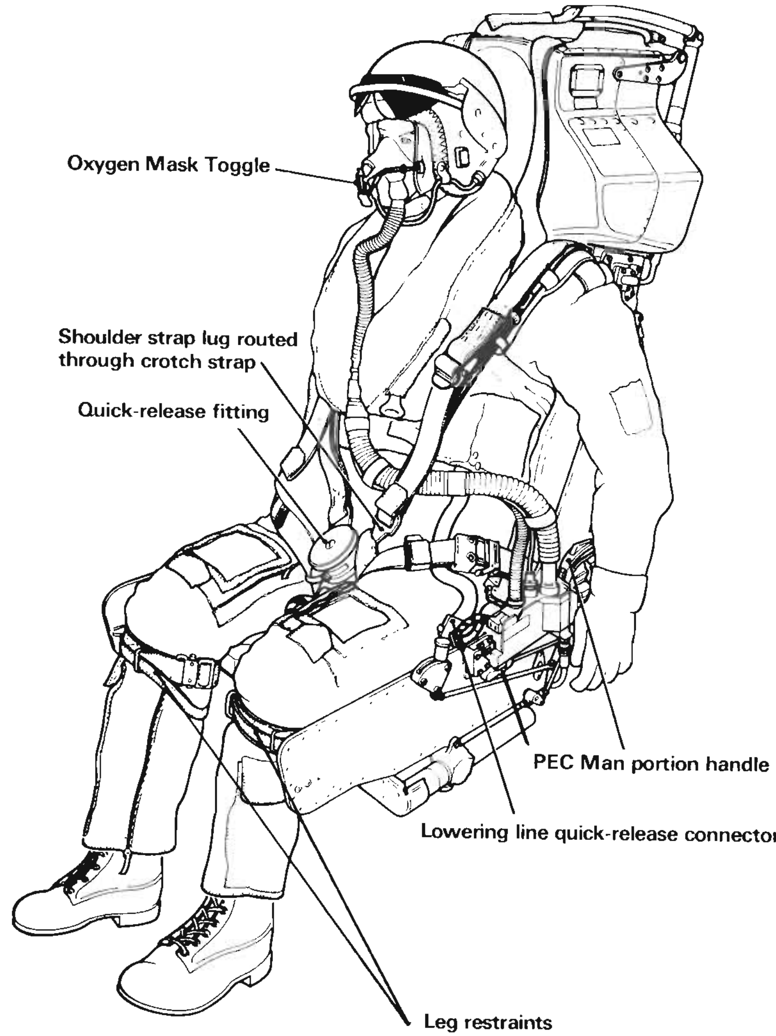


Fig. 2.5 An occupied ejection seat in a Hawk aircraft.

craft. These doors can only be opened from the inside and are, normally, hydraulically operated. Rescuers cannot operate them other than by obtaining access elsewhere.

b. Emergency hatches

The emergency hatches on military passenger aircraft take the form of removable window panels similar to those of civil aircraft. The panels are usually delineated on the fuselage and instructions stencilled adjacent. Ventral doors are also sometimes fitted but there is usually some access from the top of the fuselage if all other access is impossible.

c. Break-in points

All large military aircraft have break-in points similar to those found on civil aircraft (see Chapter 1 Section 7f). They should be regarded as a last resort, to be used only if other means of access are restricted.

d. Cockpit canopies

Cockpit canopies are found only on smaller military aircraft. They are usually slightly domed, hinged or sliding perspex hoods over the seat positions, behind a fixed windscreen of laminated safety glass or perspex which is separate to the canopy. If the aircraft has tandem seating there may be two separate hoods (Phantom) or one larger one (Buccaneer) (Plates A.4 and A.5). On most aircraft the canopy(ies) can be jettisoned prior to the occupant(s) ejecting. Firemen will have to look at each type of aircraft to get to know the differences. Even on a single type such as the Harrier there will be variations, e.g. the GR1 canopy (Plate A.4) slides rearwards but on the T2 the canopies hinge to starboard. (Fig. 2.8).

(1) Sliding canopies

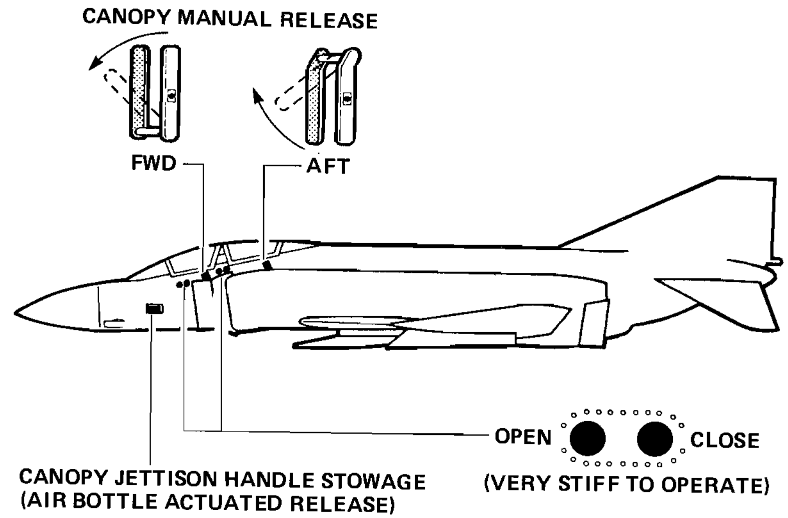
There are internal and external canopy release handles which, when pulled, open the canopy locks, enabling the whole canopy to be lifted off if necessary. Appropriate instructions are stencilled on the fuselage. Most canopies are quite heavy and should be handled carefully.

(2) Hinged canopies

These generally have a jettison mechanism which can be operated internally or externally by means of a canopy jettison release, which is indicated on the fuselage with appropriate instructions. The mechanism opens the canopy locks and fires a cartridge, which on some types pushes the forward part of the canopy up, pivoting it on the rear or side hinge and throwing it back or sideways. If the aircraft is in flight, its slipstream then tears the canopy clear. The jettison mechanism operates automatically if the aircrew eject.

(3) Miniature Detonating Cord (MDC)

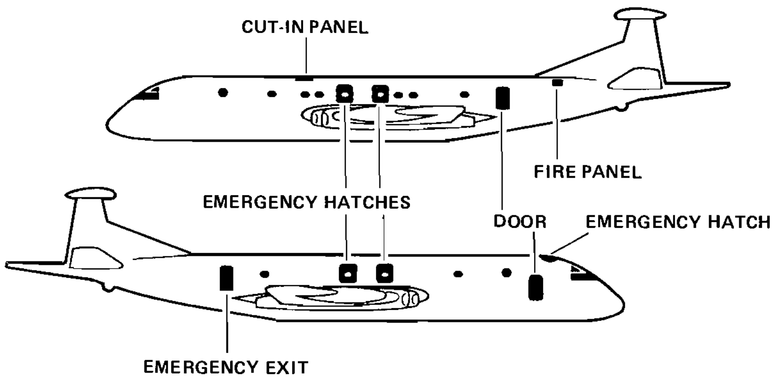
This will be found, at the present time (1985), on Harrier, Hawk, Buccaneer, and Mk5 Jet Provost aircraft, which include both sliding and hinged canopies. Other aircraft may be so equipped as they come into service.



PHANTOM —	RAF/RN/USAF
CREW	2
EJECTOR SEATS	2 Martin Baker Type 7 (6 or 7 USAF)
CANOPY RELEASE	1. Normal Pneumatic 2. Manual 3. Explosive Jettison (Air Bottle Activated)
MAXIMUM FUEL LOAD	13,250 litres
WEAPON/MISSILE HAZARDS	1. Sparrow and Sidewinder Missiles 2. Cordite in Missile Rocket Motors 3. Cartridge Jettison for all Pylons
POSITION OF LOX TANK	1 x 10 litres under Rear Cockpit (Access underneath Aircraft)
ADDITIONAL INFORMATION	1. No Fixed Fire Protection System 2. No External Fire Access Panels 3. Canopy Non-Frangible Clamshell 4. Beware of Intake if Engine Running

Fig. 2.6 General operational information on a Phantom aircraft.

The MDC consists of a thin cord of electronically detonated explosive built into the actual canopy material (Plate A.26). It can be operated from inside or outside the cockpit and its operation shatters the canopy (Fig. 7.2). It is operated automatically in the ejection sequence, and affords a clear path through which the crew member can eject (see Plate A.6). It can also be operated independently of the ejection mechanism. The hazards associated with the MDC, and the consequent precautions which firemen should take during rescue operations, are dealt with in Chapter 7 Section 3b(2).



NIMROD	
CREW	12
PASSENGERS	19, Maximum (This could be higher if the Crew is less than 12)
FUEL	38,100 kg
DOORS	1 Port Rear/1 Starboard Forward
EMERGENCY EXITS	1 on Top behind Cockpit 2 over wing each side 1 Starboard Rear Cut-in Panel on Top just Foward of Wing
WEAPONS/OTHER HAZARDS	5 Flares plus other Weapons in Warloads
ADDITIONAL INFORMATION	2 Fire Panels under each Engine Bay on Wings

Fig. 2.7 General operational information on a Nimrod aircraft.

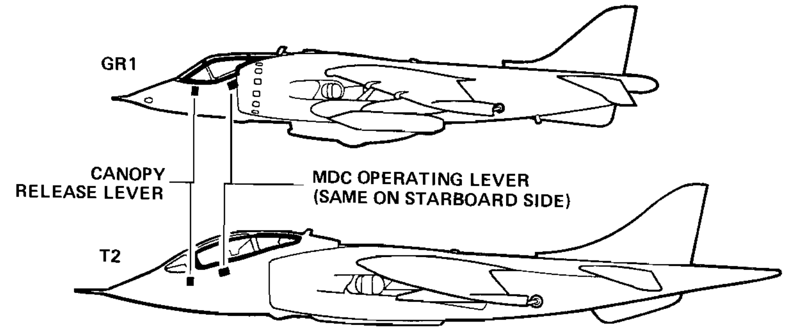
Another type of canopy-shattering device which will be found on some aircraft is the Linear Cutting Cord (LCC). This has the same basic characteristics as the MDC and should be dealt with in the same way.

(4) Breaking in

Canopies should only be broken into manually as a very last resort (see Chapter 7 Section 3b(3)).

6. Special features

Figs. 2.6, 2.7, 2.8 and 2.9, with their accompanying brief descriptions, are four examples of military aircraft common to the UK. Firemen should note the different types of canopy release mechanisms, fuel loads, LOX positions and weapon loads (Plates A.4, A.7 and A.8). The different marks of ejection seats emphasise the need for information.

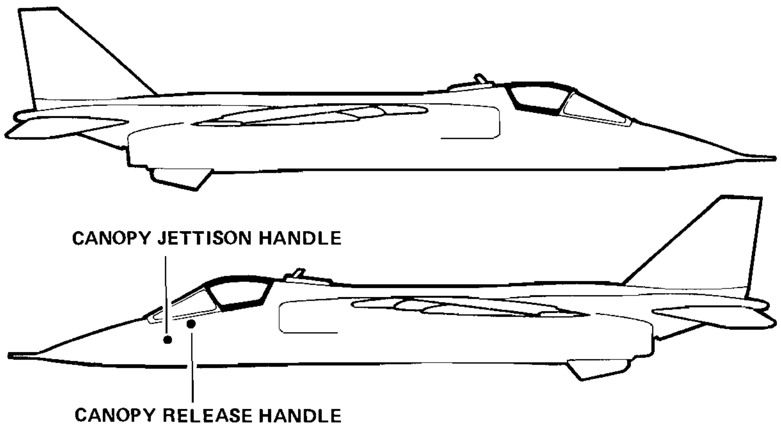


HARRIER GR1 and T2	
CREW	1 or 2
EJECTOR SEATS	1 or 2 MK6 or 9A
CANOPY RELEASE	GR1 - Unlock by pulling handle downwards, Canopy slides rearwards/Canopy is Frangible T2 – Unlock same method, Canopies hinge to Starboard/Canopy Frangible
EMERGENCY RELEASE	MDC (Miniature Detonating Cord) Buried in Perspex around Perimeter, Firing Handles located outside either side of Cockpit
MAXIMUM FUEL	2,825 litres + up to 3,135 l in Ferry Tanks
LOX TANK	1 x 5 litre in Equipment Bay
WEAPONS	Rockets, Missiles and Bombs
ADDITIONAL INFORMATION	Beware of Intake if Engine running

Fig. 2.8 General operational information on two types of Harrier aircraft.

The Phantom description (Fig. 2.6) includes reference to cartridge jettison of pylons. These, if involved in fire, might be a hazard, especially if the aircraft is in a wing-up position. The fire panels under the engine bays on the Nimrod are access positions designed primarily to enable firemen to inject halons straight into the engine. If the aircraft has crashed wheels-up, these will not be accessible, of course. The emergency exits and doors on the Nimrod are similar to those of civil airliners, and are repeated on other military transports.

The need to keep clear of the air intakes and exhausts if the engine is still running (see Chapter 7, Section 2a(1)) has added complications on the various marks of Harrier. In addition, for hovering stability, this aircraft has 'puffers'. These are small exhaust nozzles under the nose, tail and wingtips, which, together with the swivelling main jet exhausts, are very hot areas even after the engine has stopped. Firemen should make themselves aware of these positions and try to keep clear.



JAGUAR	
CREW	1 or 2
EJECTOR SEATS	1 or 2 x Martin Baker 9B MK 2
CANOPY RELEASE	1. Manual-Hinge at Rear 2. Explosive Jettison
FUEL	7,550 litres
LOX	1 x 10 litre Housed in Sealed Compartment on Right side of Nose

Fig. 2.9 General operational information on a Jaguar aircraft.

Chapter 3
Rotary-wing aircraft

1. General

Rotary-wing aircraft, which are mostly of the helicopter type, have developed very rapidly, both technically and commercially. The British Helicopter Advisory Board handbook displays photographs of 30 different types of civilian helicopter, ranging from 2-seater to 44-seater aircraft, and quotes a 1982 fleet figure of 563. There are no official categories of helicopters apart from one which deals with the technical aspect of ability to maintain flight with an engine failure. Weights and fuel capacities range from 590 kg with 90 litres of fuel to 21,300 kg and 7900 litres of fuel.

2. Construction

The construction of the airframe of a helicopter is very similar to that of the fuselage of a fixed-wing aircraft but of lighter design. There are several reasons for this: it is not stressed to carry a mainplane; the cabin is not pressurised for high altitude flight; and the undercarriage assemblies are comparatively small. The structure is likely to include members of smaller cross-section than those in fixed-wing aircraft, sheet metal of thinner gauges, and very light alloys (see Plate A.24).

Firemen should remember that helicopters operating over water are often fitted with flotation equipment. This is a water-actuated device, usually fitted in the sponsons on the wheels (Plate A.19), which operates by blowing off a metal cover and inflating a bag to approximately 1.5 m in diameter. A crash on land could operate the device accidentally, and firemen should therefore keep clear of the wheel area if possible. Should the bag become inflated, it can be cut if necessary.

3. Engines

A few of the smallest helicopters have piston engines, but all others have turbo-shaft engines, which are turbo-prop engines geared to drive rotor heads instead of propellers. Some helicopters have their engines exposed above and behind the cabin, but most are enclosed on top of the fuselage. One exception is the Boeing Vertol 234/Chinook whose engines are high up on the tail (see

Plates A.9 and A.10). Engine bays are separated from airframes and cabins by fire-resisting bulkheads and, in the case of twin engines, there is an additional fire-resisting bulkhead between the engines.

4. Rotors

Most helicopters have one large overhead rotor and a smaller stabilising rotor at the tail. The only exception flying in this country at present is the Boeing Vertol/Chinook which has two overhead rotors; these are contra-rotating and therefore do not need a stabilising rotor.

The stabilising tail rotor is a particular hazard to firemen. They must remember that, even after a crash, the engine may still be running and, although the main rotor may be damaged and stopped, the tail rotor could still be rotating, and might, in poor light, be difficult to see owing to its speed. With engines stopped, the momentum will still keep the rotor moving. Some tail rotors are enclosed in a cage for safety, and all are painted in some bright design to increase their visibility when they are in motion. Main rotors, in general, are set too high to be dangerous, but firemen should bear three points in mind:

(a) the angle of the crashed aircraft. A nose-down or canted position could bring rotor tips close to the ground.

(b) in some larger aircraft, as rotors slow down, they droop and may come dangerously low.

(c) on the Boeing Vertol/Chinook the front rotor is already canted forward and down, and when slowing the rotor tips can get very low.

The best path of approach to a crashed civilian helicopter, bearing in mind the above comments, will usually be either from

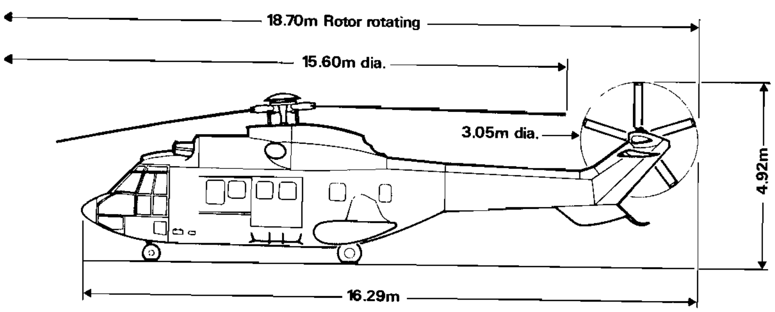


Fig. 3.1 Aerospatiale Puma 332 civilian passenger helicopter showing rotor-sweeping areas.

the rear along the opposite side to that of the tail rotor, or from the side, keeping low so as to avoid the main rotor (see Fig. 3.1).

5. Seating

This varies according to the size of the aircraft but, in the larger multi-seat types, it is similar to that of small fixed-wing airliners. Seats are usually of steel tubular frame, sometimes of the folding sort, and are arranged in rows of four across the cabin or rows of one and two seats with a gangway (see Fig. 3.2). All seats are provided with seat belts.

Any helicopter carrying more than 10 passengers has to carry a steward as part of the crew.

6. Access and exits

a. Doors

These are usually hinged or side-sliding, with a variety of opening devices (see Fig. 3.2). In some aircraft there are means of jettisoning doors both from outside and inside. Firemen must be prepared to take the weight of these doors as they come away. The Chinook offside door, which is near the front behind the crew cabin, separates into two sections, the lower folding out to form steps and the upper sliding up, in and over (Fig. 3.3).

All doors have opening instructions marked on the outside.

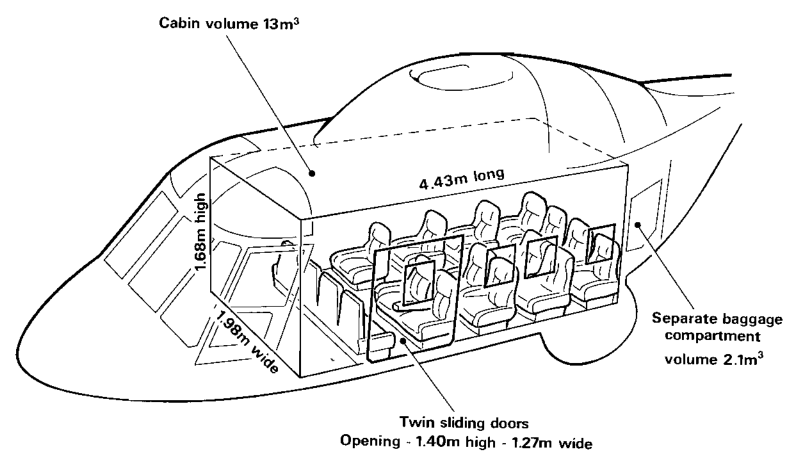
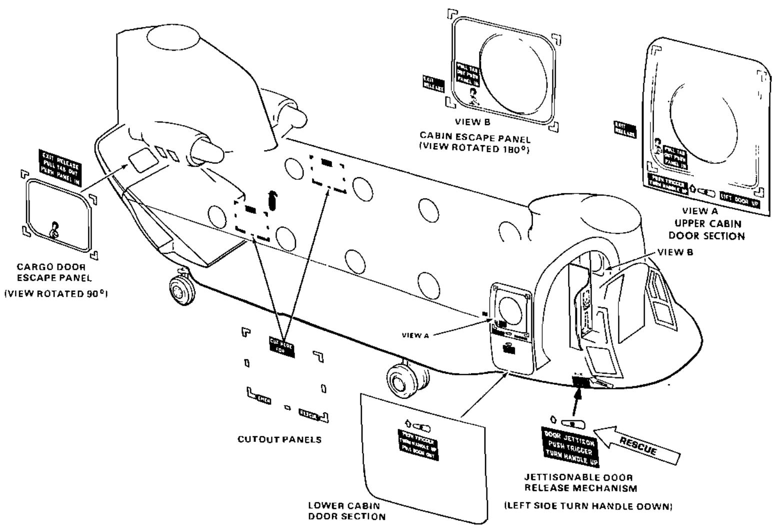


Fig. 3.2 Seating arrangements on a Westland 30 civilian passenger helicopter. Typical sliding door arrangement.



CHINOOK-HC MK I

POB 44 Troops+3 Crew
FUEL 3100 kg

Fig. 3.3 The various entry and escape facilities of a Chinook helicopter. The civilian version may vary from this arrangement.

b. Escape panels

The larger helicopters usually have, in addition to doors, several areas on the fuselage which can be removed or cut into in an emergency. They may be specially marked sections around certain windows with external means of opening, or alternatively areas prominently indicated on the fuselage where cutting-in can take place. The Chinook also has a cargo door escape panel at the rear and if necessary, once firemen are inside, the windows can be kicked out. (See Fig. 3.3).

On smaller helicopters, if for any reason doors are jammed, the construction is relatively light and, provided that adequate precautions are taken against ignition of fuel-vapour (see Chapter 7, Section 2a(6)), it should not be difficult to cut in, either through the metal struts or the perspex area.

7. Flight recorders

Flight recorders are not carried on helicopters.

8. Military helicopters

There are many military helicopters, of a number of different types, flying in the UK (see Plates A.10, A.11 and A.12). Firemen should be wary when approaching these, as they may have a variety of weapons on board. Most weapons will operate forward, but there could be pods on the side of the aircraft and these should be avoided if possible. (The hazards from weaponry are dealt with in more detail in Chapter 8).

Chapter 4
Aviation authorities, airports, and emergency procedures

1. Aviation authorities

Civil aviation is organised nationally and internationally by several regulatory authorities. National policy lies with the Department of Transport who negotiate with other countries over international matters on aviation. The Civil Aviation Authority (CAA) is an independent statutory body appointed by the Secretary of State for Transport to enforce standards of economic, technical and operational performance in the aircraft industry. In addition it provides navigational services at certain airports and, in conjunction with the Ministry of Defence, is responsible for the national network of air traffic control, the National Air Traffic Service. All civil airports in the UK must be licensed by the CAA, and an important requirement of the licence is the provision of adequate emergency services for firefighting and rescue.

Eight Scottish airports are operated directly by the CAA. Another body, the British Airports Authority (BAA), owns and maintains seven of the principal airports in the UK (Heathrow, Gatwick, Stansted, Prestwick, Glasgow, Edinburgh, and Aberdeen). The remainder—some 200—are owned and operated by local authorities or private concerns.

Military airfields are dealt with in Section 6 below.

2. Civil airport categories

All civil airports are placed within one of nine categories for firefighting and rescue purposes. Categorisation is determined by the length and width of the aircraft using the airport and the frequency of their movements. The larger the aircraft and the greater the number of movements, the higher the category number. For example, Heathrow is Category 9; Stansted and Glasgow are Category 7.

Grid maps of airports are available, showing their area and immediate vicinity, including details of topography, access roads and location of water supplies. Brigades with airports on their ground should ensure that they obtain copies and familiarise themselves with any particular problems.

3. Air Traffic Control (ATC)

All movements of civil aircraft to and from the UK and over it are regulated by the National Air Traffic Service (NATS). A branch of the RAF performs a similar function for military aircraft, but within the NATS control zones or areas such aircraft come under the additional control of NATS.

4. Emergency procedures

a. Types of emergency

ATC classify emergencies under the following headings:—

(i) Aircraft accident
An aircraft accident which has occurred on an airport.

(ii) Aircraft accident off airport
An aircraft accident which has occurred off an airport but within two miles of its boundary.

(iii) Aircraft accident imminent
An aircraft accident which has not yet occurred but is considered to be inevitable on, or in the vicinity of, the airport.

(iv) Aircraft ground incident
An aircraft on the ground which is, or is suspected to be, involved in an incident which might endanger the safety of the aircraft or its passengers.

(v) Full emergency
An aircraft in flight which is known, or suspected to be, in such difficulty that there is a danger of an accident on landing. This category may be used to classify unlawful acts, e.g. hi-jack.

(vi) Local stand-by
An aircraft in flight that has developed some problem which is not considered sufficiently serious by the captain to prevent the aircraft making a safe landing, e.g. a bomb warning when search procedures may have to be initiated.

(vii) Domestic fires and special services
A domestic fire is one within the airport boundary which might be dangerous to life, property, or aircraft operations. A special service call is when fire service personnel and equipment are needed to deal with incidents other than fires. (This category is not used when the safety of aircraft is involved).

(viii) Aircraft unlawful act (Hi-jack)
An aircraft which may or may not be in flight and has been unlawfully seized.

(ix) Aircraft bomb warnings
When information is received that a bomb is on board an aircraft which may or may not be in flight. The appropriate category, i.e. local stand-by or ground incident, will apply.

(x) Act of aggression—ground
An armed attack, bomb attack or suspected attack; the finding of suspicious objects or the taking of hostages on the airport which does not directly involve aircraft or their operation.

b. Preplanning procedures

One particular condition of the licence of civil airports is a requirement to formulate Emergency Orders. These must ensure adequate arrangements for the efficient operation of all the emergency services when an accident occurs. All Brigades will have such plans for airports and airfields in their areas and they will, of course, vary according to the size and complexity of the risk. At the major airports it is usual to have several 'rendezvous points' to which LAFB, police, ambulance etc will report to stand-by. The London Fire Brigade plan for Heathrow includes six of these points strategically placed outside the airport boundary but close enough to access gates to ensure a rapid back-up to the airport fire services if required. Some form of communication system is set up at the rendezvous which enables the appliances etc to be ordered on quickly. It is usual for an airport guide vehicle to lead the appliances when they are moving on to 'airside', i.e. into the area where aircraft could be moving, and this vehicle is in constant contact with ATC in the control tower. At smaller airfields, similar but simpler arrangements are made to direct appliances to the scene of the accident.

It is obvious that, in order to keep these plans and procedures on top line, they need to be practised on a regular basis and updated as necessary. Brigades should ensure that all personnel likely to attend are fully conversant with the plans.

c. Calls to incidents

The ATC officer on duty is responsible for alerting the emergency services in the event of an accident or other emergency. This is usually done by a telephone link to the airport fire service control room if the incident takes place on or near the airport (see Section 4a(ii) above); the call will then, if necessary, be relayed to the LAFB control room by the airport fire service control room attendant. If the incident occurs away from an airport, ATC will usually notify the police, who will in turn inform the LAFB.

Sometimes, the LAFB may receive calls from other sources. If so, they should notify the police immediately (see Chapter 6, Section 2).

d. Attendances

Generally at aircraft incidents on airports or airfields the LAFB augment the airport fire service. Although the LAFB have the statutory responsibility under the Fire Services Act 1947, it is usual for the senior airport fire service officer to be in command initially. When a senior LAFB officer arrives at the incident he will assume command of the combined operation. However, he should not alter the deployment of airport appliances, equipment or manpower without very good reason, as the airport fire service have tactical plans which they put into operation to cover certain eventualities.

At incidents occurring off an airport but within two miles of one, the airport fire service may attend in a reduced capacity, depending on the distance from the airport. In these circumstances, the LAFB will normally take full tactical control of the incident on their arrival. At distances of more than two miles, airport fire services do not usually attend.

Where an airport is near large areas of water, the Emergency Orders generally provide for the calling of assistance from RNLI, Coastguard or other marine organisations. The Armed Forces may be called upon to help by providing air-sea rescue helicopters. Some airport fire services also have water rescue craft of their own (see Chapter 6, Section 7b).

5. Civil airport firefighting facilities

a. Appliances

The appliances attached to airports and airfields will vary according to the category of the risk, but they must all comply with International Civil Aviation Organisation (ICAO) Guidance material specifications. These are laid down in Civil Aviation Pamphlets (CAP 168 for the UK). Minimum requirements with regard to performance, acceleration and braking, cross-country capability and, consequently, ground clearance limits, are all specified.

Large capacity water, foam, and, in some cases, halon tanks are the norm, giving the larger appliances a huge firefighting capability without recourse to outside supplies. A gross weight of 28 tonne is not unusual. (See Plate A.2.)

Attendance times—as little as two minutes to any part of an airport, with a given firefighting capacity—make the need for rapid acceleration obvious. High discharge rates of finished foam from appliance monitors to a distance of 80 metres, a capability to produce foam whilst moving at slow speeds, and the provision of hand lines are all normal requirements.

One development is the up-rating of former rapid intervention vehicles (RIV). These are used as 'first-strike' appliances to get to incidents, initiate rescue operations and provide fire suppression whilst awaiting the arrival of major foam tenders. Future first-strike appliances should have a much greater firefighting capacity, without sacrificing too much of their speed and manoeuvrability.

b. Water supplies

Water supply systems at airports and airfields vary considerably but are usually classified under two headings: (i) primary and (ii) secondary.

(i) The primary supply consists of a below-ground water mains system which is usually fed from street mains of the local water authority. The size of the airport main is therefore generally determined by the size of the water authority's supply, usually 150 mm or larger. Often the system is a ring main which reduces friction loss, allows water to flow in either direction, and enables different sections to be isolated without interfering with the supply to others.

(ii) Secondary supplies may be provided, in the form of high-level tanks or ground-level reservoirs; these are often fed by storm water catchments. Ponds, rivers, streams etc may be used as supplementary sources of water.

Fire hydrants are placed at strategic points around airports, their layout depending on the risk. They are usually indicated by hydrant plates, and, although most of the outlets are below ground level and require standpipes, some airports have provided pillar hydrants. All this information should be indicated on the airport grid maps.

Water supplies to airports may be metered, and it could be necessary to operate a valve to by-pass the meter. Although airport fire service personnel will know of these valves, LAFB firemen should also make themselves familiar with their location and operation.

c. Hangar protection

(1) General

Whilst major airports are equipped with efficient firefighting facilities for aircraft landing, taking off or taxying, they also have to cover the aircraft maintenance areas. An aircraft on a fairly short inspection, or period of maintenance, may be installed in a hangar with a full fuel load. The failure of a component during maintenance could result in a major fuel release in a confined space. Apart from this, the presence of highly volatile solvents, large amounts of electrical apparatus and a big human element all require a high degree of protection, not only for the occupants and the building but also for the aircraft. It is therefore important for hangars to have adequate equipment for suppressing any

incipient fire. The National Fire Protection Association's Standard 409 is closely followed in the UK, and parameters relating to hangar size, aircraft size and even aircraft design are used to categorise hangars for fire protection. LAFB firemen should visit the hangars at local airports and familiarise themselves with their layout.

Fire protection equipment falls into two basic categories: high-level and low-level.

(2) High-level protection

For large risks, there are three main systems used:

(i) High expansion foam discharged to cover the entire floor area to a depth capable of enveloping the aircraft.

(ii) Low expansion foam discharged for a given period by means of a deluge system mounted at hangar roof level.

(iii) Discharge of a foam/water solution using AFFF through the standard automatic sprinkler system.

In system (ii), the roof is divided into zones, delineated either by the type of construction or by draught curtains. Each zone contains a number of specially designed sprinkler heads, and a deluge control valve which enables it to operate as an independent unit. The number of zones brought into operation depends on the extent of heat spread from the fire.

(3) Low-level protection

When a high-level deluge system operates, aircraft, by their design shape, cause an 'umbrella' effect in that any fire under the wings or fuselage cannot be directly affected by the extinguishing medium. Any aircraft with a wing area in excess of 280 sq metres requires supplementary protection. A Boeing 747, for example, has a wing area of 510 sq metres, and Concorde approximately 360 sq metres.

The most satisfactory method of providing protection under the wings and fuselage is by either fixed or oscillating foam projectors (Fig. 4.1). Sometimes hangars have special maintenance platforms which follow the shape of the leading edge of the wings of individual aircraft (Fig. 4.2). Here, foam projectors are fixed onto the frame of the platform, cutting down the distance of throw and providing a faster attack on the fire. In other hangars, where aircraft of various types are maintained, the foam projectors may be mounted on the walls of the hangar.

Besides foam, there may be halon, CO_2 or AFFF installations for particular risks. Also, to deal with any small fires, there are usually portable extinguishers placed at strategic points.

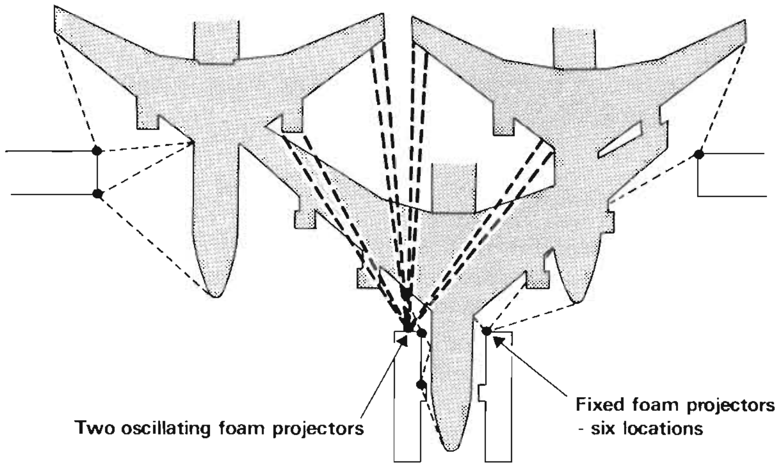


Fig 4 1 Example of underwing and overall protection from fire in hangars

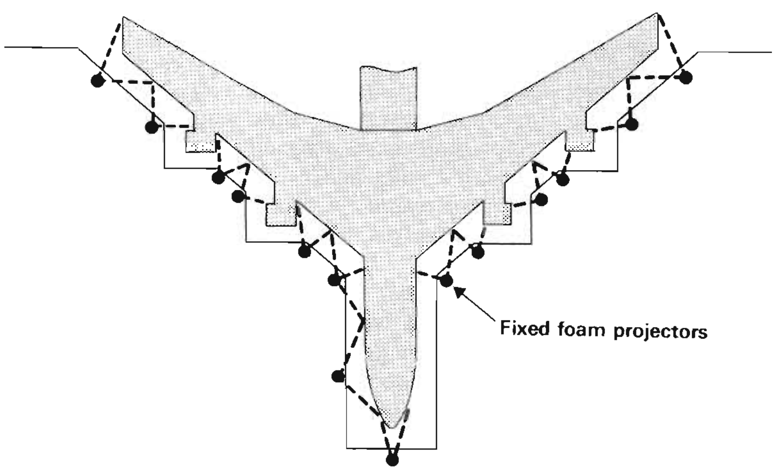


Fig. 4.2 Fire protection in hangars where fixed maintenance platforms are used.

Plate A.1 Two DC-10 aircraft showing fore and aft passenger loading doors, overwing exits and crew exits
Photo: British Airports Authority

Plate A.2 Tri-Star passenger aircraft illustrating height to engine exhaust Vehicle is a Gloster-Saro Javelin.
Photo: British Airports Authority

Plate A.3 Fully loaded Victor tanker aircraft on fire following an aborted take-off The crew escaped unharmed.
Photo: Royal Air Force

Plate A.4 Phantom and Harrier Note assorted fuel tanks and weaponry packs.
Photo: Ministry of Defence.

Plate A.5 Buccaneer aircraft with various attachments.
Photo: Ministry of Defence.

Plate A.6 Test ejection with canopy shattered by MDC about 0.7 seconds before seat fired. Front cockpit is at the initial shattering stage before ejection.
Photo: British Aerospace

Plate A.7 Two Jaguar aircraft with a variety of bombs and missiles
Photo: Ministry of Defence.

Plate A.8 A Harrier making a semi-hover approach Compare with Plate A 25
Photo: Royal Navy

Plate A.9 Boeing Vertol 234 Note the droop of the forward rotor, the rear escape hatch and the cutaway delineation The bulges at the bottom of the fuselage contain fuel tanks. Also see Plate A.10.
Photo: British Airports Authority

Plate A.10 The Chinook which can be compared with its civil version in Plate A 9 Note the break-in panel and escape hatch
Photo Ministry of Defence

Plate A 11 Mk 4 Sea King helicopter of the Royal Navy Various delineated panels and doors can be seen.
Photo Royal Navy

Plate A.12 Royal Navy Lynx helicopter The means of access is clearly marked The tail rotor of this aircraft would be very low
Photo: Royal Navy

Plate A.13 Defective nose-undercarriage landing where airport fire service has laid protective foam to forestall any ignition Illustrates type of crew door which could be encountered.
Photo: British Airports Authority

Plate A.14 Typical tyre failure on multi-wheel undercarriage. The massive suspension can be clearly seen.
Photo. British Airports Authority

Plate A.15 Good example of DC-10 deployment of an escape chute. The sheer height of the aircraft doors from ground level is worth noting.
Photo British Airports Authority

Plate A.16 A Boeing 707 of Egyptair crashed at Geneva airport. All exits have been used on the port side plus the forward chute. The engine in the foreground looks to have been the port inner
Photo: Commandant du Service Sécurité, Aéroport de Genève.

Plate A.17 The result of a flashover within an aircraft, showing an internal view of its construction and the type of cladding and seating material
Photo: British Airports Authority.

Plate A.18 An impact crash with no fire, showing examples of sheared metal

Plate A.19 A Sikorsky S61N helicopter operating the Gatwick – Heathrow air link
Photo: British Airports Authority

Plate A 20 Hawk 2-seat attack aircraft with Sidewinder missile and cannon. Compare with Plate A 23
Photo British Aerospace

Plate A.21 Boeing 747 with 3 engines running The height of the aircrew position above ground and the overall size of this aircraft is noteworthy
Photo British Airports Authority

Plate A.22 A Boeing 757 on approach.
Photo British Airports Authority

Plate A.23 An overturned Hawk This was a difficult rescue as both ejection seats were 'live' The pilot had to be supported whilst the seats were made safe.
Photo Ministry of Defence

Plate A 24 Heavy landing of a helicopter The lightness of construction can be easily seen.
Photo Royal Air Force

Plate A 25 Single-seat Harrier following a low-level crash and fire It was difficult to reach the pilot
Photo Royal Air Force

Plate A 26 The front cockpit of a Hawk aircraft Note the MDC, aircrew equipment, ejector seat and, behind the seat, the pin-rack The stencilled and visual instructions on the fuselage are self-explanatory
Photo British Aerospace

(4) Detection

There is a sophisticated system of fire detection equipment in all large hangars. Various types will be found. Some hangars use a system which responds to an abnormal rate of rise in temperature, and which is unaffected by stray ultra-violet or infra-red rays. Usually, total reliance on one system is not recommended, and this system is often backed up by another using quartzoid bulb detectors with a fixed operating temperature.

6. Military airfields

a. Categorisation and firefighting facilities

Depending on the type of airfield and the aircraft that use it, or are likely to use it, all military airfields are categorised and the airfield fire service vehicles are graded in accordance with that category.

The crews manning these appliances will all be specially trained and be specialists in aircraft crash procedures. Their organisation, appliances, equipment and training are geared to a response time of two minutes to an aircraft crash and a suppression time of three minutes from the start of firefighting operations. Appliances vary but, on the larger, busier airfields, are similar to those used on a large civil airport.

Military fire services are also used to cover the domestic risks on their airfields and, possibly, in the adjacent areas which are military property, e.g. living quarters. The attendances for these risks will be as for any other similar risk category.

Airfields used by the USAF have similar arrangements for fire cover. Their categorisation of airfields is somewhat different, and their appliances are usually larger depending on the type of aircraft using the field. Where the passenger-carrying traffic is heavy and the largest aircraft land, the LAFB could find fire appliances weighing up to 60 tonne.

b. Calls to incidents

A call to an LAFB about a military aircraft accident will usually be made by the RAF, RN or USAF via the police. If an LAFB receive a call from a different source, they should notify the police immediately, asking them to inform the appropriate military authorities and to obtain from them details of any special hazards involved (see Chapter 8, Section 3a).

c. Liaison with military authorities
In each LAFB with an RAF, RN or USAF airfield in its area, the officer-in-charge should set up the same sort of liaison with the local station commander as with the manager of a local civil airport. He should obtain, if possible, a copy of the airfield crash map (Fig. 4.3). An effective plan of co-operation should be drawn up and responsibilities allocated. There will be areas, of course, which are militarily sensitive, including some aircraft, but these will be matters to be negotiated at whatever level is appropriate. The military authorities, as well as local authorities, will have to bear in mind that, in the event of a large incident, e.g. weapon storage depot fire, the resources of the LAFB will have to be employed. Without knowledge of the risk, LAFB firemen will be at a disadvantage, especially from the safety angle.

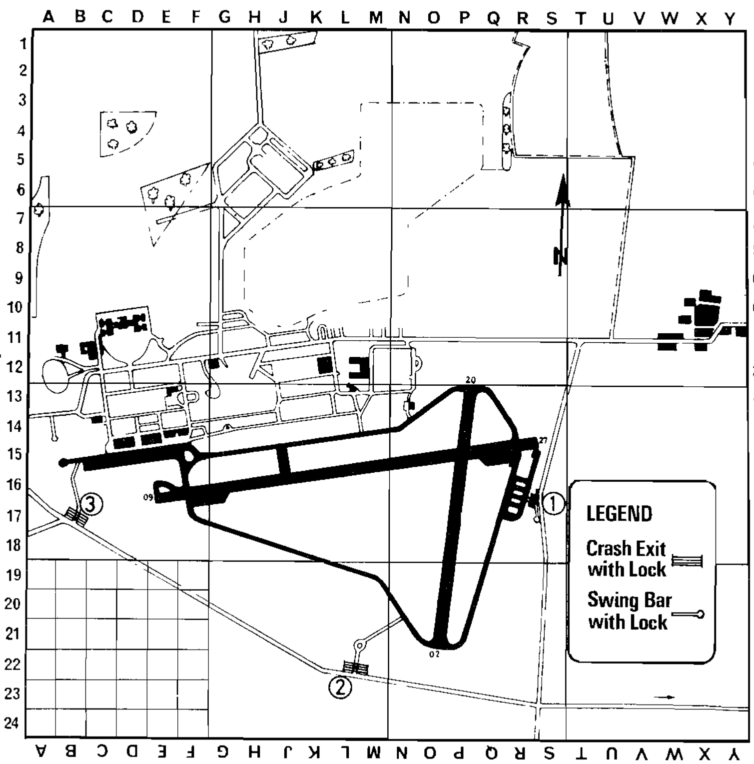


Fig. 4.3 An example of a military airfield crash map. LAFB personnel can add any local knowledge which they think could be useful.

Chapter 5
Incidents on airports

1. General

The primary object at an aircraft incident is to save life, and to do this by creating conditions where survival is possible. The extinguishment of a fire can continue after people have been rescued or given the chance to evacuate the aircraft safely. This chapter deals with firefighting procedures designed to assist survival at aircraft fires occurring on airports; actual rescue procedures are dealt with in Chapter 7.

The great speed at which fire can develop at an aircraft incident has led to the evolvement of the appliances, equipment and techniques which the airport fire services constantly use in practice and update. Nevertheless, as explained in Chapter 4, the assistance of the LAFB will obviously be vital in many incidents.

Aircraft fires are not always external and do not always involve fuel, although the risk of the fire spreading to the fuel can never be ruled out. Internal fires in flight create the urgent need for the captain to get his aircraft down on the nearest airport which can take his type of aircraft. This usually gives the fire services time to deploy, and creates the best conditions for rescue and firefighting. Unfortunately many accidents happen either on landing or take-off, and the response, although fast, often approaches a rapidly deteriorating situation. (Sometimes, of course, where a mishap occurs in flight, the captain is unable to reach an airport in time, and the aircraft consequently lands or crashes elsewhere. This eventuality is dealt with in Chapter 6).

2. Features of aircraft fires

A considerable proportion of an aircraft is occupied by highly flammable systems. An aircraft taking off will have a large fuel load, and even at the end of a flight there is still a considerable amount of fuel on board. Any serious crash will inevitably lead to an escape of fuel which will often ignite immediately. There are, moreover, numerous sources of potential ignition in a damaged aircraft which are capable of starting a fire some time after impact. The development from ignition to peak intensity can be very rapid, the fuel flowing and presenting a large flame front and huge amounts of smoke. The aircraft is quite likely to be on

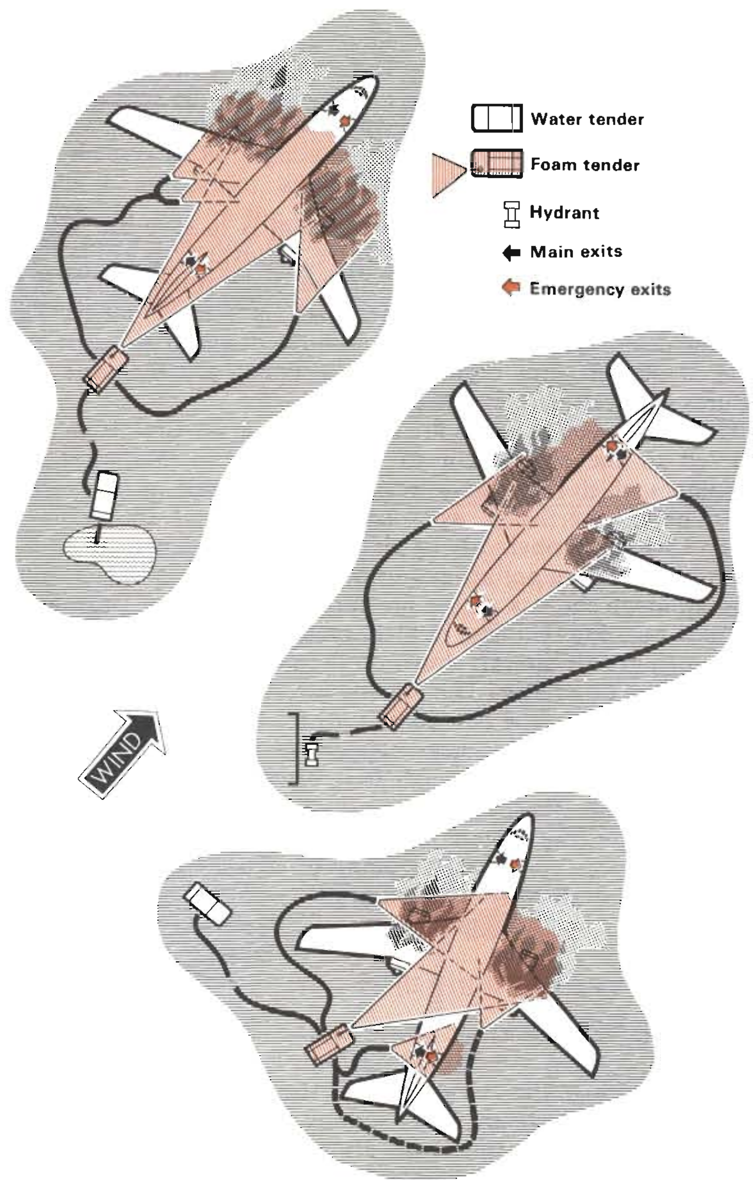


Fig. 5.1 Three examples of the positioning of one foam tender with a back-up supply of water

its belly, possibly in several broken sections, perhaps on grass or off the end of the runway.

3. Basic firefighting

a. Positioning of appliances

The first appliances to arrive will obviously be those of the airport or airfield fire service. The officer-in-charge must deploy his appliances and crew immediately to the best advantage, taking particular care to keep the doors and escape slides usable for passengers to escape. The ability of appliances to apply foam or other extinguishing media whilst on the move means that a developing, moving situation can be constantly covered. Wind may keep one side of the aircraft relatively clear, but all parts of the fuselage are vulnerable to penetration by fire, and heat can even cause internal fittings to decompose and burn, giving off lethal fumes. Fig. 5.1 gives examples of attacks mounted with one foam tender and a back-up supply of water. The diagram emphasises the efforts to be made to keep the fire from the fuselage, and illustrates the desirability of positioning appliances upwind of the incident where possible.

The aircraft may have come to rest off the runway and on very soft terrain where it would be difficult to manoeuvre appliances. In these circumstances, it will be necessary to park the appliances on the nearest solid ground and deploy hand lines. Firemen will need to bear in mind, however, that free fuel may be flowing around them, and, if not adequately covered by an extinguishant, could ignite and trap them. Similar care should be taken in respect of appliances. If any of the aircraft's engines are still running, all personnel should keep well clear of their intakes and exhaust outlets (see Chapter 7 Section 2a(1) and Fig. 5.2).

b. Application of extinguishing media

The main object of the firefighting will be to keep the fire away from the escaping occupants of the aircraft without obscuring or hampering any escape route. If fitted, the escape slides of the aircraft will have been activated and passengers will be using them (Fig. 1.9). Some passengers may make their way along the wings or down the wing roots, and any application of foam or water onto these areas could impede their escape and make the surface dangerously slippery.

Sufficient foam should be applied to the aircraft to knock down the flames and maintain the seal to prevent re-ignition. Care should be taken not to drive fuel about by too direct an application. If fire penetrates the fuselage, rapid steps should be taken to introduce a water fog into the affected area, both to cool it and to prevent the rapid build-up of heat and smoke which can trap

Fig. 5.2 Diagram of recommended lanes of approach, showing safe distances from engines if they are still running.

people inside. It may be necessary to penetrate a window in order to insert the fog nozzle. BAA are at present using a type of water-spear which combines penetration with a fog-making capacity.

If the fuselage does become smoke-logged, ventilation will be necessary. The necessity to enter for this purpose, and yet not impede passengers escaping, can require a quick decision as to the method and point of entry. Firemen must bear in mind, however, that to open up without a cooling fog may lead to a flash-over.

There could be areas where foam will not penetrate, and there is a requirement for suitable extinguishants to back up the initial attack. These can be CO_2, dry powder or a halon, usually BCF. Fig. 5.3 shows how they may be deployed.

Not all aircraft crashes are of sufficient severity to result in fire, but any free fuel is a potential danger and should be covered with foam or other suitable extinguishant, e.g. AFFF, to prevent

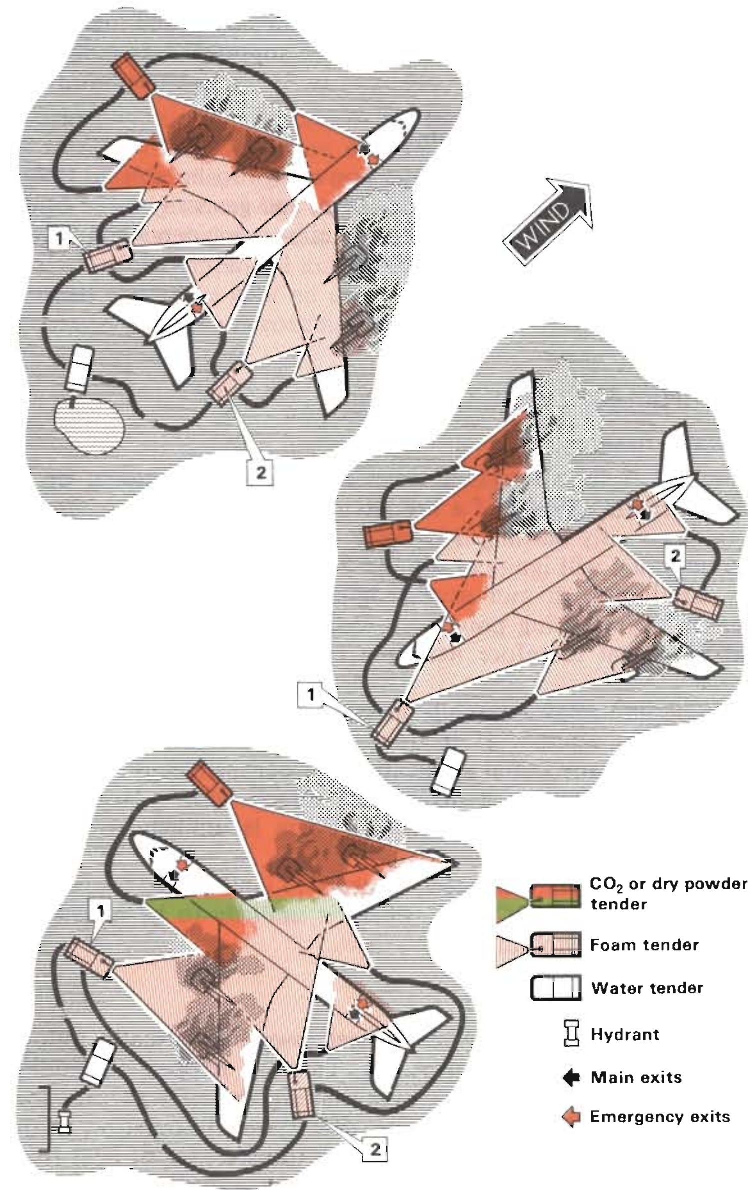


Fig. 5.3 Three examples of the positioning of appliances when using two foam tenders supported by a dry powder, CO_2 or halon unit.

ignition (see Plate A.13). If fuel is leaking from ruptured tanks or supply lines, firemen should attempt to seal off the flow. In any case, sufficient equipment should be deployed and manned so that, if a fire does break out, it can be suppressed as quickly as possible.

c. Handling of aircraft equipment

Airport firemen should have the knowledge to be able to isolate master switches, disconnect batteries etc and generally make equipment safe. LAFB firemen attending airport incidents should not tamper with any of this equipment.

4. Particular types of fires

a. Metal fires

Given the usual attendance times at an aircraft incident on an airport, the likelihood of a fire having reached a point where the metal is actually burning is remote.

Aluminium will ignite at around 800°C, but the various alloys, e.g. duralumin, do not usually ignite in aircraft fires, possibly because their melting points are well below their ignition points and the metal therefore has time to flow away from the heat source.

Magnesium alloy is usually in large sections, in which form it is not easily ignited. If it does ignite, however, it can burn violently, and any initial application of foam will cause it to burn explosively. However, a determined attack with a large jet of water will quickly cool the metal. Foam is unlikely to achieve this.

Titanium and stainless steel, in order to ignite, need a sustained temperature of 2000°C plus, which is unlikely to be reached in the course of firefighting.

b. Brake and wheel fires

The overheating of brake and wheel assemblies usually follows excessive braking (see Plate A.14). This can happen on landing when the captain feels he is over-running the runway or, more often, on aborted take-offs. Quite often tyres will burst or, as the aircraft comes to a standstill, ignite by transference of heat from the brakes. To avoid metal failure, firemen attending overheated brake and wheel assemblies should usually refrain from applying water and allow natural cooling. If there is fire apparent, however, a fine water fog from fore and aft is generally used, men and appliances being kept away from the side of the wheels in case of rim failure. Any involvement of the oleo legs should normally be

dealt with using BCF, and, if there is any possibility of undercarriage failure, personnel under the aircraft should be kept to the minimum.

c. Ground incidents

Occasionally, stationary aircraft on the aprons go on fire, often due to a fuel spillage. There may be passengers aboard and the aircraft may, or may not, be attached to its loading jetty. Firemen should be wary of driving through smoke, as an evacuation may be taking place and they risk causing casualties. Horns and lights should be fully employed and, even when appliances are at rest, the lights should be kept on until the smoke has cleared, to warn other such vehicles approaching.

Chapter 6 Incidents off airports

1. General

When an aircraft in flight develops an emergency condition, the captain will make every effort to land at the nearest suitable airport. He may, however, be forced to make an emergency landing elsewhere, and this may prove particularly hazardous if there is a shortage of flat, open land in the vicinity. Occasionally, a structural failure may cause an aircraft to plunge suddenly and uncontrollably to the ground, possibly in a built-up area. The latter type of accident can obviously result in much loss of life, injury, and damage to property.

2. Liaison

The first responsibility for liaison with civil and military air authorities in respect of aircraft in distress or crashed in the UK (other than on airports) lies with the police. On receiving information from ATC about an aircraft in distress or which has crashed away from an airport, the police immediately notify the other emergency services, giving all relevant information. If an LAFB receives such information from a different source, they should notify the police as firefighting resources are being mobilised; the police will then notify the air authorities, the ambulance service, and any other authorities they think necessary. The information should contain as much of the following as can be ascertained:—

(i) Type, description, registration number and flight number of the aircraft;

(ii) Nature of incident;

(iii) Location of incident;

(iv) Time incident occurred;

(v) Action already taken;

(vi) Name and location of officer making report;

(vii) Name and address of person making report.

3. Locating the incident

The speed with which a crashed aircraft can be located will depend on a number of factors. If the captain has been able to give his position to his ATC or if the aircraft has been seen to disappear off the radar screen at a certain spot, the circumscribed area could be reasonably small. Unfortunately some accidents happen very quickly, leaving the crew little or no time to send a distress call, and this often results in a call to the emergency services from an observer who may only be able to give a rough estimate of where the aircraft has crashed. Obviously, whoever takes the call must make every effort to get as much information as possible, especially the exact position of the observer. Most authorities, including the RAF airfield services, use the National Grid of the Ordnance Survey and, in any preplanning, a general agreement on map references based on this system is invaluable. The chances of the observer being able to give a grid reference himself are remote but, from the information gleaned, a search area based on a calculated reference point could be given to the PDA.

4. Approaching the incident

If the crash is in an inhabited area, location and approach could be relatively simple. It is when the crash has occurred in a remote rural area that local knowledge is important. In deciding on the route of approach, a lot will depend on the terrain, time of year, weather etc, and it will probably be expedient to divide the PDA and try alternative routes if there is any doubt about a particular way in. LAFB appliances are seldom designed for rough cross-country work and care must be taken not to get them bogged-down, blocking the approach to an incident. Regard should also be had to their ground clearance. Vehicles left unattended whilst personnel proceed on foot should be parked clear of the approach in a safe manner.

There will be a considerable amount of debris to be avoided, particularly if the approach follows a slide path made by the aircraft. In all cases, a sharp look-out must be maintained for survivors who may have been thrown from the aircraft or crawled away.

Once the incident has been found, Brigade Control should be informed of the exact location, the best approach method and the actual circumstances e.g. fire, scattered wreckage, the presence of any survivors, the assembly points for appliances and ambulances etc., and the need for any further assistance. If possible, a guide should be posted or, at night, portable lights positioned, to indicate the route in and, perhaps, an alternative route out.

5. Firefighting

At a crash in an inhabited area a lot will depend on where and how the aircraft has finally come to rest but, generally, the firefighting will be similar to that described in the previous chapter, with the LAFB providing the foam attack and the attendance being somewhat slower. However, at an incident in a remote rural area, involving heathland, woodland, crops etc, a fire may have been burning for some time before appliances can reach the scene, and there will be problems of water supply, wind direction and approach route. The officer-in-charge of the initial attendance may have to decide whether to:

(i) tackle the main bulk of the wreckage fire with the very limited resources at his disposal (Fig. 6.1);

(ii) wait for reinforcements whilst his men look for survivors, and then set up an attack;

(iii) use his water to prevent the spread of fire which could inhibit reinforcing appliances attending;

and so on. He must, as previously stated, give his Control all the information on the situation, state what assistance he will need, direct the approach of appliances, establish rendezvous points, liaise with the other emergency services as appropriate, look for water supplies, consider setting up a water relay etc.

If possible, appliances should be positioned as for a similar accident on an airport (Fig. 5.1), but this will depend a lot on the terrain plus, if it is a military aircraft, armaments (see Chapter 8).

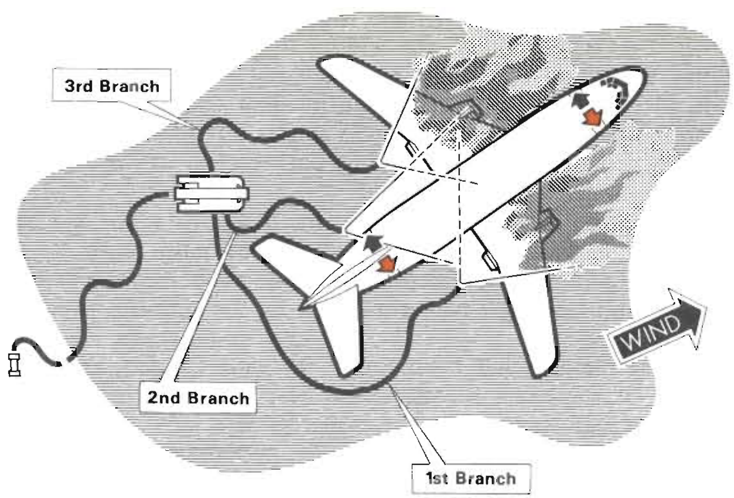


Fig. 6.1 A possible plan of attack using one LAFB appliance. The effort is directed to keeping fuselage integrity and reducing the temperature.

Appliances should normally be parked upwind of the incident, and on higher ground if possible, in order to avoid the flow of spilt fuel and fuel vapours.

6. Casualties

a. Location of casualties

Even in the most severe crashes there could be survivors, albeit badly injured, and a careful search should be made over a fairly wide area along the slide path and around the final wreckage point. In the time it could take the LAFB to find and reach the scene, people may have escaped from the aircraft, moved some distance away, and then collapsed, possibly in ditches, under bushes etc. Some people may be lying injured after being thrown out of the aircraft on impact. Many people, of course, may still be inside the aircraft or under debris, being either physically trapped or in an unfit state to escape, and the methods of rescuing them are dealt with in Chapter 7.

It should be possible to obtain, via ATC, an idea of the number of people who were aboard the aircraft. Firemen should remember that, if ATC can be given the registration number of the aircraft or even the aircraft type or operating airline, this will help to identify the flight in cases where ATC do not already know it. If the number of people on the flight can be ascertained while the LAFB is still on the scene, the officer-in-charge should check this against the number of survivors and bodies located. It should, however, be remembered that not all the accident victims will necessarily have been occupants of the aircraft, since there may be ground casualties also, especially where a crash occurs in a built-up area. The total number of persons found should if possible be carefully recorded, and this information should then be passed on to the police, who have the ultimate responsibility for ensuring that everyone is accounted for.

b. Handling of casualties

The handling of casualties in any off-airport incident will be difficult, but the advice given in Chapter 7 Section 4 should be followed. If the Ambulance Service are already in attendance, casualties should as a general rule be carried direct to waiting ambulances. If these have not yet arrived, an area safe from possible involvement in fire should be set aside where survivors can in the meantime be carefully taken and given first aid. Firemen should however bear in mind that some casualties may have injuries which could be seriously aggravated by inexpert handling; it may be desirable, depending on the fire situation, to leave such casualties in situ until the arrival of ambulancemen. (This applies particularly to ejected crew members of military aircraft, who will probably have sustained back injuries as a result of the force of the ejection). In any aircraft crash, almost all survivors are likely to be suffering from shock, and those that are able to walk will therefore need to be physically led to the ambulances or casualty clearance area, as they may not respond to directions (see the *Manual*, Book 12, Chapter 6).

It will be difficult, in a multi-casualty incident, for firemen to decide which casualties to deal with first. Even identifying who is dead and who is alive will not be easy; casualties should be assumed to be alive unless it is absolutely clear that they are not.

Firemen should ensure that the other emergency services are informed of how each casualty has been dealt with (see the *Manual*, Book 12, Chapter 4, Section 6b). The question of dealing with dead bodies is covered in Section 8b below.

7. Particular types of accident

a. Crashes involving buildings

Where a passenger aircraft crashes onto buildings, especially those which are inhabited, the problem normally assumes the classification of a major disaster (see the *Manual*, Book 12 Chapter 4). The breaking up of the aircraft could spread fire and destruction over a large area, with several major fires and many small ones developing at the same time. Apart from the aircraft casualties, the numbers involved in the buildings could be high, and the county major accident scheme should be implemented as soon as possible.

If by some chance the fuel has not ignited, it should be covered with foam and all persons in the vicinity and downwind for some distance warned to put fires out and to avoid smoking or any use of flame. It is quite likely that some of the fuel will run into the drains; the appropriate authorities must be informed of this risk, and the sewers flushed with water.

b. Crashes into water

Where airports are situated near large areas of water, there is always the possibility of an aircraft crashing into the water. Airport firefighting services which have this risk will usually include some type of rescue craft in their equipment. Heathrow, for instance, has a small hovercraft on a trailer, which can be taken to the scene by RIV. This can carry 20-man life rafts and operate not only on water but also over the extensive sewage sludge areas adjacent to the airport. Other airports have inshore rescue dinghies or arrangements with RNLI, coastguard, local pilot organisations, tug companies etc.

When an aircraft crashes into water, there is the possibility of extensive fuel leakage onto the surface of the water, which may or may not ignite. The breaking up of this fuel by jets of water,

or its coverage by foam or AFFF, can prevent ignition or at least make the spread of fire less likely. Firemen should remember that fuel, rising to the surface, may come into contact with hot parts of the aircraft or other ignition sources such as boat engines. It is likely to remain a potential hazard throughout any rescue operations, although it will, of course, disperse eventually.

Depending on how the aircraft came down, sections of the fuselage may be found floating with passengers still inside, and care must be taken to avoid disturbing their capability to float. Rescue operations should be carried out as quickly as possible in case the buoyancy is lost. Rescuers should themselves beware of being trapped inside the fuselage. Occasionally, occupied sections of the aircraft may be submerged but still retain their integrity and, depending on the depth of water, divers may be required urgently. The officer-in-charge should liaise with the police on this matter.

8. Post-accident discipline

It is generally the job of the police to provide protection to the area involved, and this could be difficult if the aircraft wreckage is spread over hundreds of metres. The Accident Investigation Branch (AIB) of the Department of Transport have the authority, under the Civil Aviation Acts, to investigate aircraft accidents, and the police will inform them of the incident. It is however the responsibility of all personnel at the scene to conduct themselves with some thought towards the subsequent investigation, and they can do that even when firefighting or carrying out rescues. The AIB are based in Hampshire, and it could be hours before they arrive.

The main aspects of post-accident discipline, taking into account the need for (i) safety and (ii) the preservation of evidence for AIB, are set out below.

a. Movement of wreckage

Even in remote areas it is surprising where people can appear from. No unauthorised person should be allowed anywhere near the incident, not only for their own safety, but also to try to ensure that wreckage is not disturbed or removed. Vital evidence can be destroyed by people clambering over wreckage and trampling equipment into the ground. Obviously firemen, in carrying out rescues and firefighting, may need to move parts of the aircraft, but they should, where possible, try to note the original position of the wreckage, having particular regard to the settings of switches, controls, levers etc. They should also bear in mind the precautions to be taken in respect of certain special hazards (Chapter 8 refers).

b. Dealing with bodies and personal effects

(1) Bodies

The positions of all dead bodies, whether in the aircraft or not, are important for their identification and, possibly, to help the AIB establish the cause of the incident (especially in the case of bodies found on the flight deck). There are many medical and legal considerations which will depend on the accurate charting of these positions, so firemen should normally leave the obviously dead in situ. Heavily carbonised bodies become brittle, and any movement of them by unskilled persons could destroy evidence of cause of death. In some cases, however, it may be necessary to move a body for the purposes of firefighting or rescuing survivors, or in order to prevent the body being destroyed by fire or some other hazard.

In a high speed crash, possibly into a forest, bodies and parts of bodies can be scattered over a large area. It is not normally the task of the Fire Service to move these.

Officers-in-charge must also bear in mind that, although firemen are usually inured to seeing a body, the scene of carnage at some incidents may have an effect on some personnel.

Further details about dealing with bodies are given in the *Manual*, Book 12, Chapter 13.

(2) Personal effects

The position of the personal effects of passengers and aircrew, not only in the aircraft but also in the rest of the incident area, can help the AIB. This is why it is important to control the number of people on the site and, when it is considered safe to do so, to carefully withdraw all personnel and vehicles whose presence is no longer essential.

c. Photographs

If it is possible to take photographs, both of the wreckage and of the position of bodies, this will help the AIB in their investigation. Although the media should not be allowed to move indiscriminately about the accident site, any photographs they take could also be valuable.

d. Documents

A large number of documents are carried by aircraft, and firemen may find them in the wreckage. Such papers should be carefully collected, provided that it is safe to do so. Those which are damaged or burnt should be preserved in the best way possible, e.g. in plastic bags. The papers should be handed over to the police at the earliest opportunity. The type of documents which can be of particular value include log books, technical logs, load and balance sheets, passenger and freight manifests, maps etc.

e. Flight recorders

As pointed out in Chapter 1 Section 9, all civil passenger aircraft, and many others, carry a flight recorder, which is usually painted "dayglow" red and is designed to resist shock and fire. If found, it should be handled as little as possible, and normally left exactly as it is, until the arrival of AIB. The police should be notified of its discovery. Only if it is in danger of being irretrievably lost, e.g. into marshy ground, should it be moved, and if so it should be handled with care and its original position should be noted. Despite its robust construction,everything possible should be done to protect the recorder from excessive heat.

f. Ignition sources

It is fairly obvious that, because of the likelihood of spilt fuel, nobody, including casualties, should be allowed to smoke in the vicinity of an aircraft accident. Any possible sources of ignition, e.g. radios, appliance engines, generators, should be shut down where there is any chance of a mixture of fuel vapour and air being present. Firemen must remember that fuel and vapour may gather in isolated pools some distance down-contour or downwind of the wreckage.

g. Evacuation of buildings

The occupants of any buildings in the danger area should be advised to leave the buildings by the safest possible route and to remain in a safe area until further notice. All doors and windows facing the aircraft should be closed, gas and electricity turned off at the mains, and any domestic fires, stoves etc extinguished.

Chapter 7
Rescue from aircraft

1. General

In any aircraft accident the evacuation and/or rescue of the passengers and crew is paramount and the accent is on speed. Firefighting, if it is necessary, must be carried out with the safeguarding of the evacuation and the protection of the fuselage as its main objectives, and the officer-in-charge must try to position his appliances with this in mind (see Chapter 5 Section 3). The method of rescue will, of course, depend on the type of aircraft, its attitude, e.g. wheels-up, nose-down, in one piece or not, and where the fire, if any, has broken out. As mentioned in Chapter 6, the likelihood of passengers or crew lying injured outside the aircraft, and possibly some distance away from it, must not be overlooked.

2. Rescue from civil aircraft

a. Gaining entry to an aircraft

(1) General considerations

In particularly serious crashes, an aircraft may hit the ground with such force that it breaks up completely, and the question of entering it will therefore not arise, although pieces of wreckage may need to be cut through in order to release trapped occupants. In less severe incidents, however, an aircraft may remain substantially whole, or may break into sections which nevertheless retain their integrity. In such cases it will be necessary for rescuers to gain entry to the aircraft through one or more of the access points provided.

Where an aircraft is still in one piece, a lot will depend on whether evacuation is being carried out at the time of the LAFB's arrival, and if so, how. The fact that an evacuation is going on should not prevent firemen from entering the aircraft for rescue purposes, provided that they can gain access without hampering the escaping occupants. Aircrews usually work on the principle that most fires occur at the forward end of the aircraft, ie where the engines and fuel are, and tend to get passengers out aft if possible.

Occasionally, depending on how hard the aircraft has landed, one or more engines may still be running, mainly to maintain power to depressurise, open doors etc. (This will also be the case in many ground incidents—see Chapter 5, Section 4c). Firemen should beware of this possibility, and approach from the wing tips. If they need to pass in front of or behind an operating jet engine, they should always keep at least 7.5 m away from the intake to avoid being sucked in, and at least 45 m away from the exhaust outlet to avoid being burned (Fig. 5.2). Special care should be taken at night.

The particular hazards associated with helicopters, and details of access points on such aircraft, are described in Chapter 3.

(2) Doors

Details of aircraft doors are given in Chapter 1 Section 7a, and examples are shown in Figs. 1.6 and 1.7 and Plate A.1. They can all be opened from the outside, according to the instructions marked on them. These should be carefully read, as failure to appreciate the correct method of opening a door could lead to considerable delay in rescue operations and possible injury to the fireman. If it is necessary for a fireman to pitch a ladder in order to reach a door, he should be careful to avoid the risk of being knocked off by the operation of the door, which will probably open quite quickly. Fig. 7.1 gives details of the heights that may be involved.

If a door is jammed, it will usually be worthwhile for firemen to spend time trying to force it whilst at the same time attempting to gain access elsewhere.

(3) Emergency stairs

Some doors may be fitted with stairs, which in an emergency can be operated from either inside or outside (see Chapter 1, Section 7b).

(4) Escape slides or chutes

As pointed out in Chapter 1, Section 7c, the operation of a door from outside will not normally result in the deployment of an escape slide. The possibility of this cannot, however, be ruled out, and, if a slide does deploy, it is likely to do so suddenly and with considerable force. Firemen should bear this in mind, especially when on ladders.

If a malfunction has caused a slide to inflate whilst still in the cabin so that it blocks the door, firemen should try to get it to deploy normally. If this cannot be done, it should be punctured so as to deflate it.

Escape slides should not be disturbed if they are being successfully used when rescuers arrive, but should be protected if possible

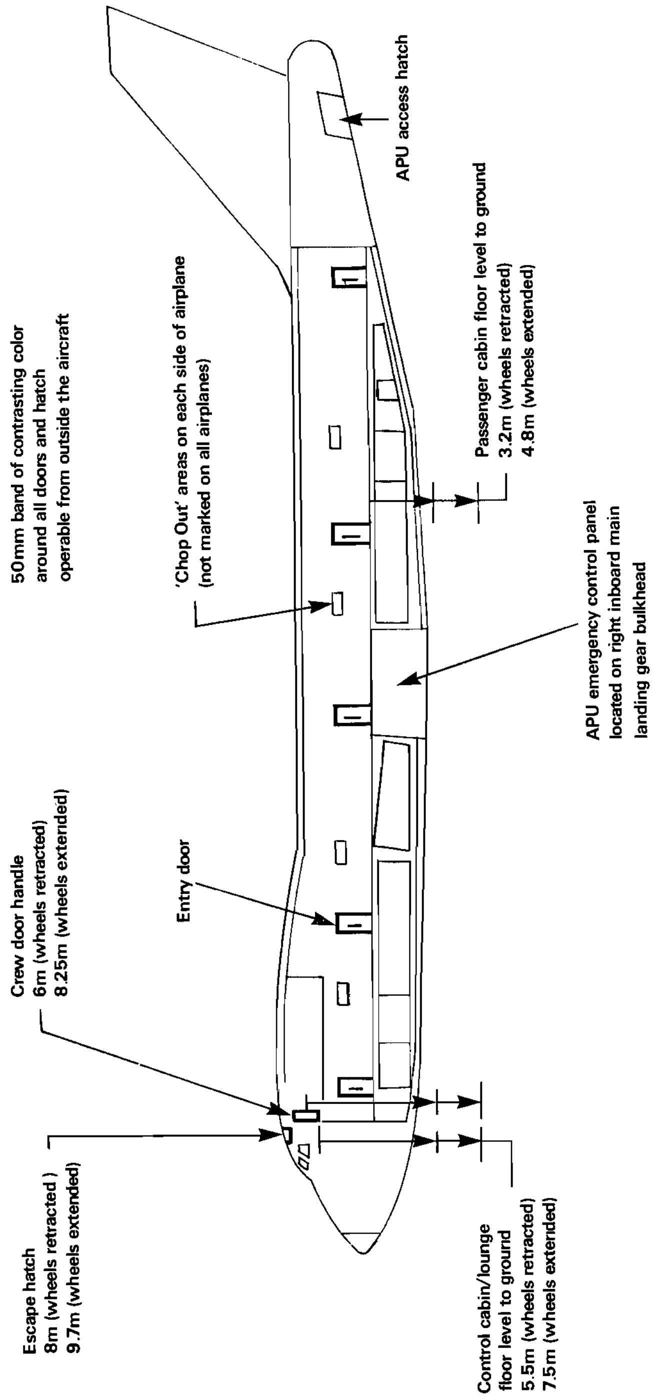


Fig. 7.1 Diagram of Boeing 747 showing the heights to the various means of escape (a) wheels extended and (b) wheels retracted. Note the depth of body below passenger compartments.

and assistance given to people evacuating (Fig. 1.9 and Plates A.15 and A.16).

(5) Emergency hatches

Where passenger doors are impassable, the emergency hatches (see Chapter 1, Section 7e) should be tried. It must be remembered by firemen that these are heavy and require firm handling. Passengers using overwing exits may have to slide off the trailing edge of the wing or use the escape lines provided, and they should be assisted down to prevent injury.

(6) Breaking in

Cutting through the airframe (see Chapter 1, Section 7f) should be a last resort. If it proves necessary, it will almost certainly entail the use of power tools, but firemen must take great care that the use of these does not cause further injury to trapped passengers. They should also remember that such tools, especially abrasive discs, can prove to be ignition sources in fuel-air atmospheres. When entry is made, any jagged edges must be suitably covered to avoid injury to passengers and firemen.

The underside of a fuselage is usually unsuitable as a break-in area because it only gives access to baggage compartments and/ or cavities under the passenger floor which often contain cables, hydraulic pipelines, fuel pumps etc (see Fig. 7.1).

b. Operations inside the aircraft

(1) General considerations

On entering an aircraft which has crashed, firemen will be confronted with probably a very chaotic situation (Plates A.17 and A.18). Luggage will have cascaded from the racks, seats may have been torn loose and wreckage may be blocking the gangways. As stressed in Chapter 5 Section 3b, any internal fire must be knocked out as soon as possible and the fuselage ventilated. LAFB firemen should not operate or interfere with any power controls or equipment unless absolutely necessary. The AIB (see Chapter 6 Section 8) should be notified, via the police, of any alterations made to the settings of switches, levers etc.

It can be assumed that if passengers and crew have not evacuated they are either trapped, stunned, unconscious, injured, or dead. Firemen must bear in mind the restricted room in the aircraft, and set up a system of releasing trapped survivors, removing them, if necessary along a 'chain' of rescuers, and taking them clear of the wreckage and out of any further danger. Civil aircrew are trained in rescue procedures and may be able to provide valuable assistance to firemen in methods and routes of removal. In serious accidents, it will almost certainly be necessary to use power tools in order to reach and extricate trapped occupants, but firemen should bear in mind the possible danger from these (see Section 2a(6) above).

The procedures for casualty handling (see Chapter 6 Section 6b) should be followed as far as possible. Persons suffering from asphyxia or haemorrhage (see the *Manual*, Book 12, Chapter 6) will require urgent attention and should be removed without delay, or, if they are trapped, should be given immediate first aid where they are. It is obvious that firemen must provide a safe environment, e.g. by foam coverage of fuel spillage and ventilation of the fuselage, before trapped or injured passengers can be left in situ, following first aid, to await careful extraction and removal. The type of injury will to some extent dictate whether passengers are to be removed immediately or left until expert medical supervision is available.

Gloves should be worn by rescuers to avoid the danger of infection. Should personnel be scratched, immediate disinfecting treatment should be given to prevent blood poisoning.

(2) Seats and seat belts

Passenger seats, as stated in Chapter 1, are designed to be easily adjustable, and crew on the flight deck also usually have a measure of adjustment in their individual positions. Using normal adjustments of even a few millimetres could expedite a rescue.

Seat belts for passengers vary in different types of aircraft, but they all incorporate a quick-release mechanism which has to be simple for the passenger to operate. They are unlikely to jam, but if for any reason this has happened the belt should be cut. Firemen must be careful to cut away from the passenger, and this may be easier if it is done at the side. Aircrew also have seat belts, which are usually slightly different but no more difficult to operate.

(3) Lighting

It may be necessary to provide lighting in the fuselage. Firemen should be mindful of the fuel vapour danger and also of the possibility of trailing cables being a dangerous nuisance. Possibly, if the removal of passengers is taking place from one side of the aircraft, any cables that may be required could be run in from the other side.

3. Rescue from military aircraft

a. General

Firemen must remember that a call to a crashed military aircraft will not necessarily involve rescues. The crew may have been able to eject, depending on the amount of notice they had of the

crash, and the aircraft may well therefore be empty of personnel. A high-speed crash, moreover, will cause an aircraft to disintegrate, and if the crew have not baled out their chances of survival will be minimal.

In cases where rescue is necessary, firemen should be careful to avoid passing in front of weapon racks, and, in the case of large RAF or USAF transport aircraft, they should always proceed on the basis that the aircraft may be carrying a nuclear weapon unless and until they are informed otherwise (see Chapter 8 Section 3).

The types of access found on military aircraft vary greatly, but the main categories are described in Chapter 2 Section 5. Firemen should remember that doors or emergency hatches may fall free once released, and they should control them firmly. There are also a number of other important points which firemen will need to bear in mind, and these are dealt with below.

b. Canopies

In single and dual seat military aircraft the perspex canopy or canopies are the only easy access to the crew. In an emergency, to facilitate entry, the canopy(ies) should, if possible, be completely removed, unless it can be seen that an attempt to eject has been made (see Section 3c below). There will be an external canopy release or MDC operating device for this purpose and instructions will be stencilled on the fuselage (see Chapter 2 Section 5d and Plate A.26).

(1) Canopy jettison

Firemen must remember that most hinged canopies have a jettison release mechanism, designed so that the slipstream of the moving aircraft tears the canopy clear. When an aircraft is at rest on the ground, the canopy may merely roll off towards one side or make a low trajectory or even just lift slightly and have to be manhandled clear. Other personnel and vehicles should be kept away while it is released.

(2) Miniature Detonating Cord

As stated in Chapter 2, some aircraft have a Miniature Detonating Cord (MDC) built into the canopy (see Fig. 7.2 and Plates A.6 and A.26). It is potentially a very hazardous device, being capable of projecting fragments of the canopy for up to 20 metres, and firemen should therefore only operate it if the normal release mechanism is out of action. The following procedure should be adopted:—

(i) A fireman should approach the cockpit in full view of the aircrew and be prepared to act on any signal from them that they are about to operate the MDC, e.g. turn away,

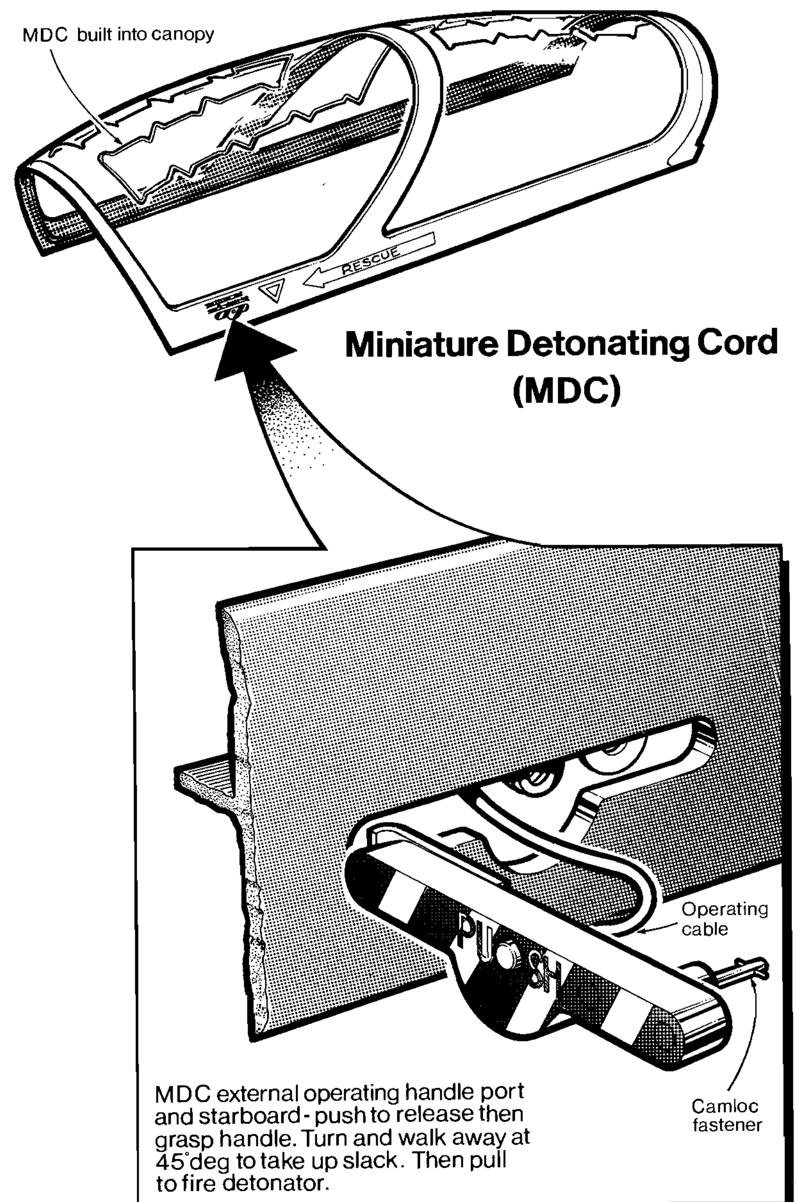


Fig. 7.2 Diagram of Miniature Detonating Cord and external operating device.

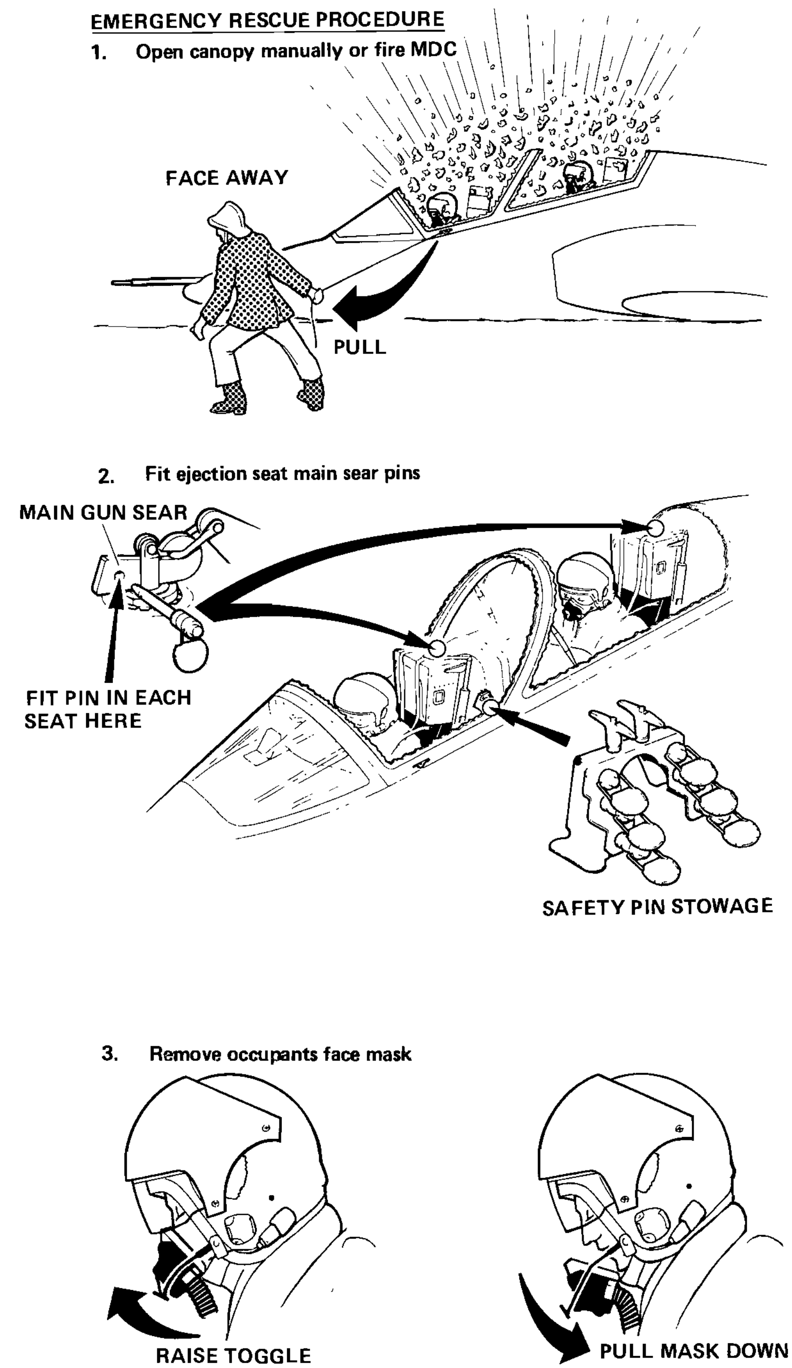


Fig. 7.3 Emergency rescue procedure on crashed military aircraft fitted with MDC and ejection seats.

crouch down as low as possible. A flash hood should preferably be worn.

(ii) He should remove the handle, as per the instructions on the fuselage, extend the cable and move in front of the cockpit as far as the cable allows. He should then face away from the cockpit, lower his head, and give the cable a sharp pull (Fig. 7.3(1)).

Firemen must take extra care if the aircraft is nose-down or canted towards the MDC operating gear side, since this could bring the trajectory of the fragments down to a low level. It may even be necessary to tie a line on to the MDC handle to extend the pull into a safer area.

Involvement in fire could cause the MDC to detonate, and an MDC-equipped canopy that has become detached from the aircraft complete could be lethal and should not be touched or even approached unless absolutely necessary.

There are two other points which firemen should remember. Firstly, if the crew are still in the aircraft they could be dazed and disorientated, and a cautious approach may be necessary in case they operate the MDC without realising that rescue is on hand. Secondly, the engines may still be running, in which case firemen should be careful to stay clear of intakes and exhausts when approaching or extending the MDC cable.

(3) Breaking-in of canopies

Attempting to smash the canopy with an axe or any other tool is absolutely the last resort. Perspex is very strong anyway, and in more modern aircraft it is laminated and virtually unbreakable. Apart from the hazard to the aircrew, there is always the chance of setting off an MDC, if fitted, or even an ejection seat, with disastrous results. Depending on the type of tool carried, it might be possible to cut the canopy with certain types of rotating saw, but the same hazards could apply.

c. Ejection seats

Chapter 2 points out that there are a variety of types of ejection seat in use, and stresses the importance of finding out details of them from the military authorities. Some basic advice on the handling of ejection seats is however given below. Great caution must always be exercised when dealing with such seats, because of the extremely powerful nature of the ejection mechanism.

(1) Martin-Baker ejection seats

Almost all Martin-Baker ejection seats can be made safe by the insertion of the safety-pin into the hole in the sear behind the head of the seat (Fig. 7.3(2)). The only exception, at present, is

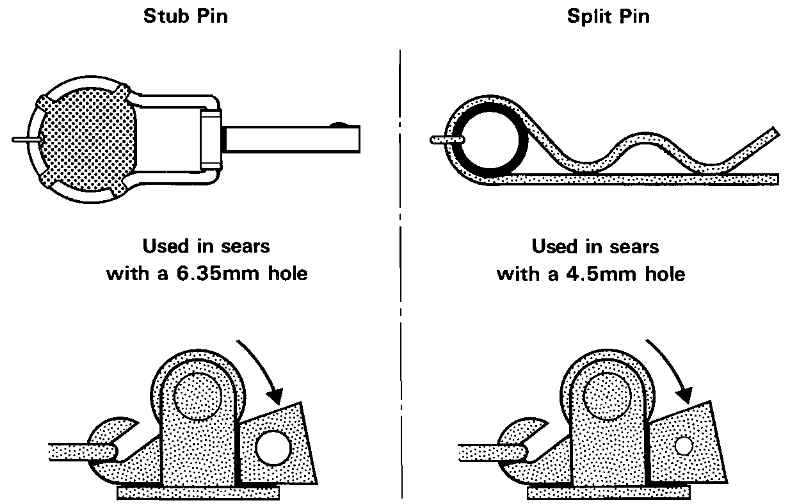


Fig. 7.4 Two different types of safety pins for insertion in ejection seat sears.

on the Tornado aircraft where there is no sear at the head but the pin is inserted in between the legs. The safety-pin stowage varies in different aircraft but firemen should look for the bright red or orange collection of tabs and from these select the 'main gun sear' (Fig. 7.3(2) and Plate A.26 show examples). Once the main gun sear pin has been inserted, the remaining sears can be made safe in a similar manner if circumstances allow. Pins can be of two types depending on the size of the sear hole (Fig. 7.4).

On some older aircraft the canopy is connected to the seat by means of a restrictor wire (Fig. 7.5), and, if the crew member has attempted to eject, the removal of the canopy will fire the seat. An unsuccessful ejection attempt will be indicated by the face-blind being out (Fig. 7.6) or the seat pan handle being loose, and in such circumstances the canopy *must not* be removed until the restrictor wire, if any, has been made safe. It will be necessary, depending on the type of canopy fitted, either to break or cut the canopy at the rear or to gain entry to the cockpit by other means, and a check should then be made to see whether there is a wire connecting the canopy to the top of the ejection seat. If there is, this wire will have to be disconnected from the canopy by removing the quick-release pin connecting the wire to the canopy. Alternatively the wire could be cut by pliers or wirecutters but, at all times, a conscious effort must be made to ensure that the wire is not pulled taut, the restrictor thereby removed, and the seat fired.

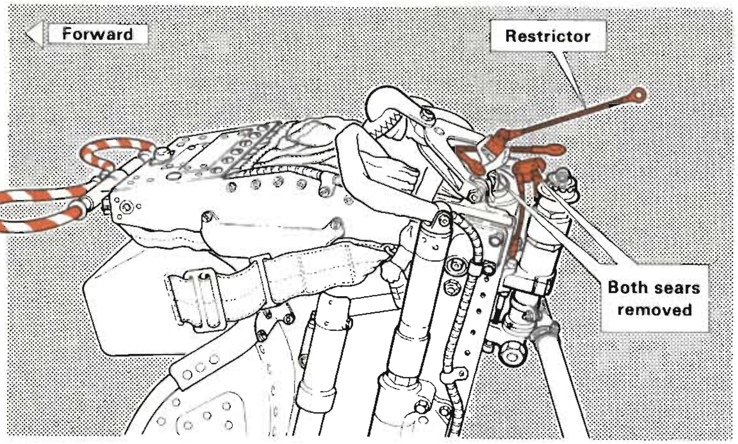


Fig. 7.5 A typical arrangement of a restrictor wire on an ejection seat.

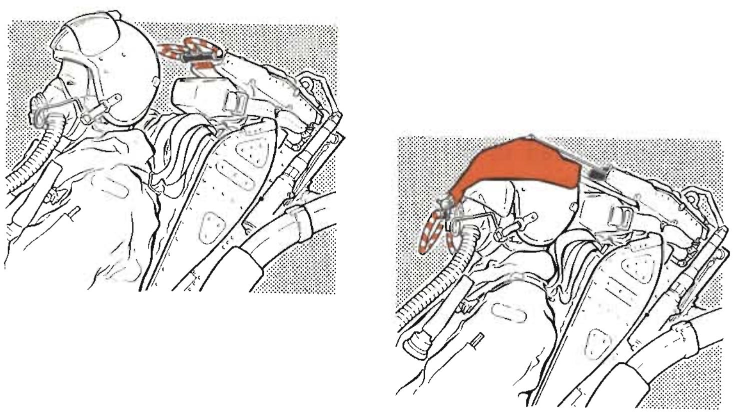
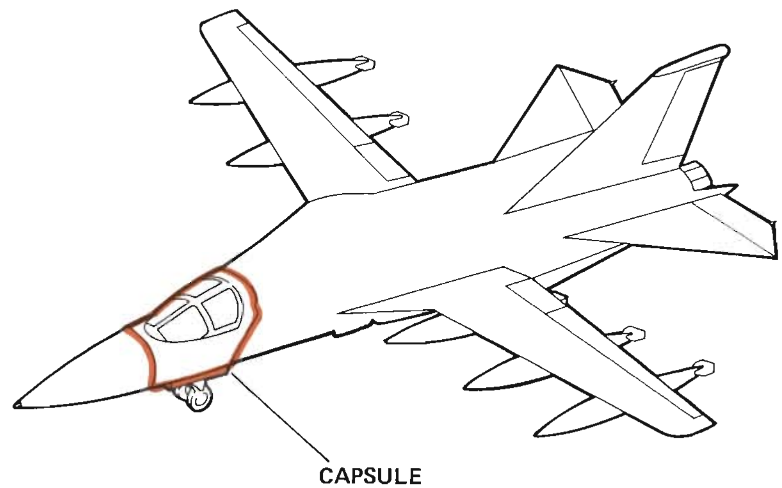


Fig. 7.6 Left: The face-blind firing handle in the stowed position. Right: The face-blind firing handle after operation.

(2) US ejection equipment

There are a considerable variety of US aircraft flying in the UK and, consequently, a number of different types of ejection equipment. Martin-Baker seats are fitted to some aircraft, similar to those in British aircraft, but there are also many US aircraft with US-designed seats of various types. Even different marks of the same type of aircraft may have different ejection seats, e.g. an F15A may be differently equipped to an F15D.

US aircraft have instructions stencilled on the fuselage on how to open canopies. Inside the cockpits, the ejection seat firing handles are easily detected by their black-and-yellow striped colouring. The locking pins for the handles and sears are, however, not kept in racks as on British aircraft, but in nylon bags at the side or, more generally, behind the aircrew. The pins are of different sizes to obviate the danger of being put in the wrong sear, and can often only be inserted one way. They may also be of a type with a press-button top which has to be depressed to get the pin in the sear. Firemen should, if possible, take time and care to study the cockpit layout and position of the crew before inserting the pins. Generally, as long as the main ejection seat handles are made safe, as in British aircraft, the remaining pins can be inserted but are not absolutely essential.



F – III – AIRCRAFT ENTRY (ALL MODELS)

1. EMERGENCY/NORMAL ENTRY

(a) Push internal lock release button, located both sides of aircraft below canopy rails

(b) Push forward end of external handle, located aft of internal lock release button, pull external handle and raise canopy to locked position

(c) Position handle back to the lock detent (midway) position to lock canopy open

2. CUT-IN

(a) Cut canopy along canopy frame

CAUTION – DO NOT CUT CANOPY FRAME

Fig. 7.7 Diagram of the ejection capsule of a USAF F111 aircraft. Similar instructions are stencilled on the fuselage.

(3) Ejection capsule

One US aircraft, the F111, has a different ejection system. On this type the whole capsule, containing the two aircrew complete with seats, cockpit etc, is fired clear of the aircraft (Fig. 7.7). As instructed in Fig. 7.7, entry into the capsule is simple and the canopy can be locked up by placing the handle at a 45° angle to the left. The two ejection handles are located between the aircrew, the pins being kept in a bag behind the pilot who sits on the port side. The pins are push-button and should be inserted in the top of the handles from the inside out. Between the crew and above are three other sears which can be made safe if circumstances allow.

d. Release and removal of aircrew

(1) UK aircraft

In modern military aircraft the aircrew are securely strapped into their seats by various harnesses and connections, even to the extent of leg restraints to prevent accidents during ejection. Firemen should, if possible, take time to read and understand any instructions visible on the aircraft, but it is important that they should know in advance what basic steps need to be taken in order to get aircrew out safely and relatively easily. These steps are listed below.

It is assumed that the canopy, if any, has been removed (except where there is a restrictor wire—see above). Provided that the initial operation in the list is *always* carried out first, the sequence of the remainder is not important and should cause no delay.

(i) *Make the seat(s) safe*. The procedures described in Section 3c above should be strictly followed.

(ii) Remove the oxygen mask (Fig. 7.3(3)) but leave the helmet on if head injuries are suspected. (Plate A.26.)

(iii) Release the personal equipment connector(s) (PEC) by pressing the thumb release and raising the handle (see Figs. 7.8 and 2.5). PECs vary in size and location but are easily identified. Their release may, in some cases, automatically disengage the leg restraints.

(iv) Release the survival pack connection (Fig. 7.9).

(v) Release the combined parachute and seat harness (Fig. 7.10) by turning clockwise and carefully pressing inwards. Firemen should bear in mind the possibility of the aircrew having internal injuries.

(vi) If the leg restraints are not released automatically (see (iii)), there may be a small lever at the side of the seat which can be lifted to release them, or the straps may have box clips similar to (iv). (Fig. 2.5). Failing this, they will have to be cut.

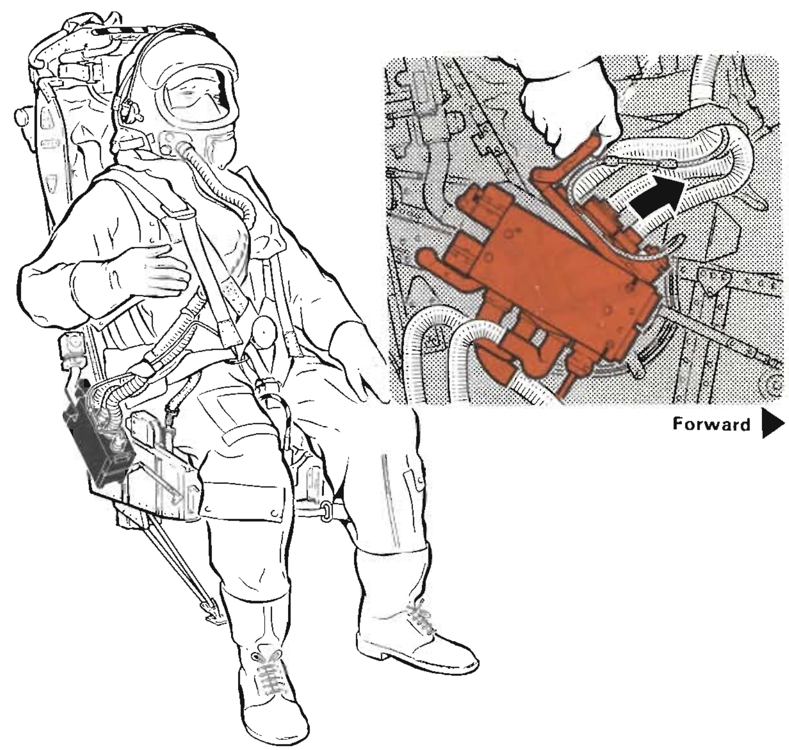


Fig. 7.8 An example of personal equipment connector (PEC) and (right) its operation.

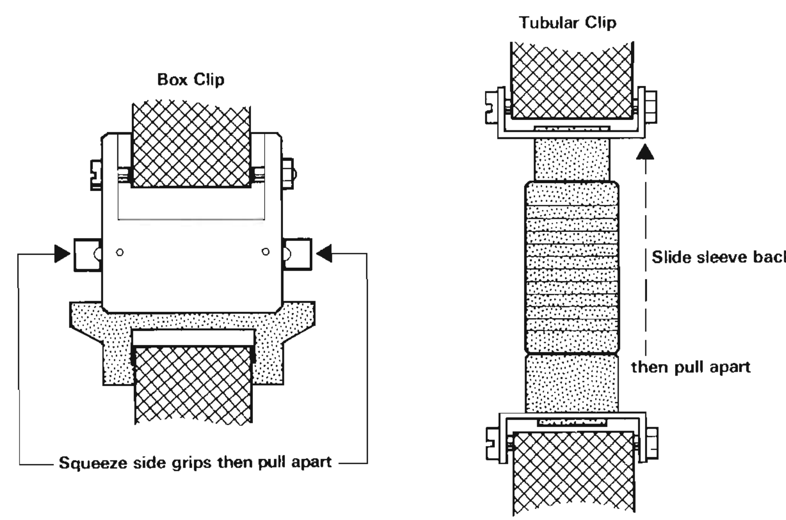


Fig. 7.9 Typical survival pack connection.

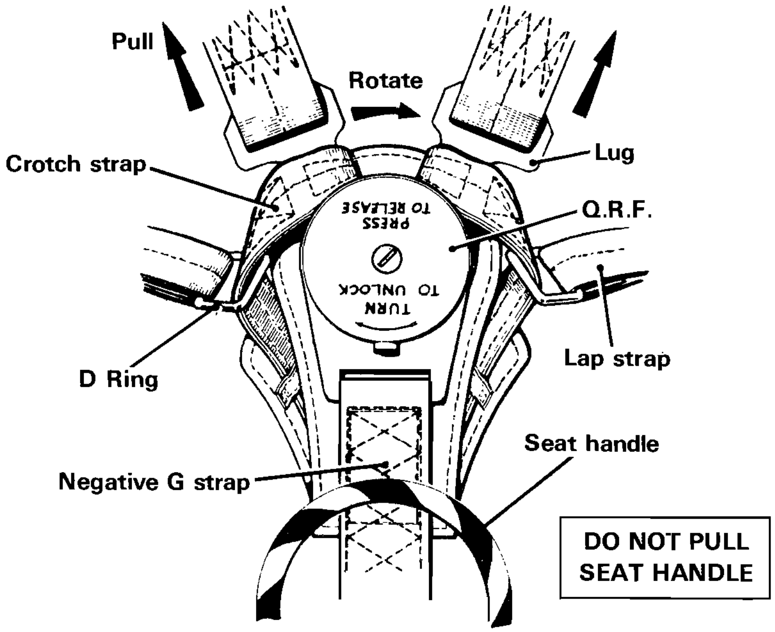


Fig. 7.10 Combined parachute and seat harness (QRF—quick release face).

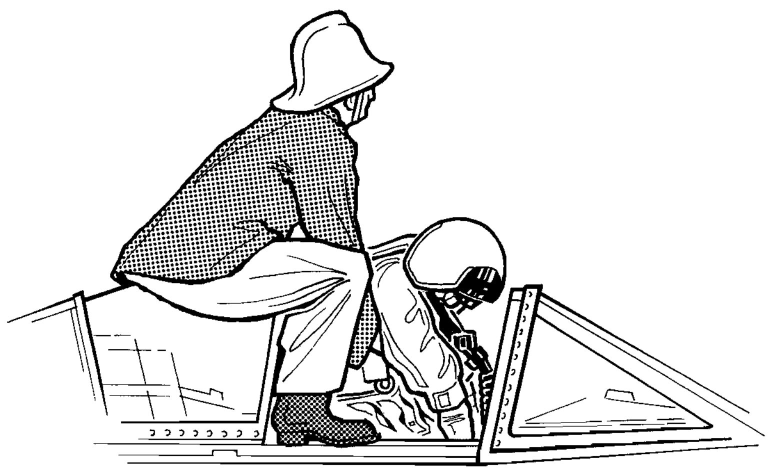


Fig. 7.11 A method of lifting a pilot from the cockpit.

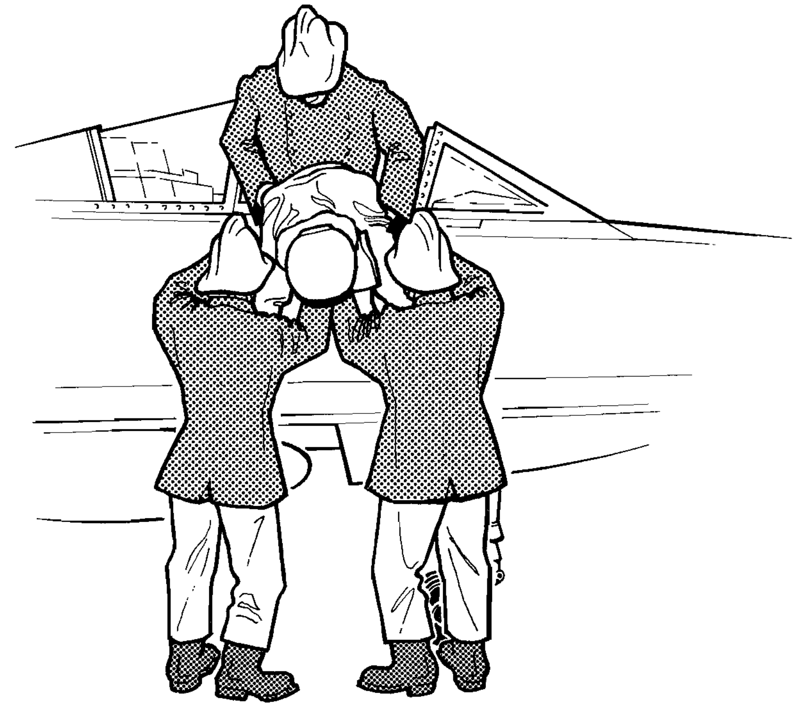


Fig. 7.12 After being lifted the pilot can be leant over a cockpit sill and assisted out onto a stretcher.

While the harness is being removed, the occupant of the seat will usually need to be supported, especially if the aircraft is upside-down (see Plate A.23). There is very little room in the cockpit, so aircrew will have to be lifted from above if the aircraft is in an upright position. The fireman should straddle the cockpit and attempt to lift the aircrew up sufficiently to lean him over the cockpit sill. Then, with the assistance of other firemen, the person can be eased down onto a stretcher and carried away. (Figs. 7.11 and 7.12.)

Firemen should be particularly careful not to operate switches, levers etc, as these could actuate weaponry.

(2) US aircraft

After the seats have been made safe, there are usually two connections to disengage: (a) a pull-off oxygen-pipe connection and (b) a harness knob to be rotated, whereby the harness straps are released. The oxygen mask should be removed from the aircrew's face to assist breathing. To lift the crew out he should be moved forward, a foot placed behind him on the seat and the body hoisted out back downwards. Firemen must remember the possibility of back injuries and take appropriate action, especially if they find an ejected capsule of an F111.

4. Treatment of casualties after rescue

Casualties (excluding the obviously dead) should normally be carried or led to an upwind (and if possible uphill) area designated by the officer-in-charge, at least 50 metres from the aircraft if possible. This should be in the best possible position accessible to ambulances or at least to medical personnel (see Chapter 6 Section 6b). The casualties should as far as possible be protected from the elements with whatever material can be improvised. Cigarettes should not be offered to them, in view of the risk that fuel may still be present in their clothing. Any necessary first aid should be given by firemen in accordance with the advice in the *Manual*, Book 12, Chapter 6, and as much detail as possible about injuries should be passed on to ambulance personnel before each casualty is taken to hospital.

If it is necessary to move any bodies away from the aircraft to prevent them from being destroyed, they should be kept well away from the designated casualty area.

Chapter 8
Special hazards in aircraft incidents

1. General

Apart from the normal risks attached to firefighting and rescue operations following an aircraft accident, certain special hazards may arise. In the case of civil aircraft, dangerous substances may be encountered in freight; these include explosives, gases, flammable materials, and substances which are poisonous, infectious, corrosive, or radioactive. Military aircraft can present such hazards as bombs, missiles and small arms ammunition, and there is even the possibility of nuclear weapons being involved. In dealing with any aircraft crash, firemen should be aware of these possible dangers, in order to safeguard people and property in the vicinity of the incident and also to avoid exposing themselves to any unnecessary risks.

The suspected presence of dangerous substances or devices should not deter firemen from searching for and rescuing survivors (whether inside or outside the aircraft) and conducting firefighting operations for the purpose of saving life. These remain their principal tasks and should be carried out with all possible speed in accordance with the advice given in Chapters 5–7. Firemen should however proceed with caution, and in particular they should be careful to avoid touching or treading on any suspect equipment or material unless this is absolutely necessary, e.g. to extricate someone who is trapped. Any such movement of dangerous items should obviously be done as carefully as possible.

Once all survivors have evacuated from the aircraft or been rescued, the officer-in-charge will need to decide whether, in the circumstances, his men should be withdrawn from the danger area immediately. It may in certain cases be preferable to let an aircraft burn rather than expose firemen to further risk.

The presence of dangerous materials may sometimes necessitate the evacuation of nearby buildings.

2. Civil aircraft

a. Identification of hazards

Under regulations devised by the International Civil Aviation Organisation (ICAO) and the International Air Transport Association (IATA), the captain of a civil aircraft must be given written information on dangerous goods which he is carrying, including any radioactive materials. In an emergency, this information would if possible be conveyed to ATC, who would relay it to the emergency services, and there is also a requirement of the operator of the aircraft to inform the country in which the accident has occurred of the dangerous goods being carried as soon as possible. Nevertheless, there may be some delay in obtaining this information, and firemen may therefore need to rely to a large extent on any visible markings indicating the presence of dangerous substances.

To facilitate the identification of dangerous freight, the International Civil Aviation Organisation has introduced a regulation (in the ICAO Technical Instructions for the Safe Transport of Dangerous Goods by Air 1984) requiring the use of United Nations substance identification numbers, as carried on land transport vehicles. Further information about the UN numbering system is given in the *Manual*, Book 12, Chapter 7. Unlike land vehicles, however, aircraft themselves do not normally bear any hazard warnings or substance identification markings. The UN numbers are, instead, marked on each of the dangerous containers or packages individually, together with an indication of the class of hazard. (There are special arrangements for crop-spraying aircraft; Book 12 Chapter 7 refers).

The UN list is continually being updated, but the rapid developments currently taking place in the chemical field may occasionally result in newly-developed dangerous substances travelling unmarked because they have not yet been added to the list. The absence of a UN number should not, therefore, necessarily be regarded as proof that a substance is safe.

All radioactive substances carry the Trefoil symbol (see the *Manual*, Book 12, Fig. 7.10).

In the case of UK-registered aircraft, the marking of dangerous freight is subject to additional regulations, and the UN number will usually be accompanied by labelling of a more detailed nature.

As explained above, firemen may receive notification from the air authorities that the aircraft is carrying dangerous goods; or they may notice UN numbers or other markings on packages or containers; or they may have some other grounds for suspecting that dangerous substances are present, e.g. they may find a freight manifest indicating this. If so, they should adopt the procedure appropriate to the type of hazard in question, as set out in the *Manual* Book 12, Chapters 8–9. Evacuation should be considered if there is firm evidence that highly dangerous material is present and that it is likely to endanger people in the vicinity—perhaps because of damage to containers resulting in the spillage or exposure of their contents.

If any dangerous substances are discovered or believed to be present but the full list of dangerous goods on board has not

been received, the officer-in-charge should immediately contact the airline concerned, via the police, and ask them to provide such a list as quickly as possible. In the meantime, firemen will have to deal with the incident as best they can, relying on any markings found and any expert advice which they are able to call on.

b. Types of hazard

The classes of dangerous substances are listed in the *Manual*, Book 12, Chapter 7. The ICAO's regulations specifically forbid certain particularly hazardous items—for example, certain types of explosives—to be transported by air under any circumstances; there are nevertheless a wide variety of potentially dangerous materials which are not prohibited. The range of substances that might be encountered is so great that it is impossible to list them all individually, hence the need for caution.

(1) Chemicals

The great majority of dangerous substances likely to be found are chemicals. The main categories of these, and the general procedure for dealing with chemical incidents, are set out in the *Manual*, Book 12, Chapter 8. A list giving details of some of the most common dangerous chemicals can be found in the *Manual*, Part 6c, Chapter 45, Section 16.

(2) Radioactive substances

The safe transport of all radioactive material by civil aircraft is essentially governed by comprehensive regulations recommended by the International Atomic Energy Agency (IAEA). The regulations are directed to ensuring that safeguards appropriate to the nature and quantity of the material are incorporated into the design of the package. It is fully recognised that radioactive material could be involved in a severe aircraft accident, and the design requirements are accordingly devised so that the package should not constitute a hazard even in extreme circumstances. In the case of packages containing material with a high level of radioactivity, the requirements include tests which demonstrate resistance in severe impact and thermal environments and the provision of a fireproof symbol indicating the presence of radioactive material. Although a substantial number of packages of radioactive material are conveyed by air over the UK each year, only a very small proportion contain appreciable levels of radioactivity. Most are radioactive isotopes for medical and research purposes.

Despite the stringent safeguards, the possibility of an escape of radioactive material in an aircraft accident cannot be entirely ruled out. The properties and hazards of radioactive materials, and the procedures necessary when dealing with incidents involving them, are detailed in Dear Chief Officer Letter 9/84 and in the *Manual*, Book 12, Chapter 9. If there is any possibility that radioactive material has escaped, the officer-in-charge should ensure that the police invoke the NAIR scheme (see Appendix), especially if members of the public are likely to be affected. (The NAIR scheme does not apply to military aircraft).

(3) Pressurised containers

Some liquids and gases, which are not in themselves dangerous, may be carried in pressurised containers, which may burst violently during a crash fire. Firemen should therefore take the usual precautions for this type of hazard, including cooling the containers.

3. Military aircraft

a. Identification of hazards

Many incidents involving military aircraft occur at airfields, and can normally be dealt with by the specially-trained firefighting personnel on the spot (see Chapter 4 Section 6a). Where an aircraft crashes away from an airfield, however, the LAFB will attend. It is essential for firemen with RAF, RN or USAF bases in their area to have some knowledge of military aircraft, and firemen in other brigades should also endeavour to acquire some basic information about them. Then, if a crash occurs in their area, they will be able to identify certain potential hazards and take suitable precautions during the immediate firefighting and rescue operations. The general features of military aircraft are described in Chapter 2. The main types of weapons, and the precautions appropriate to them, are set out in Section 3b below.

In any incident involving a military aircraft, the military authorities concerned will be able to give, via the police, details of any particular hazards involved and any special precautions that will be necessary. However, depending on where the call originates from (see Chapter 4, Section 6b), this information may not be available immediately. If it is not, firemen may need to rely to some extent on their own knowledge of military aircraft and equipment.

Military technicians will be sent to the scene of the incident as soon as possible in order to investigate it. They should be able to offer firemen some on-the-spot assistance in identifying any hazards. (For the special procedure for nuclear incidents, see Section 3b(5)).

b. Types of hazard

(1) Bombs

Bombs carried by military aircraft may be of the high explosive (HE) kind, but the majority are likely to be training bombs, which are less powerful, although they can still be very dangerous.

High explosive or training bombs do not normally explode on impact of a crashed aircraft if no fire is involved, since the fuses are not likely to have been set. Nevertheless, their behaviour is unpredictable, and there is always some risk attached to them. Except for the purpose of saving or protecting lives, firemen should not approach closer than 300 m to an aircraft known, or suspected, to be carrying HE bombs. Firemen will be reasonably safe from direct blast effects at this distance, though they should still be ready to take cover for protection against flying debris.

If a crashed aircraft catches fire, any HE bombs may explode in the resulting heat, and firemen should therefore proceed with the utmost caution if it is necessary to approach the aircraft.

The RAF uses training bombs of various types and weights. Some of these are filled with smoke-producing compounds; others are filled with a flash composition, sometimes in conjunction with a smoke-producing compound. The danger from an explosion of a bomb filled with smoke composition only is not unduly great, except where the explosion takes place close to people or property. The explosion of a bomb filled with flash composition, however, can be lethal. The intensity of light produced by some types of flash bomb can constitute a danger to the eyesight, and precautions should therefore be taken to protect the sight, even at a distance from the aircraft, if such bombs are known or believed to be present and the aircraft is on fire.

If, during rescue operations, any bombs are seen in such a position that they may become heated, they should be cooled with water spray. Foam, if available in sufficient quantities, should be used to fight any fire (see Chapter 5 Section 3b, and Chapter 6 Section 5), but should not be used for cooling bombs, because, although the water drained from the foam will assist cooling to a small degree, it will not significantly reduce the temperature. Should an RAF or USAF officer be present, his advice concerning the danger of explosion should be taken.

It is vital that, apart from cooling the bombs, no attempt should be made by firemen to move or in any way interfere with them, whether the bombs have been subjected to heat or not.

(2) Small arms ammunition

The risk of danger from small arms ammunition in an aircraft incident is remote unless fire occurs. If it does, fragments of cartridge cases and projectiles could be propelled up to a distance of 70 m. There is no risk of mass explosion, but small explosions are likely to occur with increasing frequency as the fire takes hold. These could be sufficient to cause wounds, especially where heavy calibre ammunition is involved, and it is also possible that the powder charge, or incendiary or tracer cores, may contribute to the spread of the fire.

The best protection is to keep low, avoid passing in front of the muzzles of guns, and have all belts of ammunition kept cool by water spray.

(3) Rocket projectiles

Missiles are carried externally on pylons (see Plates A.7 and A.20), and these could break free from the aircraft during a crash. This would reduce the likelihood of the missiles becoming involved in any subsequent fire. If they do become heated, however, their warheads may explode similarly to HE bombs. It is less likely that the rocket propellant would be ignited, but if this were to happen the result would be unpredictable, because the missile might still be attached to its pylon, and the pylon might be distorted. It is unlikely, however, that the missile would be fired from the aircraft. On the Phantom, the pylons may be jettisoned (see Chapter 2 Section 6).

Missiles must always be regarded as potentially dangerous, whether a fire is involved or not, and it is important that any such weapons carried by a crashed aircraft should be located as soon as possible. Once this has been done, firemen should try not to pass unnecessarily close to them, and in particular should avoid the area directly in front. In the event of fire, missiles should be cooled with water spray.

(4) Pressurised containers

Virtually all military aircraft are fitted with pressurised containers of liquids or gases, with distribution systems for aircraft services (see Chapter 2 Section 3b). Such containers may burst violently if affected by heat, but this will not occur in every case since it commonly happens that distribution piping is ruptured or melted and allows the pressure to be released before the contents of the container reach a critical temperature. Nevertheless, all pressurised containers should be cooled with water spray if the aircraft is involved in fire.

(5) Nuclear weapons

The storage and movement of nuclear weapons and assemblies are governed by very stringent regulations. The inherent safety features, which form part of the design of nuclear weapons, ensure that there is no risk of a nuclear bomb type of explosion should a weapon be involved in an accident. Nuclear weapons are never carried on combat aircraft in peacetime. They are,

however, occasionally moved in special protective containers, secured within the holds of RAF and USAF transport aircraft. The risk of an accident happening is remote but, particularly during landing and take-off, there remains a possibility that one may occur.

In appearance a nuclear weapon is similar to a conventional high explosive (HE) bomb. All nuclear weapons contain HE when they are fully assembled and thus a conventional explosion may occur when a nuclear weapon is involved in an accident. Full precautions should therefore be taken as for an aircraft carrying HE bombs. An explosion, or any damage to the containers of a nuclear weapon or its components caused by fire, may lead to the spread, over a limited area, of radioactive dust and sensitised explosive (see Glossary).

In any incident involving an aircraft which is carrying a nuclear weapon, the RAF will send a Special Safety Team (SST) to the scene as soon as possible. The SST will be trained and equipped to deal with incidents involving nuclear weapons and assemblies, and they should arrive within a comparatively short space of time. It will be for the LAFB, however, to deal with the matter initially.

The RAF authorities notify all appropriate fire brigade controls, via the police, of any aircraft carrying nuclear weapons which they know to have crashed. The officer-in-charge of the PDA may therefore know at the outset, or receive early notification from his brigade control, that the aircraft is carrying a nuclear weapon. However, this information may not reach him until after he has arrived and got to work. In view of the risks involved, officers-in-charge should proceed on the basis that any large transport aircraft of the RAF or USAF may be carrying a nuclear weapon unless they are informed to the contrary. If it is not known at an early stage whether a nuclear weapon is present, Brigade Control should report the matter to the police so that the RAF can be notified and asked for the necessary information.

Where a nuclear weapon is or may be involved, firemen should keep well away from the aircraft and any debris, unless it is necessary for them to intervene in order to save or protect lives. The advice about the minimum safe distance for HE bombs (see Section 3b(1) above) is equally applicable to nuclear weapons. If an approach to the aircraft is necessary, the appropriate procedures for a radiation incident (see Dear Chief Officer Letter 9/84 and the *Manual*, Book 12, Chapter 9) should be put into effect, including the wearing of breathing apparatus and the carrying of dosemeters and survey meters. The level of radiation should be constantly monitored until the arrival of the RAF SST. The approach should be made from upwind, and smoke should be avoided as far as possible since it may contain radioactive material.

If, in the event of a fire, a nuclear bomb or any component of such a bomb is found to have become heated, or seems likely to become so, it should be kept cool with water spray, like a conventional bomb. The spray should be kept in operation until the RAF SST Commander advises that it is no longer necessary. In the meantime, foam can be used in the normal way to tackle the remainder of the fire.

The RAF SST will be responsible for monitoring personnel for radiation, and for decontamination. When they arrive, the fire brigade officer-in-charge should accept the advice of the SST officer regarding any further firefighting measures needed in the vicinity of the nuclear weapon and any necessary decontamination of personnel, uniforms and equipment. Firemen or any other persons who have been within 300 m of the crashed aircraft or debris, or who have passed through smoke issuing from them, should under no circumstances be allowed to leave the designated area until they and their clothing have been checked for radiation by the SST and, if necessary, decontaminated; nor should they eat, drink, or smoke until this has been done. The radiation hazard is alpha, which only constitutes a risk if contaminant is absorbed internally through cuts or by ingestion or inhalation. The above precautions are designed to minimise this hazard. Because of the nature of the radiation involved, a check for radioactive contamination using the fire brigade's own radiac instruments cannot be considered sufficiently positive.

Glossary of aeronautical terms

Ailerons	Primary control surfaces at each wingtip which operate differentially (i.e. one goes up when the other goes down) to give lateral (rolling) control.
APU	Auxiliary Power Unit. An auxiliary generator usually powered by a small turbine and used to maintain batteries, services on the ground, start engines etc.
ATC	Air Traffic Control. A system used in the UK to regulate the movements of all aircraft, both civil and military.
Autopilot	A mechanical or electro-mechanical device which will maintain an aircraft on a predetermined heading and altitude, controlling ailerons, elevators and rudder through a system of gyros.
Avcat	Type of kerosene fuel, specially distilled for use in naval aircraft.
Avgas	Types of gasoline fuel used in aircraft engines.
Avpin	Isopropyl nitrate. A type of fuel used in engine starter systems on some military aircraft.
Avtag	Type of kerosene fuel used in aircraft engines; more akin to gasoline.
Avtur	Types of kerosene fuel used in aircraft engines.
Bicycle undercarriage	A system where the main landing wheels are one behind the other in line under the fuselage, usually complemented by wingtip out-rigger wheels.
Bogie	Type of undercarriage with four or more wheels to each leg.

Braking propeller	A propeller which can be reversed in pitch to create a braking effect, usually to shorten the landing run.
Canopy	The transparent fairing over a cockpit.
Cantilever	A structure supported only at one end.
Centre section	The part of the mainplane which joins the fuselage.
Co-axial propellers	Two independent propellers mounted on a common shaft but rotating in opposite directions.
Dorsal fin	A small extension of the fin (qv) along the centre line of the fuselage.
Ejection seat	A crew seat which can be fired from the aircraft, complete with occupant, in an emergency.
Elevator	The movable portion of the tailplane which provides longitudinal (dive and climb) control.
Fin	The fixed portion of the vertical tail surface.
Firewall	A fire-resisting bulkhead, usually between an engine and the remainder of the fuselage or wing.
Flap	A moving section on the trailing edge of a wing, which can be extended to improve performance of the aircraft for a particular manoeuvre.
Fuselage	The main structural body of an aircraft, carrying the mainplane, tail etc, and providing accommodation for the occupants and load.
Integral tank	A fuel tank formed by the basic structure, usually of a wing, by making a fuel-tight seal of spars, ribs and skin.
Kerosene	Aviation fuel similar to paraffin.
LCC	Linear Cutting Cord. A canopy-shattering device similar to the MDC (qv).
Leading edge	The front edge of a wing or aerofoil surface.

Longerons	Internally-placed stringers running continuously along the length of the fuselage, to which other assemblies are attached, eg cabin flooring.
LOX	Liquid oxygen system found on military aircraft.
Mainplane	The major lifting surface of an aircraft.
MDC	Miniature Detonating Cord. An explosive cord incorporated into a canopy. When operated it shatters the canopy, usually prior to the ejection of the aircrew.
Monocoque	A common form of light aircraft construction in which an outer fabric skin, supported by light frames and stringers, is a primary load-carrying structure.
Nacelle	An enclosed structure usually containing an engine.
NAIR	National Arrangements for dealing with Incidents involving Radioactivity (see Appendix).
Oleo	An undercarriage leg in which the shock is absorbed by a piston moving up a cylinder containing hydraulic fluid or compressed air.
Overshoot	(1) A misjudged landing in which the aircraft touches down too far along the runway to pull up safely. (2) The procedure of "going round again" if a safe landing cannot be made.
Payload	That part of an aircraft's total weight from which revenue can be obtained, i.e. passengers or freight.
Pitch	(1) The angle of the propeller blades to the vertical swept area. (2) Oscillation of the aircraft in rough conditions fore and aft. (3) The distance measured longitudinally between corresponding points on aircraft seats.

Pressure differential	The difference between air pressure inside an aircraft cabin and atmospheric pressure.
Pressurisation	The process of making an aircraft interior airtight and maintaining a pressure inside it higher than that outside.
Pylon	A streamlined fairing on a wing or a fuselage to carry a fuel tank, weapon etc.
Ribs	Short supporting struts placed at right angles to the spars (qv) in a wing.
Rotor	A system consisting of between two and six narrow wing-like blades carried radially on a single vertical shaft which, when rotated, produce lift, or, in the case of a tail rotor, stabilise the aircraft.
Rudder	The movable portion of the vertical tail surface, providing directional control.
Sear	A device to prevent the firing of an ejection mechanism.
Sensitised explosive	The non-nuclear explosive used to detonate a nuclear weapon. In an accident it could be sensitive to shock and become radioactive.
Slab tail	A tailplane which operates as a single entity to give longitudinal control instead of separate elevators.
Slat	A small section of a wing leading edge which can be moved to improve airflow under certain conditions.
Slot	A gap through a wing leading edge, designed to improve airflow under certain conditions. It may be fixed, or may be formed by the operation of a slat (qv).
Spars	The main support frames for a wing, running from the centre section to the wingtips or from wingtip to wingtip.
Sponsons	Small attachments to the fuselage or wheels of an aircraft, often a helicopter, sometimes in the shape of a stub-wing, to accommodate wheel mechanisms, flotation apparatus etc.

Stressed skin	The sheet metal covering of an aircraft, which is designed and stressed to take a load and to contribute to the total rigidity of the airframe.
Stringers	Metal struts running horizontally along the length of the fuselage, spaced round the circumference of the main frames. There are also internally-placed stringers, called longerons (qv).
Tailplane	The horizontal stabilising surface at the rear of an aircraft to which the elevators are attached.
Tandem seating	An arrangement of two seats one behind the other.
Torsion-box	The main load-bearing portion of a multi-spar wing, comprising front and rear spars, ribs and skin.
Vents	Automatic valves which ensure a gradual equalisation of any difference between the inside and outside air pressure due to local weather conditions.
VTOL	Vertical Take-Off and Landing. Applied to types of aircraft with the ability to reach an altitude of 15 m within 15 m distance of the take-off point.
Wing root	The part of the wing that joins the fuselage.

Part 2
Incidents involving shipping

Introduction

Fires, explosions, spillages and other incidents involving shipping almost always present the Fire Service with difficult problems. In port, firemen will have to take into account such factors as the type of ship, the location of its berth, whether it is loading, unloading, refitting or under repair, its cargo, the degree of accessibility and the availability of fireboats or fire tugs. At sea there will be problems over getting men and equipment aboard. The increase in shipping generally has made incidents more likely, particularly those resulting from collisions, and the problem has been exacerbated by the growing carriage of dangerous materials. Any coastal Fire Brigade might find itself faced with a major incident, and even inland Brigades could have to deal with incidents on canals and navigable rivers.

To cope with such incidents firemen require a good background knowledge of shipping generally. They must also familiarise themselves with any particular risks in their own areas (including transient or temporary risks). Liaison with the relevant authorities, commercial organisations etc is essential, as is adequate preplanning.

This Part of Book 4 looks initially at ship construction in general and describes the principal types of ship which firemen are likely to encounter. Fire protection and firefighting provision on board ships are dealt with separately. The basic principles of the important but complex subject of ship stability are also covered. Particular attention is given to the fighting of ship fires, involving different types of vessels, with different cargoes, in port and at sea, and the various factors involved are considered. The issue of liaison and preplanning, which necessarily involves the sometimes contentious area of responsibility at ship fires, is discussed in some detail. Advice is given on how to identify and deal with dangerous cargoes. Particular problems relating to inland waterways are also covered. At the end of the Part is a glossary of the special terms used in connection with shipping.

The old Part 7 of the *Manual of Firemanship*, which this Part of Book 4 replaces, dealt at considerable length with fireboats and seamanship. Very few fireboats are now in use by Brigades and their number may diminish further. Each brigade with a fireboat must devise its own training, arrange liaison with the relevant authorities etc and ensure compliance with local, national and international rules. Each boat is unique in design, capacity, risk area covered and method of operation. Since the work is so specialised and involves relatively few firemen it has been decided that it is unnecessary to cover the topic in the *Manual.* Some Brigades have arrangements with tug companies to use their tugs for firefighting, and this aspect is briefly covered.

Chapter 9
Ship construction

1. General

a. The variety of shipping

Ships serve various purposes, the most common being perhaps the carriage of different natural and manufactured goods, the carriage of passengers, the conduct of military operations, fishing, sport and leisure, and assistance to other navigation. Fig. 9.1 shows some of the main divisions.

Ships designed for each of these purposes vary greatly according to their precise function, the volume of goods or number of passengers carried, the requirements of individual owners, the practices of different ship-builders, different national legislation, the age of the vessel, and preferences for different materials or techniques to achieve the same ends. Clearly this Chapter cannot

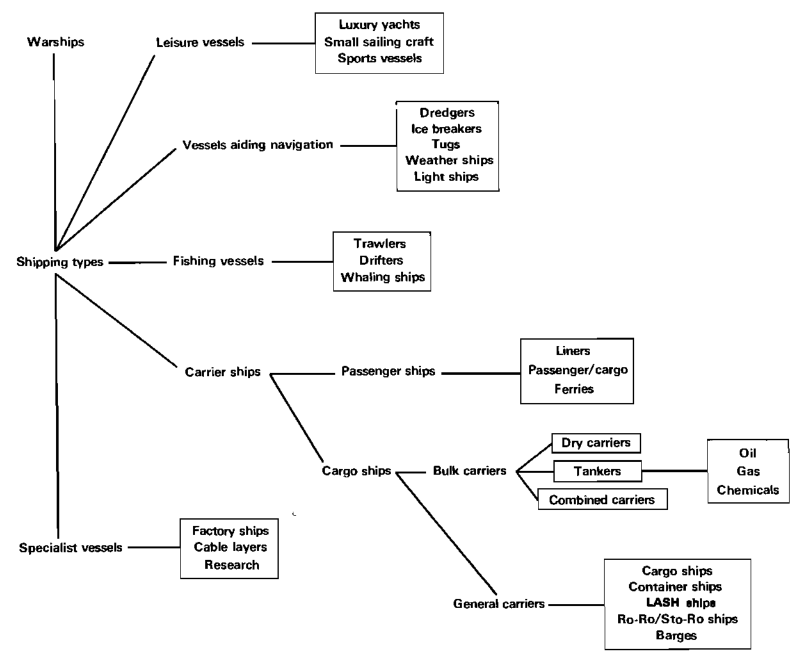


Fig. 9.1 Diagram of main shipping divisions.

give details of every one: it therefore only attempts to describe some of the more important features of the types which firemen are most likely to encounter. Firemen should take any opportunity that presents itself to get on board ships and familiarise themselves with construction, layout, controls, provisions for preventing and dealing with fire, etc.

b. Common features

Firemen should be aware that despite the differences outlined above, many ships do have certain basic features in common. Fig. 9.2 shows some features which most ships have, together with the terms used in referring to them (other terms will be explained in the text as they are encountered, or in the Glossary, and firemen should ensure they are familiar with them all). Similarly all ships have decks, or floors, horizontally dividing one part of the ship from another. These are usually of the same material as the vessel but, particularly on passenger vessels, are often sheathed in timber or a plastic composition. In large ships of metal construction the steel plating is built up on a series of ribs; there are watertight bulkheads, or vertical walls, dividing the interior of the ship into sections, and at each end of the ship there is a fore or after peak (see Fig. 9.2) used to carry stores, water ballast, or occasionally fresh water supplies. On modern ships the superstructure is increasingly of lightweight aluminium alloy rather than steel, and plastics are being used more for a wide range of purposes: structural features, fittings and, in accommodation areas, decoration. Such materials can create special firefighting problems: the plastics for instance can produce toxic fumes rapidly and in large quantities.

2. General cargo ships

a. Ship decks and holds

(1) Arrangement of decks and holds

Fig. 9.2 shows a typical general cargo ship, designed to carry the largest possible number of goods. The holds, numbered from bow to stern, may be as many as eight but are more usually five. There may be oil fuel and water ballast tanks at their sides, more especially towards the ship's centre. More modern ships tend to have their machinery towards the stern, (see Fig. 9.7), older ones towards the centre, but this does not affect the general principles of the design.

Normally each hold is separated from adjoining spaces by watertight steel bulkheads running across the ship, any openings in these being fitted with watertight doors. On the simplest ships each hold is a single compartment between two bulkheads, extending from the inner bottom to the upper deck. On more complex

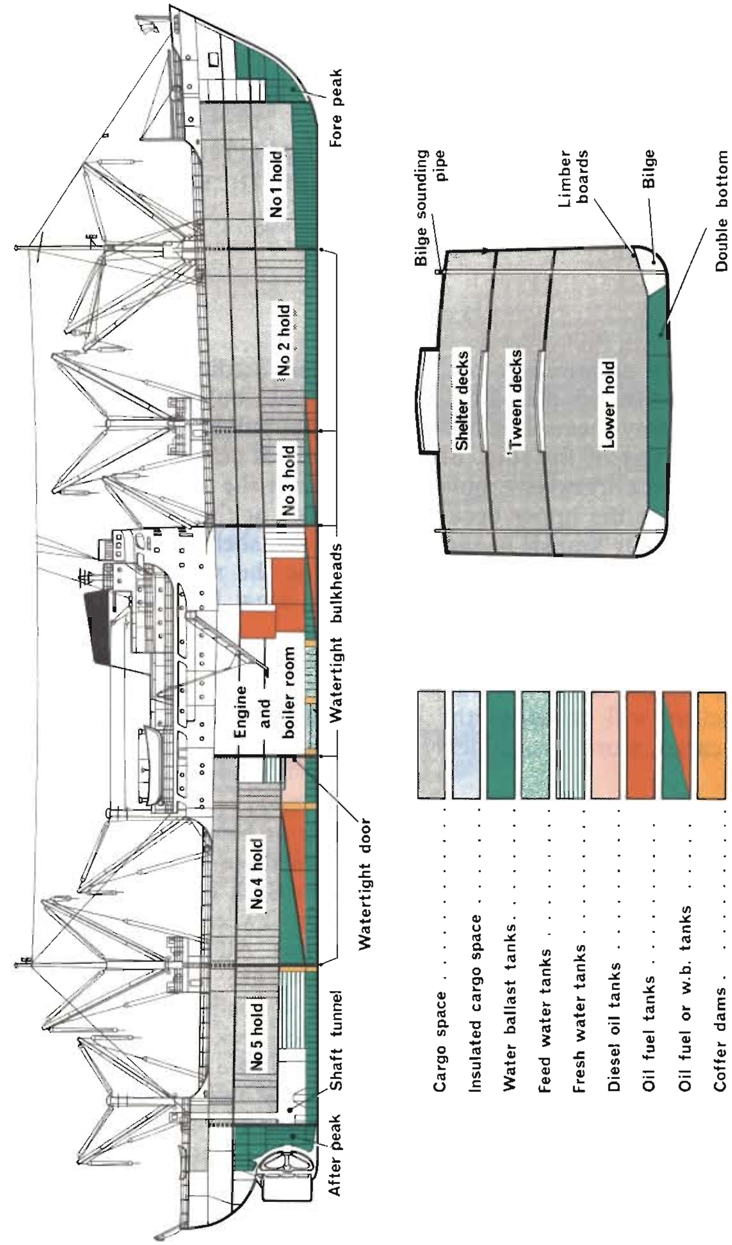


Fig. 9.2 Section through a cargo ship with shelter and 'tween deck, showing the lay-out of holds, machinery spaces etc

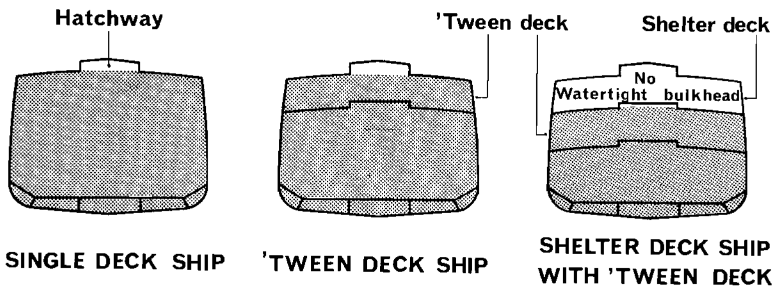


Fig. 9.3 Sections through three common types of cargo ship.

ships there are additionally one or more intermediate or tween decks, some of which may exist between certain bulkheads only. Tween decks may themselves have longitudinal bulkheads running on the centre line of the ship, or other means of sub-division. In a few vessels the transverse bulkheads between the holds do not extend as far as the upper deck but terminate at the one below. The upper deck is known in such a case as the shelter deck, and the space immediately below it is known as the shelter tween-decks. (Fig. 9.3). This is essentially an open area, but may have some means of partitioning if desired.

There are various superstructures above the uppermost continuous deck; design, layout etc vary from ship to ship. Part of the superstructure will comprise the bridge; the remainder may be used for cargo, stores, machinery or accommodation.

(2) Hatches

In the deck over each hold is a large opening or hatchway to give access for loading and unloading; sometimes there is more than one. These openings usually extend across the deck for about one third of the beam, but may be much wider. Tween decks have similar openings, usually in a direct vertical line. All are protected by hatch covers. On the upper deck, these are usually of a watertight, steel construction with hydraulic or electric operation. There are various designs (see Fig. 9.4). Tween deck hatch covers may be similarly operated, but flush-fitting, as in type 2 of Fig. 9.4, or may consist of separate steel sections like the individual leaves of types 3 and 4. The sections are usually flush to the deck and are not self-powered but have to be lifted by cranes. All hatch covers are designed to take the weight of cargo: on the upper deck this may consist of container stacks up to four high. Heat can distort the metal of hydraulically operated hatch covers and make them inoperable; in such cases they must be manually forced.

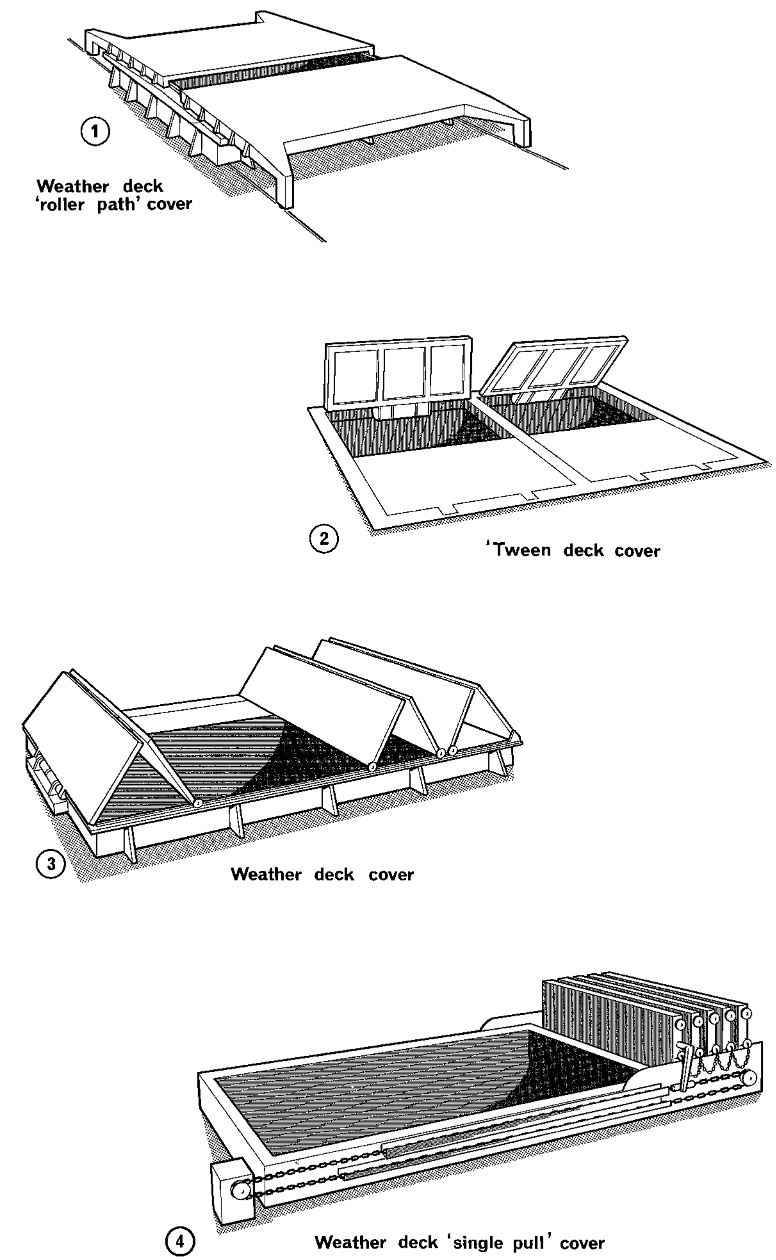


Fig. 9.4 Diagrams showing various types of hatch covers found on cargo ships.

(3) Means of access to tween decks and holds

The most common means of access are:

(i) ladders — These are the principal means. Usually they lead down from one side or end of a hatchway; sometimes they may be reached by a separate small or booby hatch. The ladders may be staggered at different deck levels.

(ii) mast houses — Trunkways may lead from a mast house on the upper deck to the lower hold (see Fig. 9.5). These contain ladders giving access to the various decks, the lower hold and the double bottom. They may also act as ventilators, with cowls on top of the mast house (see (v) below).

(iii) trimming hatches — These are small openings, usually about 600 mm square, which are sometimes found in the tween decks in the far corners from the main hatches.

(iv) bilges and sounding pipes — Water at the bottom of the hold, and usually any from the tween decks, perhaps with oil residue, drains down to bilges at the outer edge of the double bottom tanks or into sumps in the tank tops. The water is pumped out through pipelines connected to bilge pumps in the machinery space. Bilge sounding pipes, one for each side of each hold, enable measurement of the water depth. There is also likely to be access to the bilges via hatches from the lowest deck (see Fig. 9.6).

(v) ventilators — Most modern cargo ships have mechanical ventilation of holds, with supply and exhaust fans. On some older vessels, however, there may be a free flow air system, using cowl ventilators. In this system, shafts lead to the below-deck areas from above-deck cowls which can be rotated into and out of the wind. Some cowls are fitted with steel flaps which can, if necessary, be closed to prevent the entry of air; in other cases the cowl can be lifted off and the shaft blocked with a plug or a canvas cover.

b. Other ship features

(1) Deep tanks

A deep tank may replace the lower hold immediately in front of, and sometimes behind, the machinery space. It may carry water

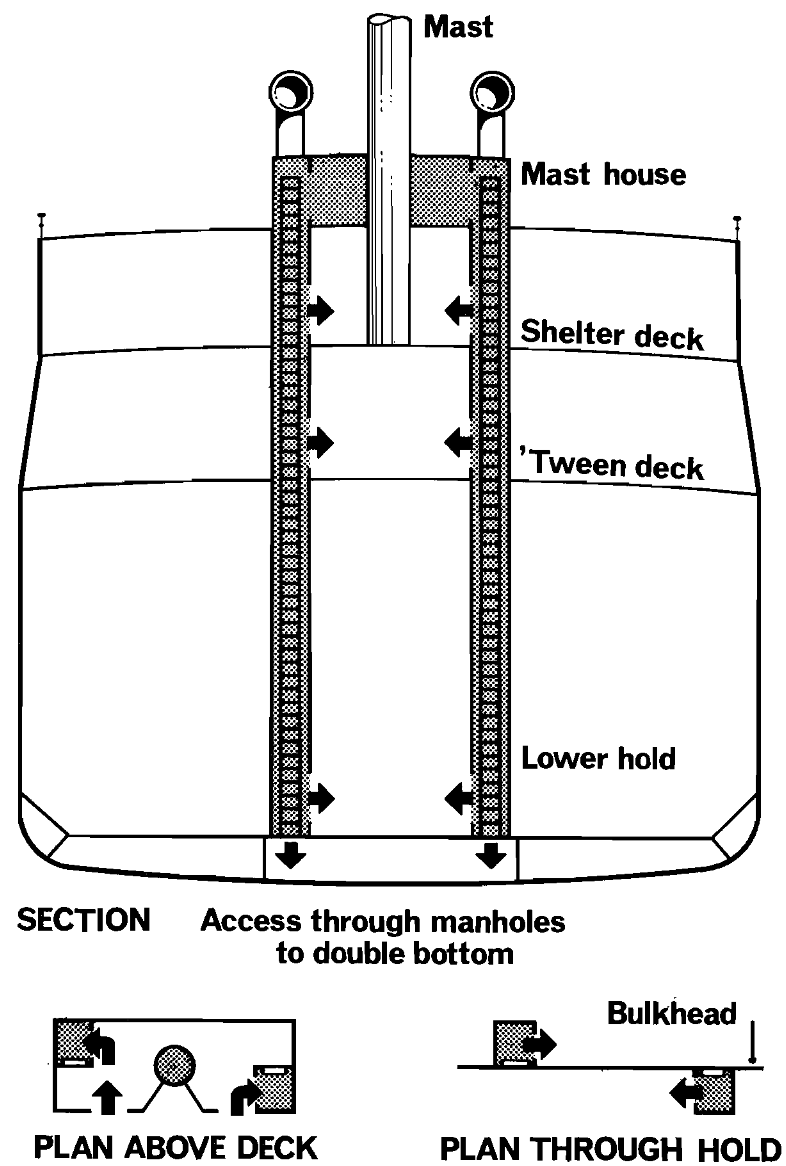


Fig. 9.5 Section and plan of one type of mast house, and access to trunkways.

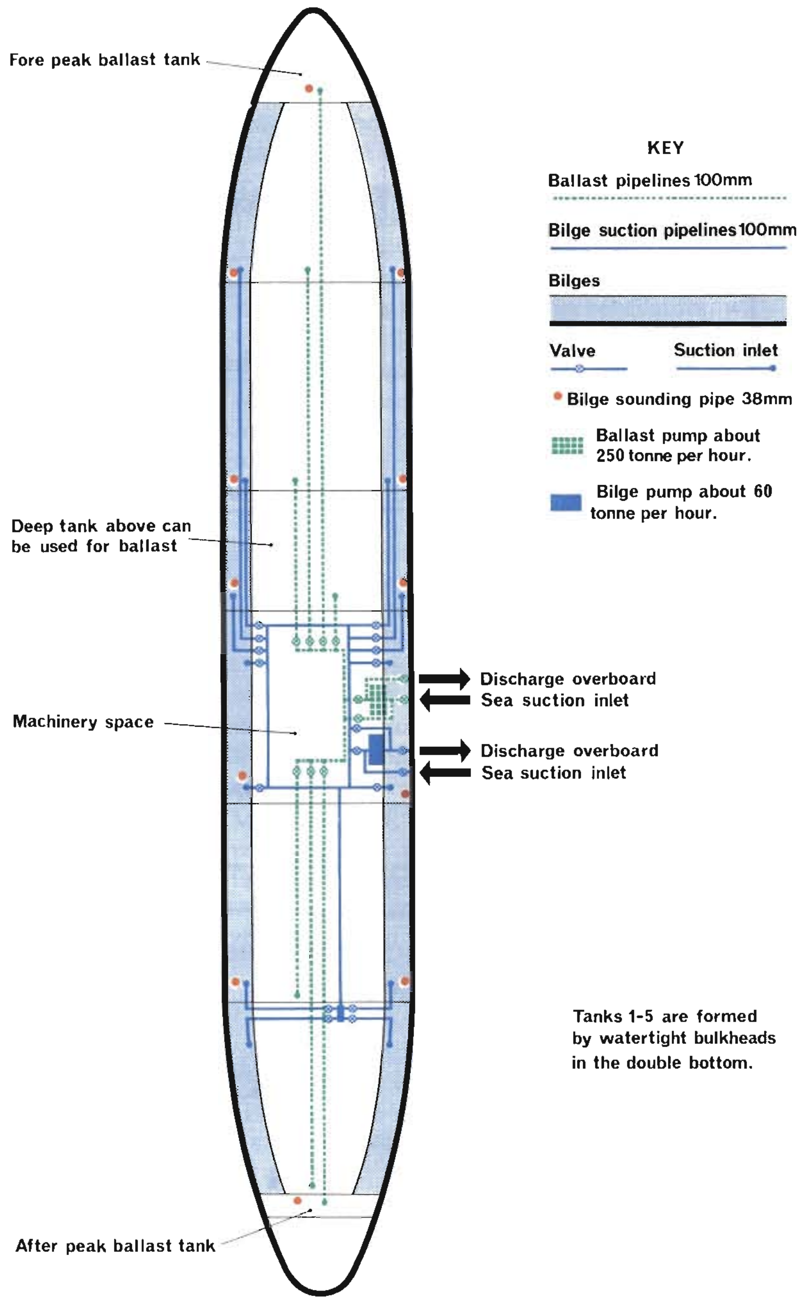


Fig. 9.6 General lay-out of ballast tanks, pipelines and bilge suction pipelines of a typical cargo ship.

ballast or oil. (See also subsection (4) below). The deep tank hatch cover is bolted on, and can be removed if necessary, but access can also be obtained through a manhole cover.

(2) Machinery spaces

These basically consist of engine and boiler rooms shut off from the holds by watertight bulkheads. Modern ships have additional areas containing such items as pumps, electrical switchboards, switchgear etc. The engine room may, on older ships, be separated from the boiler room by a bulkhead, but this will be pierced by an opening which may not be watertight. The spaces have their own ventilation. On modern ships they are usually at the stern, in older ships at the centre. They can be reached by ladders from an upper deck; these have a steep pitch and tend to be greasy.

(3) Shaft tunnel and tunnel escape

A shaft tunnel runs from the engine room aft and contains the intermediate shafting between the engine and propeller shaft (see Plate S.1). It is quite often used for the storage of paint, drums of lubricating oil, etc. A watertight door links the tunnel and engine room; methods of opening vary but there is generally a wheel in the bulkhead of the accommodation area immediately above. An escape trunk fitted with a ladder leads up from the tunnel to an upper deck (Fig. 9.7). The ladder may lead down only as far as the tunnel deckhead, with hand and foot holds then leading to the tunnel floor.

(4) Water ballast and fuel systems

Cargo ships must have provision for the carriage of water ballast since otherwise, when not fully loaded, they would present too large an area to the wind and have their propellers only partially submerged. As already noted, water ballast can be carried in the fore and after peaks and in the deep tank. Additionally, the hull of most ships has a double-bottom space of 750–1200 mm in depth, which is divided into watertight compartments. This provides a safeguard in the event of grounding and is also used for extra water ballast, feed water for the boilers and oil fuel. Oil can also be carried in double-bottom tanks or in the deep tank, or in wing compartments and cross-bunker spaces. Coffer dams usually separate compartments containing oil from those containing fresh water or cargo. They are double watertight bulkheads, usually transverse and at least 1 m in overall thickness.

From the fuel storage tanks, the oil is pumped to settling tanks in the machinery space and heated, then purified by means of a centrifuge before it is passed to the fuel pumps. The excess oil

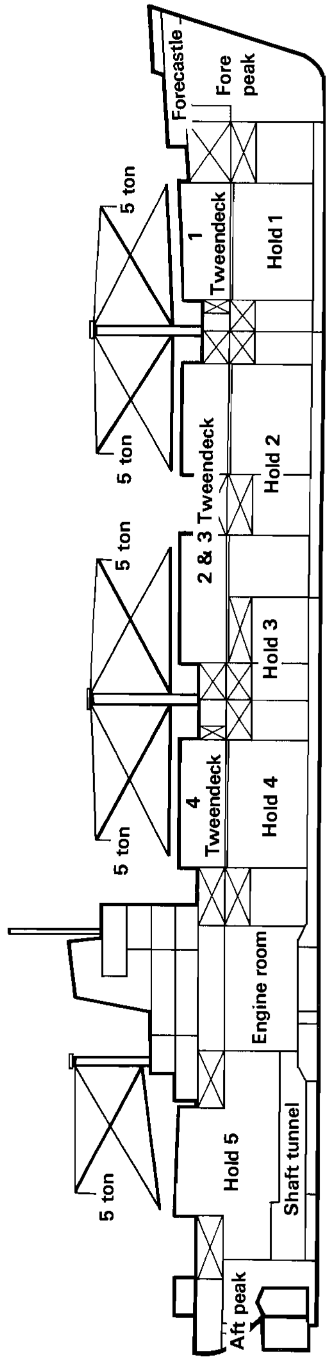


Fig. 9.7 Modern general cargo ship. An escape trunk fitted with a ladder would run up from the shaft tunnel through the aft peak.

from the centrifuge or burners should collect in oil bilges or wells. According to the Safety of Life at Sea (SOLAS) Convention, the oil should have a flashpoint not lower than 43°C.

Filling or emptying any tank (or cargo space) will affect the ship's stability, especially if it has a free surface area of liquid. (See Chapter 12).

3. Container ships

a. Types

Previously, ships have carried their cargoes in bulk or as individual items. Nowadays, however, there is a trend towards containerisation, whereby manufacturers load their goods into containers which are then transported unopened to their destination. Containers are constructed to internationally agreed dimensions; the standard sizes are $6.1 \times 2.44 \times 2.44$ metres and $12.2 \times 2.44 \times 2.44$ metres, with a maximum carrying capacity of 20 and 30 tonne respectively. Containers are usually made of mild steel, stainless steel, steel-and-aluminium alloy, fibreglass, or combinations of these materials. They vary considerably in design: apart from the standard models for miscellaneous cargoes there are insulated and refrigerated containers, open-top models, bulk models and tank models (see Fig. 9.8). They may be of single or double wall construction.

Ships designed to carry containers vary in size from 1,000 to 100,000 tonne and may hold up to 2,500 containers. They fall into three categories:

(i) full container ships	These carry containers in all available spaces, stacked in cells up to eight deep below deck and four deep above (see Fig. 9.9). Each individual cell is formed by four vertical guide rails, and heavy web frames or similar structures separate cell groups within a hold. These ships have no tween decks.
(ii) partial container ships	These have only part of their capacity designed specially for containers. The remainder may carry general cargo.
(iii) general purpose ships	These can use all or part of their capacity for either containers or other cargo.

b. Features

The design of container ships varies. The superstructure can be located in different positions and may comprise up to 12 decks

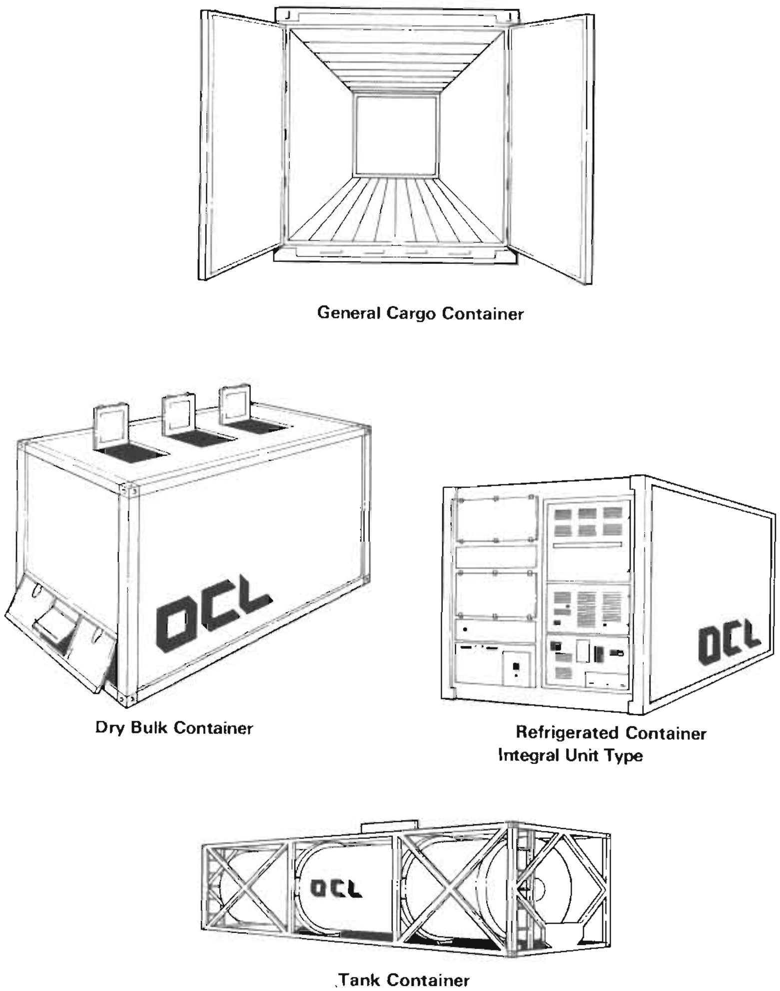


Fig. 9.8 Examples of different types of containers.

with the engine room casing in the middle, surrounded by the accommodation. These vessels do not normally have a shaft tunnel, so access to the engine room is from the decks only (see Fig. 9.10). Access to the holds is via the very large hatches provided for loading and unloading, or from a working alley below the main deck on port and starboard sides; this has small hatchways fitted with ladders. There can be up to 12 holds, each having perhaps two or three loading hatches. On some types, the top containers rest on the upper deck, in which case the deck and hatch covers are sometimes strengthened to take the weight of the

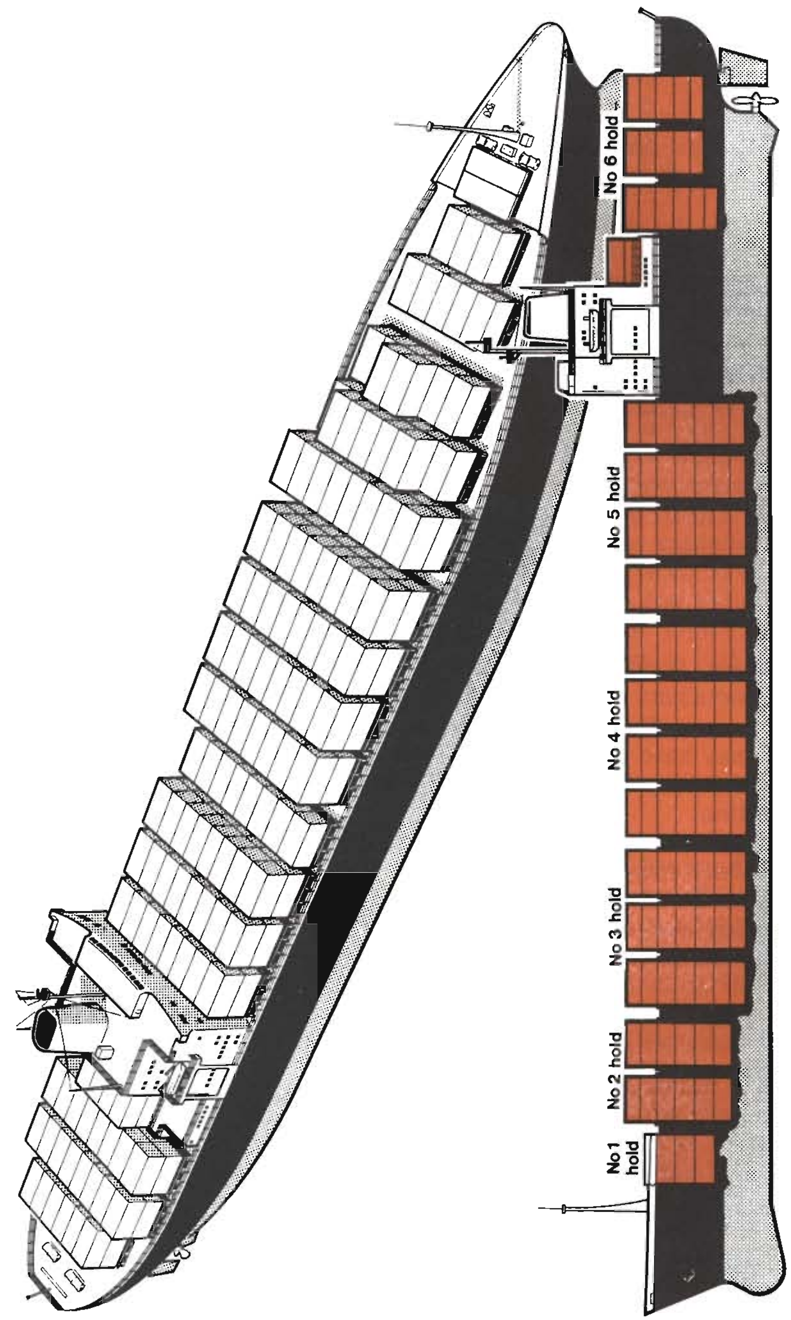


Fig. 9.9 A type of container ship showing the general arrangement of holds and container stowage.

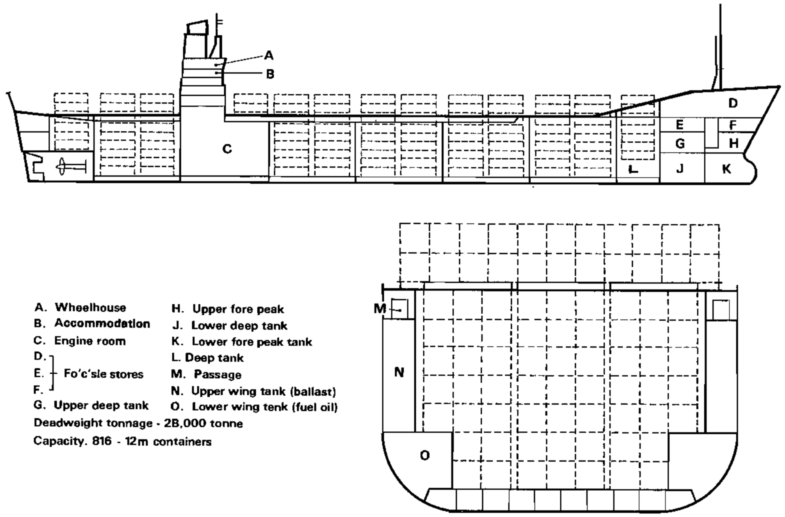


Fig. 9.10 A profile and cross-section of a container ship of 28,000 tonne dwt.

containers. Some holds are insulated (see Section 6 below) and carry containers attached by flexible pipes to the ship's refrigeration system. There may also be refrigerated containers on deck. These may have motors driven either by an integral diesel engine or by electricity fed through flexible pipes from the ship's power installation.

Some container ships are being designed especially for use at ports where there is no conventional handling gear. These have access to the cargo spaces through doors in the bow, and carry equipment such as bogies and heavy duty fork-lift trucks for loading and unloading.

4. LASH ships and barge-aboard ships

'LASH' stands for 'Lighter-aboard ship'. A lighter is a large floating box into which various goods, often mixed, can be loaded and which is then lifted aboard by crane. Some ships can carry between about 70 and 90 lighters and may have both lighters and ordinary containers on board at the same time. (Plate S.2).

Barge-aboard ships have three continuous cargo decks, with no hatch openings on the top as loading is carried out horizontally by means of a moving platform at the stern. These ships can carry 12 barges on the lower deck, 12 on the main deck and 14 on the upper.

5. Roll-on, roll-off (Ro-Ro) ships (other than passenger car ferries)

These vessels have loading ramps via which vehicles can drive on and off (see Fig. 9.11). A particular example is the bulk car carrier which can transport very large numbers of cars (2000 is not uncommon and some carry very many more) (see Fig. 9.12). One important feature is the large number of decks: 12 is typical. As on partial container ships, these may be adjustable, i.e. suspended on cables so that they can be raised, lowered or removed to facilitate loading, unloading and the carriage of different cargoes. The cars are usually driven onto the ship through bow or stern loading doors and into position via ramps, then secured. The car spaces are like large hangars, with no bulkheads, and headroom is very limited. They usually have mechanical ventilation. Movement across them is severely restricted because the cars are very tightly packed together. When the loading doors are closed, main access to the car decks is via stairs in the accommodation section and through sliding doors.

A vessel designed to carry general cargo and/or containers, in addition to vehicles, may be referred to as a Sto-Ro ship; this type of ship may still carry a large number of cars (see Plate S.3). Sto-Ro ships have remotely-controlled watertight doors in the holds, to shut off part of the ship if it springs a leak. (For passenger car ferries, see Section 10a below).

6. Insulated ships

For the carriage of some cargoes, such as fresh foodstuffs, it is necessary to keep the temperature of the hold constant. To achieve this a ship may be insulated wholly or in one or more holds only; it is not uncommon for an ordinary cargo or passenger ship to have an insulated hold. The material used for insulation varies: it may be non-flammable or it may be a flammable substance such as cork. Sometimes both are used together. The material, fitted between the ship's structure and an inner lining of wood or metal, wholly envelops each insulated hold (see Fig 9.13). Any tween decks within the hold are similarly insulated. After loading has been completed, each hatchway is closed with an insulated plug hatch (Fig. 9.13). There are thermometer tubes, one pair per deck, for each hold. Water, steam or CO_2 can be injected via these (see Fig. 9.14).

In the holds there may be ducts to circulate cooled air and these may penetrate bulkheads. Automatically operated dampers are usually provided in the ducts where they pass through bulkheads. Where actual refrigeration is necessary there may be brine

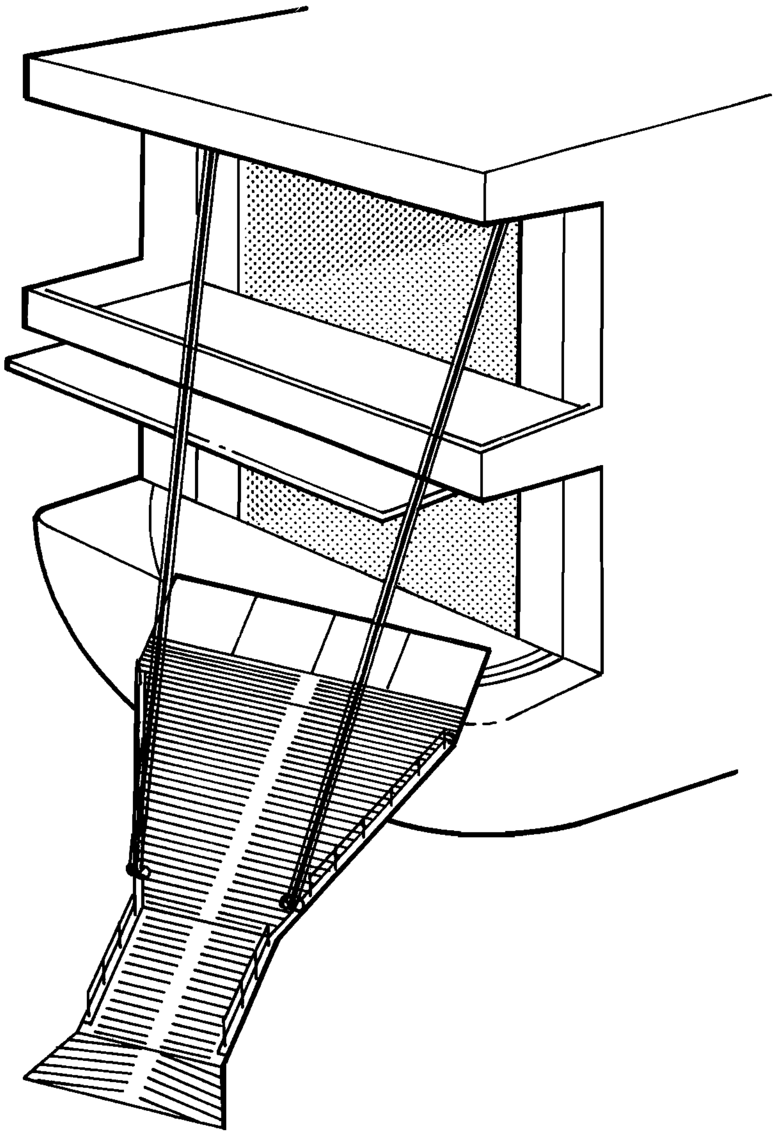


Fig. 9.11 Typical skew-ramp for loading vehicles onto a Ro-Ro.

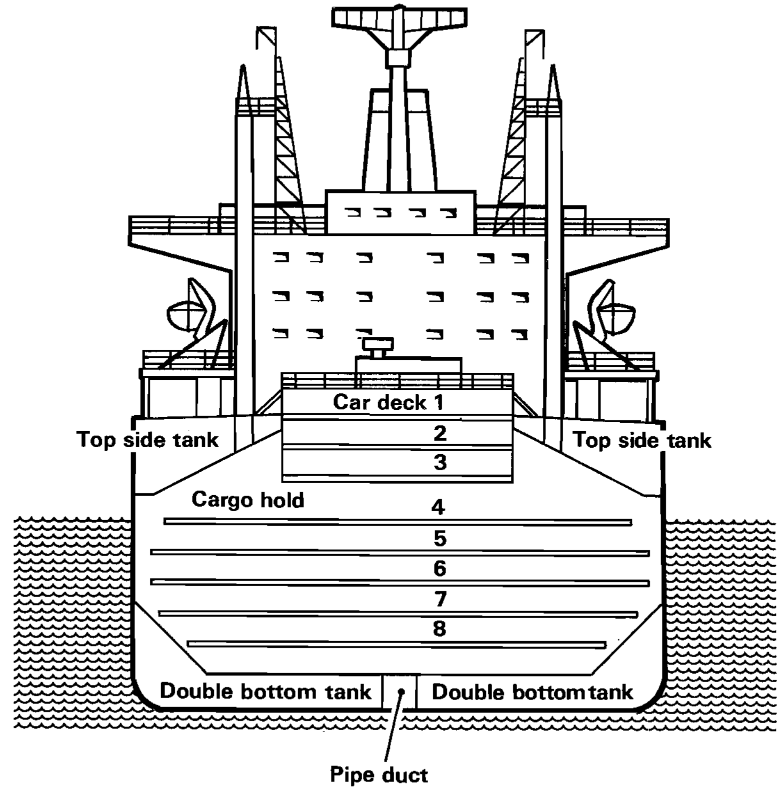


Fig. 9.12 Arrangement of portable car decks in a bulk carrier.

pipes instead of ducts. Gas compression and evaporation methods are used to cool the brine, which in turn cools the air. The gas is usually freon but may be CO_2.

7. Tankers

a. Types

Tankers are designed for the bulk carriage of oil. There are two basic types: large and small. Large tankers are generally used for the carriage of crude oil (crude oil makes up approximately 80% of the oil carried by sea). They are classified by their oil cargo capacity: large crude carriers (LCCs), 100,000–200,000 tonne; very large crude carriers (VLCCs), 200,000–400,000 tonne; ultra large crude carriers (ULCCs), over 400,000 tonne. Small tankers (typically 20,000 tonne) are referred to as product carriers and carry refined products from the oil refineries.

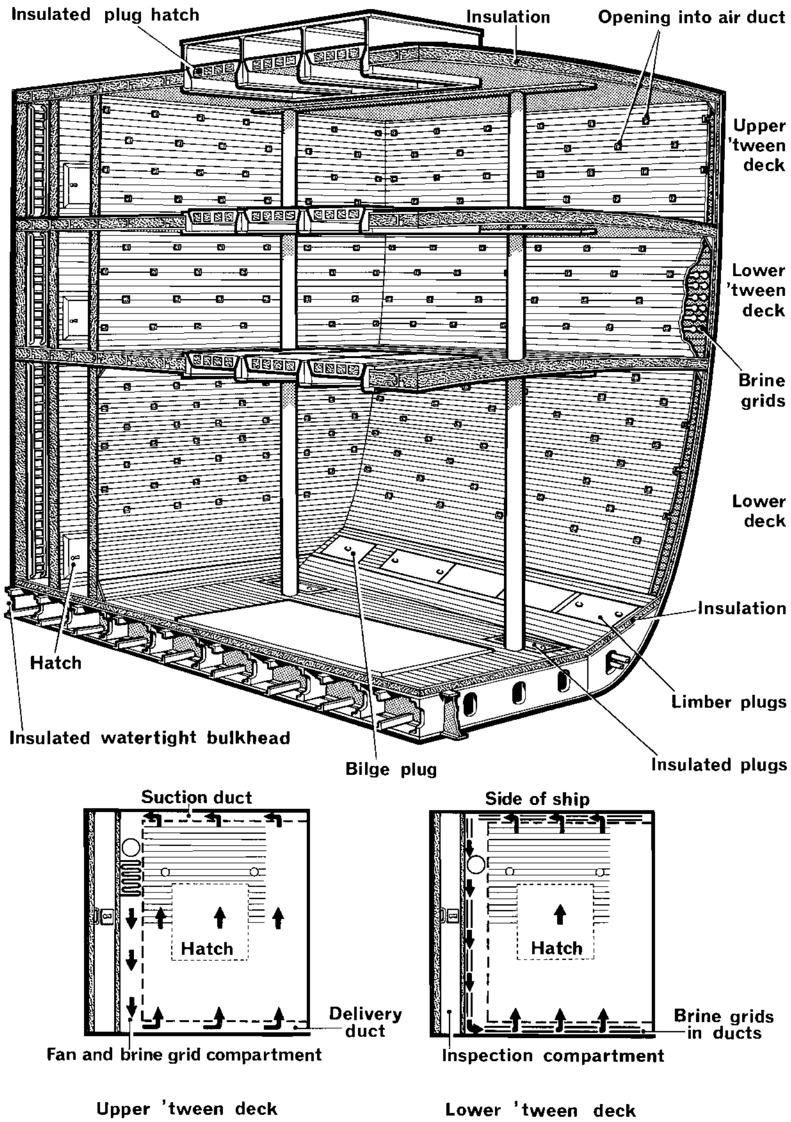


Fig. 9.13 Sectional view of a type of insulated ship showing the insulation, brine pipes and plug hatches. Plan sections of two decks are shown below.

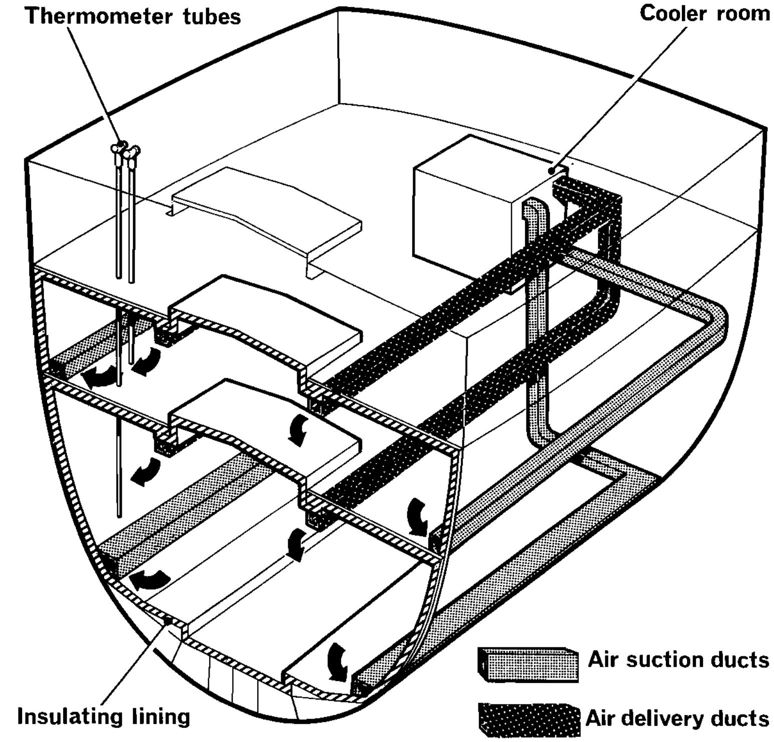


Fig. 9.14 Sectional view of the hold of an insulated ship, showing air ducts and thermometer tubes.

b. Construction

In both types most of the hull is given over to cargo space, the oil being carried in oil-tight compartments which extend about three-quarters of the length of the ship. These tanks are separated from the rest of the ship by coffer dams (occasionally by pump rooms and water ballast tanks). (See Fig. 9.15). The number of tanks varies between the product carriers and the crude carriers. The large vessels have a relatively small number. Product carriers, however, have more tanks, formed by longitudinal and athwartships bulkheads. These improve stability by breaking up the free surface area of the liquid, and enable different grades of oil to be carried separately. There are usually no double bottoms under the cargo space, though there are under the machinery space. Bunker oil may be carried in the machinery space double bottom, and also in a deep tank just aft of the cargo tanks, and in a cross-bunker tank. The superstructure is usually all concentrated at the

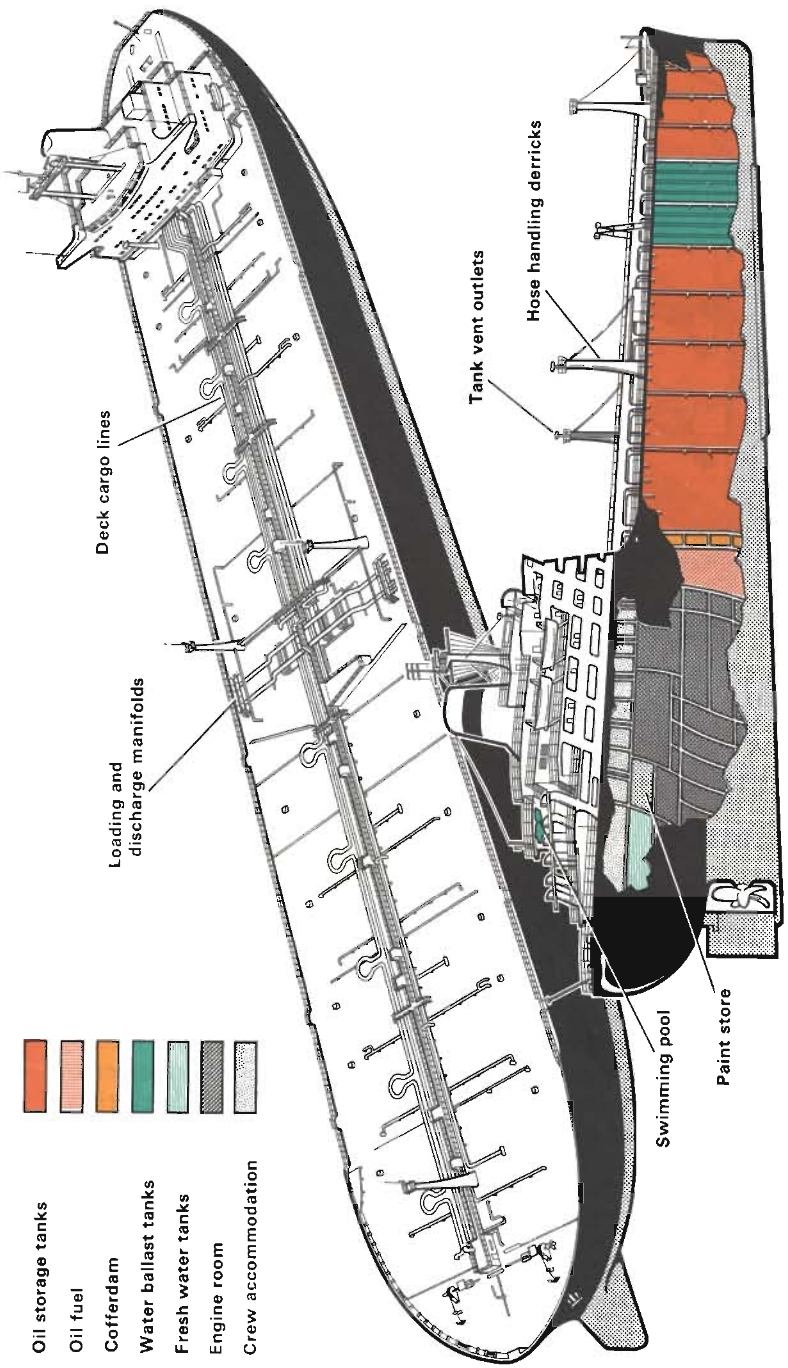


Fig. 9.15 A VLCC showing an arrangement of tanks, pipelines, ballast tanks etc.

rear of the ship above the machinery space. It can consist of up to seven decks: the top or 'monkey island' contains the standard magnetic compass, direction finder loop, signal mast, aerials, lights etc; below this is the bridge, and then accommodation areas, galleys, stores etc.

c. Loading and unloading of cargo

Oil cargo is loaded and unloaded through large hoses and hard-arms connecting the deck pipelines to the shore-lines. (See Plate S.4). Loading is achieved by shore pumps; unloading is done by the ship's pumps. Valves control oil flow on the ship: they may be operated by hand-wheels on the main deck and in the pump-room, or alternatively they may be hydraulically powered and/or remotely controlled from a cargo control room.Most large modern vessels have a free flow system of cargo handling, in which the oil is allowed to pass from one tank to another through bulkhead valves; this reduces the amount of pipework needed. Product tankers may have a simple ring main pipeline to handle different grades of oil; alternatively, there may be a central or twin duct system running the full length of the ship. The oil discharged from the tanks is usually replaced simultaneously by inert gas as a fire precaution (Fig. 9.16).

d. Safety measures

Tankers are subject to very strict safety regulations and they follow safety procedures such as the one mentioned above. In addition to numerous portable fire extinguishers and water hydrants, there may be a means of smothering with inert gas (Fig. 9.16), or a system of foam generation with monitors covering the tops of the tanks (see Chapter 10 Section 5d). There may also be a multi-spray water system in engine spaces, over turbines and boilers, and in escape routes.

8. Chemical and gas carriers

a. Bulk chemical carriers

The bulk carriage of chemicals is now extensive. Some of the chemicals carried are harmless but others are highly dangerous: they may be easily flammable, with a low ignition temperature; they may also be toxic, corrosive or harmful in some other respect. The construction of chemical carriers must take account of these dangers (see Fig. 9.17).

Some ships are specifically designed to carry one chemical and are generally quite small. More common, however, are the large parcel tankers which can carry a number of different chemicals at the same time. The International Maritime Organisation (IMO) has drawn up a code of safety provisions to which all chemical

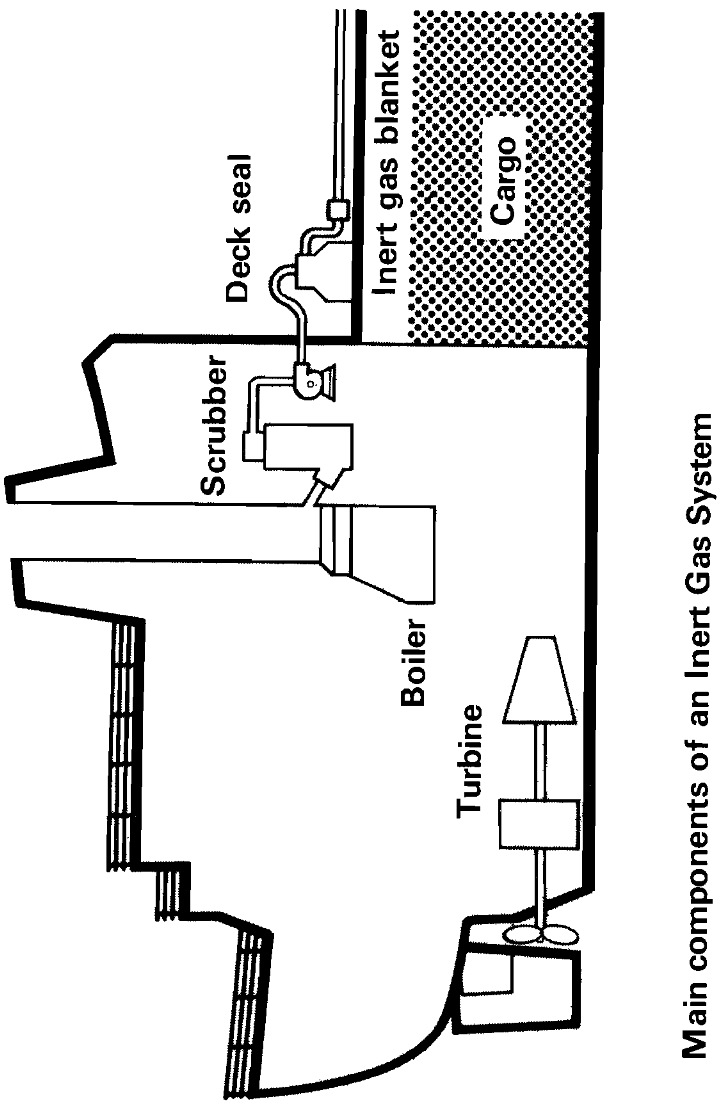


Fig. 9.16 Schematic diagram of ship inert gas system.

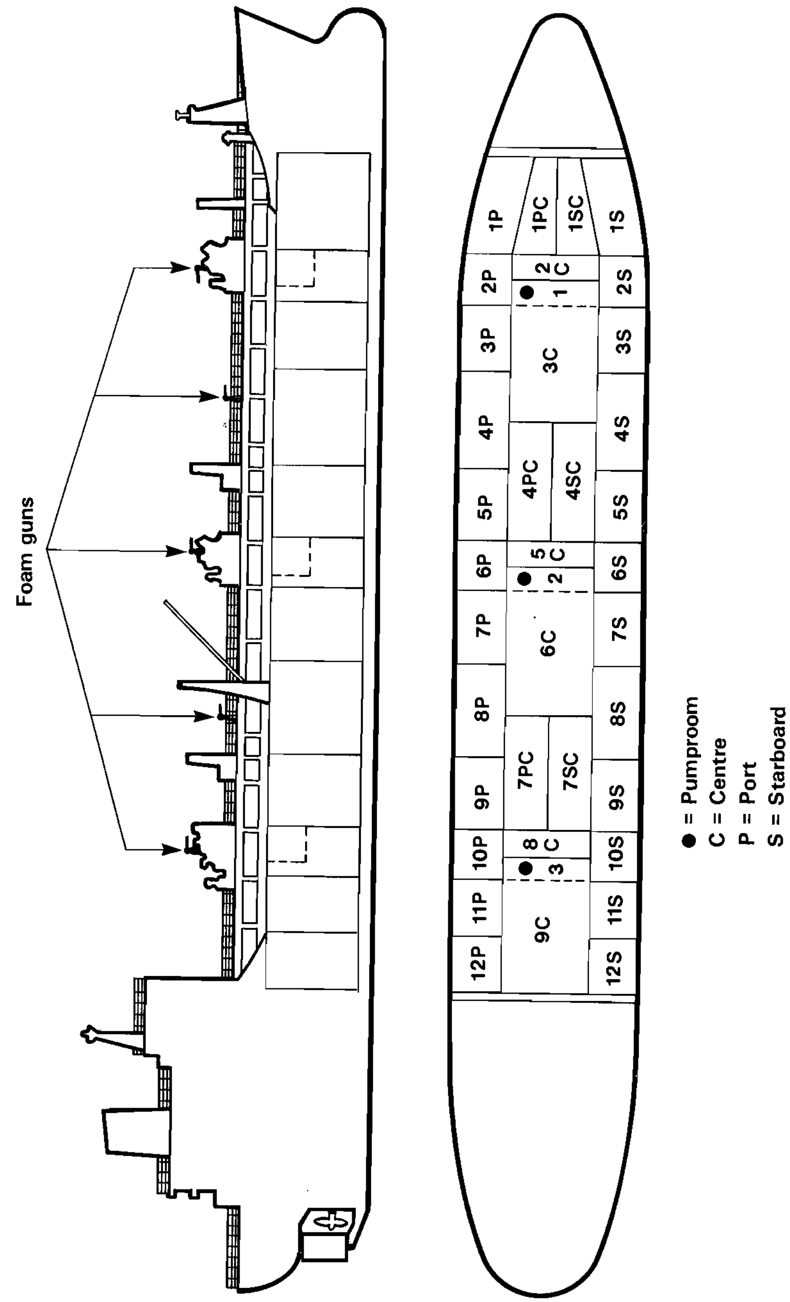


Fig. 9.17 Bulk chemical carrier showing tank numbering system.

carriers should conform. A major provision is that all chemicals, except those in the safest category, must be carried in tanks located away from the sides and bottom of the ship; certain minimum distances are specified for this purpose. There are also requirements on cargo separation. Cargoes which react dangerously with other cargoes should be separated from them by a coffer dam, void space, pump-room, empty tank or mutually compatible cargo. They should have separate pumping and piping systems which, unless encased in a tunnel, should not pass through other tanks containing chemicals that might react; and they should have separate ventilation systems.

The tanks in which the chemicals are carried can be either integral, i.e. forming an essential part of the ship's hull, or independent, i.e. not forming part of the hull structure. In modern ships, the tanks have linings that can be of epoxy, zinc silicate, or stainless steel. The allocation of cargoes to the various tanks will depend not only on the cargoes' compatibility with each other (and with any residue that may be left over from previous cargoes), but also on their compatibility with the tank linings, since these can be damaged by contact with certain chemicals.

All cargo tanks should have an appropriate ventilation system; certain substances require special ventilation arrangements. In some cases it is also necessary to have special controlled atmospheres in cargo tank vapour spaces and in the spaces surrounding the tanks. This can be achieved by:

(i)	inerting	filling the space with a gas which will not support combustion and which will not react with the cargo (see Chapter 10 Section 4e);
(ii)	padding	separating the cargo from the air by means of a liquid or gaseous filling;
(iii)	drying	keeping the cargo free of water or steam by separating it off with a moisture-free gas.

Chemical carriers usually have two or three pump rooms, each with a number of high-capacity pumps. The pump rooms should be so arranged as to ensure unrestricted passage, and access to cargo control valves should allow ease of movement to a person wearing protective equipment. Access ladders should not be vertical, and individual platforms should be fitted with guard rails. The entries to void spaces, cargo tanks and other spaces in the cargo tank area should, likewise, be accessible for a person wearing BA, and there should be direct access to the cargo tanks from the open deck.

b. Gas carriers

Gas carriers most commonly carry liquefied petroleum gas (LPG) but some carry liquefied natural gas (LNG) or chemical gases such

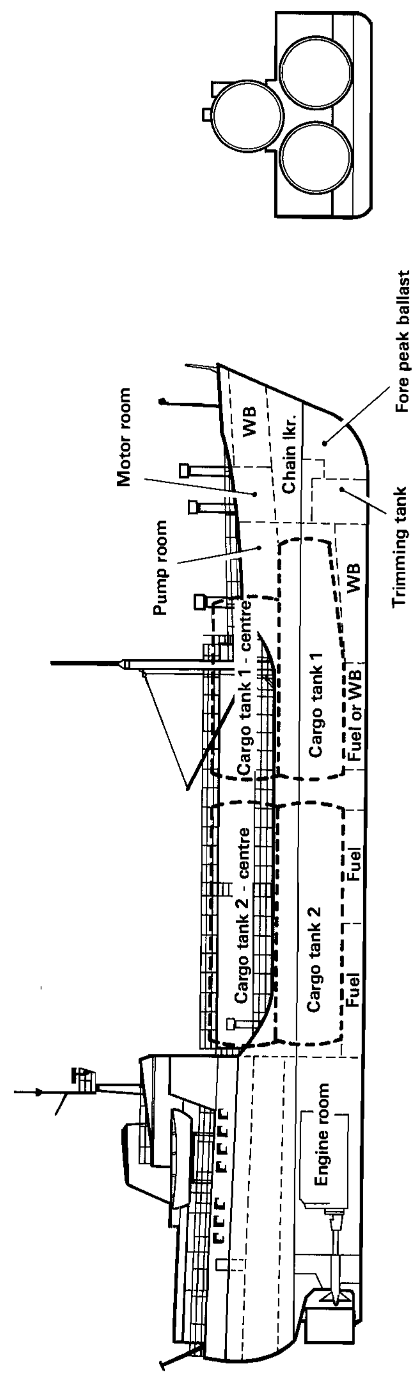


Fig. 9.18 General arrangement of LPG carrier.

as ammonia. They are normally of an all-aft design but the number, position and form of their tanks vary (see Plate S.5). They can be (a) integral tanks, forming an essential part of the vessel's hull; (b) membrane tanks, consisting of a thin metal lining (or two linings with insulation between them) supported by the insulating material within the ship's hull; (c) semi-membrane tanks, which stand alone when empty but expand to be supported by the insulation when full; or (d) independent, self-supporting metal tanks with a single or double wall, not forming part of the hull. In shape they may be cylindrical, spherical or straight-sided, or conform to the contours of the hull, and their location may be in the holds or on the decks, side by side, or on the centre line, or in pairs to port and starboard. (Fig. 9.18). The vessel may also have topside wing tanks, usually to carry water ballast.

In view of the low boiling point of the liquefied gas, cargoes have to be carried under more than atmospheric pressure, under refrigeration or under a combination of the two (Figs. 9.19 and 9.20).

Refrigeration may be to as low as −50°C in the case of LPG carriers,and −164°C in LNG carriers. In the latter, the cargo tanks have to be insulated not only to prevent cargo evaporation and pressure build-up within them but also to protect the rest of the ship's steel structure against low-temperature embrittlement. Balsa, polyurethane foam, perlite and polystyrene foam are some of the materials used for this purpose (Fig. 9.21).

These ships are usually equipped with inert gas generators and the large types with fixed and mobile firefighting systems. To cover the tanks and manifolds, remotely controlled dry powder monitors may be installed, plus handlines from mobile Monnex dry powder units. Such vulnerable areas as cargo tank domes, compressor rooms and the front of the superstructure are protected by water-spray systems. Halon 1301 systems could be found protecting the engine room, wheel house, generator areas etc.

c. Combined chemical/gas vessels

There may be, in the future, an increasing number of ships having features of both types of vessels mentioned above and designed to carry both chemicals and gases either separately or at the same time. Some already in service have very sophisticated cargo systems and can carry a wide range of both commodities. They can accommodate a considerable spread of cargo pressures, specific gravities and temperatures, with facilities for both heating and direct (vapour) or indirect (circulating liquid) cooling and extensive cargo tank insulation. The tanks are few and relatively large with a small number of hatches. Cargo is moved by pumping or by pressurising the tanks with air or nitrogen. Particular problems that might occur with these ships are poor ballast capacity,

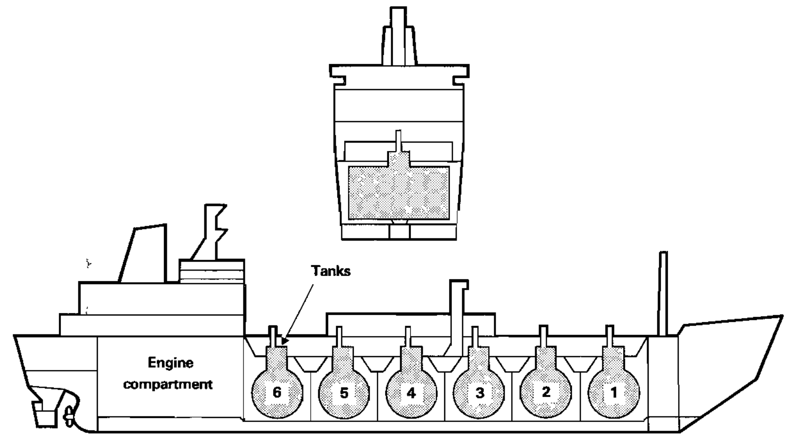


Fig. 9.19 4,100 m^3 semi-pressurised/fully refrigerated LPG/Ethylene gas carrier

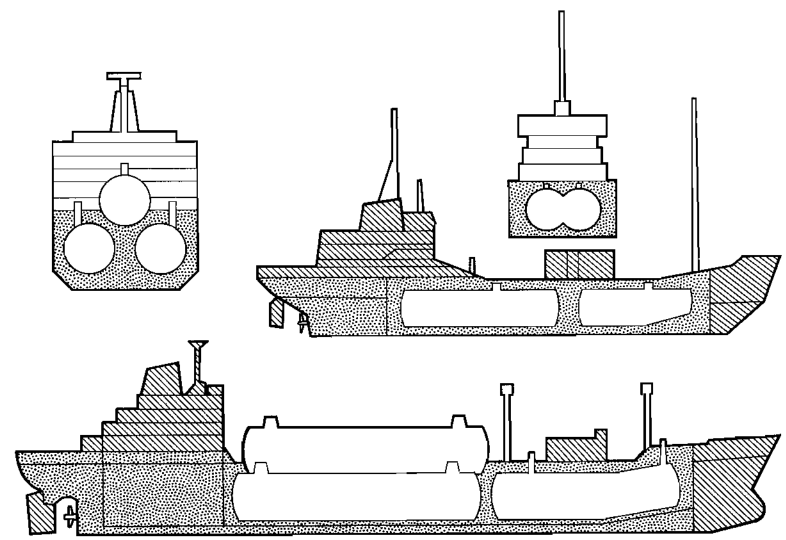


Fig. 9.20 ABOVE: Pressurised ship, 900 m^3 capacity gas carrier. BELOW: Semi-pressurised/fully refrigerated, LPG/Ammonia carrier with 12,600 m^3 capacity.

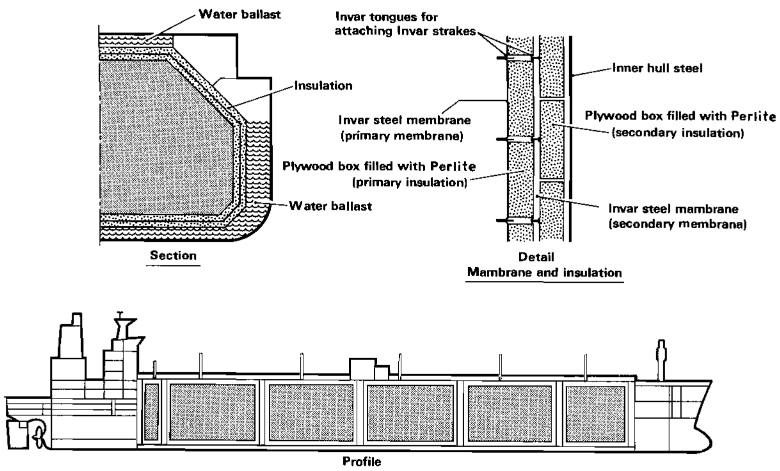


Fig. 9.21 Gas transport using membrane tank system, showing type of insulation used around the tank.

decreased stability, the absence of a cargo control room and difficulties with safety valves (those for chemicals and those for gases are not interchangeable).

9. Bulk carriers

General cargo vessels are not entirely suitable for carrying bulk cargoes such as grain, ore or coal. Special bulk carriers have therefore been developed for the transport of such goods. There are four main types as described at (a)–(d) below. Those carrying more than one type of cargo are known as combination carriers.

a. General bulk carriers

These have a large cargo hold volume with large hatches having heavy, watertight steel covers. There should be a substantial ballast capacity (see Plate S.6).

b. Ore carriers

These carry their cargo in narrow holds, the inner bottoms of which are raised up to 4 m above the keel. The surrounding spaces, or side tanks, are sub-divided and used to carry water ballast.

c. Ore and Crude Oil carriers (O/O)

These vessels can carry either crude oil or ore, but not both together. The holds are raised above the keel, but not as far as

on ore carriers. The bulkheads are specially strengthened. Hatch openings are small and oil-tight. Ore is carried in the centre holds with the wing and ballast tanks empty; oil is carried in the holds and usually in alternate wing tanks. The vessel has pipework and pumping systems similar to those of a crude carrier, and there is usually some form of cargo handling gear near the pump-house.

d. Ore/Bulk/Oil carriers (OBO)

These vessels carry ore, crude oil or general bulk cargoes (see Fig. 9.22). The holds, unlike those on the ore and O/O ships, may extend the full width of the ship and are not always raised above the double bottoms. Hatches are small with oil and gas-tight covers. Ore is carried only in alternate holds, but oil in all; there are pumping systems installed to enable this. The double bottoms and upper wing tanks are used for water ballast. On both O/O and OBO ships, coils or ducts for heating the heavy oils are usually located under the tank tops, behind shields at the base of bulkheads, or under deckheads to be lowered by winch as required. Some OBO types are known as PROBO ships (Products (oil), Ore, Bulk, Oil).

e. New developments

Developments of the bulk carrier include the 'geared' carrier for general cargo, phosphate, ore, timber or containers, cargo handling being by means of travelling gantries; and a ship which can be converted from a general bulk carrier to a car carrier by the lowering of a number of car decks.

10. Passenger vessels

a. Passenger car ferries

(1) Construction

These vessels (see Fig. 9.23 and Plate S.7) typically carry 250–500 cars, fewer if larger vehicles are carried. They usually have hydraulically operated doors at bow and stern for vehicles to drive to and from the car decks, and are sometimes included in the category of Ro-Ro ships. (The non-passenger-carrying type of Ro-Ro ship is dealt with in Section 5 above). Private vehicles may be stowed in two tiers at the sides with large commercial vehicles in the centre. At the after end of the ship is a short partition containing various services. In contrast to bulk car carriers, there is reasonable headroom, and movement between vehicles is not impossible. The main car decks have no bulkheads and are like large hangars, with side mezzanine decks. Access to them when the doors are closed is via stairs and sliding doors from the upper decks. On some ships the top deck, which is open, may be

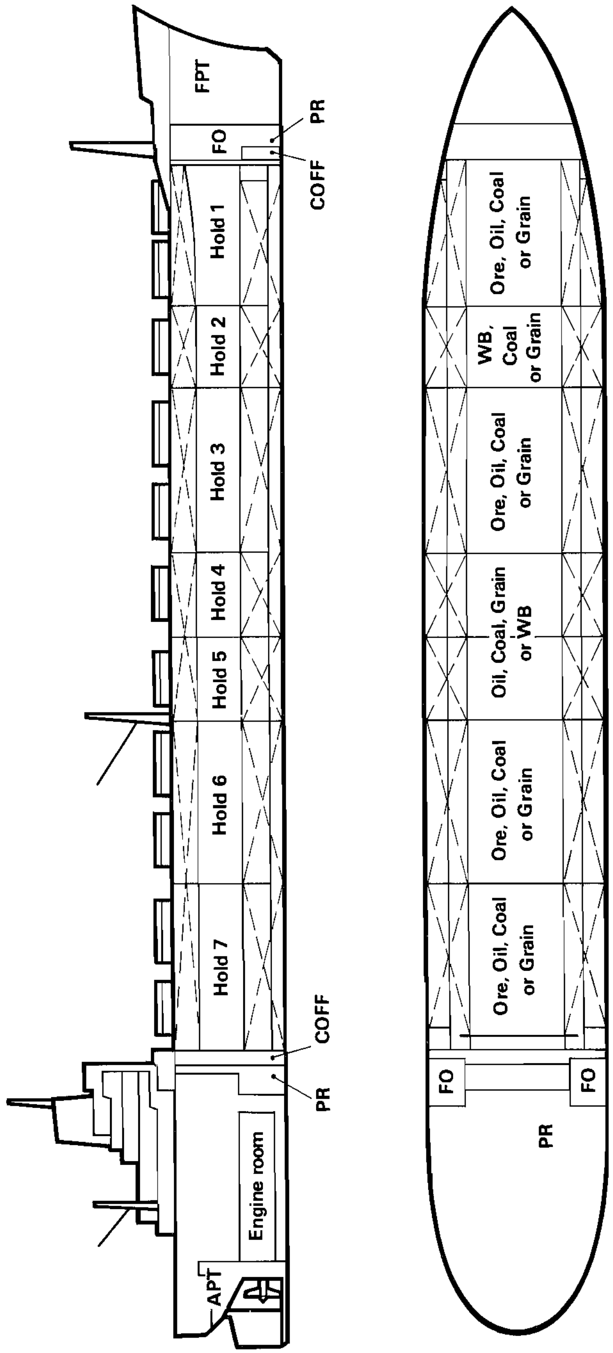


Fig. 9.22 A bulk carrier (OBO) showing lay-out of holds and compartments and a typical division of cargo.

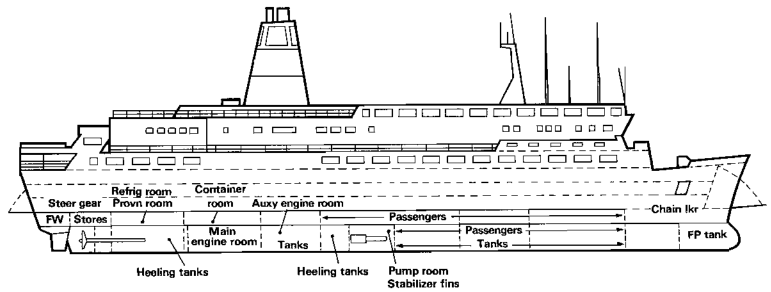


Fig. 9.23 Typical car and passenger ferry. There may be two or three car decks plus moveable mezzanine decks.

used for commercial vehicles carrying dangerous substances (see Chapter 13 Section 5e).

There may be first-class cabins at boat deck level; second-class are usually below the car decks, forward of the engine space. Access to cabins is normally via enclosed stairs from the promenade deck. At various levels there will be public facilities such as restaurants, bars and shops with their associated service areas. There may be as many as 1500 people on board.

The engine space is usually amidships at the lowest level, and the normal access to it is via staircases from the upper decks. Engine rooms sometimes have low deckheads.

(2) Fire protection

On the car decks there are usually automatic sprinkler systems or manually operated drencher systems supplied by electric pumps. Their controls and operating valves are usually in the centre partition of the car deck. Fixed CO_2, foam or water spray installations cover the main engine spaces and are operated manually from outside the engine room. Throughout the vessel there are hydrants with hose and branches nearby, fire detectors, and a manually operated breakglass fire alarm system.

b. Liners

A large passenger vessel of this sort, used for long journeys and cruises, has a large crew and can carry over a thousand passengers; it may have as many as 12 decks. The one immediately above the water level is the statutory bulkhead deck. Decks may all be lettered from the top downward but there may be a sun, boat, games, promenade or other deck above A, and other unlettered decks below those used by the passengers. Below the statutory bulkhead deck the hull is divided by watertight fire-resisting bulkheads, and compartments can be isolated off by closing the port and starboard watertight doors located in each bulkhead on each deck. The doors can be operated manually from either side, or electrically from a master control on the bridge. On the statutory bulkhead deck and above, the hull and superstructure are divided by non-watertight fire zone bulkheads (zone length being 40 m) with openings closed by fire doors. These are normally open, but close automatically by means of a fusible link if there is a local rise in temperature; they can also be closed mechanically by the release of a local control. Corridors run the length of the ship on each side of each passenger deck, with side passages to the cabins. At intervals in the main corridors, there are halls with lifts and stairs leading to the other decks and public rooms. The stairways may be located in a fire-resisting enclosure. There are often also working alleyways, separate from the accommodation, which run the length of the ship and provide the main access to working spaces.

Liners generally present a high fire risk. Passenger accommodation on these vessels is very extensive and there are numerous large public rooms and facilities. The overall pattern of rooms, corridors, etc is very complex (Plate S.9). Decoration, furnishings and fittings are generally elaborate and possibly flammable. Panels and false ceilings create air spaces which can be a particular danger in promoting rapid fire spread; they may also contain piping and cables. (On modern ships, these spaces may be fire-stopped at intervals.) Conduction of heat by metal decking can also help spread fire, and insulation of specially important areas is therefore common on modern ships. Generally there are automatic fire alarms and detectors in the accommodation and service areas, together with automatic sprinklers in the deckheads or non-combustible materials in the structural boundaries and partitions.

11. HM ships

Naval vessels differ in design according to their function: aircraft carrier, frigate, destroyer, minesweeper etc. All are very much more extensively divided into watertight compartments than comparable merchant ships, the divisions being both transverse and longitudinal. The compartments are lettered alphabetically from stem to stern. All decks below a point about 2.5 m above the exterior water level are also fitted with watertight hatches. The decks are numbered from the uppermost continuous deck down, this deck being number 1. Superstructure decks are numbered consecutively from the main deck upwards. Naval vessels do not have port-holes. The extensive use of light alloys makes possible considerable addition to the superstructure. Electrical systems are very complex. Naval vessels are generally more comprehensively equipped with mobile and fixed firefighting apparatus than are other ships, and, apart from in the magazines and weapon storage areas, they are also likely to have less flammable material aboard.

Chapter 10
Ship-board fire protection

1. Legislation

The SOLAS Convention is an international agreement drawn up under the auspices of the International Maritime Organisation and up-dated at intervals. The Convention lays down various standards relating to ship-board fire protection. It is initially at the discretion of individual member states to enforce these standards, as far as their own ships are concerned, by introducing relevant national legislation. After consultation and agreement between individual member states, a standard subsequently becomes mandatory for the shipping of them all. National legislation then becomes compulsory. Voluntary compliance with SOLAS requirements by shipping owners and others in advance of legislation is, of course, always possible.

UK law has already given effect to a number of current or earlier SOLAS requirements through various Statutory Instruments, which lay down rules concerning ship construction, life-saving appliances, firefighting equipment, means of escape etc. Although foreign ships may comply with the SOLAS requirements, the rules themselves apply only to UK-registered ships. For these the rules represent the legal minimum provision. Some ships may go further; they may, for example, comply with later SOLAS requirements. (These mostly just up-date the earlier ones and make them more specific). The *Merchant Shipping (Safety Convention) Act 1977* makes possible the introduction of new or amended rules to enforce such compliance.

2. Requirements

The exact provisions of the rules relating to fire protection are very detailed and vary according to the class and size of ship. The rules do not apply to vessels of very low tonnage.

a. Passenger ships

The following are among the more important general requirements. (These are minimum only, and higher demands may be made on large or specialised ships.)

i. There should be a fire patrol system, manual alarms throughout the passenger and crew spaces for the patrol to use, and a fire detection system in areas which the patrol cannot reach. There should also be automatic fire alarm and detection systems in all accommodation and service spaces, with certain exceptions where there is no substantial fire risk or where there is a smothering gas or similar installation. The systems should give both an audible and a visible alarm. The indicators may be on the navigation bridge, at stations having communication with the bridge, or distributed throughout the ship. They must show the location of the fire which has activated the system.

ii. There should be a facility for directing at least two jets of water into any passenger or crew space while the ship is under way, and into any cargo space or storeroom.

iii. The ship should have not fewer than two fire pumps, and there should be provision to ensure that a fire in any one compartment cannot put all pumps out of action. There should be hydrants in all designated spaces. The system should function when all watertight and bulkhead doors are closed.

iv. There should be portable extinguishers in all service, accommodation and control spaces.

v. If the ship is 1,000 t or over, it should have a fixed fire smothering installation (gas or steam) to protect certain spaces.

vi. Machinery spaces should have special fire protection (water spray, smothering gas or foam installation, foam or other portable extinguishers, sand) according to the type of machinery. When oil can drain from the boiler room to the engine room they must be treated as a single space.

vii. A minimum of two firemen's outfits (smoke helm/mask or BA, safety lamp, axe) should be carried, in widely separated spaces. At least two should include BA fitted with air hose.

viii. The ship must carry an international shore connection able to be fitted to either its port or its starboard side.

b. Cargo ships

Cargo ships, again according to size, should meet requirements similar to the above, as follows:

i. It should be possible for at least two jets of water to reach any accessible part of the ship when it is under way, and any storeroom or cargo space.

ii. The ship should have at least two main fire pumps and, if necessary, an emergency pump to ensure that a fire in one space cannot render all pumps inoperable.

iii. There should be portable extinguishers in all service and accommodation spaces (with a minimum of three).

iv. In some cases there should be a fixed fire smothering installation (gas, steam or foam according to circumstances) to protect the cargo spaces.

v. Machinery spaces should have special fire protection similar to that in passenger ships' machinery spaces.

vi. The ship must carry at least one fireman's outfit, outfits being kept in widely separated spaces. At least one must include BA fitted with air hose.

vii. If the ship is 1,000 t or over, it must have an international shore connection able to be fitted to either side (see Plate S.8).

c. Large tankers and combination carriers

The *Merchant Shipping (Fire Appliances) (Amendment) Rules 1974* lay down special requirements for large tankers and combination carriers (O/O and OBO ships etc). These relate mainly to the provision of the following facilities or their equivalents:

i. an inert gas system;

ii. a fixed deck foam system;

iii. a fixed water spray system in each cargo pump room, operated from a readily accessible position outside;

iv. hand-controlled branches with a shut-off capability.

The *Rules* specify certain requirements that these facilities must meet.

3. Fire detection and alarm systems

The basic requirements for detectors and alarms on passenger ships are set out in Section 2a above. The systems can be of various types; details are given in the *Manual*, Book 9, Part 2. Their layout will be adapted to suit the needs of each particular ship.

4. Fire extinguishing media

a. Steam

On some ships, steam is available continuously and in large quantities, provided that there is sufficient fresh water available and that the machinery spaces have not been affected by fire. The steam must be generated from fresh water since marine boilers cannot normally use salt water. It helps fight a fire by displacing the oxygen from the air and by slowly saturating the cargo as its moisture content condenses. There are, however, disadvantages associated with its use:

i. Very large quantities are necessary, especially at first when much is likely to condense.

ii. It cannot be used on cargoes on which water could not be used, since it would have the same effects, e.g., it may produce dangerous gases or cause certain cargoes to swell. Explosives may be rendered unstable by steam.

iii. If steam is used intermittently and not consistently, a vacuum may result; this will give rise to a rush of air which could worsen the situation. Air may also be sucked in during earlier stages of the operation when the steam is being condensed to water.

iv. Steam will cause almost as much damage to cargoes etc as water.

Firemen are unlikely to use steam themselves, but the officer-in-charge may in certain circumstances ask the ship's Master to arrange for this to be done.

b. Water

Water is the most common medium of attack or containment that the Fire Brigade uses, initially at least, and ships have provision to make this possible (see Section 2 above). Apart from water supplied through ship's fittings, such as sprinklers, jets may be necessary for tackling the fire and cooling the hull, and sprays for cooling bulkheads from within. Flooding a hold is also a possibility (see Chapter 13 Section 3c). Like steam, water can damage cargo or machinery and with some cargoes it may react dangerously; there are some substances on which it should never be used. The main problem in the use of water, however, is in its effect on a ship's stability (see Chapter 12).

c. Carbon dioxide

Carbon dioxide is generally recognised as more efficient than steam for smothering a fire and may form part of a ship's fixed firefighting installation. It is usually supplied from an on-board battery of cylinders for such purposes. Fire Brigades can also obtain bulk supplies of the gas by arrangement with manufacturers; it will then be brought to the scene of the incident in the firm's own road tankers (see *Manual*, Book 11, Chapter 3).

Carbon dioxide extinguishes fire by reducing the proportion of oxygen in the air around it to a level where combustion can no

longer be supported. The level which must be reached to achieve this varies according to the cargo on fire. In calculating the amount of gas required, an allowance is also necessary for that escaping through openings. Carbon dioxide has the following advantages:

i. it leaves most cargoes undamaged and unaffected;

ii. since it is carried as a liquid under pressure, it does not require pumps.

Disadvantages are:

i. Some cargoes, e.g. cotton, require the oxygen in the atmosphere to be reduced to a very low level, which will take time and necessitate large amounts of carbon dioxide. A few cargoes, such as celluloid, contain enough oxygen of their own to support their combustion even in an oxygen-free atmosphere, and carbon dioxide will therefore be unable to stop them burning.

ii. The gas may be slow to penetrate to some parts of a hold, e.g. areas blocked off by cargo or the centre of tightly-packed bales.

iii. The gas at its initial temperature is denser than air and will descend to the bottom of the space into which it is introduced, perhaps below the fire. It will mix with the air eventually, but this may take some time to happen.

iv. The gas has little cooling effect, and the cargo may therefore remain hot for a long time, with the consequent risk of the fire rekindling.

d. Foam

Section 2 notes situations in which a ship may, or in some circumstances must, have foam available as an extinguishing agent. Foam acts primarily by isolating the source of a fire from the oxygen in the air. It has a number of advantages:

i. great quantities can easily and quickly be generated for filling large areas;

ii. it requires less water than jets, thereby reducing damage to cargo;

iii. it absorbs heat, helps stop fire spread and provides a shield for firemen to move in with hand-lines;

iv. it does not affect a ship's stability in the same way as water.

Medium expansion foam is more common on ships than high expansion because it does not require such large generators. It also has other advantages: the equipment necessary is more mobile and can work in more restricted spaces; the foam is wetter and heavier and therefore less affected by air currents; and it can be projected over longer distances.

When using foam, firemen must ensure that they have water branches in readiness at openings such as hatches, internal portholes etc, since hot gases and burning vapours may be ejected through these as the foam causes displacement.

e. Inert gas

There are now several inert gas systems which use the combustion products of diesel oil. The gas produced, which is heavier than air, consists mostly of nitrogen (about 85%) and carbon dioxide (about 15%); there may also be traces of oxygen, unburnt hydrocarbons and oxides of nitrogen. The gas is non-corrosive and non-toxic and does not usually react with the cargo. Its introduction into an atmosphere makes the air so deficient in oxygen that it cannot propagate flame. The gas can be produced in a continuous supply for several hours, the quantity being limited only by the amount of diesel oil available.

f. Halons

A more recent introduction in ship firefighting is Halon 1301. This is a colourless, odourless, high-density, electrically non-conductive gas, the chemical name of which is bromotrifluoromethane (BTM). It acts by inhibiting the chemical reaction of fuel and oxygen, and has a number of advantages:

i. only a small concentration (5% by volume) is necessary to extinguish a fire;

ii. it has low toxicity;

iii. it is non-corrosive;

iv. it is chemically very stable at NTP, an advantage for prolonged storage;

v. the small amounts necessary mean a saving in weight and space for storage;

vi. its obscuration of the atmosphere is minimal, particularly by comparison with CO_2.

When exposed to flames or hot surfaces above about 510°C, BTM can become unstable and start to decompose. The by-products have a characteristically sharp, acrid odour and irritate. The amount of decomposition depends on the nature of the fire, the fuel, and the amount of gas it is necessary to discharge; but it is usually slight.

Instead of BTM, shipboard fire protection systems sometimes use Halon 1211, i.e. bromochlorodifluoromethane (BCF). This also requires a concentration of only about 5% to extinguish a fire, but it is more toxic than Halon 1301.

g. Dry powder

There may be dry powder extinguishers or installations on board a ship. The properties of dry powder are described in the *Manual*, Book 3 Chapter 5. It should never be used on small fires in machinery, such as electric motors, since this could damage or incapacitate them unnecessarily.

5. Firefighting installations

Firemen attending ship fires will find various installations on board. These will vary according to the medium they are designed to handle. They will often have instructions for their use displayed on them; in some cases this is compulsory. It is probably only rarely that firemen will operate such systems themselves: either the systems will already be in operation when firemen arrive or it will be better for the Brigade to use its own equipment. However, a basic knowledge of the systems will be helpful. This is particularly so in machinery spaces where the majority of ship fires occur. Firemen must not, however, assume that ship-board installations will actually be available and reliable in all cases, especially in some foreign vessels.

a. Steam

Fixed steam inlets to holds, where fitted, are usually laid well down into the cargo space. It may also be possible to introduce steam to a hold through the bilge-sounding pipes or bilge suction lines. Use of the suction lines is however not possible when a non-return valve is fitted to them below each hold.

On some modern ships, a continuous supply of large quantities of low-pressure steam may be unavailable. This is partly the result of a change from old-fashioned boilers, producing an immense amount of steam at low pressure, to modern water tube boilers which produce small quantities of high pressure/high temperature steam, no longer ideal for firefighting.

b. Water

Ships are fitted with pumps and fire mains to meet the requirements set out in Section 1 above. Water mains may be referred to as 'fire services' on board ship; the expression 'fire services' is used only with this meaning. The fire mains on deck may in the Merchant Navy be known as 'wash deck pipes' and used for such purposes. The mains are fitted with deliveries from which water can be supplied via hose-lines to the holds and other parts of the ship. On British ships the outlets are a standard size female instantaneous but on foreign ships they may vary. All ships of 1,000 tonne or over, however, should carry an international shore connection (see Plate S.8). This should enable water from a fire tug, or the land, to be supplied to the ship's fire services, whatever the type of coupling.

Apart from the normal equipment for delivering water in spray, fog or jet form, firemen may find certain special items of use. The most significant of these are the basement spray, the revolving nozzle, the cellar pipe and the elbow-for-nozzle. These are described in the *Manual*, Book 2, Part 2.

Ships may also have a permanently charged automatic sprinkler installation in accommodation and service spaces. In some cases this is compulsory. The installation includes a pressure tank containing a standing supply of fresh water, and a pump drawing sea water which comes into operation automatically when the pressure tank is partially exhausted. On the bridge, and/or elsewhere, there should be some means of indicating which sprinklers are operating. The ship may have fire service inlets fore and aft to which firemen, in dockside incidents, can connect their appliances so as to pump water from the shore directly into the sprinkler system. Firemen should make the same use of a ship sprinkler system as they would of a land system.

In addition to these facilities, some ships have a water-spray system over areas where oil fuel is liable to spread, such as the bilges and tank tops, and over special risks in the machinery spaces. Ships carrying liquefied gases in bulk may have more extensive systems.

c. Carbon dioxide

Carbon dioxide, as already noted, is usually supplied from a battery of cylinders in a central position on board a ship but may sometimes be brought to the scene by road tanker. It is injected into the hold via high-pressure piping from the cylinders through nozzles fitted under the deck (see Fig. 10.1). There are control valves on the different pipes leading to the nozzles and these carry an indication of which compartment they feed. There is often an installation dealing primarily with fires under boiler room floor plates where oil fuel is employed. An audible warning should sound when the gas is about to be released into any working space.

d. Foam

The fixed deck foam system (or acceptable equivalent) prescribed for large tankers (see Plate S.17) and combination carriers (see Section 2c above), and also found on some other vessels, e.g. chemical carriers, should have its main control station in a readily accessible area outside the protected zone and be able to deliver foam over the whole cargo tank area and into any tank or hold of which the deck has been ruptured. The system should include monitors and applicators, plus valves, forward of every monitor

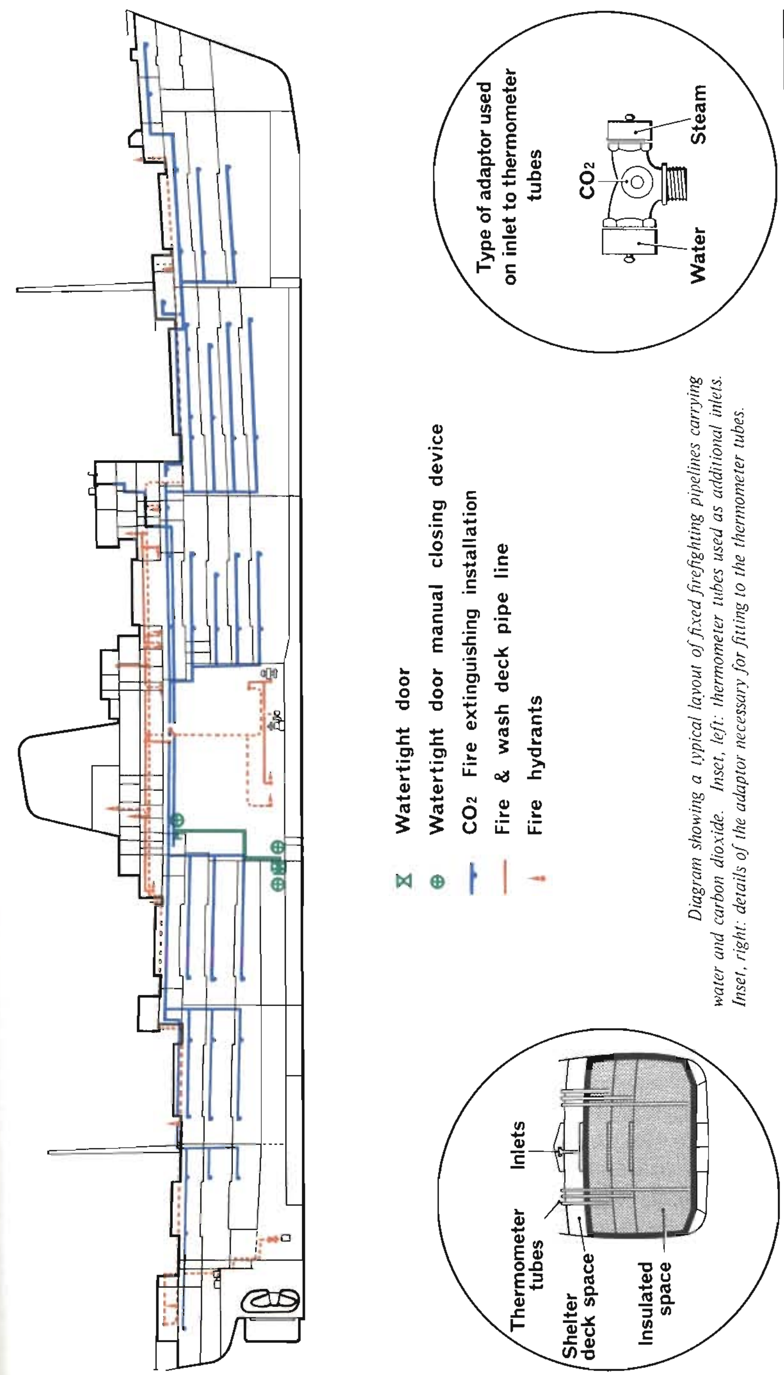


Fig. 10.1 Diagram of a type of fixed firefighting system carrying water and CO_2. Inset left: Thermometer tubes which can be used as additional inlets. Inset right: An adaptor for fitting to a thermometer tube.

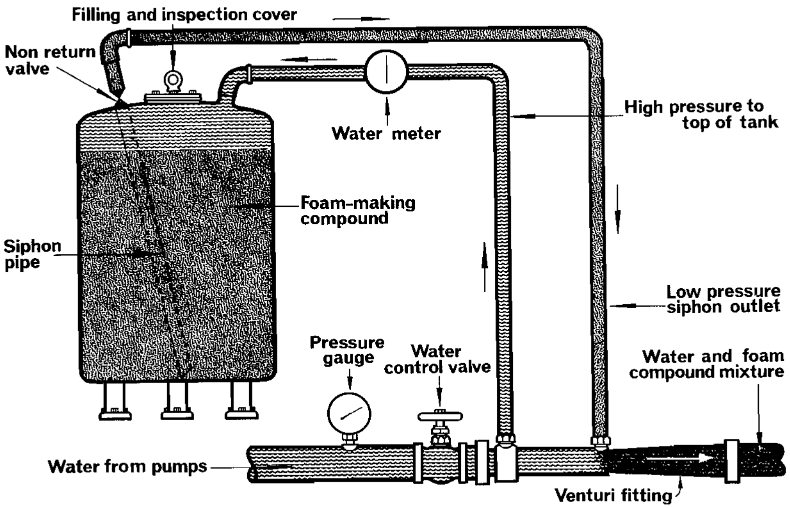


Fig. 10.2 Diagrammatic view of pump-operated type of mechanical foam installation.

position, to close off damaged sections of the foam and fire mains. It should be possible to use the minimum prescribed number of water jets from the fire main at the same time as the deck foam system is in operation. Foam installations will also be found in machinery spaces on some ships, and in the cargo spaces on certain Ro-Ro vessels. They have a permanent distribution system of piping and valves or cocks leading to fixed discharge outlets which can, in a few minutes, cover with foam the whole area involved. The installations may also include fixed and mobile sprayers. The systems take different forms, as set out below. Their layout and capacity vary from ship to ship.

(1) Pump-operated type

This has a foam concentrate tank outside the machinery space. Adjacent to it there is an inductor to which leads a dual water supply from the ship's pumps (this should ensure operation if one supply fails). The water passes through the inductor, which adds to it the correct amount of concentrate from the tank and delivers the solution to the foam generators in the boiler room. From there the foam passes to the foam spreaders. When there are two machinery spaces, the system may include distribution piping, with valves, to discharge the foam to either space.

(2) Self-contained pressurised type

This type is generally used where suitable pumps are not available on board. Its basic components are a water storage tank and a foam concentrate storage tank. The release of gas from carbon

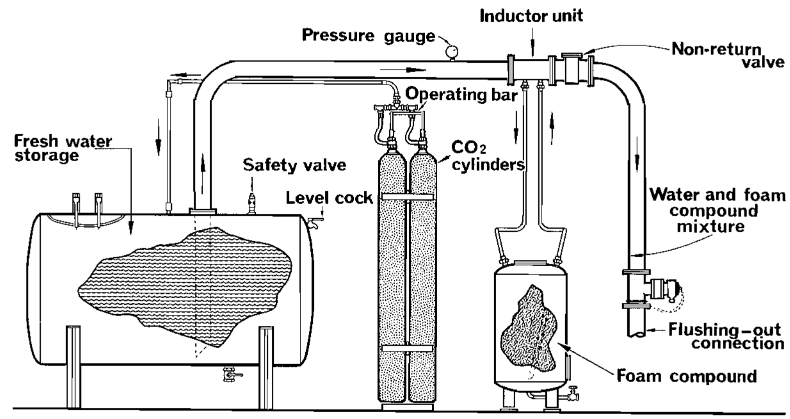


Fig. 10.3 Diagram of lay-out of a self-contained pressurised mechanical foam installation.

dioxide cylinders expels water out of the one tank and through an inductor, which draws into the stream concentrate from the other tank and delivers the solution to the foam generators in the boiler room. Again, the foam produced then passes from there to the spreaders, via distribution piping if necessary.

(3) Pre-mixed type

This system has a large tank containing foam solution. In the event of a fire, carbon dioxide is released into this tank from an attached cylinder or cylinders and drives the foam solution up a tube and along a pipe, to the foam generators, from where the foam is conveyed to spreaders.

Figs. 10.2, 10.3 and 10.4 show examples of these three types.

e. Inert gas

There are a number of types of inert gas system, varying considerably from one ship to another. They are at present mainly confined to ships' holds. The installations serve as a general protection against the outbreak of fire as well as a means of extinguishing fires that have already started. Fig. 10.5 shows an example of the combustion chamber type of generator. Diesel oil and air are supplied under pressure to a combustion chamber, from where the burnt gases pass to the cooling chamber and so to the distribution network. Water from the ship's pumps circulates round the combustion chamber and to sprays in the cooling chamber to reduce the temperature. From the generator the inert gas passes via a main pipe to manifolds fore and aft and from there, through diverting valves, via individual pipelines to discharge points in each hold.

Systems of this sort, independently generating the inert gas required, are expensive to fit and take up space. An alternative is

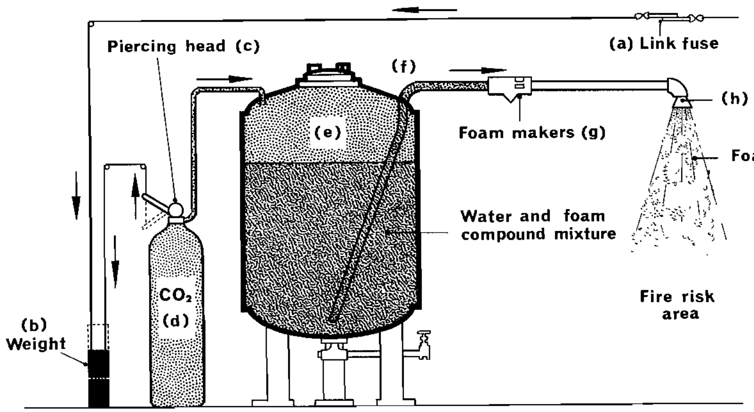


Fig. 10.4 Diagram of lay-out of a pre-mixed foam installation.

the flue gas system, the basic principle of which is that flue gas is drawn from the boiler up-take and passed through a scrubber (see Fig. 10.6) which cools the gas and removes most of the sulphur dioxide and trioxide and the solid particles. A centrifugal blower then injects the gas into the cargo holds via a deck water seal, which provides a protection against reverse flow and thus prevents hydrocarbon gases passing back into the machinery space. Sometimes a small gas generator is coupled with the flue gas system, so that it is not always necessary to bring the boiler into operation every time more inert gas is required.

Inert gas installations include means of indicating such information as the pressure, temperature and oxygen content of the gas in the inert gas main. They also include alarms to warn of dangerous conditions in the system, and automatic shut-downs when certain pre-determined safety limits are reached.

f. Halons

Halon installations are suitable, generally speaking, for all sorts of vessels but have been fitted mostly on board large tankers to protect engine and cargo oil pump-rooms. Halons can be used for local application but are most suitable for total flooding systems. The installations are usually modular in form, requiring little in the way of piping. The halon is stored in small cylinders from which it is driven under pressure to specially designed high-rate discharge nozzles.

g. Dry powder systems

Dry powder installations are found mainly on liquefied gas carriers. Where these are fitted they are usually designed for fighting fires on the deck in the cargo area. There may be two or more powder controls with associated monitors and/or hand hose lines

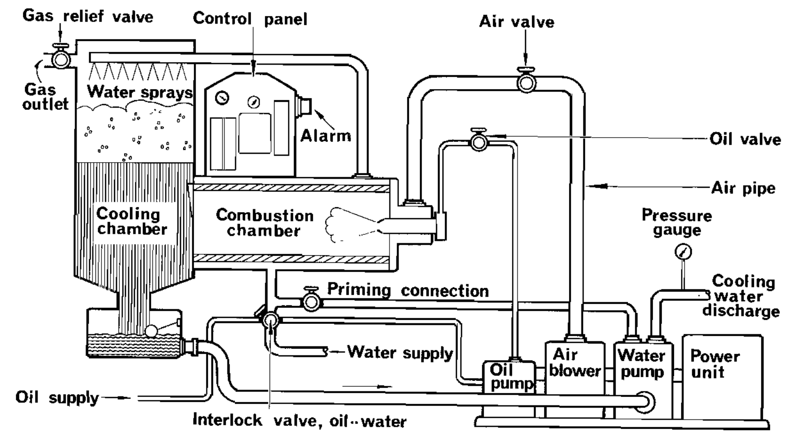


Fig. 10.5 Diagram of an inert gas generator.

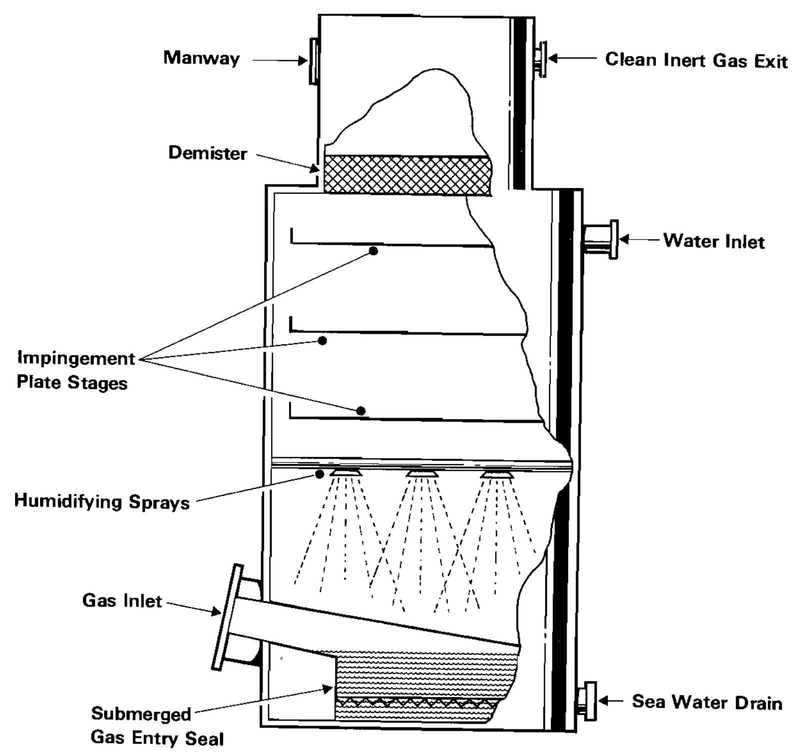


Fig. 10.6 High-efficiency scrubber for a ship's inert gas system. Usually found on deck aft near the accommodation.

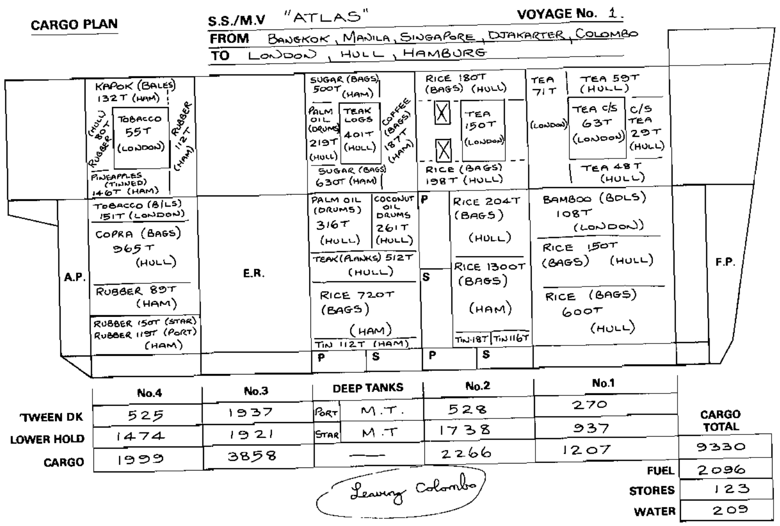


Fig. 10.7 An actual cargo plan of a small general cargo ship.

with a nozzle shut-off facility. The system is activated by an inert gas such as nitrogen stored in pressurised vessels alongside the powder installations.

6. Ship plans

Firemen should note that individual ships generally carry plans of particular value in the event of fires (e.g. fire control plan, stability plan, cargo stowage plan (see Fig. 10.7), pumping plan). They should consult these with the ship's Master, chief engineer, or chief officer. On passenger ships, and on cargo ships of 500 tonne or over, the fire control plan should show, where applicable:

(i) the position of the control stations;

(ii) the sections of the ship enclosed by fire-resisting bulkheads;

(iii) the sections of the ship enclosed by fire-retarding bulkheads;

(iv) particulars of the fire alarms;

(v) fire detection systems;

(vi) sprinkler installations;

(vii) fixed and portable fire extinguishing appliances and firemen's equipment;

(viii) means of access to the various decks and compartments;

(ix) the ventilation system, including particulars of the master fan controls;

(x) position of dampers and identification numbers of the ventilation fans serving each section of the ship;

(xi) the location of the international shore connection.

This is required to be kept up-to-date and there should be a duplicate of the plan permanently stored in the ship's 'fire wallet' in a prominently marked weather-tight enclosure outside the bridge. Information may also be posted elsewhere, e.g. at the head of the gangway when the ship is in port.

Chapter 11
Factors relevant to incidents on ships

1. Legislation

The *Fire Services Act 1947* gives the appropriate local councils, as fire authorities, certain powers and requires them to carry out certain functions. Firemen should, however, remember that the writ of fire authorities has limits.

a. Firefighting at sea

In England and Wales the off-shore boundary of a local authority is governed generally by Section 72 of the *Local Government Act 1972*. This provides that every accretion from the sea, whether natural or artificial, and any part of the sea shore to the low water mark, shall be annexed to and incorporated with the area of the authority which it adjoins; low water mark for this purpose is normally taken to mean low water at ordinary tides. However, in many areas local legislation defines particular parts of the boundary. (In Scotland, there is no equivalent general statutory provision. There, a fire authority boundary may extend to the three-mile limit of territorial water and on an estuary it is generally held to extend to the median line between the estuarial shores; again, the boundary may be subject to local legislation.) Where a fire authority attends a fire at sea outside its area, it does so in the exercise of its power under Section 3(1)(d) of the *Fire Services Act 1947*. A member of a brigade engaged in off-shore firefighting operations would be on duty while so engaged, and therefore subject to discipline (and other fire service) regulations.

b. Firefighting in ports, docks or harbour areas

The *Fire Services Act 1947* applies throughout a fire authority's area with few exceptions. Among those exceptions, however, are docks which are private property and HM Dockyards, and there are also other peculiar areas. Nevertheless, although the powers of access and firefighting of a fire authority do not operate in these localities, there are very few where there is not complete reliance on the local authority fire brigade and a complete agreement for them to exercise these powers and cover the area. It is fairly obvious that, where there is an impediment to the powers of a fire brigade, the fire authority will have come to an agreement

with the relevant organisation as to the exact position of the fire brigade in the event of a fire in the area of that organisation.

c. Special services

In the case of a special service incident—e.g. a spillage or leakage of a dangerous substance—the powers of a brigade are more limited. At a port, the Harbour Master will be formally in charge, but he may wish to delegate some operational responsibility to the brigade; this should be decided upon during the preplanning (see Section 3). At sea, the Master of the ship will have the overall responsibility.

2. Responsibilities

a. Merchant Navy

The responsibility for the fire protection of a merchant ship will usually depend on where it is and in what 'condition'. Ships under construction are the responsibility of the ship-builder. Under repair or refurbishment, they are the shipowner's responsibility unless he has delegated this to the repairer.

When a ship is at sea, or in port or harbour, it is the Master who is responsible for his ship and its safety. He can for instance, if he thinks it is necessary, ask for cessation of firefighting and leave his moorings. The Harbour Master, however, has the ultimate right to refuse entry into a harbour to a ship in a dangerous condition, e.g. on fire, and, if he considers that a vessel constitutes a danger to the port and dock installations, he can have it towed to a pre-planned beaching area accessible to the LAFB.

b. HM Ships

The commanding officer of one of HM ships has the ultimate responsibility for the safety of his ship and, in the first instance, of the firefighting measures taken. This is also the case where the ship is undergoing repairs or refit and is still in commission. If the vessel is out of commission, the shipyard authorities have the initial fire protection responsibility. On arrival at a fire on board one of HM ships in commission, the LAFB officer-in-charge will take over the responsibility for firefighting (see Chapter 13 Section 9a). Flag officers commanding Royal Dockyards have good liaison with the local fire authority and raise little objection to firemen visiting HM ships and facilities. (These arrangements do not apply to nuclear submarines—see Chapter 13 Section 9d—or to visiting foreign warships.)

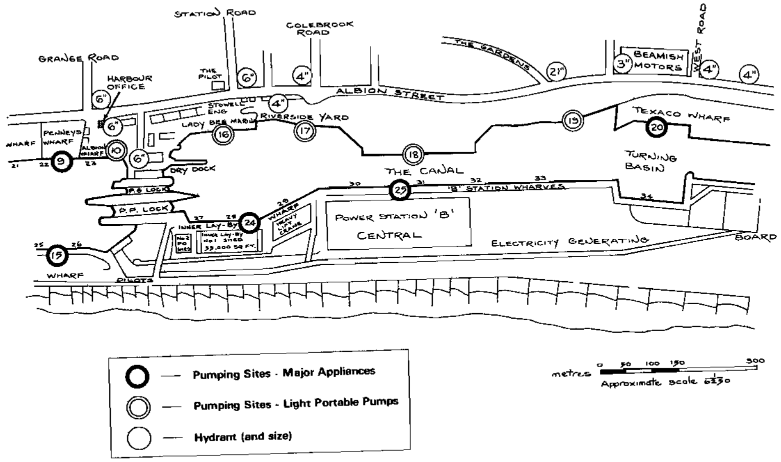


Fig. 11.1 Example of part of a brigade plan covering a harbour area.

3. Preplanning

a. General

The potential for a major incident, even in the smaller ports and harbours of the UK, appears to be increasing. The numbers and size of potentially dangerous cargoes entering and leaving have risen and, despite increasing emphasis on safety by organisations such as IMO, there can, and will, be accidents. In any dock, port or harbour, therefore, there must be some preplanning for emergencies (see Fig. 11.1).

The idea of the plan should be to co-ordinate the actions of all appropriate organisations so as to be able to contain, and deal effectively with, any major incident which threatens the area. Such incidents could involve fire, explosion, massive pollution, or the release of gas vapour clouds, highly flammable substances, toxic chemicals or radiation. They could include accidents during the loading or unloading of cargo at the dockside, or in the warehouses themselves or the approach of a vessel already on fire or suffering from the effects of an explosion and requiring assistance.

Preplanning for offshore incidents will also be necessary (see Chapter 14 Section 1).

b. Participants

The participants in the preplanning will vary with the size and complexity of a particular marine risk and, apart from the three

emergency services (fire, police and ambulance), could include the following:

Port Authority	HM Coastguard
Harbour Authority	Royal Navy
Dock Board	Port Health Authority
Health and Safety Executive	Tug companies
Department of Transport	Hospitals
Large industrial companies	Shipping companies
RNLI	

c. Main features of plan

The plan must be flexible but some of the following points should be considered:

(i) Methods of raising the alarm and alerting the essential services.

(ii) Establishment of controls and communications.

(iii) Attendance of interpreters where there are language difficulties.

(iv) Control of shipping movements, closure of port, moving of endangered vessels, provision of tug facilities.

(v) Rescue operations where life is involved; means of escape from berths.

(vi) Provision of craft to ferry firemen to ships at anchor.

(vii) Equipment for ambulance service; movement of casualties.

(viii) Provision of a series of predetermined embarking and landing points, such that the most appropriate can be selected in any particular incident.

(ix) Facilities for alerting all marine risks, especially if tide/water flow is moving the risk through the area.

(x) Provision of predetermined beaching points clear of shipping lanes and convenient for the emergency services.

(xi) Identification of dangerous substances (Chapter 15 refers), decontamination etc.

(xii) Salvage operations, including the containment, and subsequent recovery or dispersal, of oil, chemical or radioactive spillage.

The plan must be practised regularly, modified in the light of the practice, and constantly up-dated.

d. Controls

There is usually the need, at an incident in a large port, harbour or dock area, for there to be one main control point. Some ports use the Harbour Master's office, but others have different arrangements; for example, at Milford Haven, where the area runs for several miles, the main control is sited at a jetty near the incident. On the Thames the area is divided into two zones above and below Crayfordness. Above, the main control is the Thames Barrier Navigation Centre at Woolwich; below, it is the Thames Navigation Service Office at Gravesend.

There is also a need for forward controls. These could be the normal fire, police and ambulance control units on the quayside, or they could be on board vessels such as fire tugs or marine police launches or, in some cases, on the actual ship involved. Wherever they are, they must be readily identifiable. Other minor controls will also operate for BA, equipment, casualties, stability etc, and a comprehensive system of communications is essential.

e. Communications

The main problem in a situation of this type is the proliferation of wavelengths, call signs and equipment used. The usual solution is to utilise one or two of the marine radio channels (normally channel 10 or 16). These should be decided upon during the preplanning process; then, as soon as an incident occurs, they can be taken over and strictly controlled. The emergency service control units that attend port incidents are usually fitted or equipped with this type of radio system, as are fire-tugs, fireboats and most other vessels.

f. Language difficulties

It is quite common for firemen to arrive at a ship and find that no English, or very little, is spoken. This can cause real problems, and the aid of an interpreter would be invaluable. Some brigades have permanent arrangements for calling upon local colleges and universities for assistance.

4. Safety

a. General

Firemen, even those with a marine risk, do not get very much experience of ship fires and therefore such incidents take them into an alien environment. Brigades should make every effort to arrange visits by firemen to ships of all kinds and in all 'conditions'. Exercises in loading equipment on and off tugs and launches, boarding ships etc are invaluable experience for firemen. Actual progress down an escape ladder and through a shaft tunnel and engine-room will give firemen more confidence in their ability to tackle an incident.

The safety rules at ordinary fires generally apply to ship fires also, but firemen should bear in mind the following additional points. They should always wear approved lifejackets when using

vessels such as tugs or launches to go out to moored vessels and also when aboard the ship. This may not be possible when wearing BA, and officers-in-charge must bear this in mind in controlling movement aboard ships. Unless a ship is very small, laying guide lines to the fire area is always a good idea, especially on board passenger ships where, even without smoke, firemen can become confused in the maze of decks and corridors. When descending into engine rooms they should be aware that all ladders, landings and metal work are generally greasy, and take care how they proceed. They should also bear in mind that metal ladders may become very hot, even at some distance from a fire.

When climbing down into holds, firemen should pay special attention to open hatches and remember not to step back off a ladder before checking that the ladder hatch is closed. When moving in smoke, they should bear in mind the whereabouts of coamings, open hatches, ducts and chutes and, if possible, mark them with lights or even have them guarded by a designated fireman.

b. Ships under repair

Ships undergoing repair, refit or refurbishment quite often have holes cut in the decks, companionways removed, loose electrical cables strewn everywhere, and many other hazards, e.g. flammable paints and liquids, gas cylinders, heaters. Firemen should make regular visits to ships in such 'conditions', in order to see the difficulties and to carry out liaison and preplanning with the dockyard repairers.

Radioactive isotopes are sometimes used aboard ship and in repair yards. These risks should be identified and liaison with the repairers set up to ensure that firemen receive adequate information on their whereabouts if called to an incident.

c. Ships at quays or jetties

Approaching a ship at a quay or jetty can be hazardous, especially at night. Some jetties can extend half a kilometre off shore. There are not always facilities for driving appliances down to the ship, and firemen may have to walk, carrying equipment along narrow walkways which may be congested with pipelines, valves, switch-boxes etc. If these hazards cannot be illuminated, crews should be led to and from the ship with lights. (See Plates S.10 and S.11).

It is common practice for smaller craft to lie tied up to one another, beam to beam, off jetties. Firemen may have to clamber over two or three other vessels to reach an incident on an outlying one. The difficulty of this manoeuvre will depend on the distance between the vessels, the sea conditions (choppy, swell etc), the amount of freeboard, and the extent of the general deck clutter, but firemen should always exercise great care in passing from one vessel to another. They must keep their hands and feet clear of the sides to avoid being crushed, and should be careful in crossing gaps which are fluctuating in size. Lifejackets should be worn at all times during the approach to the vessel involved.

5. Use of fire and salvage tugs, launches etc.

There are only a few purpose-built fireboats still in use in the UK, but several fire authorities and some industries maintain, or can call upon, fire tugs. In most cases these vessels are normally employed as ordinary tugs in the port area, but are so equipped that they can be called to assist the brigade when required. Plate S.12 shows an example which carries three monitors, any two of which can deliver a total of 7,200 l/min of water at 8 bar, and also foam at approximately 12,100 l/min. Other facilities include deck connections for hose and foam branches, foam concentrate storage, suction hose and an Aquator salvage pump with a capacity of 800 tonne per hour.

Fire tugs come under the control of the senior fire brigade officer for firefighting purposes but the tug master is in control of navigation and the safety of his vessel. Brigades vary in their arrangements, some preferring to put firemen aboard to help operate the firefighting equipment and others leaving it to the tug master to operate it with the advice of a fire brigade officer. These tugs would be the obvious choice to put men and equipment aboard vessels lying at anchor, but many fire authorities have made arrangements with Harbour Masters, HM Coastguard, marine police, Conservancy Boards etc for launches, dorys, mooring vessels and various other craft to be made available for transporting firemen and equipment from specified embarking points to moored ships. Plate S.13 shows a small tug which was used in the initial boarding at an incident and remained as a pumping platform as the ship's pumps were ineffective. The marine police vessel alongside was used to reinforce the crews, bring reliefs and supply equipment.

Plate S.1 A typical shaft tunnel leading to an engine room amidships.
Photo: Essex Fire Brigade

Plate S.2 Modern LASH ship, 35,800 gross tonne, USSR 'Tibor Szamuely'
Photo: Skyfotos Ltd.

Plate S 3 21,000 tonne dwt 'Eleo Maersk' multi-purpose ship Can be used as Ro-Ro, Sto-ro, container carrier or bulk cargo carrier
Photo Marine Publications International

Plate S 4 An example of a hard arm facility at a refinery marine terminal The vessel discharging is the 250,000 tonne dwt 'Esso Northumbria'
Photo Esso Petroleum Co Ltd

Plate S.5 An LPG carrier, the 37,000 tonne dwt SS 'Isomeria', gas capacity 58,950 m^3, fitted with self-supporting pressurised and refrigerated tanks
Photo Harland and Wolff Ltd

Plate S.6 A general bulk carrier of 8,000 gross tonne
Photo Marine Publications International

Plate S 7 A car and passenger ferry of 8,600 gross tonne
Photo Marine Publications International

Plate S 8 An International shore connection in use.
Photo Hants Fire Brigade

Plate S.9 An interesting photograph illustrating the deck and corridor layout of a typical cruise ship. This vessel was cut in half and lengthened by having a section inserted
Photo: Marine Publications International

Plate S.10 An example of an offshore jetty leading to a marine refinery terminal Compare with Plate S.11.
Photo: Humberside Fire Brigade

Plate S 11 This is the type of narrow, unlit, partially obstructed floating jetty which could be and was, used for transporting equipment Compare with Plate S 10.
Photo Essex Fire Brigade

Plate S.13 At this incident the small tug 'Fenland' was used for the initial boarding and remained as a pumping platform. The police vessel acted as the ferry for equipment, reliefs etc Note the narrow companionway
Photo: Essex Fire Brigade

Plate S 12 A fire tug equipped with three monitors capable of a water or foam attack.
Photo Alexandra Towing Co Ltd

Plate S 14 BA entry point on board a bulk carrier with a fire in the engine room and accommodation
Photo C P Nelson

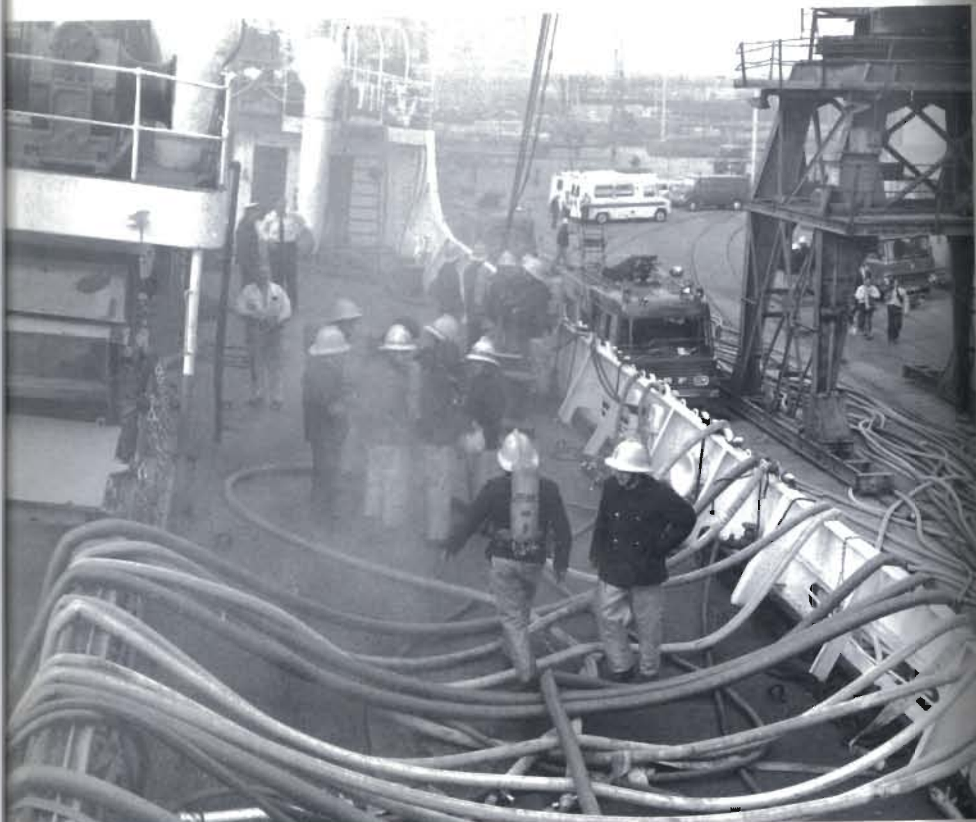


Plate S 15 Fire in the hold of a cargo ship of an older type. Note the examples of hatches, ventilators and fire main (in the scupper) There is a distinct listing of the vessel.
Photo County of Avon Fire Brigade

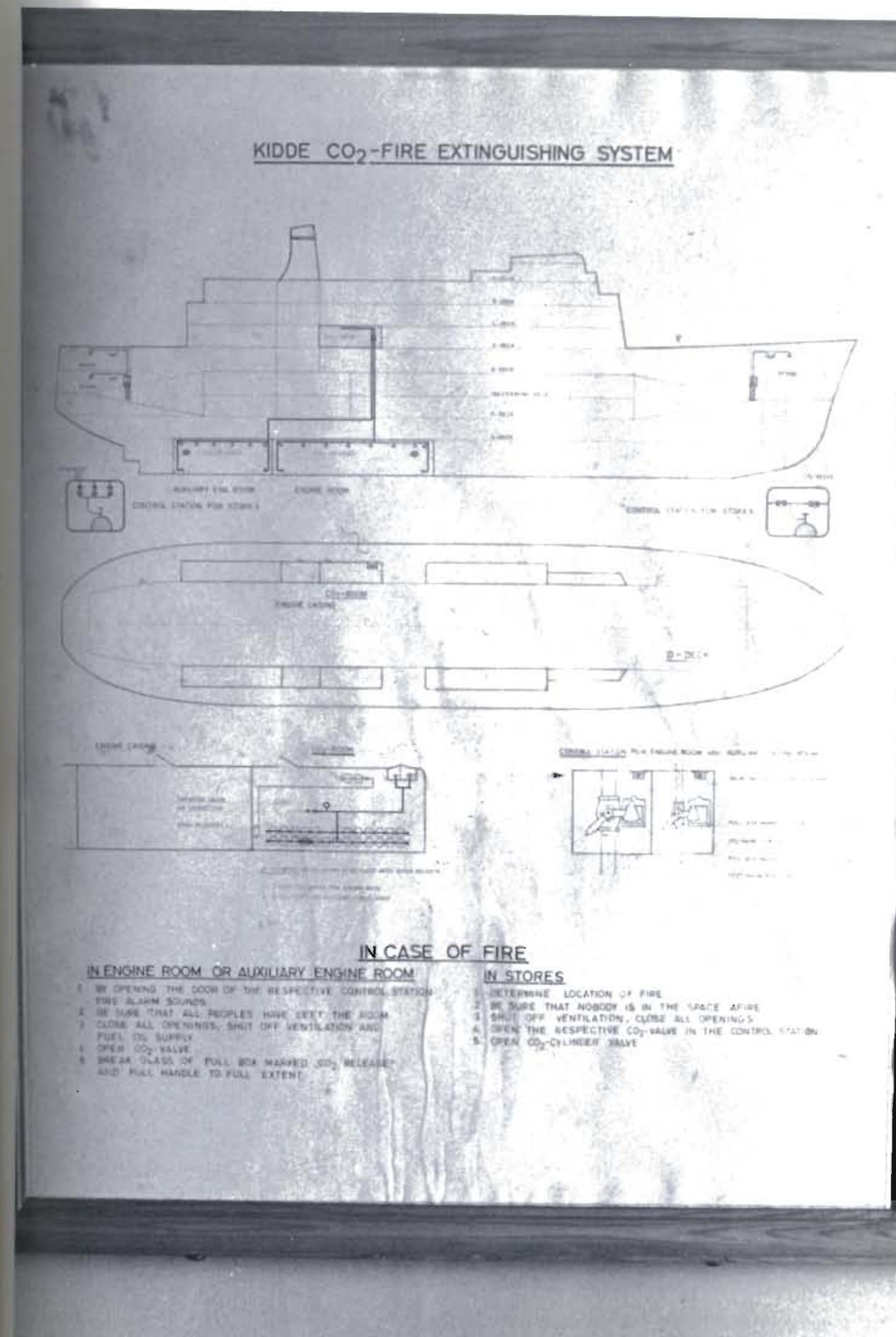


Plate S. 16 A diagram of a fixed firefighting installation aboard the car ferry 'Norwave'.
Photo: Humberside Fire Brigade.

Plate S.17 Fixed firefighting monitors covering the deck of a tanker
Photo. Stewart Bale Ltd.

Plate S.18 A gas carrier with a capacity of 12,000 m^3 Note the firefighting platforms at intervals along the centre of the deck
Photo: Marine Publications International

Plate S.19 The engine room of the car-ferry 'Norwave' following a fire A horn nozzle of the CO_2 system can be seen above the valve group The engine room was evacuated, the CO_2 system operated, and the ferry towed back into dock to enable the Brigade to tackle the fire
Photo: Humberside Fire Brigade

Plate S.20 A turntable ladder being used as a crane to load gear onto a tug
Photo Kent Fire Brigade

Plate S.22 Firemen and RAF aircrew preparing to lower a high expansion foam unit onto a ship's deck The very restricted space is obvious as is the safety harness
Photo: C P Nelson

Plate S 21 Personnel being lowered from a helicopter This Plate ties in with Plate S.14.
Photo C P Nelson

Plate S 23 A lightweight pump lashe[d] to a companionway suspended som[e] 3-4 metres above the surface of the sea
Photo Kent Fire Brigade

Plate S 24 A push-tow formation Depending on the size of the waterway either a maximum of 3 barges or 6 barges can make up the load
Photo British Waterways Board

Plate S 25 A pleasure craft fire which has had time to develop involving fuel, furnishings and, probably, LPG

Plate S.26 Illustrating the height, steepness and narrowness of access to this ship's main deck In this case all gear had to be either hauled aboard or manhandled up this companionway
Photo Essex Fire Brigade

Plate S.27 A fire in a tightly packed cargo of building board When the cargo was eventually unstowed the cause was found to be a fixed lighting installation which had been left permanently switched on
Photo Kent Fire Brigade

Plate S.28 Fixed foam monitors covering a marine refinery jetty. Operation of the fire alarm automatically brings in pumps supplying water to the jetty. The tanker also has fixed monitors.
Photo. Humberside Fire Brigade

Chapter 12
Stability

1. General

The officer in charge of firefighting operations must constantly bear in mind the stability of the ship. This can be affected by various factors, in particular:—

i. the amount and position of water put on board for firefighting;

ii. the amount and position of water pumped out from parts of the ship;

iii. the movement of cargo etc from one part of the ship to another.

Stability is a complex subject and to assess, precisely, the stability of a ship at any given time and the exact effects different actions have on it, involves complicated calculations. The ship's officers are the experts, and firemen should, where possible, rely on their advice. However, there may be occasions where no ship's officers are present, or where communication with them is hindered by language difficulties, and no other qualified persons may be available. In any case, firemen should have a knowledge of the main principles involved so that they understand what is likely to happen during firefighting operations, and what factors they must keep in mind. It could take as little as an hour for a ship's stability to be endangered by the addition of water if the situation is not handled correctly. This Chapter therefore sets out certain basic facts concerning stability; brigades should ensure that all junior officers receive further instruction in the various principles and procedures as necessary.

The ship's longitudinal stability, or *trim*, will need to be borne in mind, especially if a large amount of water has to be introduced at one end of the ship. The main problem, however, is transverse stability, and this is dealt with in Sections 2–6 below.

2. Centre of gravity

The *centre vertical line* (CVL) of a ship is an imaginary line down the centre of the ship, running at right angles from the upper deck to the keel. When a ship is evenly loaded, and lying level in the water, its centre of gravity will be on this line at a height determined by the vertical distribution of weight in the vessel (see Fig. 12.1). The *centre of gravity* (G) of a body is the point through which the force of gravity is considered to act vertically downwards with a force equivalent to the weight of the body. It is also the point about which the body would balance. G will move directly towards any added weight and directly away from any weight removed (see Fig. 12.2), and it will move parallel to any weight shifted within the body. The distance that G moves depends on the ratio between (a) the original weight, (b) the weight added or subtracted, and (c) the distance between the original centre of gravity and the weight moved. If the movement of a weight disturbs the even loading of a ship it will list.

The difference between heeling and listing should be understood. A list is the transverse inclination of a ship due to forces within the ship. Heel is a transverse inclination due to an external force, e.g. wind or wave.

3. Centre of buoyancy

A body in a fluid experiences an upward thrust equivalent to the weight of the fluid it is displacing. For a body to float, this upward thrust, or *force of buoyancy*, must be equal to the downward thrust of the force of gravity. It can be considered to act vertically upwards through a point called the *centre of buoyancy* (B) which is the centre of gravity of the displaced mass of fluid. As water is homogeneous, it follows that, in the context of ships, B is the geometric centre of the underwater volume. For a normal ship this can be regarded as being about 0.6 of the draught above the keel.

Therefore, when a ship is floating in an upright position, its centre of buoyancy will be on its CVL (see Fig. 12.3, left). When a vessel heels or lists, the submerged volume assumes a different

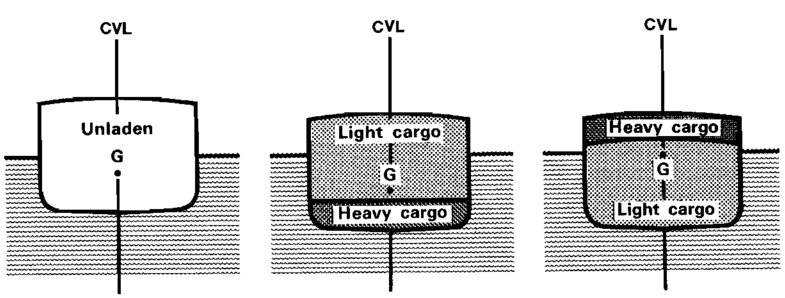
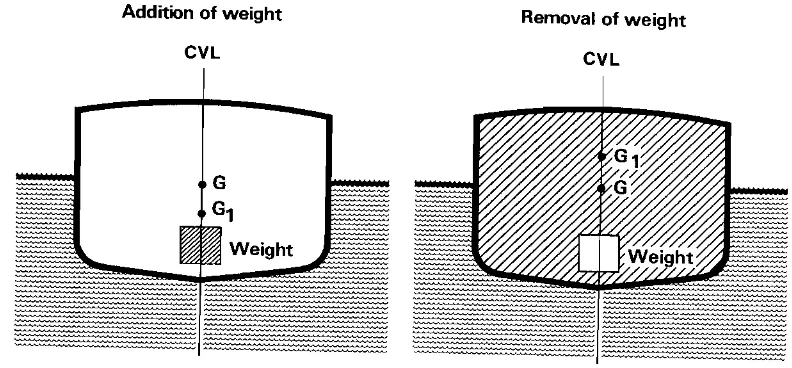


Fig. 12.1 Diagram showing the varying positions of the centre of gravity in a vessel under different conditions.
Left: Unladen. Centre: heavy cargo in bottom of the hold. Right: heavy cargo in 'tween deck.



G = original centre of gravity
G_1 = new centre of gravity after weight added

G = original centre of gravity
G_1 = new centre of gravity after weight removed

Fig. 12.2 Illustrating the difference weight makes to the position of the centre of gravity.

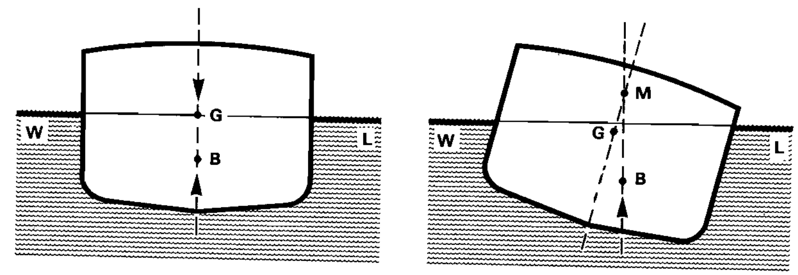


Fig. 12.3 The relationship between the centre of gravity, the centre of buoyancy and the metacentre in a stable ship.
Left: floating upright. Right: heeling to starboard.

shape, and the centre of buoyancy moves away from the CVL towards the new geometric centre of the submerged part (see Fig. 12.3, right).

4. Metacentre and metacentric height

The *metacentre* (M) of a ship is the point at which the verticals through the centre of buoyancy at two consecutive angles of heel intersect. At small angles of heel, it can be defined for practical purposes as the point where a vertical line drawn through the centre of buoyancy cuts the CVL; this point can usually be regarded as fixed. (Fig 12.3, right). The position of the metacentre depends on the distance between the CVL and the centre of buoyancy at a given angle of inclination, and hence on the shape of the underwater volume (in particular the ratio between the draught and underwater width of the upright ship).

The *metacentric height* (GM) is the vertical distance between the centre of gravity and the metacentre. A ship is said to have a positive metacentric height if the centre of gravity is below the metacentre, and a negative metacentric height if the centre of gravity is above the metacentre. Metacentric height varies considerably and determines whether a ship is 'stiff' or 'tender'. A 'stiff' ship is liable to incline with difficulty and then to return upright quickly, whereas a 'tender' ship inclines easily and is slow to return to the upright. A large positive metacentric height gives rise to 'stiffness' and a small one to 'tenderness'. If the centre of gravity rises above the metacentre, and the metacentric height thus becomes negative, the ship will lose its stability, and any appreciable inclination may cause it to capsize (see also Section 5 below). A typical cargo ship, in the worst condition of loading, could have a GM of about 0.3 m, and a typical passenger ship could have one of between 1 and 3 m. While there are obvious advantages to a ship being 'stiff', there is a danger that the rapidity and violence of its movements as it rights itself may damage its structure by racking and straining. To overcome this, part of a heavy cargo, such as iron ore, may be carried in a tween deck to reduce the metacentric height. Another method is to carry water ballast in some of the tanks placed high in the ship.

5. Equilibrium and heeling

If, when slightly heeled, a ship tends to return to the upright, it is said to be in stable equilibrium. If, when heeled, it tends to move further from the upright, it is said to be in unstable equilibrium, and if, when heeled, it has no tendency to move in either direction it is said to be in neutral equilibrium.

Fig. 12.4 (left) shows a ship in stable equilibrium which is floating upright; Fig 12.4 (right) shows the same ship slightly heeled, and indicates the ship's metacentre (M), centre of gravity (G), centre of buoyancy when upright (B), and centre of buoyancy in its present heeled position (B_1). The forces tending to bring the ship back upright are those acting through points G and B_1. They are exerted by the lever GZ which is the distance between G and a vertical line through B_1. The forces produce a turning effect, or *moment*, whose magnitude equals the weight of the ship (W) multiplied by the length of the lever, i.e. WxGZ. If G is raised further up the CVL, by the even addition of weight to the top of the ship (as in Fig. 12.5, top), or removal of it from the bottom, the lever will be shortened and the tendency of the ship to right

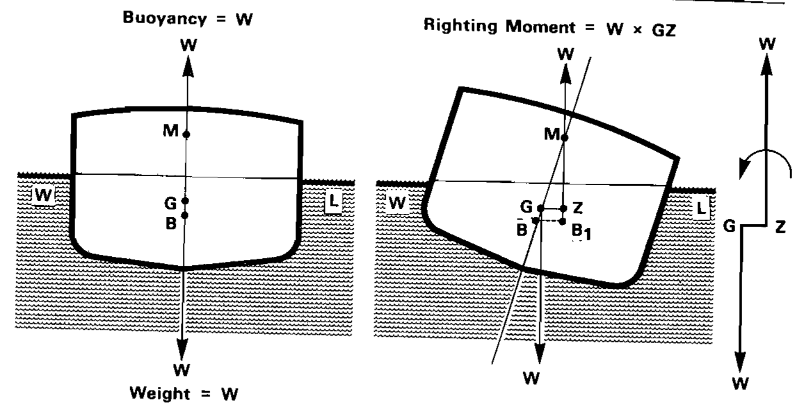


Fig. 12.4 Showing a ship in stable equilibrium and the effect of the righting moment.

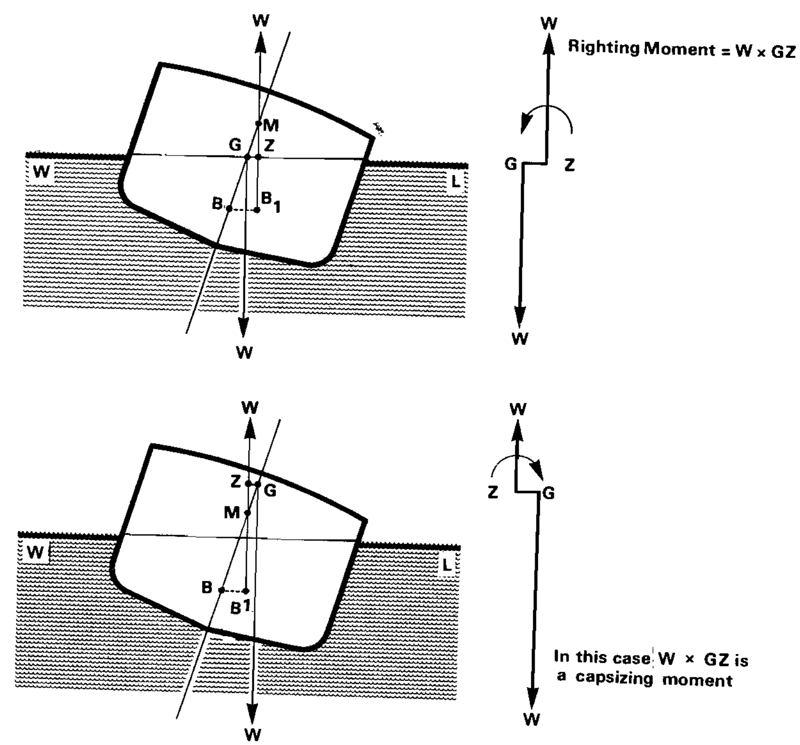


Fig. 12.5 Showing the effect on the stability of a ship when the centre of gravity is raised.
Upper: Raising the centre of gravity nearer to the metacentre (M).
Lower: Producing a capsizing moment by moving G above M.

itself will accordingly be reduced. If the stage is reached where G actually coincides with M (i.e. zero metacentric height), the length of GZ will become zero, and the ship will assume a state of neutral equilibrium.

If the process is carried a stage further, so that GZ is higher than M, the lever will be reversed in direction, and the ship will therefore tend to move further from the upright and may capsize (see Fig. 12.5, bottom). This will not always happen, however, since the metacentre—which at small angles of inclination can be regarded as fixed—will tend to rise slightly as the angle becomes larger, and may do so sufficiently to reach the ship's centre of gravity. If so, the ship will not capsize but will remain at an angle. This is known as the *angle of loll*, and the ship will tend to return to it if heeled further. Loll is a potentially dangerous condition, however, and where it exists every effort must be made to improve the stability of the vessel.

If, instead of being altered evenly, weight is added high up on the low side or removed from low down on the high side, thus moving the centre of gravity towards the line B_1Z, the process of reducing and ultimately reversing the lever GZ will be quicker and require less weight. This is a particular danger where free surface liquids are concerned (see below).

6. Free surface effect

A hold (or other space) completely full of a liquid has a fixed centre of gravity. If the hold is only partly full the liquid has a free surface area which can move as the hold moves. This alters the centre of gravity of the liquid, and therefore that of the hold, which in turn affects the centre of gravity of the ship as a whole. This 'free surface effect', as it is known, is independent of the position of the hold in the ship and of the depth of liquid in the hold.

Although the free surface effect shifts the actual centre of gravity of the ship sideways, it affects the ship's stability as if the centre of gravity had been moved upwards along the CVL. It is usual to base calculations of stability on this virtual rise of the centre of gravity. The principle is illustrated in Fig. 12.6, which shows an amount of water in a partially flooded hold. When the ship is upright (Fig. 12.6, left) the centre of gravity of the liquid is at g, but when the vessel is heeled (Fig. 12.6, right) the liquid flows to the low side and the centre of gravity of the liquid shifts from g to g_1. This causes the ship's actual centre of gravity to shift from G to G_1 parallel to g-g_1. The righting moment now is WxG_1Z_1, which is equal to WxG_vZ_v (G_1Z_1 and G_vZ_v are opposite sides of a rectangle). The virtual centre of gravity has thus risen

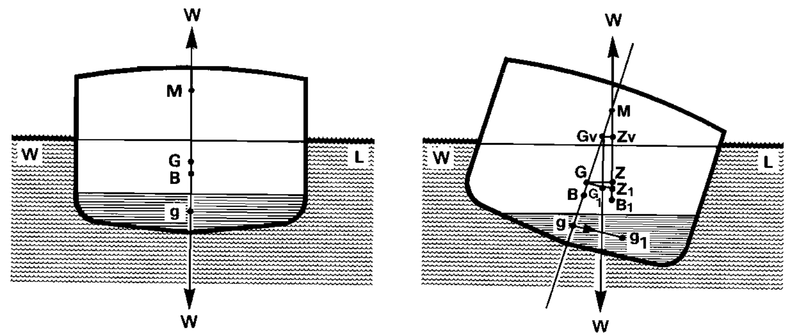


Fig. 12.6 Diagram showing the free-surface effect of a liquid in a partially flooded hold when a ship heels.

from G to G_v, and the effective metacentric height has been reduced from GM to G_vM.

The free surface effect is obviously a very important factor to be taken into account during firefighting operations. It should be noted that it is largely determined by the width of free surface. Longitudinal sub-division of an area greatly reduces the effect; for example, if a free surface width is divided into two equal halves, the reduction of the effective metacentric height will be quartered. In practical terms this might be achieved by closing doors and openings in a longitudinal bulkhead.

7. Stability procedures

Brigades with ship firefighting responsibilities usually have a prepared stability procedure to put into operation when necessary. If the officer-in-charge decides that the procedure should be introduced, he will usually designate an officer to be Stability Officer and require him to carry out the procedure. The duties of a Stability Officer vary slightly from brigade to brigade, but would include:—

i. Securing a number of firemen to act as stability crew and, if possible, identifying them by specially marked jackets etc. so that it is generally understood that they cannot be used for any other purpose.

ii. Establishing contact with the ship's officers and harbour officials, if present, and obtaining plans of the ship's pumping system, accommodation, cargo stowage (if applicable), water ballast and fuel tanks, firefighting equipment etc., together with any cargo manifest, and a report on the current state of the various tanks. Most of this information should be available in the ship's 'fire wallet' (see Chapter 10 Section 6).

iii. Setting up a Stability point, e.g. a position by the ship's inclinometer, ensuring that the officer-in-charge is aware of its position, and establishing communications with him from there. If the ship's inclinometer is inaccessible due to smoke or heat, or is likely to become so, the brigade's portable inclinometer should be set up in a prominent position on deck amidships.

iv. Obtaining all the relevant information and completing the stability board, an example of which is shown in Fig. 12.7. The information on this board should be up-dated at intervals of about half an hour, and the officer-in-charge informed of any significant change in the attitude of the ship, i.e. a change in the list or in the draught fore, aft, or overall. Two items not shown in Fig. 12.7 are the depth of water and the angle of the bottom under the ship which, as discussed in Section 8 below, are of some significance.

v. Obtaining from the ship's officers an assessment of the amount of water that can safely be put into the section(s) on fire, calculating the approximate time that it will take to reach this limit, and informing the officer-in-charge.

vi. If necessary, assembling crews, pumps and equipment to pump the ship out or recycle the water back onto the fire.

vii. Checking on any on-board firefighting installations which are in use, e.g. sprinklers, spray systems, ship's pumps, and advising the officer-in-charge as to whether any of these should be shut down.

The officer-in-charge would have to keep all interested organisations informed of the firefighting and stability position and confer with them on action to be taken to keep the ship safe.

8. Vessels in shallow water

Most ship fires will be fought in a port, dock or harbour in conditions of comparatively shallow water. The distance between the ship's keel and the bottom may therefore be small and should be taken into account when a stability officer is making his calculations (see Section 7 above). The introduction of a large amount of water may cause the ship to settle, but not necessarily evenly. An even settling onto a level bottom may be highly desirable to ensure that the ship does not list (Fig. 12.8, left).

However, there are dangers if the bottom is sloping. Fig. 12.8 (centre) shows a ship listing to starboard but grounded on a sloping bottom which tends to push the vessel upright. In Fig.

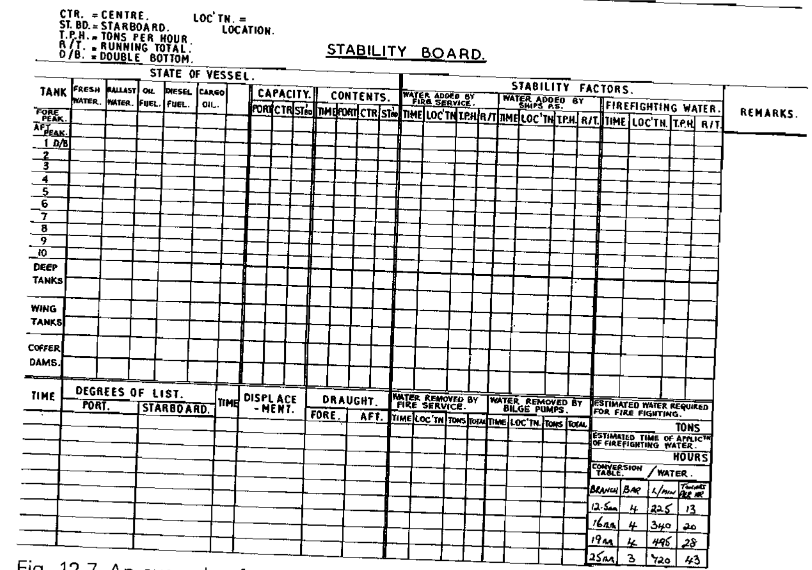
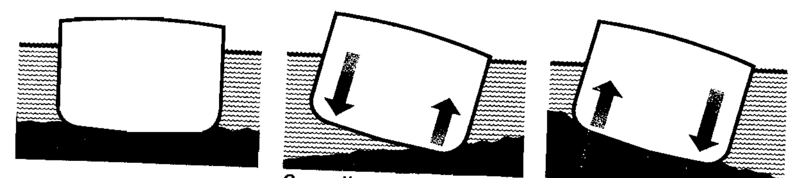


Fig. 12.7 An example of a stability board used during firefighting operations on board a ship.



Ship grounded on even keel

Grounding ship heeled to starboard being brought level by slope of bottom

Grounding ship heeled to starboard being tilted further by slope of bottom

Fig. 12.8 Possible results of allowing a ship to ground.

12.8 (right) the slope of the bottom is in the opposite direction and tends to increase the list. If a vessel suddenly slides off a sloping bottom on which it has settled, it could float again and, depending on conditions aboard, could take up a worse list or oscillate, with the sudden movement of internal water, and possibly capsize. (This could also happen if, after the extinguishment of a fire, water is pumped out of a settled ship with insufficient care—see Chapter 13—or if the water level is raised by an incoming tide. In view of the latter possibility, the state of the tide should always be taken into account.)

As a result of firefighting operations, the ship will probably not be on an even keel fore and aft, and should the keel ground at one end, the stability of the ship will be reduced and possibly lost, since the pressure on the keel is equivalent to the removal of equal weight from that point.

Close liaison and monitoring is necessary at all times.

9. Other considerations

Stability Officers should also bear in mind that certain types of ships have very little freeboard and even a slight settlement or inclination could bring the main deck under water. In such cases, they should be prepared to check that all air-pipes, hatches, doors etc. are closed or protected to avoid uncontrolled flooding.

Checks must be made of all potential openings in the hull near the waterline. In particular, all shell doors and port-holes should be examined. In Ro-Ro vessels, loading door apertures should be checked to ensure that they are properly sealed, unless it is considered safe to use them for access.

On small ships, care must be taken if a decision is made to use on-board equipment to hoist gear or cargo over the side, either onto, or from, the quayside. The actual lift or swing over the side can cause the ship to list at quite a steep angle. If there is already an inclination towards the quayside or a large amount of free surface liquid, this sudden list may become unmanageable.

Chapter 13
Fighting ship fires in port

1. General

To fight any ship fire efficiently, firemen must be familiar with the basic details of:

(i) ship construction and design (see Chapter 9);

(ii) shipboard fire protection and firefighting media (see Chapter 10);

(iii) general issues such as liaison with other authorities, emergency plans, responsibility for control of operations, and safety precautions (see Chapter 11);

(iv) ship stability (see Chapter 12).

Within this context, firemen must have regard to the particular features of different ships, and to their present 'condition', e.g. loaded or unloaded, and they must adjust their operations accordingly. Appropriate liaison and preplanning are vital, and Brigades should make every attempt to gain familiarity with, and knowledge of, any specific risks, such as naval dockyards, actually located in their areas.

2. Initial action

The first thing a fire officer will do on arrival at any ship fire is to contact an appropriate person, e.g. the ship's Master or duty officer. The engineer may also be able to help in his own particular field. From them, and from examination of the ship plans (see Chapter 10 Section 6), the fire officer should obtain details of the ship, its cargo, the firefighting measures already implemented, and any other relevant factors such as the general state of the ship's stability. Questions he might ask include:

(i) where is the fire?

(ii) what is burning?

(iii) what access to the fire is there?

(iv) are any people involved?

(v) are the on-board firefighting systems operating or operable?

(vi) are the main and auxiliary engines operable?

Usually, the shipboard installations will be in operation. When this is not the case, the best course will usually be for the Brigade to employ its own equipment, using any helpful facilities on the ship as necessary. The ship's personnel will usually be able to assist by operating doors, pumps, valves etc. If ventilation equipment is running when the brigade arrives, the officer-in-charge will need to consult with the Master or his engineer as to whether this should be turned off.

Modern ships make increasing use of electronic apparatus, which can bring problems in the event of a fire. For example, there is increasing use of computers for cargo manifests. A fire could prevent a 'read-out' being obtained, but there is often an alternative source at the shipping company's headquarters. This, however, could be anywhere in the world.

3. General cargo ships

a. Types of cargo

A large proportion of cargo is, of course, now carried in container and other specialist ships. Nevertheless, there are still general cargo ships of the traditional kind, which could carry a variety of large single units, packaged goods and bulk cargoes.

Firemen must remember that cargoes can be very varied: some are inherently dangerous to life, while others may become so in their reaction to heat or water. (The question of dangerous cargoes is dealt with more fully in Chapter 15). Some cargoes, although not chemically dangerous, pose a risk to the safety of the ship, and indirectly to life, because they affect the ship's stability by moving about, or by swelling as a result of the absorption of water. Conversely, the thoughtless use of a fire extinguishing medium, or use of the wrong medium, can cause unnecessary damage to cargo.

b. Locating and approaching the fire

The first practical task will be to try to locate the seat of the fire, if this is not already known definitely to the ship's crew. If it is, they will be able to advise on the best route to reach it. There are various possible indications of a fire's seat, e.g. the appearance of the holds and cargo, the presence of smoke, its density and temperature, and the temperature of parts of the ship's structure. The ventilators may also be a useful guide.

It may, however, be necessary for firemen wearing BA and using guide lines to enter the holds to search for the seat of the fire. BA controls should be set up as necessary on different decks (see Plate S.14). The entry points at each deck level make excellent positions for these controls. A large amount of BA will always be needed; first crews will probably only be able to lay out guide lines before having to retreat. When the fire has been found it should, of course, be attacked at once as delay, apart from causing additional damage, will lead to rapidly worsening conditions. In some cases, however, conditions will be too severe for firemen to enter the area involved, and the fire will initially have to be fought from above (see c below).

The main access gangway to the ship is usually adjacent to the accommodation spaces and therefore does not provide convenient access to fires elsewhere. Brigade ladders could be used as an alternative access.

Hatch covers are now usually of metal and hydraulic or electric in operation, although they may have to be forced manually if distorted by heat. Some, however, need a winch or crane to lift them. (See Chapter 9 Section 2a(2).) Firemen must appreciate that dockside cranes, or their operators, may not be available and, due to the fire, the ship's derricks may also be inoperable. They may have to rig their own hoisting tackle, at least to get pumps etc. on board (see Chapter 14 Section 2b). Especially on small ships, firemen should take into account that lifting equipment from the quayside by on-board tackle can have an effect on the ship's stability (see Chapter 12). Hatch covers should not be removed until firefighting equipment is in position and charged.

c. Application of extinguishing media

The choice of media is very important and will be the decision of the officer-in-charge. He should take into account the factors mentioned in b. above and in Chapters 10, 12, and 15, as well as the availability of particular media at that time and place, and any advice from the ship's officers.

(1) Use of water

An attack on the seat of the fire as quickly as possible is likely to provide the best chance of rapid extinguishment and minimal water damage. If possible, therefore, water should be applied from within the hold via hand-held branches; fresh water should be used if possible to avoid contamination of equipment and cargo by heavily polluted dock water. BA teams should enter with communications equipment and guide lines, followed by charged lines of hose. Careful supervision of BA will be essential and circumstances, e.g. excessive heat, may make reduced time limits necessary. Firemen should realise, however, that conditions within holds may not be as bad as the initial outrush of hot gases and smoke might suggest (see Plate S.15).

If it is not possible to apply water from within the hold it should be applied from above, through the hatch, by directing a jet or spray downwards across the hold in the direction of the apparent seat of the fire, or by the use of special equipment such as the basement spray, the revolving nozzle, the cellar pipe or the elbow-for-nozzle (see *Manual*, Book 2, Part 2).

When none of these methods is effective it may be necessary to cut through a vertical bulkhead in order to approach the fire from a different point. This is, however, time-consuming and not necessarily effective. Cuts must not be made in the hull of the ship, as subsequent listing could bring these holes under the water and cause the ship to capsize or sink. (A check should also be made to ensure that there are no existing openings which could have this effect—see Chapter 12 Section 9). When a cut is made, firemen must bear in mind the possibility of there being water behind the bulkhead concerned. They should cut from the bottom up, so that the cutting tool is always above any escaping water, and they should take care that large amounts of water are not released suddenly in such a way as to trap them. The cut should be above where the plates are hottest.

Water spray can be very effective in a ship fire, especially for cooling ship's plates in order to prevent them bulging and possibly fracturing. Spray is also useful in tackling cargoes such as grain, which, if unduly disturbed by jets, could produce dust clouds and possible dust explosions. For cooling the hull, however, jets are generally more effective.

There have been occasions when, due to the inaccessibility of a deep-seated fire, a decision has been made to totally flood a compartment or hold. This is usually only done after all other methods have failed and the Master and all other authorities have agreed. The stability of the ship will have to be carefully monitored and the possibility of it settling on the bottom also taken into account. This will be a matter for the Harbour or Dock Master to decide.

All openings to the compartment or hold, whether designed or introduced, would have to be securely plugged before flooding started, and a watch maintained at these points. The officer-in-charge should ensure that clear lines of retreat are kept open for any brigade personnel used for this purpose.

When the fire is considered extinguished, the hold(s) should be pumped out, the officer-in-charge still maintaining a careful watch on stability. In cases where the ship has rested on the bottom, the 'lift-off' could be hazardous if insufficient care is taken (see Chapter 12 Section 8).

(2) Use of other media

Chapter 10 discusses the advantages and disadvantages of other media. When injecting a medium such as CO_2 or foam into a hold, precautions must be taken against the displacement of hot gases and, when injection is complete, firemen should ensure that all openings are closed.

When deciding on foam application, and foam stocks required, officers-in-charge should take into account the likelihood of the first application breaking down due to the heat in the hold. Convection currents could also initially prevent the foam settling and it will probably be necessary to vary the rate of application and the ratios to make an extra-heavy attack in the first instance. The use of foam may only be an interim measure to enable a penetration with water jets to be made for final extinguishment, or, in some cases, it may be successful without any back-up. This will depend on the type of cargo, the depth of the fire in it, and how long it has been burning. In some cases a cargo fire may need several days' work before the officer-in-charge can be sure it is completely out.

d. Handling cargo

Where it is necessary to move cargo to reach the seat of a fire or to ensure that no fire remains in it, firemen must be prepared to move it themselves, but whenever possible should get assistance, or at least advice, from a skilled stevedore. Problems may arise when stevedores object to firemen moving cargo. In such circumstances it may be best to ask stevedores to do the job, while leaving firemen to carry out any necessary damping down. When any cargo is being moved, firemen should watch it for signs of fire and keep a branch in position for use if necessary. Particular care is necessary if equipment is used for moving cargo; a grain conveyor belt, for example, can draw up fire along with the grain. Partially burnt bales should only be opened up away from the scene of operations and any internal fire extinguished by covering jets.

4. Container ships, LASH ships and barge-aboard ships

Containers are usually packed and sealed at the manufacturer's premises, so, provided that they remain intact, there is little chance of their contents being ignited by an external source whilst on board ship, unless a fire becomes well established outside the containers and develops to involve them. The most likely cause of a container fire is a reaction between incompatible chemicals as the result of a leak.

Usually, certain parts of a ship are designated dangerous cargo areas, and containers holding dangerous goods will be located in these areas, e.g. an upper deck or a particular hold. Details of any such goods and their location should be readily available (see Chapter 15 Section 2).

Apart from the special problems of dangerous goods, any fire involving containers will be very difficult to deal with since the tight storage means that access for firefighting will be extremely difficult, if not impossible, and there could be problems in moving containers. Even with the necessary dockside equipment available, the process will be time-consuming, particularly if fire hinders the equipment's use. If available, modern equipment for unloading containers through the bow (see Chapter 9 Section 3b) could be helpful. Amongst other problems on container ships are the following:

(i) Ventilation could be difficult.

(ii) If the guide rails (see Chapter 9 Section 3a) become distorted by heat, it will be very difficult to remove the containers. It is therefore important to cool these rails during a fire.

(iii) Some containers are fitted with refrigeration motors, whilst others have flexible piping to the ship's refrigeration system. Holds may be insulated for the carriage of refrigerated containers.

(iv) Should any containers on the ship's deck be or become unsecured, they could move dangerously.

(v) On partial container ships, used also for the carriage of cars etc., low deckheads and car lashings can hinder access to containers.

(vi) Initial access to the ship might be difficult because of the high freeboard and, usually, the single gangway.

A ship's CO_2 installation, if fitted, could be used as the first measure against a fire, but the holds are very large and there might be insufficient supplies to be effective. An alternative is to flood the holds with high expansion foam or, in the last resort, water, although this may take some time.

With LASH ships and barge-aboard ships, the best course if the fire is confined to one particular barge or lighter is to have the affected barge or lighter removed if possible and to deal with it separately after opening up.

5. Ro-Ro ships (including ferries)

a. General

Ro-Ro ships vary according to their use. A bulk car carrier may hold several thousand cars, whereas a ferry could be carrying as many as 500 vehicles and 1,500 people. Details of the layout of the two types of Ro-Ro ship are given in Chapter 9, Sections 5 and 10a respectively.

b. Evacuation of passengers

Obviously, when a ferry is on fire in port, all passengers will be evacuated as soon as possible. Some modern vessels are being fitted with escape chutes similar in design to those fitted to large aircraft, but, in any case, firemen could encounter a large number of people leaving the ship as they arrive. Every assistance should be given to ensure their safe disembarkation. The possibility of some people attempting to return to their cars should be borne in mind.

c. Access

Methods of access to the vehicle decks are described in Chapter 9. Firemen should note that it may be necessary to wedge open some of the heavy sliding doors to avoid having hose lines cut and retreat avenues obstructed. There are alternative entrances to machinery spaces, e.g. enclosed ladders passing up through the central section to the top decks.

d. Fixed firefighting installations

The ship's Master may have operated fixed firefighting installations to try to contain the fire and he will probably be able to tell the officer-in-charge its approximate location (see Plate S.16). Arrangements should be made so that, when firemen are in a position to tackle the incident, any fixed installations operating are shut down. This applies to fires in the accommodation and machinery spaces as well as to those in cargo areas. Firemen should visit all types of ships using ports in their area to check on types of installations and outlets.

e. Fires on vehicle decks

On vehicle decks, there will often be a serious problem of access because of the very restricted space between vehicles. The degree of difficulty will depend on how the vehicles are loaded. It may be necessary to partially unload a bulk car carrier to get at the area on fire. Firemen must take extra care when vehicles are being moved by the cargo handlers.

Water jets and/or spray will usually be sufficient to put out the fire. Drainage on the vehicle decks is usually to run-offs at the sides leading to the bilges, but firemen must be aware of the danger of these being blocked. Any amount of surface water in large areas such as the vehicle decks could seriously affect stability.

BA may need to be worn, depending on how far firemen have to penetrate.

Some commercial vehicles carried on ferries may contain dangerous substances. Such substances must be notified to the shipowner or Master before being taken on board, and the vehicles concerned are usually isolated in a particular area, e.g. all aft or all forward

NORLAND SIGNED .... DATE ....

BKG NO	UNIT NO	UNIT TYPE	COMMODITY F.P.	CLASS PAGE, UN	WEIGHT	SEGREGATION	EMERGENCY ACTION
11	228292	L/T	(DIPHENYLMETHANE – 4 -- 4 Diisacyanate) LUPRANATE RESIDUE	6 PAGE 6093/3 UN 2489		AWAY FROM L/Q & FOOD	EMS 6.1 04
14	CBLU 000002	L/T	(BIPYRIDIUM PESTICIDES) REGLONE	6 PAGE 6146 UN 2781		AWAY FROM L/Q & FOOD	EMS 6.1–06
15	100115	L/T	HEXAMETHYLENE DIAMINE	8 PAGE 8096 UN 1783		AWAY FROM 2.4.1.8	EMS 8–05
54	010211	L/T	ACRYLAMIDE RESIDUE	6 PAGE 6008/2 UN 2074		AWAY FROM L/Q & FOOD	EMS 6.1–04
301	LKY 428	TRL	(PESTICIDES) TECHNICAL CONCENTRATE	6 PAGE 6146 UN 2902		AWAY FROM L/Q & FOOD	EMS 6.1–06
302	RT 147	TNK	(ETHYLENE GLYCOL MONOETHYL ETHER) ETHOXOL	3 PAGE 3134 UN 1171		AWAY FROM 2.4.1.8	EMS 3–06
302	RT 147	TNK	(ETHYLENE GLYCOL MONOBUTYL ETHER) BUTYL ETHOXOL	6 PAGE 6085/1 UN 2369		AWAY FROM L/Q & FOOD	EMS 6.1–01
70	3465	L/T	(DICHLORODIFLUOROMETHANE) ARCTON 12	2 PAGE 2045 UN 1028		AWAY FROM 1.3.4.5.8	EMS 2–09
72	3480	L/T	ARCTON 12	2 PAGE 2045 UN 1028		AWAY FROM 1.3.4.5.8	EMS 2–09
						AWAY FROM	EMS

Fig. 13.1 Typical list of hazardous cargo vehicles on board 'Norland' passenger/car ferry.

on the lower deck, or on the top deck in the open air. Details should be easily obtainable (see Chapter 15 Section 2). An example of a dangerous cargo manifest is shown in Fig. 13.1.

6. Insulated ships

a. General

Fire in insulated ships may occur either in the holds or in the insulation. A fire starting in a hold may, however, spread easily to other parts of the ship via the insulation or air ducts and through the effects of radiated or conducted heat. Firefighting is made more difficult by the large amount of fumes and smoke that can be given off, some of which may be toxic. Involvement of refrigeration plant is a particularly serious cause of fumes. Heavy concentrations of CO_2 may be present in holds carrying citrus fruit even when there is no fire. In most cases, therefore, the use of BA is essential. Usually a ship's engineer will shut off the hold(s) or deck(s) involved and leave the rest of the ship's refrigeration system working.

In an incident involving an insulated ship, the officer-in-charge of the first attendance should ascertain the details listed in Section 2 above, plus the following:—

(i) the type of insulation;

(ii) the type of ducting/piping;

(iii) the nature of the refrigerant, if applicable.

b. Fires in the holds

A fire in a hold can be dealt with in a similar way to an ordinary cargo fire, but firemen will have to pay particular attention to preventing fire spread. They should ensure that, where ducts pass through bulkheads, the dampers are closed and secured, and that the ventilating machinery is shut down; and they should watch for signs of heat in bulkheads and partitions adjacent to the seat of the fire. When the hold has non-flammable insulation such as fibreglass and its air ducts can be effectively shut off and guarded, CO_2 and high expansion foam can be used to considerable effect. When gaining access to a hold via the hatch cover, firemen must remember that there will be one or more insulated plug hatches below this and it may require a crane or derrick to remove them. (See Fig. 9.13).

c. Fires in the insulation or air ducts

If the fire is in the insulation or air ducts it will not normally be possible to tackle it by introducing extinguishing media into holds. The first necessity will be to locate the seat of the fire. The smoke emerging from the thermometer tubes may give an indication of the deck involved, and closer identification may be possible by feeling for heat through the bulkhead plates or finding signs of burning. When the approximate seat has been established, firemen will have to tackle the fire directly. How they do so will depend on various factors such as the thickness of the covering plates and the nature of the insulating material behind them. One way of dealing with an insulation fire would be to cut holes about 150 mm in diameter above the seat of the fire and insert branches. Sufficient retaining material should then be stripped away to reach more of the insulation and ensure that no pockets of fire are left. This is likewise important when there is fire in the air ducts. Insulation may consist of materials such as polyurethane foam which give off toxic fumes, and firemen should in these circumstances, or in any case of uncertainty, use BA. In air duct fires, the closing of dampers (where applicable) is obviously of vital importance.

7. Tankers

In general terms, firemen should deal with fires on tankers as they deal with oil fires on land (see *Manual*, Part 6b, Chapter 5). Some general guidance is, however, given below.

a. The risk of fire

The risk of fire varies. Cargoes of heavy refined oil present relatively little risk. Crude oil is however dangerous, as are petrol and oils having a low flash point. The danger is least when tanks are full and properly sealed. It is greatest when the tanks have been emptied of oil but still contain gas. The problem will be relieved if proper inerting procedures have been followed (see Chapter 9 Section 7c and Chapter 10 Section 4e), but this may not have happened, or the equipment might be defective or might be made so by a fire or other mishap. Fire and explosions can then be caused by, for example, a spark from a boot on a steel deck or even by static electricity. Other tanker fires may be the result of collisions which rupture the tanks. (If damage to the tanks does not immediately result in a fire, a flammable mixture may be formed as air reaches the tanks or gas escapes from them, and this may then reach an ignition source). The Brigade will therefore probably be faced with fire on the superstructure and/or on the surface of the water as well as in the tanks.

b. Fires in tanks

Usually, a collision and/or explosion will have created a hole in the top or side of the tank, sufficiently large for the efficient application of foam. When oil is burning inside a tank, large quantities of foam will be necessary and the officer-in-charge must

be sure to order on sufficient amounts of foam concentrate and an adequate number of foam branches and pumps. The supply of foam must be continuous to be successful and it is better to order on too much rather than to allow the fire to re-establish itself by having too little. Even a relatively minor incident might require as much as 13,500 litres of concentrate per hour. If fixed installations are operating, the officer-in-charge should obviously allow them to continue while mobilising his resources.

Branches should be positioned to windward so as to be clear of vapour and to maximise the distance of throw. This may be done from the deck of the ship or from a fire tug positioned nearby, depending on the circumstances. Firemen should concentrate them all on one tank at a time, so that the foam has effect as quickly as possible. Even after a fire has been extinguished, a thick layer of foam should be maintained for some hours until the plates have cooled and the danger of re-ignition passed.

Water should be used for the external cooling of plates but not allowed to enter tanks. Any system for inerting tanks should remain in operation, if undamaged, to protect those which are unaffected. Firemen should of course attempt to discover which tanks are full and which empty as soon as possible, in order to give priority to cooling full tanks. The ship's loading officer should know the current position.

c. Other fires

Apart from tank fires there may also be fire in the superstructure. Firemen should tackle this with water in the usual manner. They must take care, however, that water does not fall onto, and break up, any foam blanket which they may have applied at a lower level.

Oil leaking from a tank or floating on the water, whether ignited or not, should be broken up by powerful jets. By the cooling down and separation of the oil, any fire will be extinguished or made less likely, and fire spread from patch to patch will be prevented.

d. Other considerations

There may, with the largest tankers, be particular problems in reaching the ship and getting aboard. Chapter 14 Section 2b discusses the general question of access. When on the ship, firemen should remember that it is rare to be able to rely completely on the ship's firefighting installations. Some systems run over the top of tanks and are therefore often damaged in an initial explosion. (See Plates S.17 and S.18).

8. Liners

a. General principles of attack

The typical first attendance at a fire might consist of four pumps and an emergency tender. The crews should board with general purpose lines, adaptors, breathing apparatus, Stage 2 BA boards, delivery hose and variable control branches. On large ships they may be able to get jets to work from the ship's mains, but they will usually obtain their supplies from shore-based or water-borne pumps. If there is a sprinkler installation on the ship, they should keep this in operation until the fire is extinguished or jets are in position. On some large vessels there may be firefighting personnel and their advice should be sought on the fixed installations; they can also offer guidance round the ship. The officer-in-charge will find it beneficial to assign personnel from his crews to be responsible for such areas as:—

(i) stability (see Chapter 12);

(ii) foam;

(iii) water;

(iv) staff duties;

(v) communications;

(vi) breathing apparatus;

(vii) petrol, oil and lubricants.

A firefighting bridgehead and BA entry control should be set up on each deck.

b. Effects of the ship construction and layout

A passenger liner can be very complex in terms of the number and naming of its decks, its corridors, cabins, public rooms, service areas etc. Not only can it be difficult to locate the fire and easy to get lost but the long corridors and staircase and lift shafts can induce draughts which help fire spread. A ship's officer should meet crews boarding a ship and escort them to the fire; guides should be posted to direct later support or relief crews. Care must be taken to ensure a line of retreat in the event of an emergency; guide lines may be helpful in this respect.

Liners are divided by fire-resistant, and in some cases watertight, doors and bulkheads (see Chapter 9 Section 10b). The doors not being used for firefighting should be closed as soon as possible to confine heat and smoke and minimise fire spread. Firemen must not, however, place total reliance on these to act as fire stops. Doors and bulkheads surrounding the fire should be examined regularly for signs of heating and cooled as necessary. Watertight doors can be controlled from the bridge, and careful liaison is necessary in order not to shut crews in or sever lines of hose.

Firemen should find out the manual operation of a watertight door. As a further measure to stop fire spread it is usually desirable to have the ventilation system closed down.

Fire may spread between the ship's side and cabin walls via metal decking, or behind panels and false ceilings, through cable ducts and pipelines, etc. Firemen should therefore check the area around, above and below the fire, stripping away panelling and cooling down as necessary.

Stability is always a factor in ship fires, but can cause special problems when water is introduced high up in the accommodation of a large passenger ship. The free surface effect of water (see Chapter 12) is the main danger, especially where it lies in large areas such as the public rooms.

Public rooms can also cause other problems because of their elaborate furnishings and fittings; access through them can be made difficult by the layout of furniture. The often luxurious accommodation in cabins may be readily flammable, and the situation can be complicated by the use of materials such as foam rubber in mattresses, which can produce vast amounts of toxic smoke. In a small cabin fire, furniture should be left in the cabin so as not to impede passage in narrow corridors.

9. Royal Navy vessels

a. Responsibility

The issue of responsibility in ship firefighting is very complex and this is particularly so with naval vessels (see Chapter 11 Section 2b). A proper understanding between RN and Fire Brigade personnel is essential, since only this will guarantee the effective liaison and co-operation necessary.

When a fire occurs on board one of HM ships in commission, the Officer of the day will initiate firefighting measures with his fire-parties and call the fire brigade. He is required to keep an area clear on the quayside for LAFB appliances. Also, where the vessel has more than one brow, he is required to mark the 'on' brow with a red flag and to detail a second rating to meet the LAFB officer-in-charge at the brow. Often, the 'on' brow is the gangway marked with the ship's name.

When the LAFB arrives the RN Commanding Officer has instructions to pass the firefighting responsibilities (including control of his naval fire crews, BA controls etc) to the senior fire brigade officer present, and to assist in any way he can. He still retains ultimate responsibility for the safety of his ship, and especially its stability under firefighting conditions. Officers-in-charge of LAFB personnel may ask RN BA crews to assist as guides but must remember that, generally, RN BA sets have less duration than LAFB sets.

Each RN ship in commission has a damage control officer with whom the Fire Brigade officer-in-charge should liaise if possible. With ships not in commission he should liaise with the shipyard authority. The damage control officer will have information on the effect of firefighting on the ship's stability, and will be able to advise on any measures necessary to keep it in a stable condition.

Nuclear submarines are subject to special arrangements (see (d) below).

b. Features affecting firefighting operations

Firemen should note that the lightweight alloy metals used extensively in the superstructure of RN ships will fail quickly in fires and that bulkheads employing them may therefore not act as effective fire barriers. (The *Manual*, Part 6c, discusses metal fires in general). Other hazards on board RN vessels are the extensive and complex electrical installations, the very heavy smoke-logging which may be experienced—e.g. when unprotected butyl-covered electrical installations become involved in a fire—and, of course, the magazines, weapon storage areas and fuel tanks. The absence of port-holes on RN ships may cause problems in ventilation or getting water onto the fire.

Although RN ships have these special hazards, firemen are helped by other features, e.g. the extensive division into watertight compartments by transverse and longitudinal bulkheads and watertight hatches, and the relatively small amount of flammable material (other than in the stores and magazines). Naval ships have, in addition, more comprehensive firefighting equipment aboard than other ships, and a larger complement of personnel (though whether all are present will of course depend on the circumstances). The fire main pressure in naval ships is usually 5.2 bar on the older types and 7 bar on the newer, but all equipment is designed to operate at 2.4 bar. Instantaneous couplings on board RN ships are identical with those of LAFBs.

All magazines are fitted for flooding, usually directly from the sea, and they usually have a sprinkler system operating from the fire main. Ships which carry aircraft have particularly extensive sprinkler systems in the hangars. Firemen should be aware of the characteristics of aviation fuel that might be carried (see Chapter 1).

c. Firefighting

An important consideration, as always, will be to keep the amount of water used to a minimum. If the fire is well established, it will of course be necessary to mount a direct attack on it in the normal way. However, in a small fire where there is little combustible material, bearing in mind the generally small size of compartments on RN ships, it may be desirable to let the fire starve by shutting

off openings to the affected compartment and thereby depriving it of oxygen. If this is done, firemen should check that all surrounding bulkheads, decks and hatches are intact, and should cool them with water spray to ensure that they remain so.

It may be valuable to inject a firefighting medium other than water into the compartment to hasten the extinction process, and special equipment may be available for this purpose on some ships. Firemen should always seek the advice of the ship's officers in such circumstances. The length of time before opening up will be possible will depend on the size of the compartment and intensity of the fire. Firemen entering the compartment should remember that the atmosphere will be oxygen-deficient.

d. Nuclear submarines

(1) Under construction or repair

As soon as the nuclear reactor has been installed, RN personnel are in charge, and under no circumstances can the LAFB officer override the naval officer-in-charge. It is unlikely that the NAIR scheme will need to be invoked, since all the necessary expertise should already be available on the spot.

(2) In service

Under no circumstances may LAFB personnel board a nuclear submarine in service. All firefighting will be carried out by RN personnel, although the LAFB may supply water to the gangway. When the LAFB attend such an incident, they should mobilise their radiation-checking equipment as a precaution.

10. Bulk chemical carriers

a. General

As described in Chapter 9 Section 8a these vessels, despite stringent international regulations, present problems to the Fire Service not only from possible fires but also from spillages, interaction of cargoes, gas clouds etc. The introduction, by mistake, of a chemical incompatible with a tank lining, the inadequate separation of mutually incompatible chemicals, the breakdown of a tank lining, or the failure of piping, pumps, tank walls or bulkheads are examples of conditions which could lead to highly dangerous incidents. There could be a need for local specialist reinforcement to a brigade's chemical data retrieval system, as it is the results of the mixing and interaction, plus possible fire, which will need to be tackled correctly. For example, tanks often need 'washing-out' and it is not unknown for the 'washings' to react. Methanol is one substance used as a 'washer' and is flammable and highly toxic; it is therefore a hazard in itself, even if it does not react with the contents of a tank.

As part of the preplanning arrangements, it may be worthwhile to set up a system whereby the brigade is notified of the arrivals and departures of these vessels, and their cargoes, especially where 'parcel' tankers are concerned. This information would be available to the officer in charge of the first attendance to an incident, to enable him to have some idea of the possible problem.

b. Dealing with an incident

The immediate necessity, after any rescues have been carried out, will often be to protect the undamaged portion of the ship and the dockside risk. The Master may have got his foam monitors, water spray systems etc. into action but much will depend on the competence of the crew, the reliability of the equipment and whether damage to the systems has left them ineffective.

Depending on the size of the incident it may be necessary to wait to accumulate enough suitable extinguishing agent before making an assault on the fire. If water is an unsuitable agent, firemen will have to take care when cooling down round the area involved. Tank linings can be damaged by careless use of equipment.

Even in the open air, BA will probably be necessary, perhaps with protective clothing, followed by decontamination. IMO requires that access to various parts of a ship be adequate for firemen wearing BA sets, not only for firefighting but also for rescue (see Chapter 9 Section 8a). Firemen must remember that on any ship, but especially on chemical and gas carriers, any small enclosed area, merely by its position, could be oxygen-deficient or contain toxic fumes. BA should be worn anywhere a fireman has to make a difficult or restricted entrance in order to search or check for fire spread.

c. Gas clouds

Occasionally, a brigade may be faced with an incident involving the leakage of a toxic or flammable gas or vapour. Whether the resulting cloud is visible or not will depend on its ingredients and the weather. Preplanning should have taken this contingency into consideration and arrangements for evacuation, movement of shipping, monitoring equipment (e.g. explosimeters), emergency shut-down of heating systems etc. should be put in hand by the appropriate authorities as soon as possible. The infinite number of conditions possible at such an incident forces planning to be very flexible. The officer-in-charge must try to keep his men out of the gas cloud, insofar as he can ascertain its extent. Firemen should if possible keep upwind. If, for the purposes of rescue, an entry into a gas cloud must be made, it should be by as few men as possible, and they should spend only as much time in the danger area as it takes to perform the rescue. They should be

warned against operating any electrical equipment, including radio, and, if lights are necessary, they must switch them on before entering the cloud and switch them off only after leaving it.

11. Gas carriers

a. General

The range of gases that can be carried by these vessels is very wide. The cargo tanks are pressurised and/or refrigerated, often to a very low temperature (see Chapter 9 Section 8b). In order to facilitate unloading, the gases are often heated. Additional heat from a fire can cause problems with a possible discharge of gas through pressure relief valves, with the possible formation of an explosive mixture. Polyurethane foam (usually encased in metal) is widely used as tank insulation; the possibility of its breakdown and the consequent production of toxic gases under fire conditions should be taken into account.

b. Firefighting

Depending on the nature of the fire/explosion the Master should, if possible, have operated some or all of the shipboard fire protection systems. The first job of the brigade will be to cool the unprotected areas while the Master attempts to shut down cargo pumps etc. Because of the tank configurations on these vessels, many of them have a poor ballast capacity and therefore their stability can easily be upset. The liaison between the various organisations needs to be particularly close here to keep the ship stable.

12. Fires in parts of ships

a. Fires in stores

Fires often start in the boatswain's stores. Even a small fire there can give off quite a lot of smoke because of the materials present, e.g. plastics. Flooding is not the best way of dealing with such fires since the fire may be on an upper level which the flooding would take some time to reach. Firemen should instead make an attack at close quarters with a spray/jet, or possibly HEF. It may be necessary to wear BA.

The engineer's store and workshop, usually located in the engine room, can present special problems due to the clutter of oily material. Fires there are hard to fight and it is important to tackle them as quickly as possible to avoid serious damage to the machinery and cabins above (see (b) below for machinery space fires in general).

Equipment may also be stored in shaft tunnels (see (d) below).

b. Fires in machinery spaces

One of the main causes of fire in a machinery space is the leakage or accidental release of oil. For example, a pressurised oil-pipe may split (see Plate S.19) causing fine droplets of oil to be sprayed onto a hot manifold which then ignites with a rapid build-up of heat and smoke. Usually, if the fire is serious enough, the Master will stop all machinery, evacuate engine room staff, close the doors, and operate a CO_2 or foam system. This procedure often means, however, that all powered systems, including fire pumps, are closed down. Firemen would then have to take their own pumps aboard or pump from the dockside.

A major problem with this type of fire is the difficulty of access via ladders and platforms so that firemen can locate the fire and deal with it. They must never use engineer's lifts to reach the area. The normal means of access are the engine room ladder, the boiler room ladders and the shaft tunnel. Firemen must remember that any close-fitting doors may have warped in the heat, and they may find it necessary to use hydraulic spreaders, rams or toe-jacks to open them. It may sometimes be necessary to cut holes in bulkheads. Personnel and equipment must be kept clear of air intakes where machinery is running.

BA will always be necessary, with the emphasis on controls and guide lines. In some circumstances the fire can result in a serious risk from radiated and conducted heat. It may produce extremely hot working conditions. The officer-in-charge must be especially careful to protect personnel from heat exhaustion; a very low limit on working time may be necessary. When large-scale cooling operations are called for, firemen must have due regard to the question of stability; the use of spray and variable nozzles will help.

Boiler room fires, in particular, are hot and difficult to contend with. Fine judgement is necessary, especially in deciding when to ventilate. In all machinery space fires it is necessary to keep a check on adjoining compartments: materials on the other side of bulkheads can ignite very easily. Painted surfaces, too, rapidly assist fire spread. In machinery spaces there is a major risk of re-ignition because of the number of hot areas with which oil can come into contact. Caution is therefore necessary even when the fire is apparently out.

In fighting the fire, firemen must heed any advice given by the ship's engineer. To prevent the fire from spreading, the oil supply should be shut off if at all possible. As far as firefighting conditions allow, cold jets should not be played on hot pipes or the fronts

of boilers and their gauge glasses, to avoid fractures. Various methods are available for extinguishing the fire (see below), and certain installations may be fitted (see Chapter 10).

(1) Carbon dioxide, halons and inert gas

These agents have the disadvantage that it may take some time to clear the space afterwards. They also have little cooling effect. They do, however, have the advantage of not damaging machinery and electrical equipment.

(2) Foam

Medium expansion foam from hand branches can be useful, so long as the oil supply has been cut off, and provided that it can be applied in the right area. The network of pipes makes it difficult for the foam to reach all parts and firemen must therefore ensure that it is not too thick to flow freely. Alternatively, high expansion foam might be used to advantage, although, due to the heated convection currents, it might be difficult to get it to flow down to, or remain at, the level of the fire.

Foam from the ship's installations is at its most effective when the oil is in a sump or tank. If, however, the oil is thinly spread out over a wide area, this foam will not always be suitable since it may not flow freely enough. Much will depend on the type of installation and the foam ratios used.

(3) Water

The use of water spray branches is often best. Turning several spray/jets into the engine casing above the machinery space has a considerable cooling effect and creates a blanket of steam. The up-draught is lessened and the vaporisation rate of the oil reduced, so that a closer attack with the branches becomes possible. Water spray is particularly useful for cooling when there is a thin layer of unfired oil in contact with hot plates (e.g. on the top of a tank), since, otherwise, radiant or conducted heat might fire the oil. The value of diffuser branches is however reduced where intervening pipework inhibits their full use.

(4) Starvation

If the application of extinguishing media is not practicable, firemen may be able to starve the fire of oxygen by closing all openings into the machinery space. This will usually, however, only be possible on very small ships: engineering advice should be taken on the practicalities and the best methods.

c. Fires in up-takes

Up-take fires usually involve the combustion of unburnt carbon deposits. They can be difficult to deal with and it is usually better to allow them to burn out whilst providing cooling spray at the appropriate points. Opening the up-takes to gain access can aggravate the situation by increasing the draught.

d. Fires in the shaft tunnel

The shaft tunnel is often used for the storage of paints, oils, gas cylinders etc., and these may become involved in a fire. If a fire does occur and for any reason its seat cannot be reached, it may be possible to close the watertight door between the tunnel and the engine room (see Chapter 9 Section 2b(3)) and flood the tunnel (see Plate S.1).

e. Bilge fires

These are very smoky due to the presence of oil residue, and are difficult to detect but relatively easy to extinguish. The application of water-fog or HEF through the hatches is usually effective.

13. Pollution

Officers-in-charge must beware of the restrictions and regulations regarding the washing of dangerous substances and pollutants into waterways. Consultation with the appropriate authorities will be necessary if such cargoes become involved.

Chapter 14
Incidents at sea

1. Contingency plans

Although a fire authority has no legal responsibilities for fighting fires on ships at sea outside its area (see Chapter 11), most authorities with coastal boundaries have considered the problem and made appropriate arrangements. These contingency plans must be drawn up in consultation with other services, e.g. Coastguard, RNLI, tug companies, armed forces. Where, as often happens, two or more authorities have a common estuary it may be necessary to set up a joint committee to co-ordinate planning and response.

a. Notification of incidents

The fact that the Master of a vessel reports a fire, explosion or other emergency at sea does not necessarily mean that he requires assistance. He may decide to tackle it himself, bearing in mind the possibility of salvage claims. Fire authorities will make their own arrangements locally with the coastguard as to what is reported to them and how, but should ensure that their assistance has been expressly requested by the owners, agents or Master before attending the incident. Also, when the officer-in-charge of the first attendance, or reconnaissance, arrives, he should confirm with the ship's Master that the assistance of the brigade is still required. If the Master has requested help from a brigade, he should obviously co-operate and listen to advice from the officer-in-charge.

b. Coastguard organisation

The Coastguard organisation in Great Britain is divided into twenty-six regions, each with its constantly manned operations room. There are about 550 regular coastguards assisted by about 8000 auxiliaries. Liaison would best be made through one of the six Maritime Rescue Co-ordination Centres (MRCC).

c. Sea transport

No fire authorities operate sea-going fireboats, so arrangements must be made with other organisations for transport out to the ship involved. Whatever craft are employed they must be readily available, seaworthy, and capable of carrying sufficient equipment and personnel safely. They must have sufficient range, be easy to load and, what is more important, be relatively easy to get alongside a ship and unload.

Some brigades have developed pre-packaged equipment, using pallets or boxes which can be quickly transported to the quayside and, depending on tide, either loaded over the side or, using a TL as a crane (see Plate S.20), lowered onto the deck of the transporting vessel and secured.

d. Air transport

Some authorities have made arrangements with the RAF or RN for helicopters to be made available to transport personnel and equipment to ships at sea. Any authority considering using this method will need to bear in mind the limitations of using such aircraft, especially as regards range and weightlifting capacity. A third criterion is weather conditions, especially from the fireman's safety point of view, although helicopter pilots do not consider operations at sea as particularly hazardous.

Pre-packaged equipment, whose weight is known to the captain of the aircraft, will help him quickly calculate his load, including personnel, according to the prevailing conditions and circumstances (see Fig. 14.1). It will also enable a brigade to decide quickly on what equipment to get aboard to make a first attendance to a certain type of risk.

e. Communications

Experiences by brigades who have undertaken firefighting operations at sea have shown that, unless there is very detailed preplanning, communications can be very difficult. Harbour craft, tugs etc within port operational areas use the marine channel 16 for emergencies but this has limitations for brigades. Most brigades find it more efficient to take, as part of their reconnaissance and first attendance equipment, portable radio pack sets which maintain a separate link either to forward controls on shore or into the brigade network. This ensures that radio discipline is maintained, the channel does not become overloaded and other services are not interrupted.

Brigades should ensure that firemen learn and understand maritime phraseology so that, when they talk to maritime personnel, everybody is clear about the situation. (Some of the more common terms are explained in the Glossary at the end of this Part).

f. Safety and training

If firemen are to respond to these calls for help, brigades must ensure that the maximum safety measures are taken. This can best be guaranteed by comprehensive training, and such training must be done under actual sea-going and air-lifting conditions.

Operational Procedure Sea King Aircraft		Totals
DROP 1		
Initial Individual Drops		
4 x personnel c.w Radio Pack set	370 kg.	370 kg
DROP 2		
No. 1 Container		
4 x 25 m x 45 mm hose		
1 Dividing Breeching (alloy)		
2 Variable Branches (AWG type)		
1 Suction Strainer (alloy)		
1 First Aid Kit		
2 Handlamps		
1 Ships Adaptor FI to N and S fitting		
Food, water, sea sickness tablets		50 kg
DROP 3		
No. 2 Container		
1 BA set c.w. 1800 litre cylinder	21 kg.	
2 BA cylinders (1800 litre)	29 kg.	
1 BA servicing kit comprising -		
'O' ring washers		
anti-dim		
disinfectant		
cloths		
D.S.U. key		
24 torch batteries		
Bardic torch key	3.5 kg.	
1 BA entry board	1.2 kg.	
		54.7 kg
DROP 4		
No. 3 Container		
1 BA set cw 1800 litre cylinder	21 kg.	
2 BA cylinders (1800 litre)	29 kg.	
1 x 30 m GP line	6. 4 kg.	
2 handlamps	1. 6 kg.	
2 axes (small)	2. 6 kg.	
		606 kg
DROP 5		
LPP pump cw slings, suction wrenches, etc.		180 kg
DROP 6		
3 x 3 m x 100 mm suction hose (alloy)	54. 5 kg.	
1 x GP line 15 mm	3. 2 kg.	
Petrol 1 x 18 litre	19 kg.	
		76.7 kg
	Overall Total Weight	
	TOTAL	792 kg

Fig. 14.1 An example of preplanning to carry equipment out to a ship by helicopter.

Only this will give firemen the necessary experience of ships and aircraft and make them more confident when attending actual incidents. Some of the measures and techniques which could be covered in training are listed below:

(i) Always wearing lifejackets and/or immersion suits and knowing the correct procedures if immersed;

(ii) The correct way to move about a ship and the rigging of safety lines;

(iii) techniques of climbing a rope ladder;

(iv) loading and securing equipment aboard sea or air transport;

(v) handling pumps and hose-lines aboard;

(vi) boarding an abandoned vessel;

(vii) co-operation with tug, helicopter and ship's crews;

(viii) techniques of winching on and off ship's decks from helicopters (see Plate S.21);

(ix) techniques of boarding helicopters on land; and

(x) keeping suctions submerged in a strong current e.g. under way.

This list is, obviously, not comprehensive and brigades will vary their training to cover the kind of offshore operations which they are prepared to undertake.

2. Dealing with the incident

Most of the problems of firefighting in port will obtain at sea, but they will be compounded by the relative isolation of the firefighters.

a. Reconnaissance

Experience has shown that the initial call to a brigade for assistance often gives insufficient information as to what the situation is or even exactly where it is. If possible, a small reconnaissance group led by a senior officer should be sent out to the stricken vessel. This can be done whilst equipment and personnel are being assembled at embarkation points. The reconnaissance group could look at the situation and radio back information which would be invaluable in assessing the necessary response.

The information could include such items as:—

(i) Precise location of incident.

(ii) Fire situation, e.g. what part(s) of ship are involved, whether fire is spreading.

(iii) Name of the vessel and its owners or agents.

(iv) Type of vessel and tonnage.

(v) Whether manned or unmanned.

(vi) Stability situation and amount of freeboard.

(vii) Whether ship's pumps and firefighting equipment are usable.

(viii) Whether fire tugs could be used.

(ix) Special equipment required e.g. HEF, ejector pumps.

(x) Manpower required—especially for BA.

(xi) State of weather and whether equipment could be air-lifted.

The officer-in-charge of the reconnaissance group may find that the Master has already taken some steps to control the incident himself, e.g. rigging hose-lines, injecting halon or other media, ventilating or, conversely, battening down and turning the ventilation off. Officers-in-charge should give careful consideration to why these moves were made before advising to the contrary.

b. Boarding the ship

This can be problematical in relatively calm weather and very difficult in rough weather. On a very large ship, e.g. a VLCC, the freeboard could be 20–25 m. Usually a companionway will have been lowered in readiness for the brigade to board but occasionally, if the crew have abandoned ship, this may not have been done. If a reconnaissance has been carried out by helicopter and personnel put aboard, it should be possible to rig rope ladders and safety lines to help personnel to get onto the ship. On no account should personnel be linked to each other by line, even when mounting a companionway. This ensures that if one fireman slips he does not drag others with him.

It will then be necessary to get equipment aboard (see Plate S.22). If carried by helicopter, this will be controlled by the air-crew and man-handled by the fire-crew on deck. If the equipment is transported by sea, it may be possible to use the ship's jibs, operated by the ship's crew; otherwise firemen will have to rig their own tackle for hoisting.

c. Pumping

If the ship's "fire services" are out of action and there is no fire tug available, the brigade will need to use its own pumps. The amount of freeboard could preclude any lifting of water over the side of the ship, but it may be possible to place a pump on a lower landing of the companionway (Plate S.23) or open a loading door lower down the ship's side. Failing this, pumps may have to be set in over the side of the tug or other vessel which has transported the equipment out, and water relayed up to the deck of the burning ship. This could be reasonably easy in calm weather, but even with only a swell running the task of keeping suctions submerged, engines and electrics dry and hose connected would be difficult. Firemen must also remember that the Master of the ship may want to, or indeed may have to, keep under way either to make port or at least to maintain his position. This will add to the problems.

d. Stability

The theory and problems of stability have already been dealt with in Chapter 12 and this will be the same at sea. Close liaison between the Master, the officer-in-charge and his stability officer will be necessary. Due to the possible 'tenderness' of the ship, deteriorating weather conditions etc, the Master may want firefighting to stop. The officer-in-charge will have to abide by this decision until the Master considers it is safe to resume operations.

e. Breathing apparatus control

The relative isolation of the fire crews aboard can cause problems of supply and not least of these, in a prolonged attack, is the recharging of BA sets. One of the important facets of preplanning is ensuring that, once the firefighting begins, a continuous attack can be sustained. The initial supply of BA cylinders may well be used up in finding the fire and laying guide lines. A rapid build-up of BA supplies may be necessary because worsening weather conditions may seem likely to preclude further supplies or, at least, to delay them. Once on board, the usual main BA control will be set up but the officer-in-charge may think it necessary to have forward controls on each deck of a large vessel. The need for several safety BA crews will have to be taken into account on the reconnaissance when estimating numbers of personnel. When working up and down vertical ladders or steep companionways, BA crews should not be attached to one another by personal lines but should be individually attached to the guide line.

3. Salvage tugs

If the vessel involved has sent a general 'Mayday' signal, the officer-in-charge may find other vessels in attendance when he arrives. It could also happen that other vessels may come alongside whilst the officer-in-charge is aboard without him initially being aware of them. The question of salvage is always present at these incidents, and the brigade could find that another vessel has rigged hoses and brought them aboard the burning ship. If such incidents occur, the officer-in-charge should note the name of the vessel and some details of its actions. It is not unknown for the fire authority to be asked, at a later date, for information on the

activities of these vessels, and it would be to the advantage of the officer-in-charge to be able to confirm or deny any allegations.

4. Abandoning, beaching and coming into port

Officers-in-charge must remember that the Master of a vessel on fire may also be the owner. Under these circumstances he will obviously take all measures he can to avoid a total loss, mitigate damage to his cargo and prevent salvage claims. In doing so he may hazard the ship and the lives of everybody aboard. Even if he is not the owner he may be under instructions from the owners or agents to the same effect. A decision by him to abandon ship would therefore not be taken lightly, but it may be taken very late and the officer-in-charge must be prepared for it. Methods of withdrawing personnel quickly from below decks, especially BA men, should be set up from the start of firefighting and all firemen instructed accordingly.

A decision may be made to beach the vessel. There could be quite a conflict of opinions here between the Master, pilot, Harbour Master, tug skipper, agents etc as to the best spot. The brigade officer must, however, be ready to point out that to beach the vessel in such a position that the firefighting becomes more difficult may result in a total loss anyway, e.g. where at low tide even fire tugs or fireboats cannot get alongside and land appliances cannot approach near enough on shore. Here again the fire authority's arguments and the final decision reached should be recorded by the officer-in-charge, because such evidence may be necessary later.

The Master of the ship may wish to enter port to get his problem solved, e.g. to unload so as to get access to the cargo involved. The decision as to whether he may enter a particular port, and if so, where he may berth, is down to the Harbour Master, who will probably make this decision after consultation with the brigade to ensure that (a) any special facilities required are available, (b) any isolation necessary is possible, e.g. in a chemical incident, and (c) the ship can be berthed in a position readily accessible to the brigade by land. He may ask the brigade for its opinion on the possible hazard to the port. This will depend on the type of cargo involved, but in most cases it will be advantageous to proceed to a berth, however remote, because of the concentration of personnel and equipment which can be made available there, plus the facilities for moving cargo etc.

If the ship's Master is unable to find a nearby British port which is willing to accept the ship, he may try to enter a foreign port. If so, the fire officer will have to decide whether firemen should disembark beforehand or proceed with the ship to its destination. In reaching his decision he should consult the ship's Master and bear in mind the fire situation.

5. Sea and air-sickness

During training it will become apparent that some personnel are unsuitable for air or sea travel due to sickness. However, fire authorities should bear in mind that a supply of anti-sickness pills should be available for rough weather conditions. Even in good weather an air trip can be bumpy, and an issue of this medication before embarkation should lessen the problem.

Chapter 15
Dangerous substances on ships and in port areas

1. General

The carriage of dangerous substances by ships is increasing. Apart from fires, there are currently about 300 incidents a year involving dangerous substances on ships and these are mostly normal chemical incidents. There are, however, the added complications of usually quite large quantities, possible mixed cargoes, pollution dangers, decisions on berthing, and movement of tides. Incidents may also occur at port installations during loading, unloading or storage. Brigades will have included such factors in their preplanning, and should implement the normal routines for dealing with such incidents, bearing in mind the points mentioned in this chapter. (Dangerous goods carried on inland waterways are dealt with in Chapter 16; nuclear submarines are mentioned in Chapter 13.)

a. Ships

The *Merchant Shipping (Dangerous Goods) Regulations 1981* (MSDGR) (SI 1747/1981), which are designed to implement the provisions of the 1974 SOLAS Convention, lay down the statutory requirements for the carriage of dangerous goods on UK ships, and on foreign ships that are loading or unloading cargo, passengers or fuel within UK waters. Other relevant documents are the Report of the Department of Trade and Industry's Standing Advisory Committee (the 'Blue Book'), the *International Maritime Dangerous Goods (IMDG) Code*, and the IMO Codes relating to dangerous bulk cargoes.

b. Port areas

The IMO recommendations for the transport, handling and storage of dangerous substances in port areas were published in 1981. These will be followed in 1985 by statutory requirements for such areas, called the *Dangerous Substances in Harbours and Harbour Areas Regulations* (DSHR). These are being formulated by the Health and Safety Executive and will replace most of the present local byelaws and regulations. A Code of Practice will be issued at the same time.

2. Identification of hazards

a. On ships

The MSDGR require the shipper to provide the shipowner or Master with information as to the nature of any dangerous goods to be carried, whether packaged or in bulk. In the case of packaged goods (including those carried in containers, vehicles or portable tanks), such information must include the correct technical name of each substance, the UN number if one exists, the class of hazard, the number and type of packages, and the total quantity of dangerous goods. A ship with packaged dangerous goods on board must carry a manifest or equivalent document stating the name, classification and quantity of each item, and a record of the location of the goods. (An example of such a manifest is shown in Fig. 13.1). In addition, each individual package, container etc must be clearly marked with the name of the goods and an indication of the nature of the hazard (e.g. a hazard warning diamond as shown in the *Manual*, Book 12 Chapter 7).

In view of the above requirements, the officer-in-charge at an incident on a ship will normally find little or no difficulty in ascertaining details of any dangerous substances from the ship's officers. (If the ship is in port, the port area requirements—see below—will operate in addition). Problems might occur, however, in the case of a call to a foreign ship at sea.

In addition to the basic information required by the MSDGR, there will in some cases be fuller details available, e.g. IMO emergency schedules (see Section 4a below).

Where goods are shipped in road tankers, UKTHIS or ADR labels may be found (see the *Manual*, Book 12, Chapter 7). Firemen should remember, however, that the emergency action (Hazchem) code shown on UKTHIS labels is designed for road incidents and may not be appropriate on a ship.

b. In port areas

The DSHR will normally require the Master of a vessel bringing dangerous goods into a port area to provide the Harbour Master and berth operator, in advance, with information about the nature of the hazard; the proposed Code of Practice recommends that this information should include the name, the substance identification number where available, and the quantity of each item. Where 250 kg or more of a dangerous substance, or any quantity of explosives or dangerous bulk goods, is being loaded into or unloaded from a ship, or stored before loading or after unloading, the berth operator will be required to ensure that information as to the identity, quantity and location of the substance is immediately available to the emergency services. In the case of bulk cargoes,

he will also have to include information about the nature of the hazard and the emergency action that should be taken.

It could be advantageous for the brigade to arrange for the port authorities to notify them routinely of the cargoes of all bulk chemical carriers entering or leaving the port (see Chapter 13 Section 10a).

3. Segregation of dangerous goods

The IMDG Code sets out requirements for the segregation of incompatible dangerous goods from one another, and from other goods such as foodstuffs, on board ship (see Fig. 13.1). Some of these requirements are based on distance, and others on fire-resistant decks and bulkheads.

There are no detailed guidelines for the segregation of goods in port areas, but the proposed DSHR will contain a general requirement for goods to be stored in a safe manner. Storage areas do not usually have fire-resistant partitions, but do have the space for distance segregation.

4. Emergency arrangements by port authorities

It will be a requirement for port authorities to make plans for dealing with emergencies under the DSHR, although in all probability this will already have been done. Such plans must include not only the control of the ships carrying the dangerous substances but also the storage and handling etc, the means of escape for people from the berth, methods of communication with the emergency services and effective means of warning people in the vicinity. The plans should be set up in co-operation with the emergency services; further details are given in Chapter 11 Section 3.

5. Dealing with the incident

a. On ships

Procedures for dealing with a shipping incident involving dangerous substances will closely follow those used at land incidents (Book 12 Part 2 of the *Manual*). Officers-in-charge should remember that expert advice is available from the CIA (Chemsafe), Department of Transport, NAIR etc, and should consider invoking this part of the contingency plan at an early stage. The IMO publish emergency schedules, giving information to Masters about action to be taken at incidents, and these could be aboard.

The circumstances of these incidents vary considerably, but one important factor to be borne in mind is the possibility of explosion. Most cargo ships do not have intrinsically safe electrical gear, and any movement of electrically operated hatches, switching of ventilating systems etc could therefore be dangerous if there is a potentially explosive atmosphere present. Moreover, very few brigades have intrinsically safe hand-held radios. There are very strict regulations regarding the use of radios near certain types of explosives, and the positioning of appliances, e.g. control units, must be carefully considered under these circumstances.

It may be necessary to monitor a vessel by means of explosimeters. If a brigade does not have these, officers-in-charge can obtain them through the Chemsafe scheme together with personnel trained to use them. In some parts of the country the HSE Factory Inspectorate have fully-equipped vehicles for dealing with this type of incident. Brigades should investigate these and any other sources of expertise on 24-hour availability.

Under the MSDGR, UK ships, and foreign ships loading or unloading within UK waters, are subject to certain special safety requirements regarding the stowage of explosives and the type and quantity that may be carried.

b. In port areas

In addition to the considerations applicable to ships generally, there are several specific points which should be noted in connection with port incidents.

Where vessels carrying dangerous substances are berthed, the berth operator must provide adequate means of escape from the berth, e.g. duplicate gangways to the jetty or shore. He should bear in mind the possibility of smoke or fumes, or perhaps burning material on the water, in deciding what provisions to make.

If dangerous conditions exist on a vessel, the numbers of personnel on board should be kept to the minimum. Any passengers should, of course, be evacuated and the main fire-crews kept at readiness on the quayside or as near as is considered safe. According to the proposed DSHR, however, the Master of a vessel carrying certain dangerous substances must have his vessel in a constant state of readiness to move, tidal conditions permitting. For this purpose he is expected to ensure that there are sufficient crew and supervising officers available on board at all times. How this apparent clash of requirements is to be resolved is a further point for discussion in the preplanning stage.

Pollution of harbour or dock waters is also strictly controlled, and brigade personnel should try to prevent any pollutant entering the water. The Department of Transport have a Marine Pollution Control Unit which is available to provide assistance. It can be contacted, on a 24-hour basis, through any of the Coastguard regional control rooms (see Chapter 14 Section 1b).

Chapter 16 Inland waterways

1. General

Of the estimated 4,800 km of inland waterways in the UK, about 1,500 km are used for commercial transport and are estimated to move about 60 million tonne of assorted goods per year. The British Waterways Board (BWB), which control some 3,200 km, are the largest administrators of inland waterways, but certain areas are controlled by port authorities, local government, regional water authorities, or other bodies. Most of the commercial tonnage is carried on non-BWB-controlled waterways (mainly port or dock areas). The actual definition of an inland waterway is somewhat blurred; many river or canal vessels are capable of operating outside smooth water limits. Some can carry several hundred tonne of cargo. There is an increasing move to up-rate inland waterways, and their associated cargo handling and storage facilities, to enable larger vessels to proceed further inland. Large quantities of liquid fuel (approx. 40 million tonne per annum) are carried in the UK domestic sea-borne trade and many vessels are coastal tankers operating to places in the inland waterway network e.g. Llandarcy to Quedgeley, Isle of Grain to Ipswich. The River Thames, River Trent and Aire and Calder Navigation are also areas where there is considerable liquid fuel traffic. Probably more than one quarter of the goods transported by inland waterway in the UK have dangerous characteristics.

2. Types of vessels

The specialization seen at sea has also developed to some extent in vessels using inland waterways. The old type of barge formation towed by tug and the modern push-tow system (Plate S.24) are operating, augmented by the LASH, SEABEE and BACO systems of ship-borne barges or lighters off-loaded from a 'mother' ship and push-towed inland. There are also various types of small cargo coasters, self-propelled tank barges, and small parcel tankers, as well as 'specials' designed to carry chlorine, caustic soda, sulphuric acid, acetic acid or other bulk cargoes (see Figs. 16.1, 16.2, 16.3). In at least one instance, nuclear waste is shipped from a port situated on an inland waterway. Although there is a great deal of commercial traffic, firemen must not forget that there are also

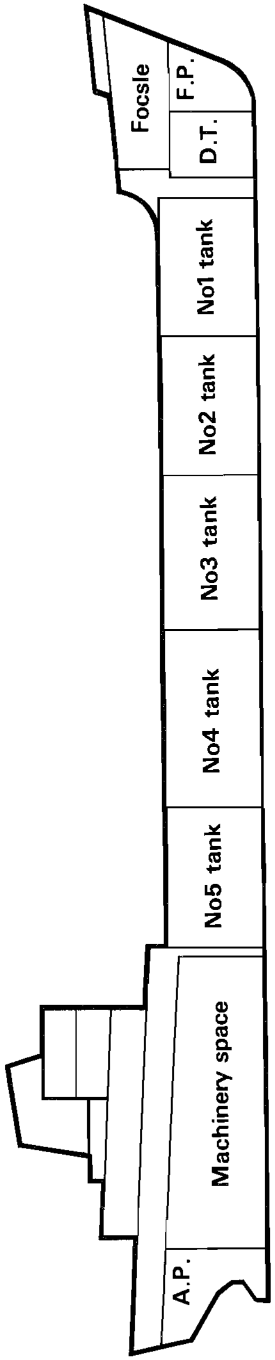


Fig. 16.1 Coastal tanker of about 3,000 tonne dwt used to come alongside riparian oil product depots.

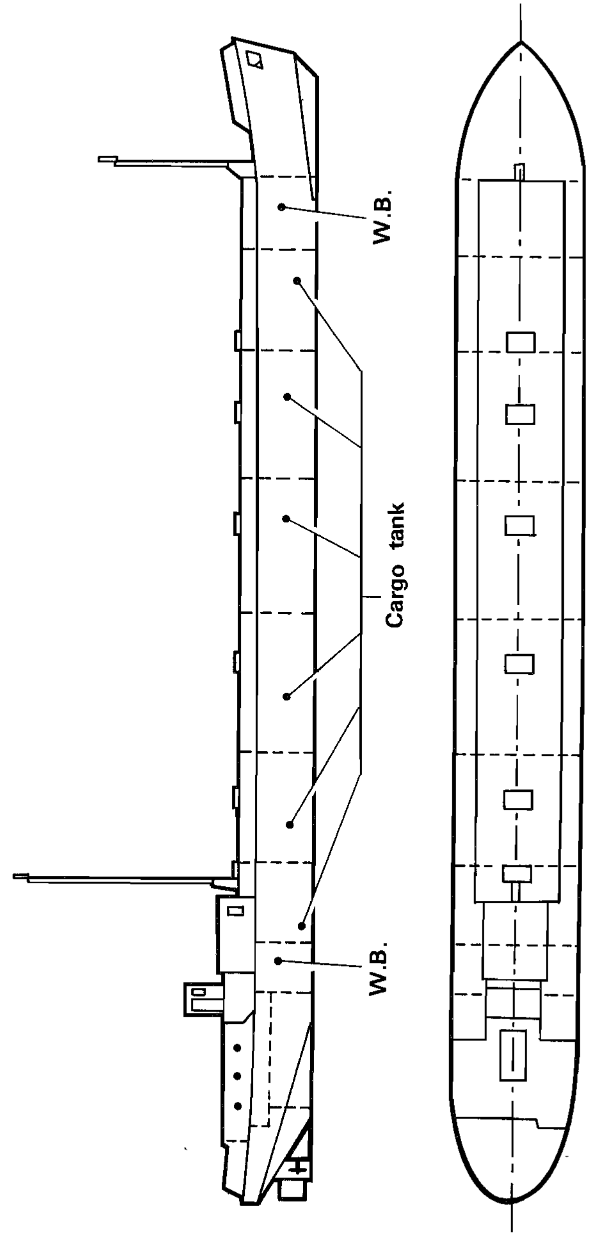


Fig. 16.2 Example of inland waterways tank barge of about 380 tonne with cargo capacity of 780 m^3.

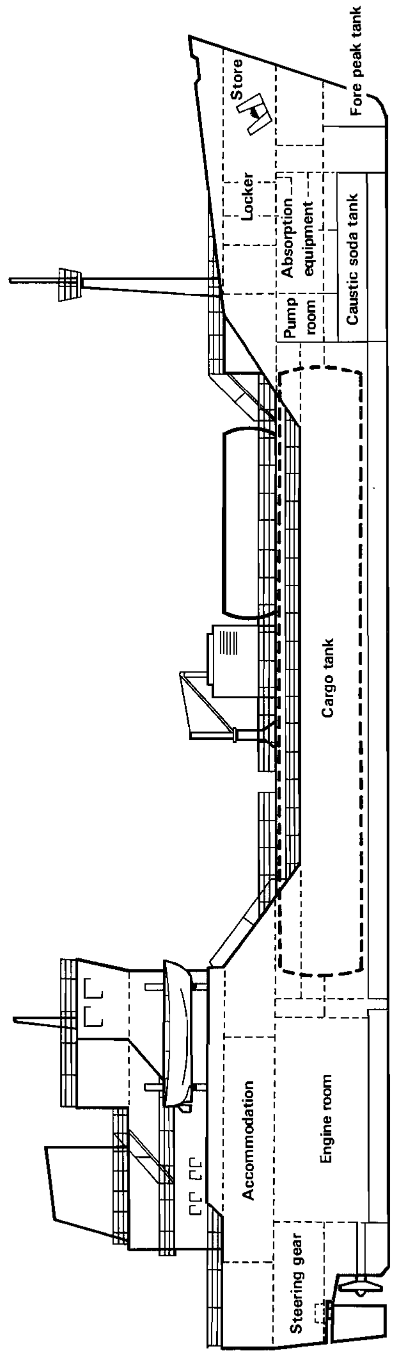


Fig. 16.3 Small gas carrier carrying a regular load of liquid chlorine.

very many pleasure craft ranging from 20 m narrowboats to 2.5 m cabin cruisers. Where they congregate, either for maintenance or support, there is a considerable risk (see Section 3c below).

3. Brigade procedures

a. Familiarisation and preplanning

It is apparent that the commercial use of inland waterways is increasing and therefore, despite international and national controls, incidents are likely to become more frequent. Firemen should make themselves aware of the water-borne traffic passing through their area, the mooring and storage areas, and all means of access to canals and rivers. Because of the variance in areas of controlling authorities, firemen will find different arrangements for conveying dangerous goods, calling the brigade, transferring cargo, storage etc. They should make visits to the wharves and the vessels and liaise with the owners, Masters, wharfing and berthing agents etc. to pre-plan for any emergencies.

b. Incidents

At present many vessels (especially those carrying dangerous goods) are equipped with radio, usually on a marine band, but sometimes also a land waveband to keep in touch with their base or head office. Brigades may therefore receive a call from a port authority, a lock-keeper, a commercial firm, a member of the vessel's crew, or any member of the public and, as on a motorway, the exact location of the incident must be ascertained as accurately as possible. The preplanning will dictate the attendance, and nearest attendance point or points. Getting aboard should not present difficulties, but, because of the narrowness of most waterways, firemen must remember certain facts. There is not much flow in a canal and any spillage of flammable substances, e.g. petrol, is therefore likely to remain close to the affected craft. In a river, however, the dispersion downstream will be rapid and some fire-cover will need to be deployed in that direction. Firemen should also bear in mind the danger of pollution, which will be the responsibility of the owner of the waterway, e.g. the regional water authority in the case of rivers. If chemicals or other pollutants have to be diluted they must not be allowed to flow into the waterway. If they do, the waterway and environmental authorities must be informed immediately.

It is vitally important to prevent a vessel sinking if at all possible; such an event in a narrow waterway would be very serious and, in a lock, disastrous. The officer-in-charge must think of this at all times during the incident. The stability procedures described in Chapter 12 should be put into effect where appropriate.

c. Small craft

The use of inland waterways by small pleasure craft, such as narrowboats and cruisers, is also increasing. The main hazard on these vessels appears to be either petrol or LPG leakages. These, coupled with relatively light construction and plastic foam furnishing, quite often result in a fierce fire leaving little above the waterline (see Plate S.25). When called to small craft, firemen should remember the almost certain fact of an LPG cylinder being aboard and take extra precautions (see the *Manual*, Part 6c, Chapter 45). Where large numbers of these craft are moored, e.g. at marinas, reaching the affected boat may be the most difficult part. At night, care should be taken in negotiating narrow jetties, and appliance searchlights or floodlights should be used if possible.

4. Dangerous substances

a. Legislation

In the UK, control of the movement, handling and storage of dangerous substances in inland waterway areas is limited and fragmented. The Petroleum (Consolidation) Act 1928 and the Explosives Acts 1875 and 1923 are the main general legislation. The BWB have produced a set of requirements for their own areas (see below); elsewhere the control of dangerous goods is largely governed by local byelaws and regulations. Not all operating authorities have, however, prepared controls under the above legislation, and many of those that have been prepared are inadequate and well out of date. The Health and Safety Executive will be preparing comprehensive new legislation for inland waterways when they have dealt with port areas. Because, on mainland Europe, inland waterways assume more importance, the Economic Commission for Europe (ECE) of the United Nations has made recommendations for controlling the international carriage of dangerous goods by inland waterway (ADN), and the International Maritime Dangerous Goods (IMDG) Code applies to sea-going shipping which uses this type of waterway.

The system of controls produced by BWB for their waterways, warehousing, road transport, port areas etc. consists of:

(i) A schedule of dangerous goods (the Green Book).

(ii) Terms and conditions for the transport of dangerous goods on the Board's waterways and docks.

(iii) Code of practice for the loading, unloading and handling of dangerous goods at BWB docks, wharves and depots.

The main BWB requirements are summarised below. For non-BWB areas, brigades will need to ascertain the particular arrangements applying in each case.

b. Identification of hazards

(1) Provision of information

BWB require advance notification of any intention to transport dangerous goods on their waterways or to bring them into their premises. In addition, such goods must be accompanied during transit by written information from the sender, giving details of the goods and stating the appropriate precautions and emergency action to be taken.

(2) Marking of vessels

BWB require inland waterway vessels, both dumb and motorised, to be externally marked so that, in the absence of a crew, emergency services can be warned of the cargo. UKTHIS panels (see the *Manual*, Book 12, Chapter 7) are, therefore, coming into use in those areas controlled by BWB. For sea-going vessels in BWB areas, external marking is optional.

There is a problem that emergency procedures developed for land transport are not always relevant to water-borne transport and, although IMO have prepared emergency procedures for goods listed in the IMDG Code (Chapter 15 refers), some of these are not necessarily appropriate for inland waterway transport. Consequently BWB have decided that the space for the Hazchem code, e.g. 3YE, should be left blank until procedures specifically designed for inland waterway transport have been developed. Instead this space should be crossed by black diagonal bars (Fig. 16.4). (The *Dangerous Substances in Harbours and Harbour Areas Regulations 1987* will require this type of hazard warning panel to be displayed on barges carrying 3,000 kilograms or more of dangerous substances, and on tank barges carrying any amount of such substances, in harbour areas generally.)

Officers-in-charge should remember that their own list of emergency action codes may not be applicable to inland waterways, and they should take the action laid down for this mode of transport under their brigade procedure.

(3) Marking of packages

Every package or receptacle containing goods defined in BWB's Green Book as dangerous must be distinctly marked to indicate (a) the identity of the goods, with the correct technical name, and UN number if available, and (b) the nature of the hazard. (The DSHR will lay down certain basic marking requirements for any packaged dangerous goods brought into a harbour area from inland.)

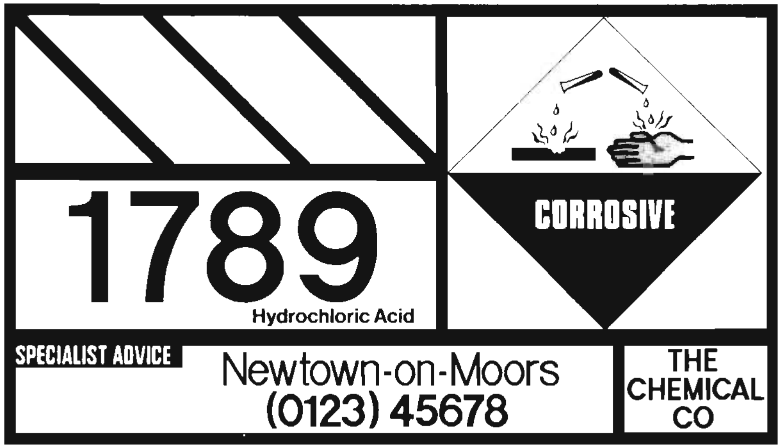


Fig. 16.4 British Waterways Board adaption of the Hazchem Code land transport sign to their vessels carrying dangerous goods.

(4) Marking of storage areas

BWB warehouses and other buildings in which dangerous goods are stored should be marked to indicate that such goods are inside.

(5) Signals

BWB require that vessels carrying dangerous goods on their waterways display the following visual signals in addition to the appropriate navigation lights:

(i) By day, Flag B (a red swallowtail) of the International Code of Signals (Fig 16.5).

(ii) By night, a red light if the vessel is moored or at anchor, and a blue light if it is under way. Where towing or pushing is undertaken, the light will be carried by the motorised vessel plus, in the latter case, the vessel at the head of the convoy.

Fig. 16.5 Day signal for British Waterways Board vessels carrying dangerous goods (International Code of Signals Flag 'B').

Vessels carrying petroleum spirit and calcium carbide are exempt and will continue to display a red flag with a white circular centre by day and a red light by night.

c. Segregation of dangerous goods

The BWB Terms and Conditions require that dangerous goods carried on inland waterway craft should be segregated in accordance with the IMDG Code (see Chapter 15 Section 3).

BWB have not yet produced any formal requirements regarding the segregation of dangerous goods in their shore facilities such as storage and transit sheds, but they plan to do so once the DSHR have been finalised (see Chapter 15 Section 1b). In practice, brigades can expect to find some form of such segregation already in operation in BWB storage areas.

Glossary of shipping terms

Abaft	To the rear of.
Abeam	At right angles to the fore and aft line of a ship.
ADN	Accord Européen Relatif au Transport International de Marchandise Dangereuse par voie de Navigation intérieure: European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterway.
After peak	The space within a ship directly in front of its stern.
Ahead	Directly in front of the bows.
Astern	Directly behind a ship.
Athwart	Across.
Ballast	Heavy material used to help keep a ship stable.
Battening	Securing tarpaulins over hatch covers.
Beam	The central part of each side of a ship.
Bilge	The space towards the bottom of a ship, at the outer sides of the double bottom tanks, into which water drains from the bottom of the hold and, usually, from the tween decks.
Bilge sounding pipes	Pipes at the side of a ship, running from the upper deck to the bilges; there is one for each side of each hold.
Boat deck	The deck on which the lifeboats are located.

Booby hatch	A small hatch, separate from the main one, which usually gives access to a ladder.
Bows (port and starboard)	The fore part of a ship, adjoining the stem.
Bridge	The high part of a ship's superstructure from which it is primarily steered.
Bridge deck	A non-continuous deck level with the bridge.
Bulk cargo	A homogeneous, unpackaged cargo, e.g. grain, coal, oil, chemical.
Bulkhead	An internal wall, used to divide a ship into compartments. Bulkheads may be fire-retardant or fire-resistant, and below the waterline they must be watertight.
Bunker	A compartment in which fuel is stored.
Bunker oil	Fuel oil for the ship's own use.
Coaming	Raised metalwork surrounding a hatch.
Coffer dam	A double watertight bulkhead separating an oil tank from any other space.
Combination carrier	A ship designed to carry oil and other bulk cargo (though not necessarily at the same time).
Companionway	A staircase which can be lowered over a ship's side to give access from water level to the main deck.
Condition	The state of a ship in port,—under repair, in dry dock etc.
Continuous deck	One extending from stem to stern across the whole width of a ship.
Dampers	Devices for blocking air ducts in the case of fire.
Deck	One of the floors dividing a ship horizontally.

Deckhead	The underside of a deck, forming a ceiling to the deck below.
Deep tank	A tank which sometimes replaces the lower hold of a ship.
Derrick	A type of crane on board a ship.
Dory	A type of small open boat.
Double bottom	A space under part or the whole of the hold and machinery spaces. It runs practically the whole length of a vessel and is divided into watertight compartments, some of which may be tanks for oil fuel.
Draught	The distance from a ship's keel to the waterline.
Dumb barge	A barge without its own source of power.
Epoxy	A flexible thermosetting resin used in coatings.
Ferry	A vessel providing a regular service between two ports for passengers and, in some cases, vehicles.
Fire services	The water mains of a ship.
Flag officer	A senior naval officer entitled to fly a flag denoting his rank.
Forecastle/fo'c'sle (pronounced 'fokesel')	The part of a ship's superstructure above the main deck at the bows.
Fore peak	The space within a ship immediately behind the stem.
Freeboard	The height above the waterline of the highest continuous deck.
Free surface effect	The effect on a ship's stability of a tank or other space being partly, but not completely, full of a liquid.
Galley	A ship's kitchen.
Hard	A stone or concrete extension to the foreshore which is uncovered at low tide.

Hard-arm	A pivoted crane carrying flexible oil pipelines for loading and unloading tankers.
Hatch/hatchway	An opening into a hold for the loading and unloading of cargo. (The term 'hatch' is sometimes applied to the cover rather than the opening itself).
Heel	Of a ship: to lean to one side as the result of an external force.
Hold	An empty space within a vessel, used for the carriage of cargo.
Hull	The frame of a ship.
IMCO	Inter-Governmental Maritime Consultative Organisation: the former name of IMO.
IMO	International Maritime Organisation: a specialised agency of the United Nations existing to provide means for co-operation and the exchange of information among governments on technical matters relating to international shipping, with special regard to safety at sea and the prevention of pollution.
Inclinometer	An instrument for measuring the angle of inclination of a ship.
Keel	The lowest part of a ship, forming the backbone on which it is built.
Lee side	The side of a ship away from the wind.
Lighter	A large floating cargo container, lifted on and off ship by crane.
Liner	A large passenger vessel plying a particular long-distance route or undertaking leisure/educational cruises.
List	Of a ship: to lean to one side as the result of the uneven distribution of weight within the ship.

LNG	Liquefied natural gas. A mixture of mineral gases consisting mainly of methane.
Loll	An inclination of a ship which may occur if the ship becomes marginally unstable in the upright position (see Chapter 12). (Note: It is not necessarily a sign of uneven weight distribution, and must not be confused with *list*. The two conditions require different methods of correction).
LPG	Liquefied petroleum gas. A mixture of petroleum hydrocarbons consisting mainly of propane and butane.
Magazine	An area of a naval ship where ammunition is stored.
Manifest	A ship's list of its cargo.
Master	The captain of a merchant vessel.
Mast house	A compartment built around a mast, which contains trunkways to the lower hold.
Monkey island	A familiar name for the uppermost part of a tanker's superstructure.
Perlite	A type of glass forming a lightweight aggregate when heated.
Plug hatch	A specially designed self-sealing hatch used on insulated ships.
Pontoon	A floating structure which may be used as a buoyant support.
Poop	The after part of a ship. The poop deck is a high non-continuous deck at the stern.
Port	The side of a vessel on the left of a person looking forward.
Port-hole	A circular window in a ship's side or in a bulkhead.
Push-tow system	A system of barge propulsion in which the motorised vessel can either push or pull.

Quarter	The part of a ship's side near the stern.
Refrigeration	Method of cooling parts of a ship to enable it to carry perishable goods or, in some cases, liquefied gas at low temperatures.
Ribs	Curved steel members of the side of a ship running from keel to deck, to which the steel cladding of the hull is fixed.
Scuppers	Openings along the sides of a ship's main deck to allow water to drain over the sides.
Shaft tunnel	A tunnel running from the engine room aft, containing the intermediate shafting between the engine and propeller shaft at the stern.
Shell door	A loading door in a ship's hull.
Shelter deck	A name given to the upper deck when the bulkheads do not extend to its underside but only to the deck below.
Starboard	The side of a vessel on the right of a person looking forward.
Statutory bulkhead deck	The deck up to which watertight bulkheads must extend, usually about $2\frac{1}{2}$ m above water level.
Stem	The vertical continuation of the keel at the bows.
Stern	The rear end of a ship.
Superstructure	The parts of a ship above the uppermost continuous deck.
Trim	The angle of a ship's fore and aft horizontal plane to the surface of the water.
Trimming hatch	A small opening sometimes found in the far corners of tween decks, away from the main hatches.
Tween deck	On a cargo ship, any deck between the upper deck and lower hold.

Tunnel escape	A vertical means of escape from the shaft tunnel, usually at the after end.
Under way	Of a ship: moving under its own power.
Ventilation	Natural or mechanical means of supplying fresh air to an interior part of a vessel.
Washing-out	Cleaning a tank after discharging cargo.
Weather deck	An open continuous deck.
Weather side (or windward side)	The side of a ship towards the wind.
Wing tank	A tank high up on the side of a ship.

Part 3
Incidents involving railways

Introduction

Working on or near railway lines is hazardous and, though the Fire Service has always emphasised the safety aspects of operational procedures in such circumstances, accidents have still occurred. To ensure safe working, firemen must:

(i) fully recognise the dangers involved;

(ii) have a thorough working knowledge of railway systems;

(iii) familiarise themselves totally with the safety procedures adopted by railway authorities and Brigades; and

(iv) engage in regular local reconnaissance and preplanning.

This Part gives a basic description of railway systems and procedures, and sets out the essential factors to bear in mind for the safe and efficient conduct of operations. Firemen must appreciate, however, that systems and procedures vary from area to area, and that areas themselves vary in their physical characteristics. They must respond to local conditions. Close and regular liaison with the local railway authorities, preplanning and exercises are therefore essential.

The Glossary at the end of this Part lists some of the more common terms used by railway staff. Firemen should familiarise themselves with these terms, although it is normally undesirable to employ them in Fire Brigade messages unless their meaning is obvious. (NB. In this Part, the expression 'on or near the line' is used in the sense given in the Glossary.)

Chapter 17
Features of railways

1. The permanent way

a. Track

The greatest nroportion of BR track is double-line, but most branch lines and some minor through lines are single. Some sections of route are multi-track. On all lines, trains can travel in both directions and signals cannot be relied on to indicate the usual direction of traffic. Fig. 17.1 shows a typical section of track.

A large proportion of track is situated in cuttings or on embankments, and this can make rescue operations difficult (see Chapter 21, Section 1). Tunnels, bridges and viaducts present special problems; firemen should reconnoitre such features in their own areas and relevant provision should be made in preplanning. When a feature spans two Brigade areas, close liaison is essential. Chapter 20 Section 4 gives details of the safety features and procedures which firemen should bear in mind during operations.

b. Points

A typical set of points is shown in Plate R.1. Points may be fitted with point heaters to prevent them freezing (see also Fig. 17.2), and there may be a supporting propane gas system located nearby.

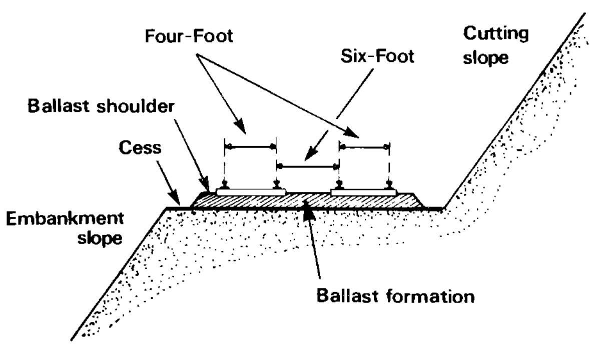


Fig. 17.1 Cross-section of a double track indicating railway terminology.

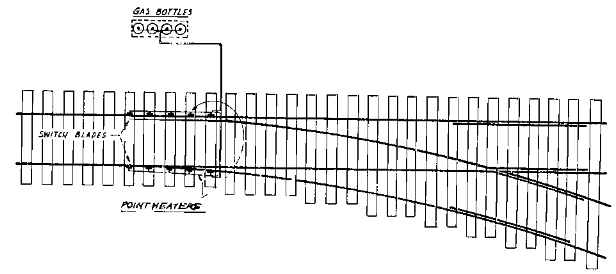


Fig. 17.2 Typical set of single points, heaters and gas cylinders.

Points may also have electrical motors which may remain live even when traction power is isolated. Firemen should not stand on point rodding, on wires or between blades (see Plate R.2).

c. Signalling

Signals are of two major types: the mechanically-operated semaphore and the electrically-operated colour light. (See Fig. 17.3).

2. Electrification

Increasingly, trains are powered by electricity. There are two systems of supply. In all cases, the voltage is sufficient to kill anyone touching a conductor.

a. Overhead line equipment (OLE)

Overhead line equipment consists of a contact wire suspended by a catenary wire which is, in its turn, supported by a complex system of suspension cables, arms and tensioning devices (see Fig. 17.4 and Plate R.3). The equipment is fed from railway feeder or sub-feeder stations and, in virtually all cases, operates at 25kV, AC. The greater part of the suspension system is electrically live and carried on insulators. Structures supporting the OLE bear an identifying letter and number.

The height of the contact wire is normally between 4.7 m and 5.1 m, but at low bridges may be as little as 4.2 m and at public road level crossings is increased to 5.6 m. A retractable pantograph on the roof of the locomotive or motor unit collects the current from the contact wire (see Fig. 18.4 and Plate R.4).

The overhead line equipment is divided into sections by means of switchgear in feeder stations, sub-feeder stations and track sectioning cabins. All these are usually closed, locked and unattended, and firemen should not normally enter them without first contacting BR via Brigade Control (see Chapter 20 Section 2).

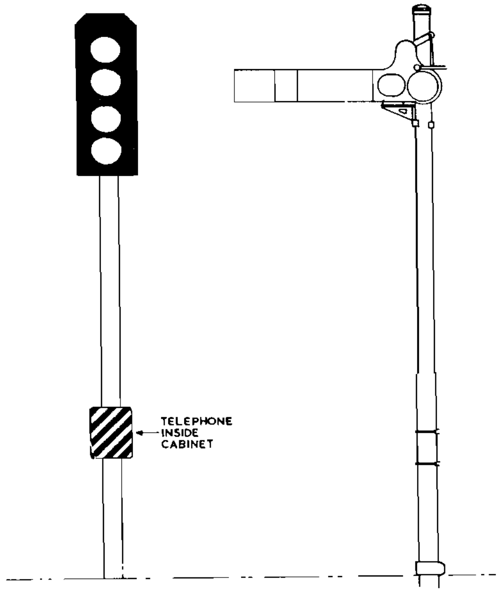


Fig. 17.3 Examples of simple mechanical semaphore signals and electrically operated coloured light signals.

The switchgear is remotely controlled from an electrical control room. Switches on the OLE further divide each section. Railway staff operate these manually from ground level, or occasionally by remote control.

b. Rail-level supply

Conductor rail (third rail) systems operate at a maximum of 1200v DC. Shoes on the train pick up the current from a rail or conductor to one side of, and 50–75 mm above, either running rail. The return circuit is provided by the axles, wheels and running rails. In some systems, such as the London Underground, a fourth rail between the running rails is also part of the return circuit and may carry current up to 250v DC.

Sub-stations convert alternating current to the direct current supplied to the conductor rails, and the overall control of circuits is supervised from a control room. Railway staff can also isolate local sections by the manual operation of trackside switches.

3. Telephones

BR have a comprehensive domestic telephone network giving communication between control offices, stations, depots, most

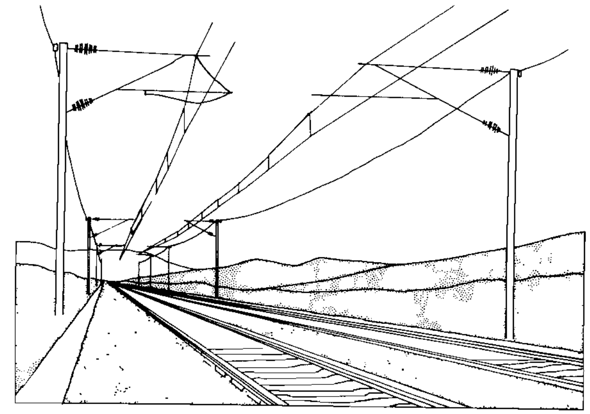


Fig. 17.4 Simplified illustration of overhead line equipment (OLE).

level crossings, signal boxes etc. Trackside telephones fall into three groups.

(i) **Signal post to signal box.** These are identified by black-and-white hatching on the cabinet lid. They can be in groups of up to 12 on one circuit, only one being usable at a time. Nearly all coloured light signals, but few semaphore signals, have telephones (see Fig. 17.3).

(ii) **Electrification telephones.** These are identified by a red telephone symbol on white. They provide communication with the electrical control room only.

(iii) **Other telephones.** These are identified by a black diagonal cross on white. Usually they give communication between two specific points, but they may be dialling telephones giving access to the whole BR network. The telephone cabinet will give instructions on use.

Trackside telephones will not normally be adequate for Fire Brigade purposes (see Chapter 20 Section 2).

4. Underground railways

Underground railways operate in London, Glasgow, Tyne and Wear and Merseyside. The Merseyside underground forms part of the wider suburban electric network operated by BR, generally in accordance with standard practice, but the other systems are largely self-contained. Their equipment, procedures etc. may not be the same as for BR and, where necessary, firemen should get information from the relevant railway authorities.

5. Miscellaneous hazards

Where there are temporary speed restrictions, there will be signs illuminated by propane systems similar to those used on point heaters. Firemen should take the usual precautions with regard to cylinders, controls and piping.

Railway personnel sometimes use detonators to warn train drivers of work being carried out on the track. These are small devices which can be clipped to a running rail and which explode with a loud bang when a train passes over them. Fire may also cause them to explode, and all personnel in the vicinity should therefore beware of flying shrapnel. Detonators should never be used by firemen. A trackside hut could contain up to 120 detonators, depending on the number of permanent way gangs who use it as their base.

There is also the possibility that a hut could contain small amounts of Thermit. This substance is toxic, and dangerous when exposed to heat or flame; the oxide-metal reaction is difficult to stop as it has its own oxygen supply. Hazchem code 2Y applies. If the Thermit is not involved in fire it should be kept cool; if it is involved, attempts should be made to protect the surrounding area, and BA should be worn. Firemen should ascertain where Thermit is likely to be found on their ground, and be prepared to deal with it.

Chapter 18
Features of trains

1. Types of trains

a. Passenger trains

There are five main types of passenger train, as set out below. The first is used mainly for local and suburban services, plus some Inter-City routes on Southern Region, the others for longer journeys. Their appearance does not generally indicate the direction in which they will move.

(1) Multiple unit

Multiple-unit trains can travel at speeds of up to 145 kph. There are four types: diesel mechanical, diesel electric, AC electric and DC electric (see Figs. 18.1 and 18.2). AC electric units use OLE; DC electric, which are mainly found on Southern Region and London Midland Region, use third-rail supply. All units have their motors below floor level; diesel electric units, on Southern Region, also have generators in above-floor compartments.

(2) Locomotive hauled or propelled

The locomotives, which may be at either end of the train, are diesel electric or AC electric powered (Figs. 18.3 and 18.4), and travel at speeds of up to 160 kph. Coaches are mostly of the saloon type, but there is still much compartment stock in use. Sleeping cars run on some trunk routes and have one or two-berth compartments.

(3) High Speed Train (HST/Inter-City 125)

These trains (Fig. 18.5) can travel at speeds of up to 200 kph. They have a self-contained driving cab and engine at both ends and their coaches are of a modern saloon type.

(4) Motorail trains

These convey sleeping cars, compartment coaches and flat trucks to carry cars.

(5) Advanced Passenger Train (APT)

This recently developed type of train is designed to travel at up to 240 kph, with a tilting mechanism enabling the vehicle bodies to lean 9° either side of the vertical axis on bends. It operates by

EXTERNAL EQUIPMENT

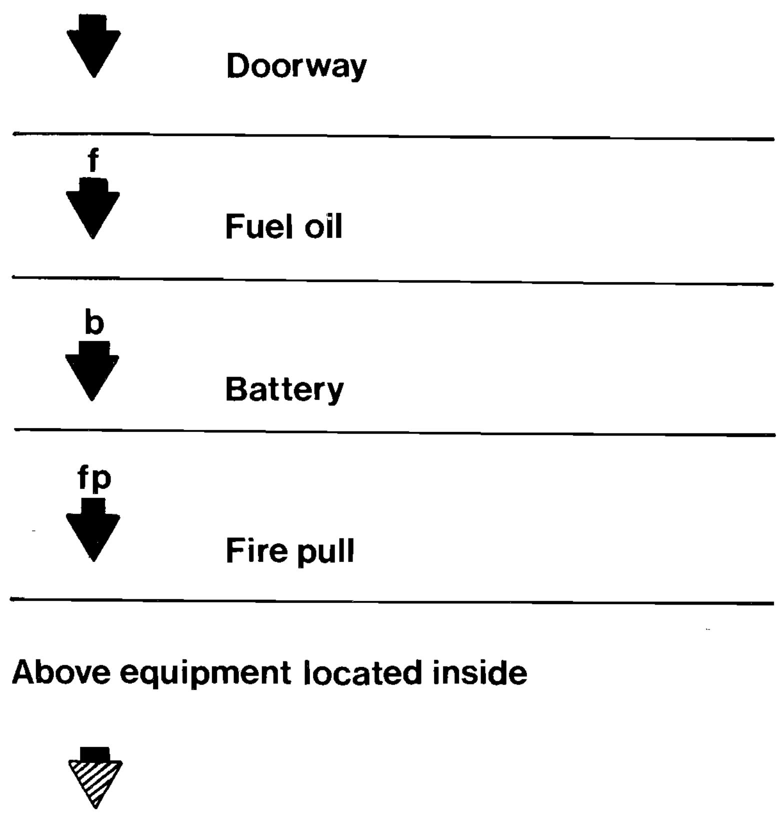


Fig. 18.1 Key to Figs. 18.2, 18.3, 18.4.

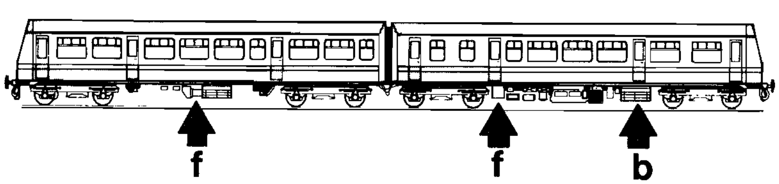


Fig. 18.2 Diesel multiple-unit.

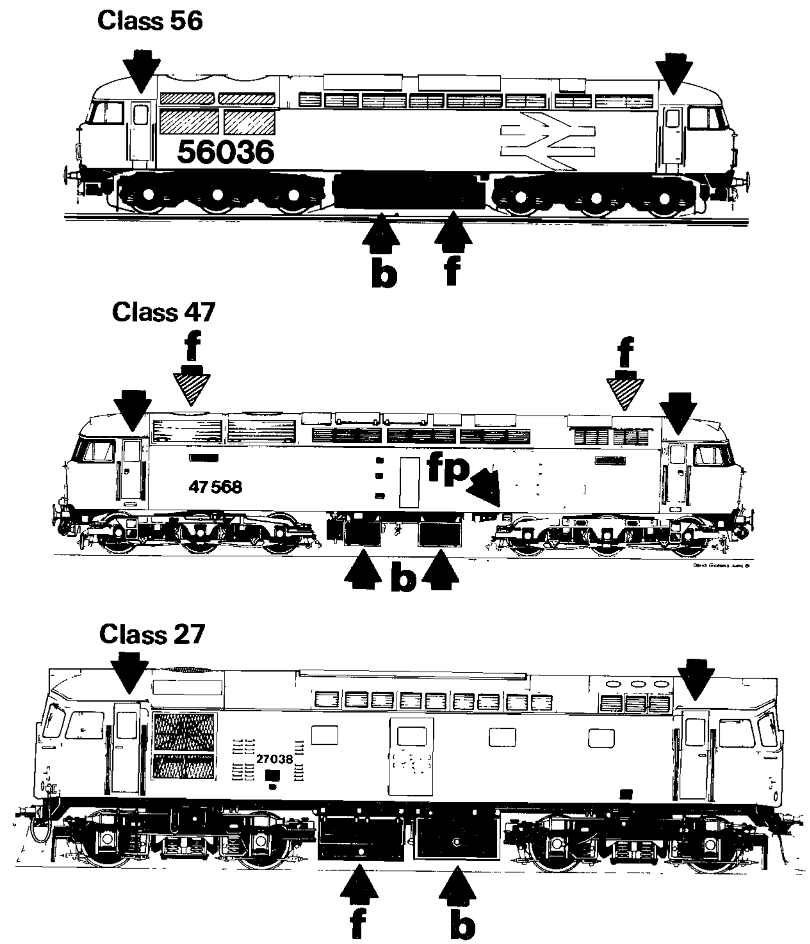


Fig. 18.3 Three types of diesel locomotive.

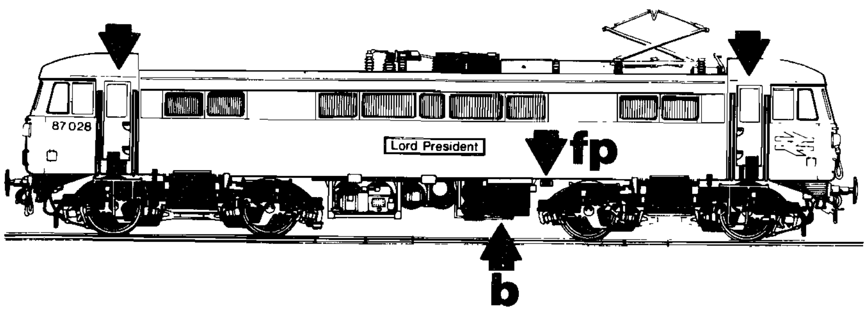


Fig. 18.4 Electric locomotive.

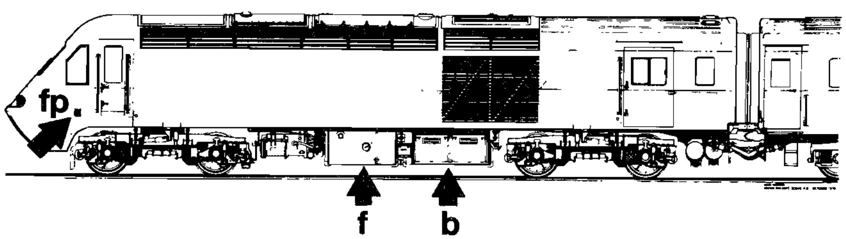


Fig. 18.5 HST/Inter-City 125.

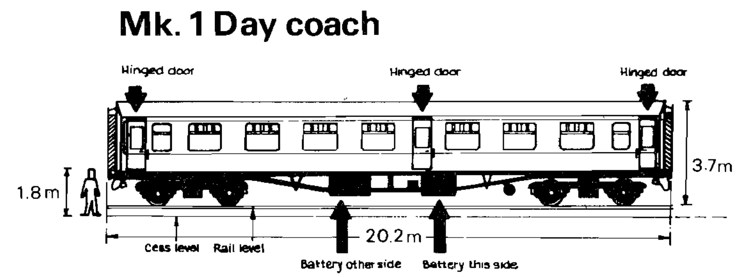
OLE and, in addition to normal couplings, the power cars have a 25 kV linkage at roof level. The train has a stand-by diesel generator set immediately behind each cab.

(6) Rail-bus

One other type of train which will be seen about the country is the Rail-bus. Here a normal bus body is fitted onto a railway chassis.

b. Non-passenger trains

Freight trains of mixed stock have largely been replaced by trains of suitably-marked special purpose vehicles, e.g. containers (for various goods, including explosives), tanks (for petrol, oil, and flammable or otherwise dangerous chemicals), hoppers (for minerals), car carriers, and closed bogie vans (for parcels).



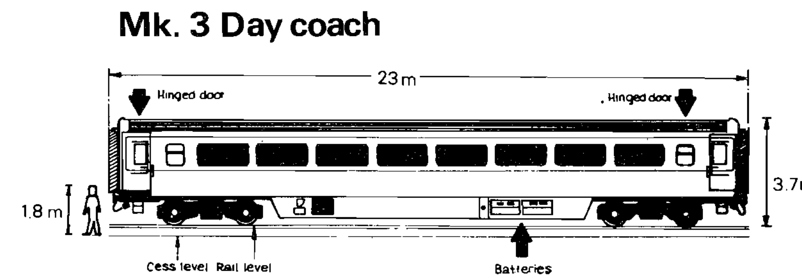


Fig. 18.6 Diagram showing height of average person standing on the cess compared with carriage doors and windows.

2. Design and construction of passenger carriages

a. General

Over the past 40 years there has been rapid advancement in the development of passenger carriages and, because these are built to good lasting standards, there are many different types in use on all routes. This proliferation brings problems to the Fire Service at an incident, because the construction of the different types could determine how the Service tackles the job of extracting people from the wreckage, if they cannot use doors. Firemen should, if possible, liaise with British Rail and visit local railway yards and sheds. One aspect, not readily apparent to the normal traveller in the United Kingdom, is the sheer height of carriages above the ground or cess. Depending on the ballasting and configuration of the track, the height to the bottom of some windows of a carriage on the rails could be two metres (Fig 18.6). When it is lying on its side, or propped up on top of another carriage, following a collision, the difficulties of approach and mounting, *before attempting entry*, have to be considered (Plate R.5). The following description and comments deal with relatively

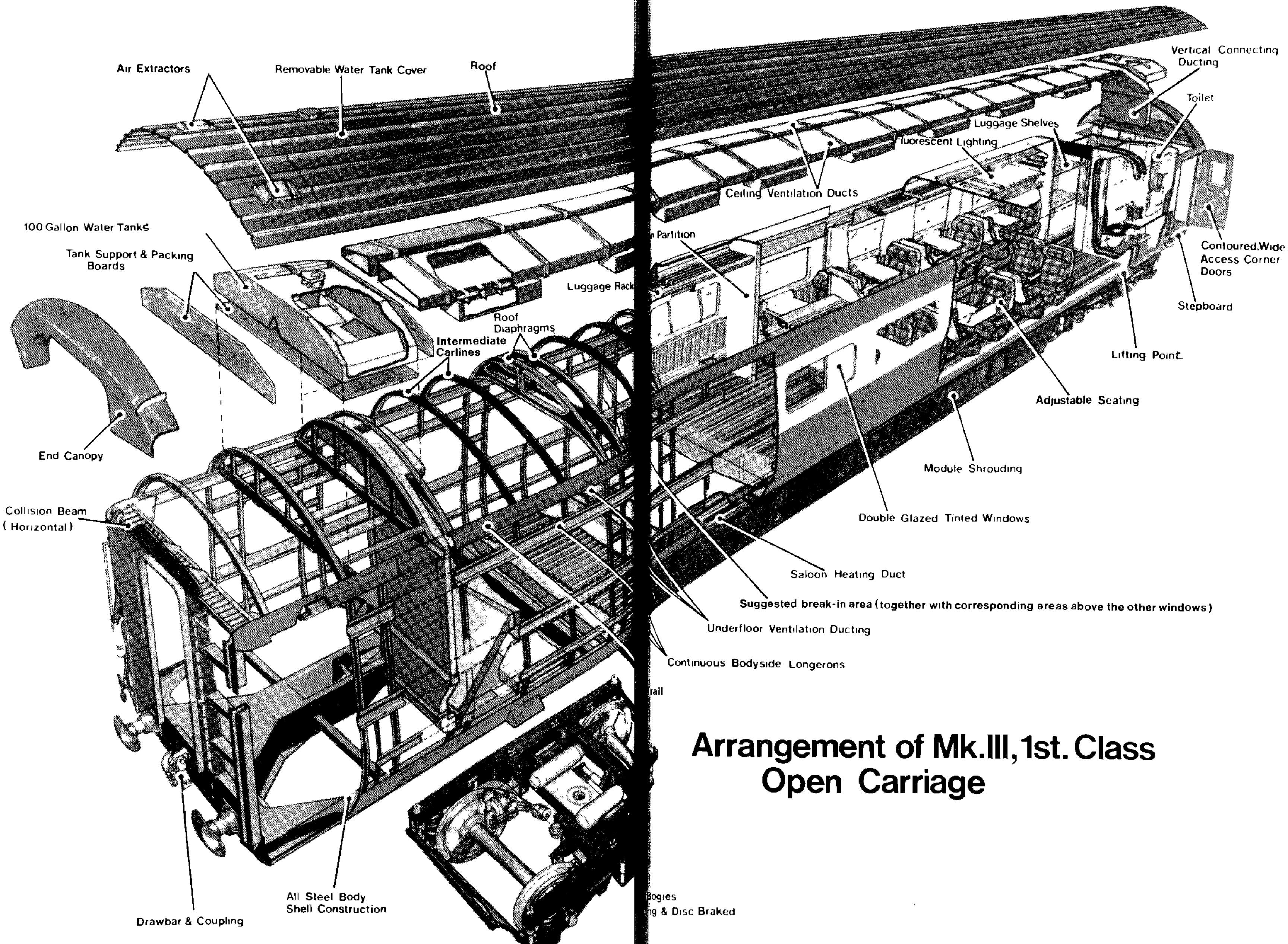


Fig. 18.7 Typical carriage on long-distance passenger train.

modern stock on the fast inter-city trains which, if involved in an accident at high speed, are more likely to be derailed and overturned. (Sleeping cars may present special problems; these are dealt with in Chapter 21).

b. Typical passenger carriage

(1) Bodywork and floor

The body frame is usually of an integrated steel structure with vertical pillars at intervals supported, and connected by, roof diaphragms and intermediate carlines (see Fig. 18.7). These are welded together and to a very strong base which, in turn, is mounted on the bogies. The frame is braced longitudinally by metal longerons. At high stress areas, e.g. adjacent to bogie pivots, the frame has a double skin of sheet steel to transmit loads to roof members. At other places there is a single steel skin with an inner skin of body-trim panelling, usually plywood/melamine. The 'floor' consists of an integrated construction of sheet steel, fibreglass packing and fibreboard to a depth of 250–300 mm, containing underfloor ventilation ducts, piping etc. Each end of the carriage is designed so as to transmit the shock of a collision along the whole frame, to minimise crumpling.

(2) Roof

This, in the example in Fig. 18.7, is a corrugated steel sheet fixed to the diaphragms and intermediate carlines. The corrugations give it strength and dispense with the need for roof longerons. Inside this there is a 50 mm thickness of foil-backed fibreglass which is sandwiched between the roof and a thin melamine, or melaluminium, sheeting which forms the interior. The roof is double-skinned only along the cantrail.

(3) Doors

In the design shown, the doors are set in each corner of the carriage and are of the conventional latch-opening type.

(4) Windows

The windows in the type of carriage illustrated are completely unopenable, because the interior is air-conditioned. They consist of double-glazing units set into frames, the windows themselves being 1.8 metres long by 0.6 metres tall.

(5) Fittings

The seats, which are adjustable and generally include a full-width head-rest, are arranged in twos or ones and are either facing with tables between or uni-directional. The seats are not always pitched to align with the windows. Their construction can be either (a) a

plastic back on a steel frame, or (b) a glass reinforced plastic (GRP) moulded seat and back on a tube support, with part interior spring and polyurethane foam padding and seat filling. The luggage racks are of aluminium supported on steel brackets attached to the steel pillars.

Ventilation ducts run both under the floor with openings at floor level, usually beneath the tables, and at roof level in the centre. Fan-assisted heating and extraction is used to keep the interior air-conditioned. Lighting is by fluorescent tubes inset in the ceiling under the air-ducting. Although not shown in the illustration, carriages are joined by corrugated plasticised rubber fabric diaphragms.

3. Firefighting equipment on trains

Diesel multiple units, diesel electric multiple units, HSTs, and some main-line diesel locomotives have automatic CO_2 or BCF fire extinguishing installations. Some of these systems can be operated by an external handle or button, located as shown in Figs. 18.3–18.5. All stock have hand-held BCF or water extinguishers in the cabs and there may be similar extinguishers in brake vans, passenger carriages, catering vehicles and sleeping cars.

Chapter 19
Emergency procedures for railway incidents

1. Preplanning and liaison

Good liaison between Fire Brigades and local railway authorities is essential. BR divide England and Wales into four regions, each composed of a number of divisions, which are, in turn, divided into areas; Scotland forms a fifth region, which is divided only into areas. Fire Brigades should have contact with area managers, divisional control officers and divisional managers (in England and Wales outside Greater London), the Chief Operating Manager (Waterloo) in Greater London, and area managers, control officers, and the regional chief operating manager in Scotland. They should record:

(i) the appropriate BR telephone numbers;

(ii) the details of BR 'on call' arrangements (control offices are usually continuously open, but each division also has a duty officer on call).

Brigades should also ensure that they have full details of large stations and depots, fuelling points, tunnels, bridges, viaducts, cuttings, water supplies, points of access etc. Firemen must ensure regular, close liaison to keep details up-to-date, arrange s.1.1(d) inspections, and organise periodic exercises. These are very important in checking that contingency plans work efficiently and familiarising personnel with the procedures and problems they might face.

For railways other than those operated by BR, firemen should contact the General Manager concerned.

2. BR attendance at incidents

Whether railway operating staff will attend an incident depends on its size. It is important therefore that the Fire Brigade officer-in-charge at the scene passes full information to his Brigade Control for onward transmission to BR. The following attendance is usual:

(i) **Minor fires on trains**—crew only;

(ii) **Larger fires on trains**—a railway official, who will attend as quickly as possible;

(iii) **Major collisions and derailments**—a railway officer-in-charge, who will attend as quickly as possible. Usually this person will be an Operating Officer (identified by a marked helmet, high conspicuity jacket, or armband) and will be accompanied by Engineering Officers. The railway officer-in-charge will set up a command post on arrival.

The information in this section relates only to BR. Other railways may use similar systems but, again, for the full and accurate information necessary, firemen should contact the appropriate General Manager.

3. Identifying the location of incidents

Whatever the source of information about an incident, Brigade Control should establish contact with the appropriate railway traffic control. A considerable problem will be identifying the location of an incident. Members of the public supplying information are likely to be very imprecise about this, particularly in areas unfamiliar to them. Even a train driver reporting a fire may not be too precise, particularly when the information can only be passed on at the next trackside telephone point (few trains have radio communication). It is important therefore that the Fire Brigade officer-in-charge confirms the location of an incident to his Brigade Control on arrival. This benefits both railway traffic control and further Fire Brigade crews that might be necessary. It is also vital in ensuring that disruption to railway traffic is kept to a minimum.

The possible difficulty of locating incidents again emphasises the vital importance to firemen of familiarising themselves with the local situation and liaising with the local rail authorities. It might be helpful if appropriate appliances carried a track layout manual, available from local area managers. Many BR area managers produce for their staff a handbook on emergency procedures which contains a schematic diagram of the area rail network and identifies the location of key structures and, most importantly, access points to the track. Brigades should seek to obtain copies of such manuals. Further assistance in specifying the location of an incident comes from the individual numbers marked on bridges and tunnels (in some regions), on most signal gantries, and on all OLE supports. There are also mile marker posts alongside all lines; these are numbered consecutively from London or other big cities. There may also be quarter-mile posts

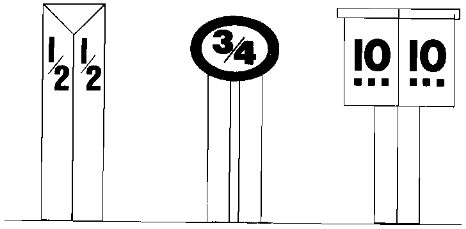


Fig. 19.1 Typical mile and quarter-mile marker posts.

(Fig. 19.1). BR also make common use of National Grid references to identify locations, and firemen are recommended to do the same where it is possible and appropriate.

Accidents have a habit of occurring in the most inconvenient spots, and, even when the location has been accurately identified, the actual journey to an incident may well present difficulties if it is in a remote area. Firemen should bear in mind the general points made in Chapter 6 Section 4.

4. Access points

Access points may take the form not just of gateways but also of level crossings, stations, roads over, or vantage points such as bridges. They are all numbered, and in listing them BR specify their position by this number, the number of the nearest marker post, the National Grid reference, and a description. Firemen should familiarise themselves with a particular route to each access point.

It may not always be most convenient for firemen to gain access to the track by these points, however. This is particularly so where they are dealing with fires on an embankment or on land adjoining the track. If they must breach the perimeter fencing, it is particularly important that they notify BR of the location (BR may be unaware that firemen are attending an incident on their property).

5. Major disasters

In their liaison with BR and preplanning for incidents, Brigades must bear in mind the special requirements of major disasters (see the *Manual*, Book 12, Chapter 4). The decision as to whether to classify an accident as such will depend on its severity and the numbers of casualties involved.

A major disaster is generally taken to be a serious accident involving 50 or more casualties which will require an extraordinary combined effort to resolve. This is not, however, meant to be a

rigid figure; for example, a derailment involving 10 carriages off the rails but virtually upright means possibly 500 shaken and bruised passengers and is merely a large evacuation problem, whereas a high-speed crash where 30–40 people are trapped in a tunnel means a prolonged, difficult and dangerous exercise requiring all a county's resources. The main problem in any serious railway accident is usually that of gaining entry to carriages in order to release trapped or injured occupants (Chapter 21 Section 4 refers).

Chapter 20
Action at the scene of a railway incident

1. General

a. Types of incidents

There are essentially three main types of incident on railways where Fire Service personnel are involved:

(i) Non-hazardous—where it is possible to deal with an incident on railway property without firemen going on, or within a hazardous distance of, the track;

(ii) Hazardous with maximum safety procedures—where it is essential for firemen to go on or near the track and full safety procedures can be established before operations begin;

(iii) Hazardous without all safety procedures—where, in exceptional circumstances, an immediate risk to life leaves the officer-in-charge no alternative but to attempt rescue before all safety procedures have been established.

b. Duties of members of brigades

It must be remembered that no fireman should go on or near the track unless it is essential. The officer-in-charge should, on arrival:—

(i) Assess the situation, decide whether immediate action is necessary (e.g. firefighting, rescue), and set up safety procedures as quickly as possible.

(ii) Identify, accurately, the location of the incident to his brigade control. They will alert railway traffic control to the brigade's presence on or near the track.

(iii) Request, through brigade control, the measures he wishes the railway authorities to take, and ensure by confirmation that it has been done.

(iv) Inform brigade control of the actions he is taking.

(v) Exercise rigid control of all personnel in the danger area, including BR staff, and be ready to change the disposition of men, appliances and equipment to ensure the greatest safety under all circumstances.

(vi) Make sure all LAFB personnel are wearing high conspicuity jackets. (Plate R.6).

Every fireman has a personal responsibility to comply with all the safety measures put into operation and to avoid any action liable to detract from his safety or that of any other person.

2. Communications

Although trackside telephones are common on BR (see Chapter 17 Section 3), they normally give access only to the nearest signal or panel box or to electrical control rooms. These electrical controls can only disconnect the traction current; they cannot stop diesel units (see Section 4d below). Furthermore, electrification telephones are just under a kilometre apart on overhead powered lines and further apart on third-rail systems. **It is obvious therefore that firemen must have contact with BR regional headquarters or divisional traffic control and that the only proper channel of communications and control is via an appliance radio, through Brigade Control**. Fire Brigades and local railway authorities must be in complete agreement about the arrangements for stopping, cautioning and restarting trains and for cutting and restoring power, and firemen must be totally familiar with these.

Brigade Control must always identify itself when contacting BR for the removal or, more importantly, the restoration of power; other Brigades could be working on the same section of track and BR would need to ensure that it was all clear.

Further advice about the stopping and cautioning of trains is given in Section 4d–e below.

3. Rescue

Where an officer-in-charge considers that an immediate rescue attempt must be made, certain minimum safety measures should be put in hand. Because of variations in circumstances, it is not possible to lay down precise minimum measures, but they should include:

(i) An assessment of the possible risks against the likelihood of success of the action;

(ii) Use of the minimum number of personnel with as little equipment as possible on or near the track;

(iii) Rapid deployment of look-outs and clear instructions to all personnel regarding their safety and withdrawal on approach of traffic;

(iv) Immediate attempts to have trains stopped and any current isolated.

Firemen must not touch an injured person if this means that they would have to come within one metre of live OLE or if the person is lying that close. On a conductor rail system, not exceeding 750v DC, a person in contact with the live rail should not be touched. Firemen should normally wait for the current to be cut off in either case. If this cannot be done without undue delay, a dry rope or wooden pole may be used to pull, or push, an injured person away from live apparatus.

Chapter 21 deals with the particular question of rescue from trains.

4. Safety precautions

Safety is at its greatest when personnel understand the procedures. An officer-in-charge must see that this is so before beginning operations.

a. Safe working distances

Officers-in-charge must identify the extent of the area where it will be safe to work. If trains continue to run, or current is left on, safe working will, as a general rule, only be possible at least 3 metres from the outside rail of the nearest line still in operation. This distance should be increased where high-speed trains are running, because of the suction effect. Other factors which could affect the safe working distance are:

(i) Weather and other conditions e.g. smoke, affecting visibility;

(ii) Local topography e.g. cuttings, embankments;

(iii) Hazards of operations, e.g. use of water near electrified track or OLE;

(iv) The nature of the incident, e.g. derailment, collision, fire;

(v) The presence of any dangerous substances, e.g. explosives, toxic gases.

b. Crossing the track

If possible, crossing the line at track level should be avoided, appliances and equipment being repositioned, if necessary, to achieve this. There are many dangers from live rails, OLE, signal wires, points etc., and for firemen carrying equipment the chances of an accident are increased. Carrying ladders or other long equipment near OLE is especially hazardous. On third-rail systems, it is advisable never to step on any rail, because of the risk of confusing conductor rails and running rails.

c. Places of safety

(1) General

In certain circumstances, e.g. rescue, it may be necessary for firemen to approach closer than the recommended safe distance to a track which is still operating. If so, they should take extreme

Plate R.1 Points, point operating mechanism, point heaters, rodding and LPG cylinders Access to this particular place looks difficult.
Photo: British Rail

Plate R 2 A typical accumulation of railway equipment Note which sections of line are movable
Photo British Rail

Plate R 3 Multiple overhead line equipment with 25 kv lines, tensioning devices etc
Photo London Fire Brigade

Plate R 4 Typical pantograph which is retractable
Photo London Fire Brigade

Plate R 5 An illustration of the difficulties at an incident in a steep-sided cutting Positioning of lighting here is essential to all services
Photo: Evening Argus, Brighton.

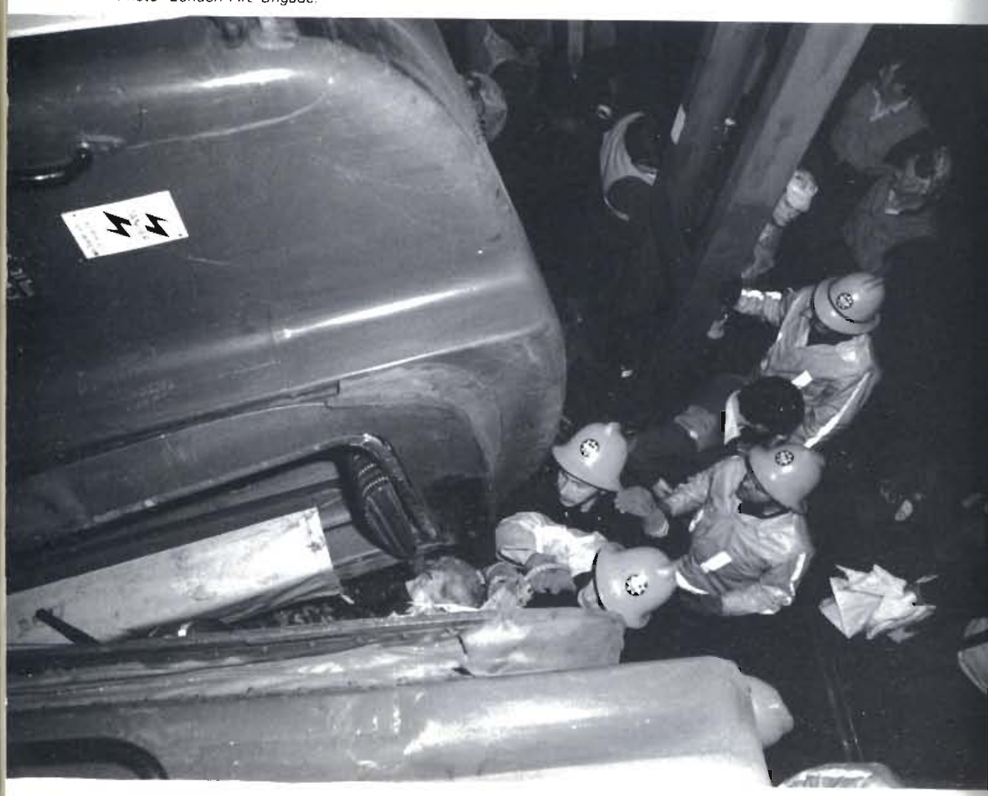
Plate R.6 The height of a carriage lying on its side is obvious. An attempt is being made to extricate a body partly pinned under the train.
Photo. London Fire Brigade

Plate R 7 Passenger coach on embankment secured by Tirfor equipment during rescue operations
Photo: Daily Record, Glasgow

Plate R 8 An unsuccessful attempt to cut into the floor of a sleeping car Even if the next section can be penetrated there could still be berths and other equipment to circumvent
Photo Northumberland County Fire Brigade

Plate R 9 An illustration of cutting into the roof of a carriage, showing the insulation, parts of the carlines, trunking and the ceiling of the compartment
Photo Northumberland County Fire Brigade

Plate R 10 A casualty being removed via the connecting sleeves between coaches The girders support the OLE and, fortunately, this was not brought down as a result of the accident.
Photo London Fire Brigade.



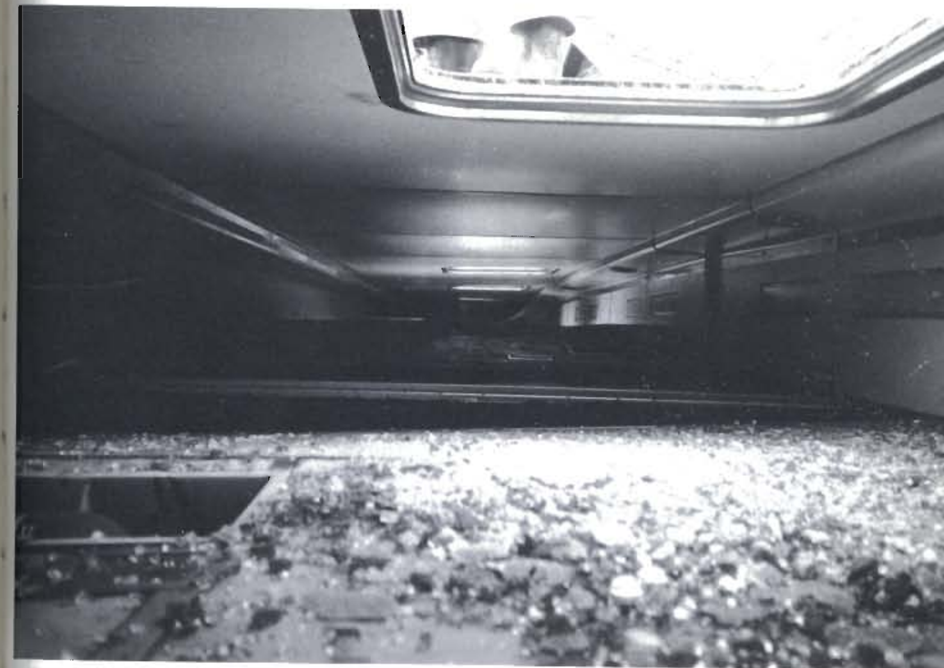


Plate R 11 View along the corridor of an overturned sleeping car showing the restricted access to the compartments The roof is to the right
Photo Northumberland County Fire Brigade

Plate R 12 This carriage struck the side of a house and crumpled This could cause doors to jam, impeding rescue
Photo Northumberland County Fire Brigade

Plate R 13 Looking down into adjacent sleeping compartments of an overturned sleeping car.
Photo Northumberland County Fire Brigade

Plate R 14 A typical LPG tank wagon with a white barrel and horizontal orange stripe
Photo Standard Railway Wagon Co

Plate R 15 Tank wagon used to carry AVTUR aviation fuel
Photo Standard Railway Wagon Co

Plate R 16 Combined efforts of Brigade, BR and medical team (right) in the extrication of trapped passengers (see also Plates R.5 and R 17)
Photo Evening Argus, Brighton

Plate R 17 Raising a casualty up the steep side of a railway cutting using a 135 ladder as a slide (see also Plates R 5 and R 16).
Photo Evening Argus, Brighton

Plate R 18 Aerial view of incident shown in Plate R 7 This train was being pushed by the locomotive The two isolated coaches were the first and second and both have turned completely through 180 degrees
Photo D C Thomson and Co Ltd

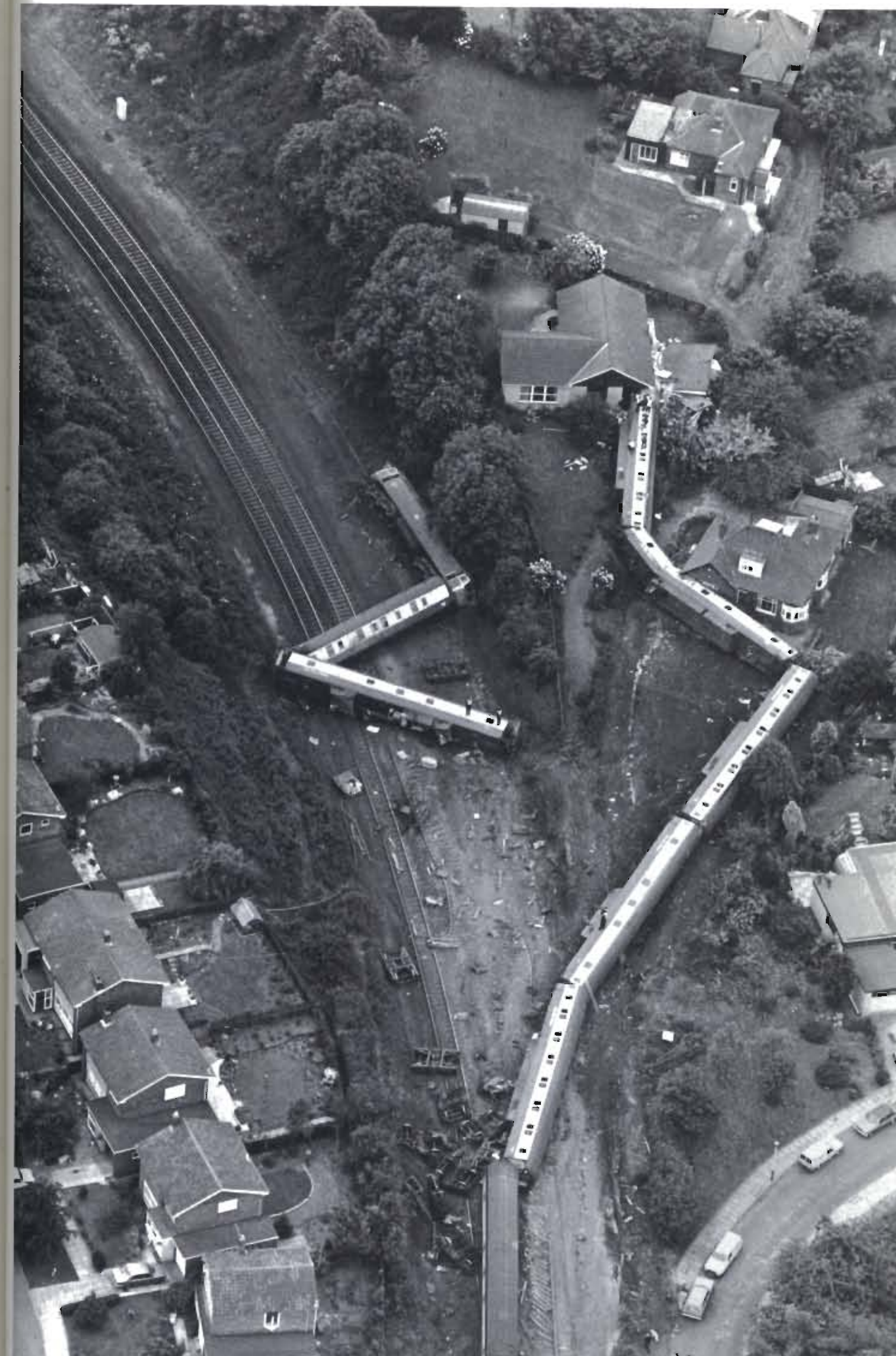


Plate R.19 High-speed derailment involving sleeping cars. Note alternate coupling of cars — those with five single windows are corridor uppermost. See also Plates R.8, R.9, R.11, R.12 and R.13.

Photo: Northumberland County Fire Brigade.

Plate R.20 Two passenger coaches destroyed following a collision between a diesel locomotive and a tanker-train carrying gas-oil. The resulting fireball engulfed the locomotive and these coaches.
Photo Greater Manchester Fire Brigade.

care to avoid conductor rails and OLE, bearing in mind the advice given in Section 3 above, and should preferably walk along the cess (see Fig. 17.1) on the side of the approaching traffic. They should be careful not to walk on cable troughs, as broken slabs can cause injury. Nor should they walk on cables, track rodding, rail segments, chocks, insulators and other such clutter (see Plate R.2). When a train approaches, they should acknowledge any signals from the driver by raising their arm, and should move to a refuge or other place of safety where possible.

A place of safety is generally held to be any place which leaves more than 3 metres between a person, or the equipment he is carrying, and the nearest rail of any line on which a train is approaching. The officer-in-charge must, as far as possible, designate such a place for each individual and see that his instructions are understood. However, the amount of space available may be restricted in such areas as cuttings, narrow embankments, bridges, viaducts and tunnels, and it may be that a fireman cannot reach a place of safety in time before a train arrives. He should then, if possible, lie face down in the clear space between sets of tracks, or in the cess, and hold his helmet down onto his head. Trains travelling at high speeds can cause considerable turbulence and move small objects which could become missiles. Even in refuges firemen should turn away from the tracks to protect themselves.

Firemen, if they have to use refuges while wearing BA, should angle themselves so that their BA cylinders do not protrude. Their face-masks will give some protection against dust, but not necessarily against small stones etc., so they should still turn their faces away into the refuge.

On high-speed lines, blue-and-white chequered boards at the side of the track (Fig. 20.1, left) indicate that there is no place of

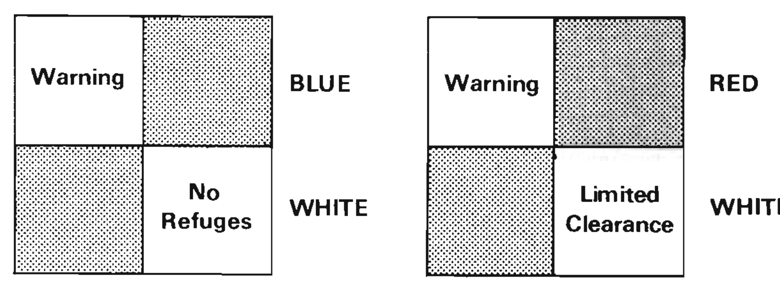


Fig. 20.1 Warning boards at the side of the track.
Left: On high speed tracks blue-and-white chequered indicates no place of safety on that side. Right: Red-and-white chequered shows clearance between structure and nearest rail is less than 1.5 m.

safety on that side. Red-and-white chequered boards (Fig. 20.1, right) at the side of any track indicate that the clearance between a structure and the nearest rail is less than 1.5 m.

(2) On viaducts and bridges and in tunnels

Viaducts, bridges and tunnels require special care and officers-in-charge should not normally send firemen onto, or into, these places unless trains are stopped or they are completely satisfied that the men would be able to take up positions of safety when necessary. Refuges on viaducts and in tunnels, where provided, will usually hold about four men. Firemen entering these hazards must be aware of their allocated safety areas and be particularly alert and ready to move quickly to them. When firemen are wearing BA the officer-in-charge should remember that refuges in tunnels may not accommodate as many men, and alter his safety precautions as necessary.

On no account should firemen enter tunnels on underground railways unless accompanied or authorised by responsible railway staff.

d. Stopping trains and cutting off current

(1) General

If safe working areas cannot be set up away from moving trains and live electrical equipment, the officer-in-charge must consider whether to ask for trains to be stopped and the current cut off. This action will obviously be essential on a line which is obstructed by a crashed or derailed train, but it may also be necessary on adjoining tracks, especially in the event of fire (see Section 5a below). All firemen should assume that trains are running normally with current on until there is definite confirmation that the action requested has been taken. In the case of a line obstructed by a train, BR traffic controllers will normally stop trains and cut off current as a matter of course immediately they hear of the incident, but it should be borne in mind that the Brigade may be the first to notify them of it.

Firemen must remember that an incident which necessitates interruption of services on a railway causes a great many problems, not only for the Service. The normal minimum section that can be isolated on a third-rail system is 2.5 km, but on an OLE system it is 24 km. Isolation of OLE can therefore cause considerable disruption. Railway traffic controllers will act without delay when asked to stop or caution trains or cut off current, but such requests must be precise and briefly explain the reason. The need for precision is most evident when there is an incident, for instance, on a multi-track section in a large conurbation during the rush-

hour. Here the officer-in-charge must consider whether large-scale disruption would be justified; but also, more importantly, whether his men could be at risk from those tracks not directly involved. Where life is not at risk it may be better to await the arrival of a railway official who can personally give advice.

Trains should normally be stopped by signals in addition to any cutting off of current, because although the latter procedure will slow and eventually stop electric trains it will not affect diesel units. A diesel unit could run for up to 1.5 km before receiving a warning, and until its driver asks, via a trackside telephone, why a signal is unexpectedly at red, traffic control cannot confirm to the brigade that all trains are stopped. All this could take some time.

(2) Isolation of OLE sections

Except for rescue purposes (see Section 3 above), no part of a fireman's body, tools or water jets should come within 3 m of the OLE or anything in contact with it, nor should he go above the top window level of a carriage or above the sides of other rolling stock (when the train is on the track), until he is advised by a responsible railway official that the current has been cut off.

Arcing and sparking must be expected from OLE even if it has been electrically isolated. The OLE is only considered to be safe from 25 kV traction current after an 'Emergency Isolation' has been carried out. This entails not only the opening of the circuit breakers at the insulated sections but also the closing of the intermediate track circuit breakers so ensuring the bonding of the OLE and reduction of its potential to a safe voltage. The officer-in-charge should therefore request an 'Emergency Isolation' and treat the OLE with respect until this has been confirmed. It would also be prudent to request an earth to be provided.

(3) Isolation of third-rail sections

On third-rail systems, isolation of one section of track does not guarantee that current cannot flow through it. Because all the pick-up shoes on a train will be live as long as one is in contact with a live conductor rail, the train itself may bridge the gap between two sections and re-energise an isolated section of conductor rail. To prevent this happening, railway staff also isolate adjoining sections.

e. Cautioning trains

When a safe working area is being established but there is no need for trains on particular tracks to be stopped, officers-in-charge can ask for drivers to be cautioned, e.g. when firemen are working on an embankment or where there are a number of tracks not all of which need to be blocked. Cautioning means

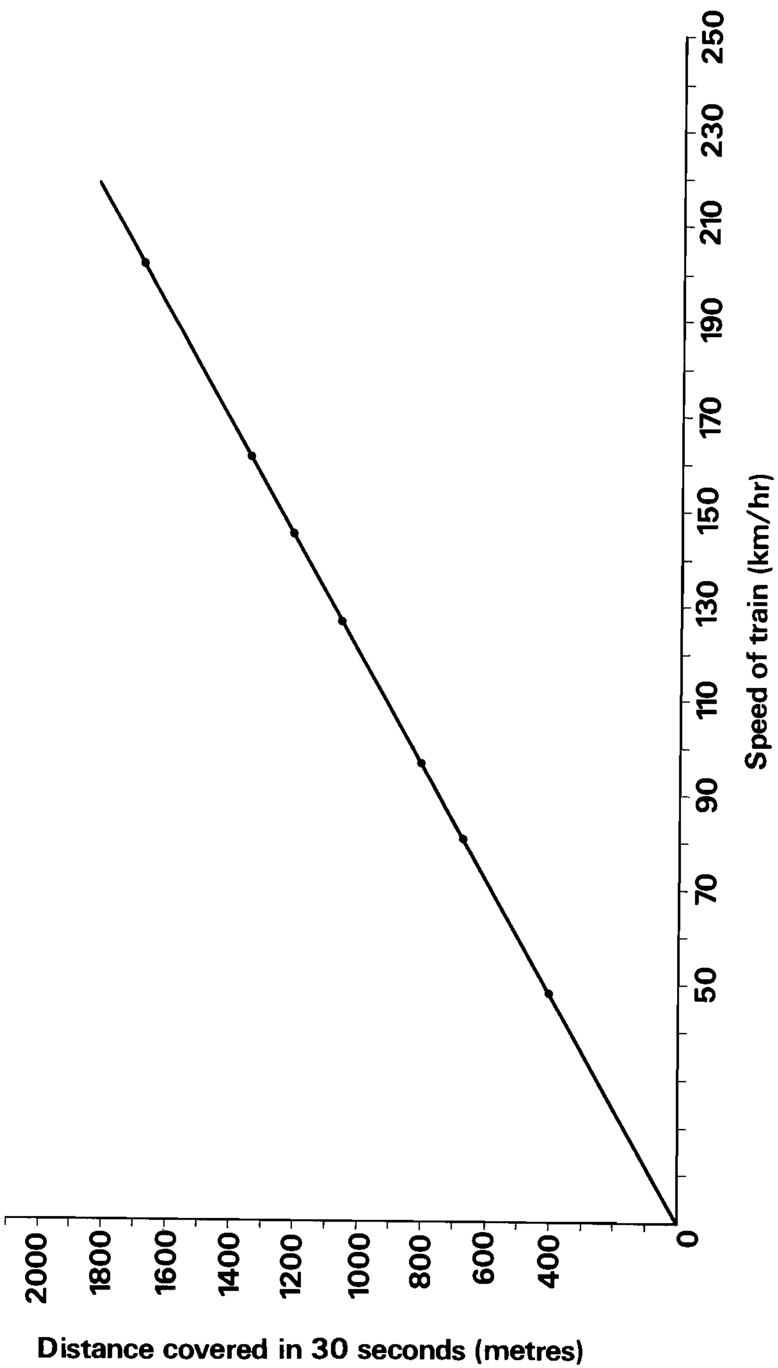


Fig. 20.2 Graph showing travel distances at various speeds.

that drivers are warned of the presence of firemen but it is left to the judgement of each driver to decide on his speed. This can vary from as low as 25 kph up to 95 kph according to local conditions, the type and make-up of the train, and the exact nature of the cautioning message. Firemen should avoid any tracks, either to work on or to cross, where trains are running under caution.

f. Look-outs

It is absolutely essential for look-outs to be posted in cases where brigade operations require firemen to work on or near railway tracks. Look-outs can be posted in other circumstances at the discretion of the officer-in-charge. Their position must be such that they can see an oncoming train and have time to give *at least* a 30-second warning, e.g. by means of a horn, so that crews affected can reach a place of safety.

There can be no rigid rules for these posts: local knowledge, weather, visibility, curvature of the track and uncertainty about the speed of local traffic are all relevant. The officer-in-charge must take into account the highest likely speed of trains on that line and post his look-outs accordingly. The graph at Fig. 20.2 shows the distance covered in 30 seconds at different speeds; for example, a train travelling at 50 kph would cover approximately 0.42 km in that time, whereas one travelling at 200 kph would cover approximately 1.66 km. All trains which attain speeds of 160 kph or more have their headlights permanently on.

The officer-in-charge should establish the signalling system. Thus the look-out, at the first sign of approaching traffic which could constitute a danger, should give a series of short blasts on his horn and repeat them until he receives acknowledgement. Personnel, on hearing the warning, should raise an arm above their head, move to safety and remain there until the danger is past and they receive instructions to carry on operations. At night, or in poor visibility, acknowledgement should be made by the circular movement of a torch towards the look-out. As with the rest of the crews, all look-outs should wear high conspicuity jackets and carry a hand-lamp for their own safety.

To ensure that look-outs are effective, the officer-in-charge should bear the following points in mind and see that they are carried out:

(i) Each look-out should make a test blast of his warning horn before operations start, to ensure that firemen working at the incident can hear it, and that the look-out can clearly see the acknowledgements to the warning.

(ii) Where necessary, e.g. on bends or where noise might make it difficult to hear warnings, there should be intermediate look-outs to relay the warning signals. The officer-in-charge must take extra care that these duties are fully understood and co-ordinated.

(iii) Where crews share one look-out, the officers-in-charge of each crew must jointly instruct the look-out and the crews. The crews will then know who is guarding them, and each look-out will be aware which personnel he is warning and from whom he can expect acknowledgement.

(iv) If, because of changing circumstances, e.g. mist, smoke, failing light, the look-out considers that protection is becoming inadequate, he should sound his horn. When everyone has moved clear he should explain the situation to the officer-in-charge. The officer-in-charge must also keep this under consideration and act to keep the situation safe.

(v) Fireground communications equipment can be used to keep in contact with look-outs but it should not be used instead of a warning signal directly audible to the crews at work.

g. Lights

Coloured lights on railways have special connotations, and firemen should avoid the use of any flashing or coloured lights on or near the line as this may confuse train drivers.

5. Firefighting

Small grass fires on railway embankments are common and will not normally present any serious problems to firemen. At the other end of the scale are the occasional serious train fires putting many lives at risk and, in the case of flammable freight, also having the potential of a major accident involving the surrounding area. Normal firefighting procedures appropriate to the risk and severity of the incident should in general be followed.

Firemen should bear in mind the particular points mentioned below. (Tunnels pose special problems and are dealt with in Section 6).

a. Electrical hazards

The Service should always be wary of fires and the use of water near electrified railways. The commercial use of railway property, e.g. railway arches, is widespread, and any fire close to a railway could damage electric cables. The presence of a large amount of water could lead to areas some distance from the railway becoming 'live', and officers-in-charge should keep this in mind. Under no circumstances should water or foam be directed at or near electrical equipment unless the electrical supply has been cut off.

b. Hose

Firemen should only consider taking hose across the tracks when it is quite certain that trains have been stopped, and any electrified rails isolated. Modern methods of laying ballast make it impractical to dig out and lay hose under the track, and this could only be considered if there was a lengthy incident and a desire to get tracks running again. If, inadvertently, a train approaches a section of track across which hose is laid, there is no chance of a derailment, so firemen should not attempt to remove the hose and endanger themselves.

c. Fires in trains

When firemen are called to fires in trains, any fixed firefighting installations will probably have operated, and the train crew should already have used their portable appliances. Gas may therefore have been discharged into the engine compartments of locomotives. The detailed procedures for dealing with train fires will, of course, vary according to the circumstances, but firemen should check the following points:

(i) On diesel locomotives—that the engines have stopped and the battery isolation switch is open.

(ii) On diesel multiple units—that the engines have stopped and the heaters are off.

(iii) On electric locomotives and multiple units operating from OLE—that the pantograph has been lowered and the battery isolation switch opened. On third-rail systems—that the conductor rail has been isolated.

(iv) On passenger carriages—that the 1 kV electric heating supply is off.

Sleeping cars and catering units carry LPG cylinders, for which there should be a main supply shut-off valve. If it is possible to isolate a burning vehicle from the rest of the train, the officer-in-charge should ask the train crew to do this.

In any freight train fire, the possibility of a flashover, BLEVE or explosion must be borne in mind. Tank wagons containing flammable substances or chemicals are particularly dangerous, and early identification of the load is essential. When tanks carrying fuel oils are heated in a fire, the rise in vapour pressure will eventually operate a relief valve. Liquid and vapour may be ejected and one of the above occurrences take place. Foaming and/or cooling should be carried out as soon as possible.

6. Fires in tunnels

A fire in a tunnel presents particular problems e.g. divided attendance, sometimes deep penetration, rescue, lengths of hose-lines, logistics of moving equipment, communications, BA control, difficulty of underfoot conditions, excessive heat and, often, thick smoke. Most tunnels of any length usually have one or more air-shafts which can help in ventilation but also act as flues drawing in large amounts of fast-moving air from the tunnel entrances.

If the incident involves a passenger train, evacuation may be taking place towards both ends of the tunnel. There could be little light (depending on the length of the tunnel and the position of the train) and panic may ensue. The call to the brigade will probably be delayed whilst the train crew evacuate passengers, tackle the fire and find a telephone.

The danger from a freight train fire will depend on the type of wagons and their contents. A tank wagon fire (see Section 5c above) is likely to be extremely hazardous in the confined space of a tunnel. Much will depend on the diameter of the tunnel and the position and size of any air-shafts.

Brigades will have pre-planned for incidents in major tunnels, but the following points should be remembered:

(i) All traffic through the tunnel should normally be stopped and the current cut off, preferably before firemen enter. Where necessary, officers-in-charge should ensure that there are adequate places of safety inside the tunnel (see Section 4c(2) above). If OLE is involved, the lines may have been brought down and could certainly be a hazard in any firefighting. Most tunnels in the UK carry only two rail-lines, and an incident of any size will affect both.

(ii) It is vitally important to control the movements of *all* personnel inside the tunnel, and to restrict their numbers.

(iii) BA controls, and any forward controls, will need to be rigidly supervised. The position of air-shafts, if any, may dictate the positioning of such controls because the venting of smoke up a shaft should keep the area towards the tunnel entrance relatively clear. Any flashover etc. could also vent up a shaft, with a possible slight overlap beyond the shaft, depending on its severity. It would therefore be prudent to site controls at least 20 metres beyond the shaft towards the tunnel entrance, if this is convenient.

(iv) If pre-tests show that radio is inadequate, firemen should use field telephone systems or any other appropriate communication system proved by actual testing in the tunnel.

(v) Lighting will be essential and BR have plenty which can be mobilised under preplanning arrangements. Cables should be laid, if possible, where they will not be immersed in water run-off.

(vi) Any lightweight pumps, generators or motorised HEF units will generate exhaust fumes. Experience has shown, how-

ever, that the air flow in a tunnel usually alleviates the problem.

(vii) Flammable liquid may filter out of the tunnel in the water run-off and into local watercourses. The police and water authorities should be alerted at an early stage if there is any risk of this happening. When flammable liquid spills into ballast it is often unable to form a pool, and this can have a suppressant effect on any flames.

(viii) Rapid evacuation of firemen may be necessary and officers-in-charge should remember to keep the number of personnel in dangerous areas to a minimum. An adequate emergency signal should be arranged at the preplanning stage.

7. The end of the incident

When fire brigade operations are considered to be finished, the officer-in-charge should inform the railway authorities, via Brigade Control, that they can now resume normal working.

Chapter 21
Rescue from trains

1. General

The incidence of major railway accidents involving passenger rolling stock, such as to necessitate rescue operations, is not high in the United Kingdom, but such accidents do occasionally happen. The actual circumstances can vary greatly, and to attempt to describe all likely difficulties is impossible. Plates R.5 and R.17 show an incident in a steep cutting where it was necessary to pitch 13.5 m ladders and to haul and manhandle casualties up the slopes. They also highlight the height of carriages lying one on top of the other, and the problems of lowering casualties to the ground before removing them from the cutting. Other incidents have happened on high bridges and embankments, leaving carriages suspended by their couplings and, in one case, carriages fell onto a beach when the tide was rising. In some cases, carriages may come to rest in an unstable position and will need to be secured, e.g. with Tirfor equipment or other cables (see Plate R.7). The officer-in-charge of the PDA must try to get an overall picture of the incident so that he can decide his priorities and determine how much assistance he requires, and of what kind.

2. Evacuation of passengers by train crew

When possible, the train crew will arrange the evacuation of passengers. If the train is not at a platform, the crew will usually try to remove or assist them onto the ballast shoulder or cess by means of a short extension ladder, which is normally carried in the guard's compartment. If passengers are in immediate danger, however, they will have to jump down if they can.

In addition to the ladder, trains carry items such as a crowbar, club hammer and panel cutting tool to help in rescue work. In some cases, firemen may be able to make use of these.

3. Search and clearance

Officers-in-charge at railway collisions or derailments should quickly set up a system of carriage-by-carriage search. Each carriage should be allocated a number of crews under an officer who will:

(i) co-ordinate the search and rescue;
(ii) request any special equipment he requires, e.g. lighting, cutting gear;
(iii) keep a tally of people rescued;
(iv) mark, clearly, the compartments searched and cleared;
(v) assist the other emergency services;
(vi) keep the Fire Service Incident Officer informed of progress.

4. Gaining entry to passenger carriages

Chapter 18 Section 2b describes one particular type of carriage. The points of interest to the Service discussed below try to cover a variety of aspects which may be found at an incident. The particular problems that may be encountered on sleeping cars are discussed in Section 5 below.

a. Floors

Whatever the position of a carriage following an accident, gaining entry through the floor will be an almost impossible task. Even where the space between the bogies is not cluttered with batteries, pumps, pipework, ducting and electrical wiring in conduit etc., the construction of the floor will require more effort to cut through than elsewhere (see Plate R.8). If a fireman were to penetrate to a compartment, he might very well encounter a seat or some other obstruction which would have to be cleared before entry could finally be made.

b. Doors

Although many commuter trains now have sliding doors, there is still a large proportion of passenger stock with ordinary hinged doors as in Fig. 18.7. Their positions and number vary from one in each corner through various combinations to the separated compartments with individual doors on either side. Corridor stock could have individual compartment doors on one side and possibly only two or three doors on the other, with internal sliding doors to compartments. Whatever the variation, they will afford a fireman quick access in the majority of cases. Firemen should remember the weight of doors, especially if the carriage is on its side. Doors should be opened carefully and may need to be propped open to prevent injuries, especially if wrecked stock is unsteady. When opening a door on stock which is upright but leaning towards the direction of approach, firemen should beware of being knocked off a ladder. The internal end doors on corridor and connected stock are usually sliding, and, depending on the angle of the carriage following an accident, firemen should try to jam them open.

Sliding main entrance doors are usually operated pneumatically and are designed to be openable if the air-pressure fails. Firemen should be able to force them with little difficulty. Again, firemen should prop them open to avoid accidents.

One design door, on the drawing-board at present, is the 'plug' type. Acting pneumatically, similar to a door on an aircraft or bus, it opens to the side and outwards and presents a tight, smooth profile when closed. Experiments are still being conducted on means of opening the door if the pneumatics fail, but firemen should be prepared to see this door in service in the near future.

On the Rail-bus (see Chapter 18 Section 1a(6)), the normal pneumatic concertina bus doors will be fitted. The whole concept here, as far as firemen are concerned, is a bus, and the usual rescue techniques for such vehicles should be used.

c. Windows

Although windows are the other obvious means of entry to a carriage, firemen should take care. There are a great variety of types—some openable, some part-openable, and others (as illustrated in Fig. 18.7) completely sealed. Some of the large panes are double-glazing units, but others could be 12.5 mm plate glass. It may, especially at night or in poor visibility, be difficult or impossible to distinguish between the two, and if firemen have to break in they should expect the worst, i.e. shattering plate glass. A blow with a sharp-pointed piece of equipment in one corner, preferably an upper corner, will reveal the type of glass. Plate glass will shatter and fall, probably in large pieces, whilst double-glazing should craze and require tapping out. If possible, firemen should try to warn passengers inside and firecrews outside to remain clear during this operation. When breaking or tapping out glass, firemen should try to keep above the fragments.

d. Other means of entry

If, because of the position of the wreckage, neither the doors nor windows are available, other means of entry must be tried.

The side shell of a carriage is built up on a frame of longerons and pillars with bracing struts under the windows in between. Although there are areas about 0.6 m by 0.3 m where there are no struts, in many carriages these areas are blocked internally by seats, tables, ventilating ducts etc. and would not provide easy entry or an easy passage out for injured passengers. However, provided that the accident is not in a tunnel or under a bridge, the area centrally above a window and for approximately half a metre up from the edge of the roof (see Fig. 18.7) is usually a good point to cut in. In the case of corrugated roofs there will be no longerons and, normally, a space of approximately 0.6 m wide between roof carlines (see Plate R.9). Roofs with longerons can

be cut through fairly easily, and should not present too much difficulty. Firemen could encounter an aluminium luggage rack below this area but it should not impede their entry, and, once they are inside, the middle section of the rack can be cut away, leaving a clear way.

Firemen should also consider the ends of the coaches if they are corridor or connected stock. Cutting into the concertina fabric is not difficult, and it may even be possible to lever the connecting rings apart. (See Plate R.10).

e. Cutting through fittings

Having entered a carriage, firemen may in some circumstances need to cut through internal fittings in order to release trapped occupants. This should not present too many problems, however, as the fittings are generally of fairly light construction (see Chapter 18 Section 2b(5)).

5. Problems associated with sleeping cars

Firemen should, if possible, inspect the normal type of sleeping car which passes through their area. One type contains 12 sleeping compartments, each with a window but no external door and, on the other side of the carriage, a corridor with five windows. At each end of the carriage there is an external door on both sides. The doors between the corridor and the compartments open inwards. The roof is of the corrugated type (see Fig. 21.1), the windows are double-glazed, fixed, toughened glass, and the four external doors are of the normal hinged type with latch.

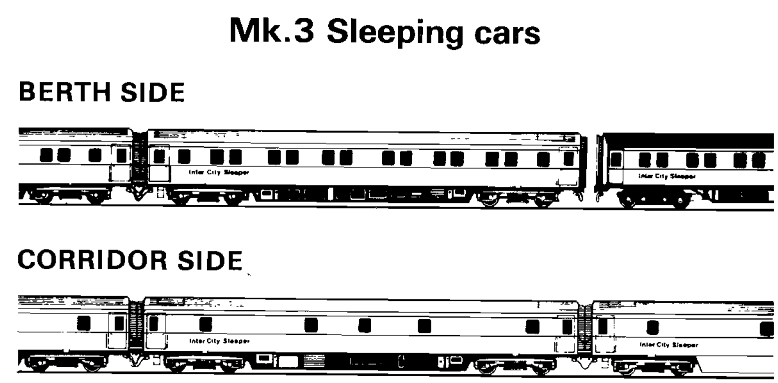


Fig. 21.1 Diagram of one type of sleeping car showing lay-out of doors and windows. There is usually one attendant to every two cars.

The usual coupling of these carriages is such that corridors alternate from one side of the train to the other. This means that, in a derailment, if coaches overturn some will come to rest with their compartment windows up and others with their corridor side uppermost (Plate R.11). Gaining access when compartment windows are accessible is relatively simple; the windows are of ample size for the passage of a normal person.

On the corridor side, the windows do not correspond with all the internal compartment doors, and the corridor is only about 575 mm wide at the maximum. The internal compartment doors are usually locked and, if the carriage has suffered some crumpling (Plate R.12), they could be jammed. However, since they are of light construction they can be broken down without too much difficulty.

There are also connecting doors between compartments, adjacent to the corridor. If, however, the carriage comes to rest with its compartment windows uppermost, it will probably be difficult to use the connecting doors, because all the movable contents of the compartments are likely to be piled up against them (Plate R.13).

Gaining entry through the roof could be less easy than usual because of its construction and contents. As on other types of carriage, entry through the floor would be virtually impossible due to the proliferation of services under the carriage (Plate R.8).

6. Handling and treatment of casualties, bodies and personal effects

The possible difficulties of removing casualties are mentioned in Section 1 above. Firemen should give casualties any necessary first aid and take care not to aggravate their injuries. The advice given in Chapter 6 Section 6b and Chapter 7 Section 4 should in general be followed, although, since the inside of a railway carriage is usually a less dangerous place than that of an aircraft fuselage, certain modifications may be made. It may, for example, be desirable in some cases to leave certain casualties temporarily inside the train in order to protect them from the elements, bearing in mind that they should, if possible, be informed of why this is being done.

In a railway incident, the position of dead bodies is generally of less importance than it is in an aircraft crash, and it will therefore usually be preferable to remove them all to a temporary mortuary, which should be set up away from the area reserved for injured survivors. Similarly, the personal effects of the accident victims (alive or dead) should be searched for and collected, to enable them to be documented by the police.

Chapter 22
Dangerous substances carried on trains

1. General procedures for dangerous freight

A large amount of dangerous substances are moved by rail and it is quite usual to have complete trains of wagons, tank-wagons or containers conveying dangerous cargoes. To keep track of all freight, BR use TOPS (Total Operations Processing System). This consists of a central computer connected to control offices, marshalling yards and depots throughout the country. From these points, details are fed into the computer of wagons, loaded and unloaded, freight train movements and type of traffic conveyed. Any control office can obtain from the system, on demand, information on any wagon or freight train and its cargo. In addition, every train carries a consist (see Glossary), which may or may not be available when the fire brigade arrives.

BR lay down the conditions under which they are prepared to accept dangerous goods in their *List of Dangerous Goods and Conditions of Acceptance*, BR 22426. Their *Working Manual for Rail Staff*, BR 30054 Part 3—commonly known as 'the pink pages', sets out specific instructions to staff on the handling of dangerous materials. All Brigades have a copy. It contains guidance on the action necessary in emergencies, explains how to obtain specialist assistance, and requires staff to call the emergency services when an incident occurs. It also includes illustrations of labels used on packages of dangerous substances and on the wagons containing them. The *Manual of Firemanship*, Book 12, Chapter 7, gives further details of the labelling requirements for the carriage of such substances. For information on decontamination following an incident, see Book 12, Chapters 8 and 9.

2. Tank wagons

Tank wagons, in addition to carrying a wagon label indicating dangerous goods, also display a United Kingdom Transport Hazardous Information System (UKTHIS) placard similar to that prescribed for road tanker vehicles (see the *Manual*, Book 12, Figure 7.1). The exceptions to this are tank wagons running on international traffic which come under the CIM regulations (see the *Manual*, Book 12, Chapter 7). Apart from carrying the BR wagon label and the UKTHIS placard (or CIM identification), tank wagons carrying certain classes of dangerous goods can be identified by their colour. LPG tank wagons have a white barrel with a horizontal orange stripe round the barrel at mid-height (Plate R.14). Tank wagons carrying flammable liquids are painted dove grey and the sole bars are painted signal red (Plate R.15).

The presence of the UN number for petroleum fuel (1270) on tank wagons often signifies that the train is carrying a wide range of petroleum products; individual wagons may contain a lesser risk than that specified. Where the number 1270 appears, therefore, the fire brigade should always ask BR to obtain precise details from TOPS.

3. Explosives

Only commercial explosives are covered by BR 22426, and the total amount to be conveyed on any one train is limited to 36.25 tonne. Military explosives are covered by the *Conveyance by Rail of Military Explosives Regulations 1977* (SI 1977 No. 889). The weight limits for military explosives, and for mixed commercial and military loads, are given in BR 30054/3.

The wagon labels for explosives (both commercial and military) include, in place of an individual UN number, a set of four characters identifying the category of the explosive, as described in BR 30054/3. Thus a wagon label whose emergency code begins with the characters Ø11D would indicate an explosive of Division 1.1, Compatibility Group D, i.e. an explosive presenting a mass explosion hazard. (See Fig. 22.1). Reference to this is made in Dear Chief Officer Letter No. 12/1983.

4. Radioactive materials and irradiated fuel flasks

BR 30054/3 categorises radioactive materials and the specified labelling, numbers of packages, where and how they are to be stored or transported, distances etc. Depending on this, such material may be found in passenger train guards' compartments or in ordinary freight wagons. Under these conditions the dangers would be minimal but firemen should still avoid contact if possible and, if it appears necessary, institute such Brigade procedures as they think appropriate.

Irradiated nuclear fuel is transported in massive, shielded and, usually, water-filled containers called 'flasks' (Figs. 22.2 and 22.3 give examples). They are subject to stringent regulations and supervision. The flasks themselves are designed to international standards to withstand impact and fire without leaking. They are clearly marked (Fig. 22.2) and in the unlikely event of an accident the Irradiated Fuel Transport Flask Emergency Plan (IFTFEP) will be brought into operation. This provides for the nearest

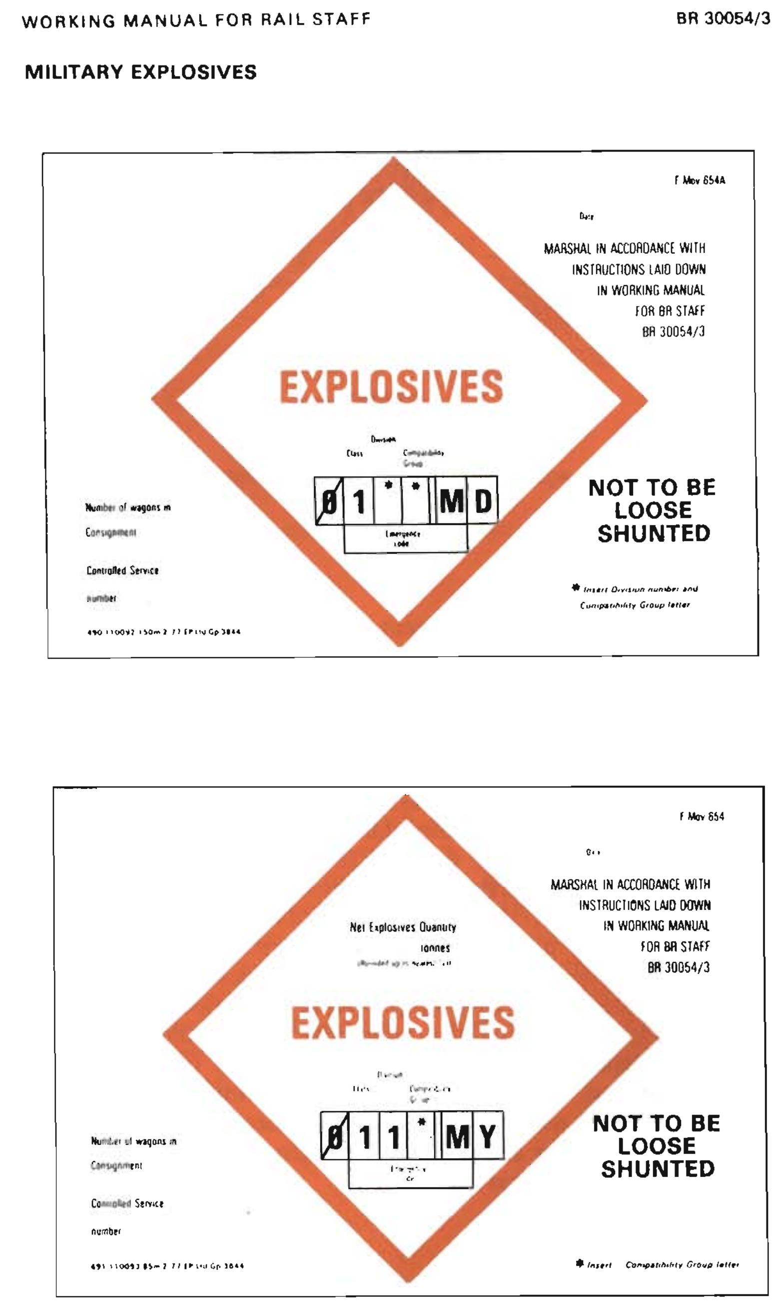


Fig. 22.1 Typical wagon label for explosives (both commercial and military).

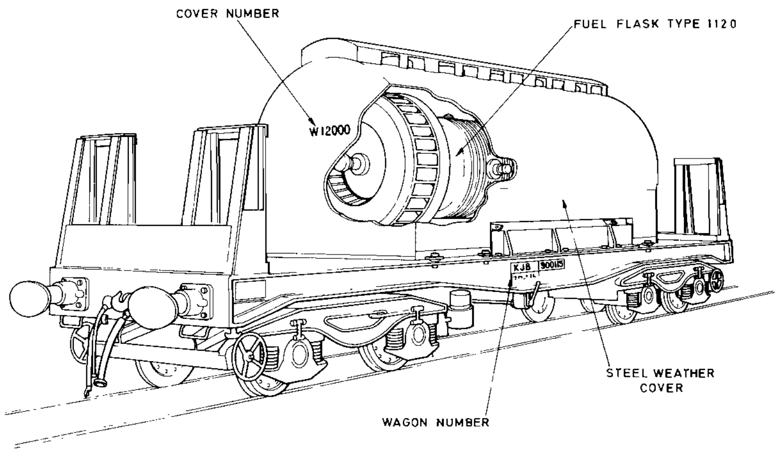


Fig. 22.2 Special rail wagon loaded with UK Atomic Energy Authority flask with fitted weather cover.

appropriate nuclear establishment to be alerted and a nuclear physicist to be dispatched to the scene of the incident to monitor and advise. This scheme is separate from NAIR (National Arrangements for Incidents involving Radioactivity). However, if the alerting procedure is, or could be, delayed, any NAIR Stage II establishment could be called in. (See the Appendix). If there is evidence of damage to the flask, everyone should keep at least 50 m away in all directions, especially downwind. If this area has to be entered for rescue, firemen should wear BA, protective clothing and dosemeters, and the usual radiation procedures should be carried out. All personnel involved should be checked also by the nuclear physicist when he/she arrives.

Even in the event of severe damage to a flask, however, there is no immediate danger of a large release of radioactivity. If the water leaks it may be slightly radioactive and should be avoided if possible, especially any contact with the eyes or skin. In the event of the flask being involved in fire, it should be cooled by water-spray. The nuclear physicist will check the run-off and inform the local water authority of the slight chance of radioactive contamination of any water course.

5. Multi-loads

When packaged dangerous goods are conveyed, they are labelled as per BR 30054/3 (see Section 1 above) but a problem arises when one wagon carries a mixed load of dangerous substances.

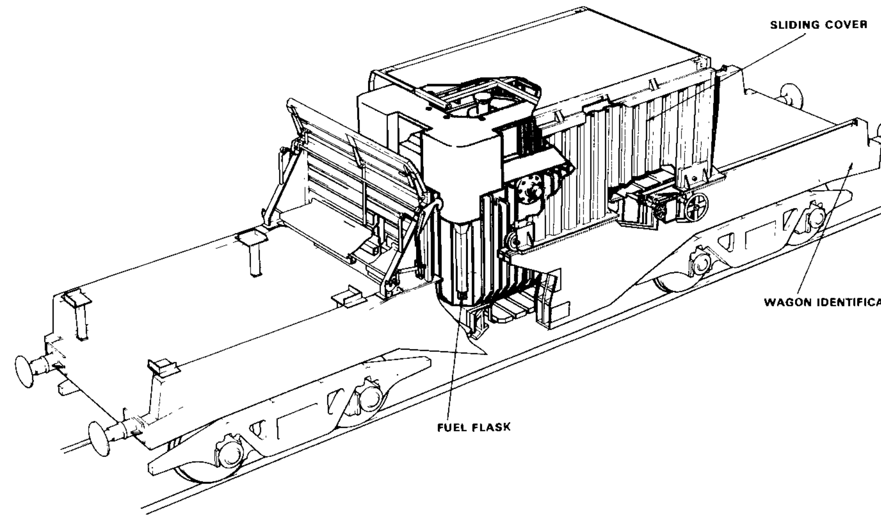


Fig. 22.3 Special rail wagon loaded with Central Electricity Generating Board flask with sliding cover.

The solution is to use a wagon label with an exclamation mark symbol, and the Emergency Code includes the number 8989.

6. Blue asbestos

Some BR passenger rolling stock still contains blue asbestos as an insulating material between the inner and outer skins of carriages. New carriages contain none, and as the older carriages come in for repair it is being removed or the carriage is scrapped. If a passenger carriage is involved in an accident, firemen should check whether there is a hazard by contacting the railway control office and quoting the carriage identification number (painted on the waist on each side of one end). Unless and until it is confirmed that blue asbestos is not present, they should assume that it is and take the appropriate precautions.

Glossary of railway terms

Ballast shoulder	The graded edge of the ballast either side of a pair of rails.
Bogies	The wheeled supporting structures on which a train runs. Each one has a pivotal centre plate to enable the train to negotiate bends and fluctuations in the track.
Bogie van	A large 2-bogie covered wagon used for non-bulk freight, e.g. parcels.
Brake compartment	The part of a passenger train usually occupied by the guard.
Cable trough	Covered ducting containing electrical cables, usually running alongside the rails in the cess, but sometimes found in the six-foot.
Cantrail	The metal longeron at the junction of the side and roof of a carriage.
Catenary wire	The cable supporting the contact wire in an OLE system. It is itself supported by a system of suspension cables, arms and tensioning devices.
Cautioning	An oral warning to a train driver of operations on or near the line ahead. He should proceed with caution, but his actual speed will depend on circumstances and will not necessarily be very slow.
Cess	The area immediately outside the ballast shoulder (q.v.).
CIM	Convention Internationale Concernant le Transport des Marchandises par Chemins de Fer: International Convention Concerning the Transport of Goods by Rail.

Conductor rail	A rail carrying live traction current.
Consist	A computer print-out from TOPS, carried by the driver or guard (or both) of a freight train, giving a list of the wagons, in order, and their contents.
Contact wire	The cable from which a train's pantograph collects the current.
Detonator	A small explosive device clipped to a running rail by a railway employee to warn a train driver of a hazard ahead.
Four foot	The space between the running rails of one line.
Isolation	The disconnection of electrical supply from a section of line. (NB The line is not blocked: diesel trains can still run and electric trains can coast for considerable distances.)
Line blocked	A term signifying that trains are stopped, with no traffic passing over the section of line in question.
Locomotive	A unit designed solely for the purpose of propelling a train.
Look-out/look-out man	A man whose sole duty is to watch for approaching trains and warn those working on or near the line.
Multiple unit	A train made up of one or two motor units and a number of carriages.
OLE	(Electrical) overhead line equipment.
On or near the line	A position on or near enough to the line for a person, appliance or equipment to risk being hit or sucked under by a passing train.
Overbridge	A bridge over the railway.
Pantograph	Apparatus for collecting current from OLE, kept in contact by tensioning and mounted on the roof of a motor unit.
Pick-up shoe	A sprung device enabling a train to pick up current from a conductor rail.
Refuge	A space, set back from the trackside, where personnel can shelter from trains.

Rodding:	
(1) Track rodding	A system of rods connecting the points-operating switch to the point rodding.
(2) Point rodding	A system of rods and arms running transversely under the track from the track rodding to the points.
Running rails	The non-electrified rails on which trains actually run.
Sighting distance	The distance at which a look-out can first sight a train, or a train driver can sight a signal.
Six foot	The space between rails of adjacent lines (not necessarily a safe area).
Sole bar	The bar at the edge of the chassis of a wagon.
Thermit	An aluminothermic reacting material often used to weld rails together.
Track or line	The rails and sleepers over which trains run.
Underbridge	A bridge carrying the railway over, for example, a road or river.
Up/down	Terms used to distinguish the direction of traffic on a line. There is no hard and fast rule on their use by railway staff, and firemen must therefore establish their meaning in relation to each particular line in their area.

Appendix
National Arrangements for dealing with Incidents involving Radioactivity (the 'NAIR' scheme)

1. At an incident in which radioactive materials are involved, fire service responsibility is to perform its normal tasks of firefighting, rescue etc. To fulfil this role, the fire service equips and trains firemen to protect themselves from harmful exposure to radiation. However, neither equipment nor training enables them to deal fully with all the hazards from such an incident or to be able to ensure the protection of the public. There are arrangements for securing specialist assistance to deal with any radiation hazards. At any incident where there is actual or potential release of radiation, experts should be summoned to control radiation aspects of the incident and to protect the public, e.g. by measuring radiation and instituting general decontamination and health measures. The limitations of the knowledge, equipment and training of firemen must be recognised,and regard paid to the advice of those with the relevant specialist knowledge.

2. Because of the increasing use of radioactive materials and the possible dangers to the general public if a mishap should occur (for example, if a radioactive isotope were lost), the NAIR scheme was established in 1964. Under this scheme, experts are available at any time of day or night and may be called by the police to an incident involving radiation where there might be risk to the public.

3. The scheme has been based on the knowledge that in the majority of cases these incidents do not involve a fire but are concerned with accidental loss or discovery of radioactive sources, or with damage to radioactive consignments in traffic accidents. The scheme assumes that the police will most frequently be notified of an incident; will be first on the scene; and will have general responsibility for the safety of the public. In the majority of fires or other incidents involving radioactive sources, there will be technical assistance available on the spot. Should there be no such assistance and it is not clear that the police have summoned expert help, the police should be notified without delay. They will take any necessary steps to obtain qualified advice and assistance.

4. Assistance under the NAIR scheme is in two stages; each will be invoked by the police. Under Stage 1, suitably qualified individuals will be able to advise the police as to whether radioactivity should be taken into account when the incident is being dealt with, and, if so, the appropriate action required. If the situation demands it, Stage 2 will provide further help comprising a team from a body such as the United Kingdom Atomic Energy Authority, the Generating Boards, British Nuclear Fuels Ltd and others who can deploy larger resources than Stage 1 advisers. Each police authority holds the names of the Stage 1 and Stage 2 contacts. The list of contacts is maintained by the National Radiological Protection Board which is responsible for co-ordinating the scheme.

5. The police and other participants in the NAIR scheme are aware that firemen receive training in protection from radiation hazards, and that brigades have a limited range of equipment for self-protection. On occasion the police may seek Fire Service advice before invoking the NAIR scheme. In such cases it is advisable to err on the side of safety and to recommend that experts be called in. Brigades called to any radiation incident should always ensure that the police are informed. Firemen's training does not cover the procedures required to detect low levels of contamination or minute leakages of radioactive substances, and the equipment held by brigades may not be able to detect certain types of radioactivity. The decision to declare an area safe for the general public should be left to suitably qualified persons. Because of the potential dangers involved in an escape of radioactive material, those responsible for the NAIR scheme accept that it should be activated whenever an escape of radioactive material is suspected.

Index

Structure and publishing history of the *Manual of Firemanship*

The *Manual of Firemanship* was first published in a series of nine 'Parts' (1–5, 6a, 6b, 6c, and 7) between 1943 and 1962.

In July 1974, it was decided that these nine Parts should be gradually replaced by 18 'Books' and a revised format for the *Manual* was drawn up. The new Books were to up-date the information given and arrange the subjects covered in more compact and coherent groups, each group occupying one of the new Books. The following pages show the original plan, *as amended to date*. Book 4 is the twelfth of these Books to be published.

Since 1974 there have been many developments in Fire Brigade practice and equipment and in the problems which firemen may have to face. To remain an authoritative and up-to-date survey of the science of firefighting the *Manual* must take these developments into account. Not all the necessary changes can be accommodated within the format announced in 1974. The reader should therefore be aware that the structure of unpublished Books of the Manual, as set out on the following pages is subject to change. Such changes will be publicised as far in advance as possible.

The next Book planned for publication is the second edition of Book 7 which will include a Part on 'Pumps, primers and pump operating'.

Manual of Firemanship

Book 1 Elements of combustion and extinction (published in 1974)

Part	Formerly Part	Chapter
1 Physics of combustion	1	1
2 Chemistry of combustion	1	1
3 Methods of extinguishing fire	1 and 2	
	6a	32(III)

Book 2 Fire Brigade equipment (published in 1974)

Part	Formerly Part	Chapter
1 Hose	1	4
2 Hose fittings	1	5
3 Ropes and lines, knots, slings, etc.	1 and	7
	6a	39
4 Small gear	1	13

Book 3 Hand pumps, extinguishers and foam equipment (published in 1988)

Part	Formerly Part	Chapter
1 Hand-operated pumps	1	8
2 Portable fire extinguishers and fire blankets	1	9
3 Foam and foam making equipment	1	10

Book 4 Incidents involving aircraft, shipping and railways (published in 1985)

Part	Information available in Part	Chapter	Last edition
1 Incidents involving aircraft	6b	4	1973
2 Incidents involving shipping	7	1–3	1972
3 Incidents involving railways	6b	3	1973

Book 5 Ladders and appliances (published in 1984)

Part	Formerly Part	Chapter
1 Extension ladders, hook ladders and roof ladders	1	6
2 Escapes	2	3
3 Turntable ladders	2	4
4 Hydraulic platforms	2	5
5 Special appliances	2	6
6 Pumping appliances	2	1

Book 6 Breathing apparatus and resuscitation (published in 1974)

Part	Formerly Part	Chapter
1 Breathing apparatus	1	11
2 Operational procedure	6a	32(V)
3 Resuscitation	1	12

Book 7 (first edition) Hydraulics and water supplies (published in 1975)

Part	Formerly Part	Chapter
1 Hydraulics	3	19
2 Hydrants and water supplies	3	20
3 Water relaying	3	21
Appendices		

Book 7 (second edition) (not yet published)

	Formerly Part	Chapter
Parts 1 & 2 as above plus		
3 Pumps, primers and pump operating	2	1–2
4 Water relaying	3	21
Appendices		

Book 8 Building construction and structural fire protection (published in 1975)

Part	Formerly Part	Chapter
1 Materials	4	23
2 Elements of structure	4	23
3 Building design	4	23

Book 9 Fire protection of buildings (published in 1977)

Part	Formerly Part	Chapter
1 Fire extinguishing systems	4	24/26
2 Fire alarm systems	5	28
3 Fire venting systems	4	23

Book 10 Fire Brigade communications (published in 1978)

Part	Formerly Part	Chapter
1 The public telephone system and its relationship to the Fire Service	5	27
2 Mobilising arrangements	5	29
3 Call-out and remote control systems	5	30
4 Radio	5	31
5 Automatic fire alarm signalling systems	5	28

Book 11 Practical firemanship I (published in 1981)

Part	Formerly Part	Chapter
1 Practical firefighting	6a	32
2 Methods of entry into buildings	6a	35
3 Control at a fire	6a	33

Book 12 Practical firemanship II (published in 1983)	*Formerly*	
Part	*Part*	*Chapter*
1 Fire Service rescues	*6a*	*36*
2 Decontamination	—	—
3 Ventilation at fires	*6a*	*37*
4 Salvage	*6a*	*38*
5 After the incident	*6a*	*34*

Book 13
Contents not yet decided

Book 14 Special fires I (not yet published)	*Information available in*		
Part	*Part*	*Chapter*	*Last edition*
1 Fires in animal and vegetable oils	*6c*	*45(8)*	*1970*
2 Fires in fats and waxes	*6c*	*45(3)*	*1970*
3 Fires in resins and gums	*6c*	*45(13)*	*1970*
4 Fires in grain, hops, etc.	*6c*	*45(6)*	*1970*
5 Fires in fibrous materials	*6c*	*45(4)*	*1970*
6 Fires in sugar	*6c*	*45(15)*	*1970*
7 Fires in paint and varnishes	*6c*	*45(9)*	*1970*

Book 15 Special fires II (not yet published)	*Information available in*		
Part	*Part*	*Chapter*	*Last edition*
1 Fires in dusts	*6c*	*45(1)*	*1970*
2 Fires in explosives	*6c*	*45(2)*	*1970*
3 Fires in metals	*6c*	*45(7)*	*1970*
4 Fires in plastics	*6c*	*45(10)*	*1970*
5 Fires involving radioactive materials	*6c and*	*45(11)*	*1970*
	6a	*33(VI)*	*1971*
6 Fires in refrigeration plant	*6c*	*45(12)*	*1970*
7 Fires in rubber	*6c*	*45(14)*	*1970*

Book 16 Special fires III (not yet published)	*Information available in*		
Part	*Part*	*Chapter*	*Last edition*
1 Fires in rural areas	*6b*	*1*	*1973*
2 Fires in electricity undertakings	*6b*	*3*	*1973*

Book 17 Special fires IV (not yet published)	*Information available in*		
Part	*Part*	*Chapter*	*Last edition*
1 Fires in fuels	*6c*	*45(5)*	*1970*
2 Fires in oil refineries	*6b*	*5*	*1973*
3 Fires in gas works	*6b*	*2*	*1973*

Book 18
Contents not yet decided

Printed in the United Kingdom for HMSO
Dd293603 10/90 C30 G443 10170

HMSO

HMSO publications are available from:

HMSO Publications Centre
(Mail and telephone orders only)
PO Box 276, London, SW8 5DT
Telephone orders 071-873 9090
General enquiries 071-873 0011
(queuing system in operation for both numbers)

HMSO Bookshops
49 High Holborn, London, WC1V 6HB 071-873 0011 (counter service only)
258 Broad Street, Birmingham, B1 2HE 021-643 3740
Southey House, 33 Wine Street, Bristol, BS1 2BQ (0272) 264306
9-21 Princess Street, Manchester, M60 8AS 061-834 7201
80 Chichester Street, Belfast, BT1 4JY (0232) 238451
71 Lothian Road, Edinburgh, EH3 9AZ 031-228 4181

HMSO's Accredited Agents
(see Yellow Pages)

and through good booksellers

ISBN 0-11-340584-7

9 780113 405848

HMSO PRICE CODE BH