

ISGOTT

International Safety Guide for Oil Tankers and Terminals

Fifth Edition

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OIL COMPANIES INTERNATIONAL MARINE FORUM
INTERNATIONAL ASSOCIATION OF PORTS AND HARBORS

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The International Chamber of Shipping (ICS) is a voluntary organisation comprising national shipowners' associations. It represents approximately two thirds of the world's merchant tonnage. Established in 1921, ICS is the trade association for the shipping industry, its interests covering all aspects of maritime affairs, particularly marine safety, ship design and construction, pollution prevention and maritime law. ICS has consultative status with several inter-governmental organisations, including the International Maritime Organization.



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The International Association of Ports and Harbors (IAPH) is a voluntary world-wide association of port authorities, founded in 1955. Current membership includes 219 regular and 138 associate members encompassing 87 countries. IAPH is committed to the exchange and promotion of ideas and technical knowledge on issues of concern to those who work in ports and related industries. Its consultative status with UN and other organisations, including IMO, is a positive benefit in this regard.

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FOREWORD

One of the main functions of the international associations that have prepared this publication is to represent the industry's interests at regulatory bodies such as the International Maritime Organization (IMO). The International Chamber of Shipping (ICS), the Oil Companies International Marine Forum (OCIMF) and the International Association of Ports and Harbors (IAPH) all contribute significantly to the work of IMO through their active participation in IMO meetings.

IMO provides the forum for developing and adopting and, thereafter, reviewing and updating, as may be necessary, the world-wide regulatory framework within which shipping operates. In the years since the adoption by IMO of the SOLAS and MARPOL Conventions, the safety and security record and the environmental performance of the tanker industry has improved considerably. Such an improvement, however, cannot be brought about by regulation alone; it is also testimony to the good practices adopted and constantly refined by industry, and the dedication to safety and environmental protection of the people it employs. This commitment to continuous improvement, a concept embraced by the IMO International Safety Management (ISM) Code, is demonstrated by the industry's efforts to keep the *International Safety Guide for Oil Tankers and Terminals* – or ISGOTT, as it is widely known within the tanker industry – updated.

It therefore gives me great pleasure to introduce this revised edition of the Guide. For many years, IMO has recognized ISGOTT as one of the principal industry reference manuals on the safe operation of oil tankers and the terminals that serve them, and it is referred to in many IMO regulations and recommendations.

This new, fifth edition continues to provide best known safety practices on the operation of oil tankers and terminals but now also embraces a risk based control philosophy. By enhancing risk awareness, ISGOTT now seeks to foster an environment where the uncertainties associated with some shipboard operations are reduced not solely by prescription, but also by encouraging seafarers and their employers to identify the risks in everything they are doing and to then implement fit-for-purpose risk reduction measures. This puts the focus back on people and is, therefore, entirely consistent with the ISM Code and IMO's strategy related to the human element.

I am confident that this new edition of ISGOTT will not only contribute to the further improvement of the tanker industry's excellent safety record but will also bring us closer to the goal of zero accidents to which we all aspire. I, therefore, commend it to all interested parties.

Efthimios E. Mitropoulos
Secretary-General
International Maritime Organization

INTRODUCTION TO THE FIFTH EDITION

Safety is critical to the tanker industry. *The International Safety Guide for Oil Tankers and Terminals* (ISGOTT) has become the standard reference work on the safe operation of oil tankers and the terminals they serve. To remain so, the Guide must keep abreast of changes in ship design and operating practice, and reflect the latest technology and legislation.

In this text, the Fifth Edition, account has been taken of latest thinking on a number of issues including the generation of static electricity and stray currents; the use of mobile telephones and pagers, which are now ever present; the use of new materials for mooring lines and emergency towing-off pennants; the toxicity and the toxic effects of benzene and hydrogen sulphide; and, importantly, the introduction of the principles underlying the *International Safety Management (ISM) Code* and the *International Ship and Port Facility Security (ISPS) Code*. The Ship/Shore Safety Check-List has been completely revised to better reflect the individual and joint responsibilities of the tanker and the terminal.

The Guide is now divided into four sections: "General Information"; "Tanker Information"; "Terminal Information" and the "Management of the Tanker and Terminal Interface". Care has been taken to ensure that, where the guidance given in previous editions was still relevant and accurate, it has not been changed or deleted in moving to the new format.

The authors believe that ISGOTT continues to provide the best technical guidance on tanker and terminal operations. All operators are urged to ensure that the recommendations in this Guide are not only read and fully understood, but also followed.

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PURPOSE AND SCOPE

This Guide makes recommendations for tanker and terminal personnel on the safe carriage and handling of crude oil and petroleum products on tankers and at terminals. It was first published in 1978 by combining the contents of the *'Tanker Safety Guide (Petroleum)'* published by the International Chamber of Shipping (ICS) and the *'International Oil Tanker and Terminal Safety Guide'* published on behalf of the Oil Companies International Marine Forum (OCIMF). In producing this Fifth Edition, the content has again been reviewed by these organisations, together with the International Association of Ports and Harbors (IAPH), to ensure that it continues to reflect current best practice and legislation. Increasing the amount of information on terminal safety systems and activities has extended the scope. This has been achieved, in part, by incorporating information from the OCIMF publication *'Guide on Marine Terminal Fire Protection and Emergency Evacuation'*.

This latest edition takes account of recent changes in recommended operating procedures, particularly those prompted by the introduction of the *International Safety Management (ISM) Code*, which became mandatory for tankers on 1st July 1998. One of the purposes of the Guide is to provide information that will assist companies in the development of a Safety Management System to meet the requirements of the ISM Code.

The purpose of the Guide is also to provide operational advice to assist personnel directly involved in tanker and terminal operations. It does not provide a definitive description of how tanker and terminal operations are conducted. It does, however, provide guidance on, and examples of, certain aspects of tanker and terminal operations and how they may be managed. Effective management of risk demands processes and controls that can quickly adapt to change. Therefore, the guidance given is, in many cases, intentionally non-prescriptive and alternative procedures may be adopted by some operators in the management of their operations. These alternative procedures may exceed the recommendations contained in this Guide.

When adopting alternative procedures, operators should follow a risk based management process that incorporates systems for identifying and assessing the risks and for demonstrating how they are managed. For shipboard operations, this course of action must satisfy the requirements of the ISM Code.

It should be borne in mind that, in all cases, the advice given in the Guide is subject to any local or national terminal regulations that may be applicable, and those concerned should ensure that they are aware of any such requirements.

It is recommended that a copy of the Guide be kept and used on board every tanker and in every terminal to provide advice on operational procedures and the shared responsibility for operations at the ship/shore interface.

Certain subjects are dealt with in greater detail in other publications issued by IMO, ICS or OCIMF or by other maritime industry organisations. Where this is the case, an appropriate reference is made, and a list of these publications is given in the bibliography.

It is not the purpose of the Guide to make recommendations on design or construction of tankers. Information on these matters may be obtained from national authorities and from authorised bodies such as classification societies. Similarly, the Guide does not attempt to deal with certain other safety related matters, e.g. navigation, helicopter operations and shipyard safety, although some aspects are inevitably touched upon.

It should also be noted that the Guide does not relate to cargoes other than crude oil and petroleum products that are carried in oil tankers, chemical tankers, gas carriers and combination carriers certified for the carriage of petroleum products. Therefore, it does not cover the carriage of chemicals or liquefied gases, which are the subject of other industry guides.

Finally, the Guide is not intended to encompass offshore facilities including Floating Production Storage and Offloading Units (FPSOs) and Floating Storage Units (FSUs); operators of such units may, however, wish to consider the guidance given to the extent that good tanker practice is equally applicable to their operations.

Comments and suggestions for improvement are always welcome for possible inclusion in future editions. They may be addressed to any of the three sponsoring organisations as follows:

International Chamber of Shipping
12 Carthusian Street
London EC1M 6EZ
United Kingdom
www.marisec.org

Oil Companies International Marine Forum
27 Queen Anne's Gate
London SW1H 9BU
United Kingdom
www.ocimf.com

International Association of Ports and Harbors
7th Floor, South Tower
New Pier Takeshiba
1-16-1, Kaigan
Minato-ku
Tokyo 105-0022
Japan
www.iaphworldports.org

BIBLIOGRAPHY

The following publications are referred to within this Guide and should be consulted as appropriate for additional information.

IMO	BCH Code – Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk
BSI	Circular Flanges for Pipes, Valves and Fittings (Class Designated). Steel, Cast Iron and Copper Alloy Flanges. Specification for Steel Flanges (BS 1560. 3-1)
UK MCA	Code of Safe Working Practices for Merchant Seamen
IMO	Crude Oil Washing Systems
ICS	Drug Trafficking and Drug Abuse: Guidelines for Owners and Masters on Prevention, Detection and Recognition
OCIMF	Effective Mooring
IEC	Electrical Apparatus for Explosive Gas Atmospheres – Part 10: Classification of Hazardous Areas (IEC 60079-10)
IEC	Electrical Installations in Ships – Part 502: Tankers – Special Features (IEC 60092-502)
CENELEC	Electrostatics – Code of Practice for the Avoidance of Hazards Due to Static Electricity (Technical Report CLC/TR 50404)
IMO	Emergency Procedures for Ships Carrying Dangerous Goods – Group Emergency Schedules
ICS	Guide to Helicopter/Ship Operations
OCIMF	Guide to Purchasing, Manufacturing and Testing of Loading and Discharge Hoses for Offshore Moorings
IMO	Guidelines on Fatigue
OCIMF	Guidelines for the Handling, Storage, Inspection and Testing of Hoses in the Field
IMO	Guidelines for Inert Gas Systems
IMO	Guidelines for Maintenance and Monitoring of Onboard Materials Containing Asbestos (MSC/Circ.1045, 28 May 2002)
OCIMF	Guidelines for the Control of Drugs and Alcohol Onboard Ship
ICS	Guidelines for the Preparation of Garbage Management Plans
ISF	Guidelines on Good Employment Practice
IMO	Guidelines on Maintenance and Inspection of Fire Protection Systems and Appliances (MSC/Circ.850, 8 June 1998)
ICS/ISF	Guidelines on the Application of the IMO ISM Code
OCIMF	Guidelines on the Use of High Modulus Synthetic Fibre Ropes as Mooring Lines on Large Tankers
OCIMF	Health, Safety and Environment at New-building and Repair Shipyards and During Factory Acceptance Testing
IMO	IBC Code – International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk

IMO	IMDG Code – the International Maritime Dangerous Goods Code
IMO	International Safety Management (ISM) Code and Guidelines on Implementation of the ISM Code
IMO	ISPS – International Ship and Port Facility Security Code
OCIMF	Marine Terminal Baseline Criteria and Assessment Questionnaire
OCIMF	Marine Terminal Training and Competence Assessment Guidelines for Oil and Petroleum Product Terminals
IMO	MARPOL 73/78 – International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978
ICS/ INTERTANKO	Model Ballast Water Management Plan
ICS	Model Ship Security Plan
OCIMF	Mooring Equipment Guidelines
ICS/OCIMF	Prevention of Oil Spillages Through Cargo Pumproom Sea Valves
IMO	Principles for Hot Work Onboard all Types of Ships (MSC/Circ. 1084, 13 June 2003)
OCIMF	Recommendations for Equipment Employed in the Mooring of Ships at Single Point Moorings
IMO	Recommendations for Material Safety Data Sheets for MARPOL Annex 1 Cargoes and Marine Fuel Oils (MSC Res.150(77))
OCIMF	Recommendations for Oil Tanker Manifolds and Associated Equipment
IMO	Recommendations on the Safe Transport of Dangerous Cargoes and Related Activities in Port Areas
IMO	Recommended Procedures to Prevent the Illegal or Accidental Use of Low Flashpoint Cargo Oil as Fuel (A.565(14))
IMO	Revised Minimum Safety Standards for Ships Carrying Liquids in Bulk Containing Benzene (MSC/Circ.1095, 18 June 2003)
BSI	Rubber Hose Assemblies for Oil Suction and Discharge Services – Recommendations for Storage, Testing and Use (BS 1435)
BSI	Rubber Hose Assemblies for Oil Suction and Discharge Services – Specification of the Assemblies (BS EN 1765)
ICS/OCIMF	Ship-to-Ship Transfer Guide (Liquefied Gas)
ICS/OCIMF	Ship-to-Ship Transfer Guide (Petroleum)
OCIMF	Single Point Mooring Maintenance and Operations Guide
IMO	SOLAS 74/88 – International Convention for the Safety of Life at Sea, 1974 and 1988 Protocol, as amended
OCIMF	SPM Hose System Design Commentary
IMO	Standards for Vapour Emission Control Systems (MSC/Circ.585, 16 April 1992)
IMO	STCW – International Convention on Training, Certification and Watchkeeping for Seafarers, 1978
ICS	Tanker Safety Guide (Chemicals)

Details of these and other publications are available from the following internet web sites:

IMO	www.imo.org
IAPH	www.iaphworldports.org
ICS	www.marisec.org
OCIMF	www.ocimf.com

DEFINITIONS

For the purpose of this Guide, the following definitions apply:

Administration

Means the government of the state whose flag the ship is entitled to fly.

ALARP

As low as reasonably practicable.

Antistatic additive

A substance added to a petroleum product to raise its electrical conductivity to a safe level above 50 picoSiemens/metre (pS/m) to prevent accumulation of static electricity.

Approved equipment

Equipment of a design that has been tested and approved by an appropriate authority, such as a government department or classification society. The authority should have certified the equipment as safe for use in a specified hazardous or dangerous area.

Auto-ignition

The ignition of a combustible material without initiation by a spark or flame, when the material has been raised to a temperature at which self-sustaining combustion occurs.

Bonding

The connecting together of metal parts to ensure electrical continuity.

Cathodic protection

The prevention of corrosion by electrochemical techniques. On tankers, it may be applied either externally to the hull or internally to the surfaces of tanks. At terminals, it is frequently applied to steel piles and fender panels.

Clingage

Oil remaining on the walls of a pipe or on the internal surfaces of tanks after the bulk of the oil has been removed.

Closed operations

Ballasting, loading or discharging operations carried out without recourse to opening ullage and sighting ports. During closed operations, ships will require the means to enable closed monitoring of tank contents, either by a fixed gauging system or by using portable equipment passed through a vapour lock.

Cold Work

Work that cannot create a source of ignition.

Combination carrier (also referred to as Oil/Bulk/Ore (OBO), Oil/Ore (O/O))

A ship that is designed to carry either a petroleum cargo or a dry bulk cargo on separate voyages.

Combustible (also referred to as 'Flammable')

Capable of being ignited and of burning. For the purposes of this Guide, the terms 'combustible' and 'flammable' are synonymous.

Combustible gas indicator (also referred to as 'Explosimeter')

An instrument for measuring the composition of hydrocarbon gas/air mixtures, usually giving the result as a percentage of the Lower Flammable Limit (LFL).

Company

The owner of a ship or any other organisation or person, such as the manager or the bareboat charterer, who has assumed the responsibility for the operation of the ship from the owner of the ship, including the duties and responsibilities imposed by the ISM Code.

Competent person

A person who has been adequately trained to undertake the tasks they are required to perform within their job description. For personnel in the shipping industry, they should be able to demonstrate this competence by the production of certificates recognised by the ship's administration.

Dangerous area

An area on a tanker which, for the purposes of the installation and use of electrical equipment, is regarded as dangerous. (For terminal, see 'Hazardous area'.)

Dry chemical powder

A flame inhibiting powder used in fire-fighting.

Earthing (also referred to as 'Grounding')

The electrical connection of equipment to the main body of the 'earth' to ensure that it is at earth potential. On board ship, the connection is made to the main metallic structure of the ship, which is at earth potential because of the conductivity of the sea.

Enclosed space

A space that has limited openings for entry and exit, unfavourable natural ventilation, and that is not designed for continuous worker occupancy.

This includes cargo spaces, double bottoms, fuel tanks, ballast tanks, pump rooms, cofferdams, void spaces, duct keels, inter-barrier spaces, engine crankcases and sewage tanks.

Entry permit

A document issued by a Responsible Person allowing entry into a space or compartment during a specific time interval.

Explosimeter

See 'Combustible gas indicator'.

Explosion-proof (also referred to as 'Flame-proof')

Electrical equipment is defined and certified as explosion-proof when it is enclosed in a case that is capable of withstanding the explosion within it of a hydrocarbon gas/air mixture or other specified flammable gas mixture. It must also prevent the ignition of such a mixture outside the case either by spark or flame from the internal explosion or as a result of the temperature rise of the case following the internal explosion. The equipment must operate at such an external temperature that a surrounding flammable atmosphere will not be ignited.

Explosive range

See 'Flammable range'.

Flame arrester

A permeable matrix of metal, ceramic or other heat-resisting materials which can cool even an intense flame, and any following combustion products, below the temperature required for the ignition of the flammable gas on the other side of the arrester.

Flame-proof

See 'Explosion-proof'.

Flame screen

A portable or fitted device incorporating one or more corrosion resistant wire-woven fabrics of very small mesh, which is used for preventing sparks from entering a tank or vent opening or, for a short time, preventing the passage of flame. (Not to be confused with 'Flame arrester'.)

Flammable (also referred to as 'Combustible')

Capable of being ignited and of burning. For the purposes of this Guide, the terms 'flammable' and 'combustible' are synonymous.

Flammable range (also referred to as 'Explosive range')

The range of hydrocarbon gas concentrations in air between the Lower and Upper Flammable (explosive) Limits. Mixtures within this range are capable of being ignited and of burning.

Flashlight

See 'Torch'.

Flashpoint

The lowest temperature at which a liquid gives off sufficient gas to form a flammable gas mixture near the surface of the liquid. It is measured in a laboratory in standard apparatus using a prescribed procedure.

Flow rate

The linear velocity of flow of liquid in a pipeline, usually measured in metres per second (m/s). The determination of the flow rates at locations within cargo pipeline systems is essential when handling static accumulator cargoes.

Foam (also referred to as 'Froth')

An aerated solution that is used for fire prevention and fire-fighting.

Foam concentrate (also referred to as 'Foam compound')

The full strength liquid received from the supplier which is diluted and processed to produce foam.

Foam solution

The mixture produced by diluting foam concentrate with water before processing to make foam.

Free fall

The unrestricted fall of liquid into a tank.

From the top, or Overall

See 'Loading over the top'.

Froth

See 'Foam'.

Gas free

A tank, compartment or container is gas free when sufficient fresh air has been introduced into it to lower the level of any flammable, toxic or inert gas to that required for a specific purpose, e.g. Hot Work, entry etc.

Gas free certificate

A certificate issued by an authorised Responsible Person confirming that, at the time of testing, a tank, compartment or container was gas free for a specific purpose.

Grounding

See 'Earthing'.

Halon

A halogenated hydrocarbon used in fire-fighting that inhibits flame propagation.

Hazardous area

An area on shore which, for the purposes of the installation and use of electrical equipment, is regarded as dangerous. Such hazardous areas are graded into hazardous zones depending upon the probability of the presence of a flammable gas mixture. (For ships, see 'Dangerous area'.)

Hazardous task

A task other than Hot Work which presents a hazard to the ship, terminal or personnel, the performance of which needs to be controlled by a risk assessment process such as a Permit to Work system or a controlled procedure.

Hazardous zone

See 'Hazardous area'.

Hot Work

Work involving sources of ignition or temperatures sufficiently high to cause the ignition of a flammable gas mixture. This includes any work requiring the use of welding, burning or soldering equipment, blow torches, some power driven tools, portable electrical equipment which is not intrinsically safe or contained within an approved explosion-proof housing, and internal combustion engines.

Hot Work Permit

A document issued by a Responsible Person permitting specific Hot Work to be done during a particular time interval in a defined area.

Hydrocarbon gas

A gas composed entirely of hydrocarbons.

Inert condition

A condition in which the oxygen content throughout the atmosphere of a tank has been reduced to 8 per cent or less by volume by the addition of inert gas.

Inert gas

A gas or a mixture of gases, such as flue gas, containing insufficient oxygen to support the combustion of hydrocarbons.

Inert gas plant

All equipment fitted to supply, cool, clean, pressurise, monitor and control the delivery of inert gas to the cargo tank systems.

Inert Gas System (IGS)

An inert gas plant and inert gas distribution system together with means for preventing backflow of cargo gases to the machinery spaces, fixed and portable measuring instruments and control devices.

Inerting

The introduction of inert gas into a tank with the object of attaining the inert condition.

Insulating flange

A flanged joint incorporating an insulating gasket, sleeves and washers to prevent electrical continuity between ship and shore.

Interface detector

An electrical instrument for detecting the boundary between oil and water.

International Safety Management (ISM) Code

An international standard for the safe management and operation of ships and for pollution prevention. The Code establishes safety management objectives and requires a Safety Management System (SMS) to be established by the Company and audited and approved by the flag administration.

Intrinsically safe

An electrical circuit, or part of a circuit, is intrinsically safe if any spark or thermal effect produced normally (i.e. by breaking or closing the circuit) or accidentally (e.g. by short circuit or earth fault) is incapable, under prescribed test conditions, of igniting a prescribed gas mixture.

Loading over the top (also referred to as 'Loading overall')

The loading of cargo or ballast through an open-ended pipe or by means of an open-ended hose entering a tank through a deck opening, resulting in the free fall of liquid.

Loading rate

The volumetric measure of liquid loaded within a given period, usually expressed as cubic metres per hour (m³/hr) or barrels per hour (bbls/hr).

Lower Flammable Limit (LFL)

The concentration of a hydrocarbon gas in air below which there is insufficient hydrocarbon to support and propagate combustion. Sometimes referred to as Lower Explosive Limit (LEL).

Material Safety Data Sheet (MSDS)

A document identifying a substance and all its constituents. It provides the recipient with all necessary information to manage the substance safely. The format and content of an MSDS for MARPOL Annex I cargoes and Marine Fuel Oils are prescribed in IMO Resolution MSC.150(77).

Mercaptans

A group of naturally occurring organic chemicals containing sulphur. They are present in some crude oils and in pentane plus cargoes. They have a strong odour.

Naked lights

Open flames or fires, lighted cigarettes, cigars, pipes or similar smoking materials, any other unconfined sources of ignition, electrical and other equipment liable to cause sparking while in use, unprotected light bulbs or any surface with a temperature that is equal to or higher than the auto-ignition temperature of the products handled in the operation.

Non-volatile petroleum

Petroleum having a flashpoint of 60°C or above, as determined by the closed cup method of test.

Odour threshold

The lowest concentration of vapour in air that can be detected by smell.

Oil/Bulk/Ore (OBO), Oil/Ore (O/O)

See 'Combination carrier'.

Oxygen analyser or oxygen meter

An instrument for determining the percentage of oxygen in a sample of the atmosphere drawn from a tank, pipe or compartment.

Packaged cargo

Petroleum or other cargo in drums, packages or other containers.

Pellistor

An electrical sensor unit fitted in a flammable gas detector for measuring hydrocarbon vapours and air mixtures to determine whether the mixture is within the flammable range.

Permit (to work)

A document issued by a Responsible Person which allows work to be performed in compliance with the ship's Safety Management System.

Permit to Work system

A system for controlling activities that expose the ship, the terminal, personnel or the environment to hazard. The system will provide risk assessment techniques and apply them to the varying levels of risk that may be experienced. The system should conform to a recognised industry guideline.

Petroleum

Crude oil and liquid hydrocarbon products derived from it.

Petroleum gas

A gas evolved from petroleum. The main constituents of petroleum gases are hydrocarbons, but they may also contain other substances, such as hydrogen sulphide or lead alkyls, as minor constituents.

Phase of oil

Oil is considered to have three phases in which it can exist depending on the grade of oil and its temperature. The three phases are the solid phase, the liquid phase and the vapour phase. The phases do not exist in isolation and operators must manage the carriage of oil with an understanding of the combinations of the phases of oil in the cargo being carried.

Pour point

The lowest temperature at which a petroleum oil will remain fluid.

Pressure surge

A sudden increase in the pressure of the liquid in a pipeline brought about by an abrupt change in flow rate.

Pressure/vacuum relief valve (P/V valve)

A device that provides for the flow of the small volumes of vapour, air or inert gas mixtures caused by thermal variations in a cargo tank.

Pump purging

The operation of clearing liquid from submerged pumps.

Purging

The introduction of inert gas into a tank already in the inert condition with the object of further reducing the existing oxygen content and/or reducing the existing hydrocarbon gas content to a level below which combustion cannot be supported if air is subsequently introduced into the tank.

Pyrophoric iron sulphide

Iron sulphide capable of a rapid exothermic oxidation causing incandescence when exposed to air and potential ignition of flammable hydrocarbon gas/air mixtures.

Reid Vapour Pressure (RVP)

The vapour pressure of a liquid determined in a standard manner in the Reid apparatus at a temperature of 37.8°C and with a ratio of gas to liquid volume of 4:1. Used for comparison purposes only. See 'True Vapour Pressure'.

Relaxation time

The time taken for an electrostatic charge to relax or dissipate from a liquid. This time is typically half a minute for static accumulator liquids. Not to be confused with 'Settling time' – see definition.

Responsible Officer (or Person)

A person appointed by the Company or the Master of the ship and empowered to take all decisions relating to a specific task, and having the necessary knowledge and experience for that purpose.

Resuscitator

Equipment to assist or restore the breathing of personnel overcome by gas or lack of oxygen.

Safety Management System (SMS)

A formal, documented system required by the ISM Code, compliance with which should ensure that all operations and activities on board a ship are carried out in a safe manner.

Self-stowing mooring winch

A mooring winch fitted with a drum on which a mooring wire or rope is made fast and automatically stowed.

Settling time

The time it takes for tank contents to stop moving once filling has stopped, and therefore the cessation of further static electricity generation. Typically, this time is 30 minutes. Not to be confused with 'Relaxation time' – see definition.

SOLAS

The International Convention for the Safety of Life at Sea 1974 and its Protocol of 1988, as amended.

Sounding pipe

A pipe extending from the top of the tank to the bottom through which the contents of the tank can be measured. The pipe is usually perforated to ensure the level of liquid in the pipe is the same as the level of liquid in the body of the tank and to prevent the possibility of spillages. The pipe should be electrically bonded to the ship's structure at the deck and at its lower end.

Sour crude oil or products

A term used to describe crude oil or products containing appreciable amounts of hydrogen sulphide and/or mercaptans.

Spiked crude oil

A crude oil blended with a liquefied gas or condensate.

Spontaneous combustion

The ignition of material brought about by a heat producing (exothermic) chemical reaction within the material itself without exposure to an external source of ignition.

Spread loading

The practice of loading a number of tanks simultaneously to avoid static electricity generation when loading static accumulator cargoes.

Static accumulator oil

An oil with an electrical conductivity of less than 50 picoSiemens/metre (pS/m), so that it is capable of retaining a significant electrostatic charge.

Static electricity

The electricity produced by movement between dissimilar materials through physical contact and separation.

Static non-accumulator oil

An oil with an electrical conductivity greater than 50 picoSiemens/metre (pS/m), so that it is incapable of retaining a significant electrostatic charge.

Stripping

The final operation in draining liquid from a tank or pipeline.

Tank cleaning

The process of removing hydrocarbon vapours, liquid or residue from tanks. Usually carried out so that tanks can be entered for inspection or Hot Work or to avoid contamination between grades.

Tanker

A ship designed to carry liquid petroleum cargo in bulk, including a combination carrier when being used for this purpose.

Tension winch (automated or self-tensioning mooring system)

A mooring winch fitted with a device that may be set to maintain the tension on a mooring line automatically.

Terminal

A place where tankers are berthed or moored for the purpose of loading or discharging petroleum cargo.

Terminal Representative

A person designated by the terminal to take responsibility for an operation or duty.

Threshold Limit Value (TLV)

Airborne concentrations of substances under which it is believed that nearly all workers may be exposed day after day with no adverse effect. TLVs are advisory exposure guidelines, not legal standards, and are based on industrial experience and studies. There are three different types of TLVs:

- **Time Weighted Average (TLV-TWA)** – The airborne concentration of a toxic substance averaged over an 8 hour period, usually expressed in parts per million (ppm).
- **Short Term Exposure Limit (TLV-STEL)** – The airborne concentration of a toxic substance averaged over any 15 minute period, usually expressed in parts per million (ppm).
- **Ceiling (TLV-C)** – The concentration that should not be exceeded during any part of the working exposure.

Topping-off

The operation of completing the loading of a tank to a required ullage.

Topping-up

The introduction of inert gas into a tank that is already in the inert condition with the object of raising the tank pressure to prevent any ingress of air.

Torch (also referred to as 'Flashlight')

A battery operated hand lamp. An approved torch is one that is approved by a competent authority for use in a flammable atmosphere.

Toxicity

The degree to which a substance or mixture of substances can harm humans or animals.

'Acute toxicity' involves harmful effects to an organism through a single short term exposure.

'Chronic toxicity' is the ability of a substance or mixture of substances to cause harmful effects over an extended period, usually upon repeated or continuous exposure, sometimes lasting for the entire life of the exposed organism.

True Vapour Pressure (TVP)

The absolute pressure exerted by the gas produced by evaporation from a liquid when gas and liquid are in equilibrium at the prevailing temperature and the gas liquid ratio is effectively zero. See 'Reid Vapour Pressure'.

Ullage

The space above the liquid in a tank, conventionally measured as the distance from the calibration point to the liquid surface.

Upper Flammable Limit (UFL)

The concentration of a hydrocarbon gas in air above which there is insufficient oxygen to support and propagate combustion. Sometimes referred to as Upper Explosive Limit (UEL).

Vapour

A gas below its critical temperature.

Vapour Emission Control System (VECS)

An arrangement of piping and equipment used to control vapour emissions during tanker operations, including ship and shore vapour collection systems, monitoring and control devices and vapour processing arrangements.

Vapour lock system

Equipment fitted to a tank to enable the measuring and sampling of cargoes without release of vapour or inert gas pressure.

Volatile petroleum

Petroleum having a flashpoint below 60°C as determined by the closed cup method of test.

Water fog

A suspension in the atmosphere of very fine droplets of water usually delivered at a high pressure through a fog nozzle for use in fire-fighting.

Water spray

A spray of water divided into coarse drops by delivery through a special nozzle for use in fire-fighting.

PART 1

GENERAL INFORMATION

BASIC PROPERTIES OF PETROLEUM

This Chapter describes the physical and chemical properties that have the greatest bearing on the hazards arising from handling petroleum liquids. These properties are vapour pressure, the flammability of the gases evolved from the liquids and the density of these gases.

1.1 Vapour Pressure

1.1.1 True Vapour Pressure

All crude oils and the usual petroleum products are essentially mixtures of a wide range of hydrocarbon compounds (i.e. chemical compounds of hydrogen and carbon). The boiling points of these compounds range from -162°C (methane) to well in excess of $+400^{\circ}\text{C}$, and the volatility of any particular mixture of compounds depends primarily on the quantities of the more volatile constituents (i.e. those with a lower boiling point).

The volatility (i.e. the tendency of a crude oil or petroleum product to produce gas) is characterised by the vapour pressure. When a petroleum mixture is transferred to a gas free tank or container, it starts to vaporise, that is it liberates gas into the space above it.

There is also a tendency for this gas to re-dissolve in the liquid, and equilibrium is ultimately reached with a certain amount of gas evenly distributed throughout the space. The pressure exerted by this gas is called the equilibrium vapour pressure of the liquid, usually referred to simply as the vapour pressure.

The vapour pressure of a pure compound depends only upon its temperature. The vapour pressure of a mixture depends on its temperature, constituents and the volume of the gas space in which vaporisation occurs; that is, it depends upon the ratio of gas to liquid by volume.

The True Vapour Pressure (TVP), or bubble point vapour pressure, is the pressure exerted by the gas produced from a mixture when the gas and liquid are in equilibrium at the prevailing temperature. It is the highest vapour pressure that is possible at any specified temperature.

As the temperature of a petroleum mixture increases, its TVP also increases. If the TVP exceeds atmospheric pressure, the liquid starts to boil.

The TVP of a petroleum mixture provides a good indication of its ability to give rise to gas. Unfortunately, this is a property that is extremely difficult to measure, although it can be calculated from a detailed knowledge of the composition of the liquid. For crude oils, it can also be estimated from the stabilisation conditions, making allowance for any subsequent changes of temperature or composition. In the case of products, reliable correlations exist for deriving TVP from the more readily measured Reid Vapour Pressure and temperature.

1.1.2 Reid Vapour Pressure

The Reid Vapour Pressure (RVP) test is a simple and generally used method for measuring the volatility of petroleum liquids. It is conducted in a standard apparatus and in a closely defined way. A sample of the liquid is introduced into the test container at atmospheric pressure, so that the volume of the liquid is one fifth of the total internal volume of the container. The container is sealed and immersed in a water bath where it is heated to 37.8°C. After the container has been shaken to bring about equilibrium conditions rapidly, the rise in pressure due to vaporisation is read on an attached pressure gauge. This pressure gauge reading gives a close approximation, in bars, to the vapour pressure of the liquid at 37.8°C.

RVP is useful for comparing the volatilities of a wide range of petroleum liquids in a general way. It is, however, of little value in itself as a means of estimating the likely gas evolution in specific situations, mainly because the measurement is made at the standard temperature of 37.8°C and at a fixed gas/liquid ratio. For this purpose, TVP is much more useful and, as already mentioned, in some cases correlations exist between TVP, RVP and temperature.

1.2 Flammability

1.2.1 General

In the process of burning, hydrocarbon gases react with the oxygen in the air to produce carbon dioxide and water. The reaction gives sufficient heat to form a flame, which travels through the mixture of hydrocarbon gas and air. When the gas above a liquid hydrocarbon is ignited, the heat produced is usually enough to evaporate sufficient fresh gas to maintain the flame, and the liquid is said to burn. In fact, it is the gas that is burning and is being continuously replenished from the liquid.

1.2.2 Flammable Limits

A mixture of hydrocarbon gas and air cannot be ignited and burned unless its composition lies within a range of gas in air concentrations known as the flammable range. The lower limit of this range, known as the Lower Flammable Limit (LFL), is that hydrocarbon concentration below which there is insufficient hydrocarbon gas to support and propagate combustion. The upper limit of the range, known as the Upper Flammable Limit (UFL), is that hydrocarbon concentration above which there is insufficient air to support and propagate combustion.

The flammable limits vary somewhat for different pure hydrocarbon gases and for the gas mixtures derived from different petroleum liquids. Very roughly, the gas mixtures from crude oils, motor or aviation gasolines and natural gasoline type products can be represented respectively by the pure hydrocarbon gases propane, butane and pentane. Table 1.1 gives the flammable limits for these three gases. It also shows the amount of dilution with air needed to bring a mixture of 50% by volume of each of these gases in air down to its LFL. This type of information is very relevant to the ease with which vapours disperse to a non-flammable concentration in the atmosphere.

In practice, the Lower and Upper Flammable Limits of oil cargoes carried in tankers can, for general purposes, be taken as 1% and 10% by volume respectively.

Gas	Flammable limits % volume hydrocarbon in air		Number of dilutions with same volume of air to reduce a mixture of 50% by volume to LFL
	Upper	Lower	
Propane	9.5	2.2	23
Butane	8.5	1.9	26
Pentane	7.8	1.5	33

Table 1.1 – Flammable limits of propane, butane and pentane

1.2.3 Effect of Inert Gas on Flammability

When an inert gas, typically flue gas, is added to a hydrocarbon gas/air mixture, the result is to increase the Lower Flammable Limit hydrocarbon concentration and to decrease the Upper Flammable Limit concentration. These effects are illustrated in Figure 1.1, which should be regarded only as a guide to the principles involved.

Every point on the diagram represents a hydrocarbon gas/air/inert gas mixture, specified in terms of its hydrocarbon and oxygen content. Hydrocarbon gas/air mixtures without inert gas lie on the line AB, the slope of which reflects the reduction in oxygen content as the hydrocarbon content increases. Points to the left of the line AB represent mixtures with their oxygen content further reduced by the addition of inert gas.

The lower and upper flammability limit mixtures for hydrocarbon gas in air are represented by the points C and D. As the inert gas content increases, the flammable limit mixtures change as indicated by the lines CE and DE, which finally converge at the point E. Only those mixtures represented by points in the shaded area within the loop CED are capable of burning.

On this diagram, changes of composition due to the addition of either air or inert gas are represented by movements along straight lines directed either towards the point A (pure air), or towards a point on the oxygen content axis corresponding to the composition of the added inert gas. Such lines are shown for the gas mixture represented by the point F.

It is evident from Figure 1.1 that, as inert gas is added to hydrocarbon gas/air mixtures, the flammable range progressively decreases until the oxygen content reaches a level, generally taken to be about 11% by volume, when no mixture can burn. The figure of 8% by volume of oxygen, specified in this guide for a safely inerted gas mixture, allows a margin beyond this value.

When an inerted mixture, such as that represented by the point F, is diluted by air, its composition moves along the line FA and therefore enters the shaded area of flammable mixtures. This means that all inerted mixtures in the region above the line GA go through a flammable condition as they are mixed with air, for example, during a gas freeing operation.

Those mixtures below the line GA, such as that represented by point H, do not become flammable on dilution. It should be noted that it is possible to move from a mixture such as F to one such as H by dilution with additional inert gas (i.e. purging to remove hydrocarbon gas).

1.2.4 Tests for Flammability

Since hydrocarbon gas/air mixtures are flammable within a comparatively narrow range of concentrations of hydrocarbon gas in air, and concentration in air is dependent upon vapour pressure, in principle, it should be possible to evolve a test for flammability by measuring vapour pressure. In practice, the very wide range of petroleum products, and the range of temperatures over which they are handled, has prevented the development of one simple test for this purpose.

Instead, the oil industry makes use of two standard methods. One is the Reid Vapour Pressure test (see Section 1.1.2) and the other is the flashpoint test, which measures flammability directly. However, with some residual fuel oils, it has been shown that the flashpoint test will not always provide a direct indication of flammability (see Section 2.7).

1.2.5 Flashpoint

In this test, a sample of the liquid is gradually heated in a special pot and a small flame is repeatedly and momentarily applied to the surface of the liquid. The flashpoint is the lowest liquid temperature at which the small flame initiates a flash of flame across the surface of the liquid, thereby indicating the presence of a flammable gas/air mixture above the liquid. For all oils, except some residual fuel oils, this gas/air mixture corresponds closely to the Lower Flammable Limit mixture.

There are many different forms of flashpoint apparatus but they fall into two classes. In one, the surface of the liquid is permanently open to the atmosphere as the liquid is heated and the result of such a test is known as an 'open cup flashpoint'. In the other class, the space above the liquid is kept closed except for brief moments when the initiating flame is introduced through a small port. The result of this class of test is termed a 'closed cup flashpoint'.

Because of the greater loss of gas to atmosphere in the open cup test, the open cup flashpoint of a petroleum liquid is always a little higher (by about 6°C) than its closed cup flashpoint. The restricted loss of gas in the closed cup apparatus also leads to a much more consistent result than can be obtained in open cup testing. For this reason, the closed cup method is now more generally favoured and is used in this Guide when considering the classification of petroleum. However, open cup test figures may still be found in the legislation of various national administrations, in classification society rules and other such documents.

1.2.6 Flammability Classification of Petroleum

There are many schemes for dividing the complete range of petroleum liquids into different flammability classes based on flashpoint and vapour pressure and there is a considerable variation in these schemes between countries. Usually, the basic principle is to consider whether or not a flammable equilibrium gas/air mixture can be formed in the space above the liquid when the liquid is at ambient temperature.

Generally, in this Guide, it has been sufficient to group petroleum liquids into two categories entitled non-volatile and volatile, defined in terms of flashpoint as follows:

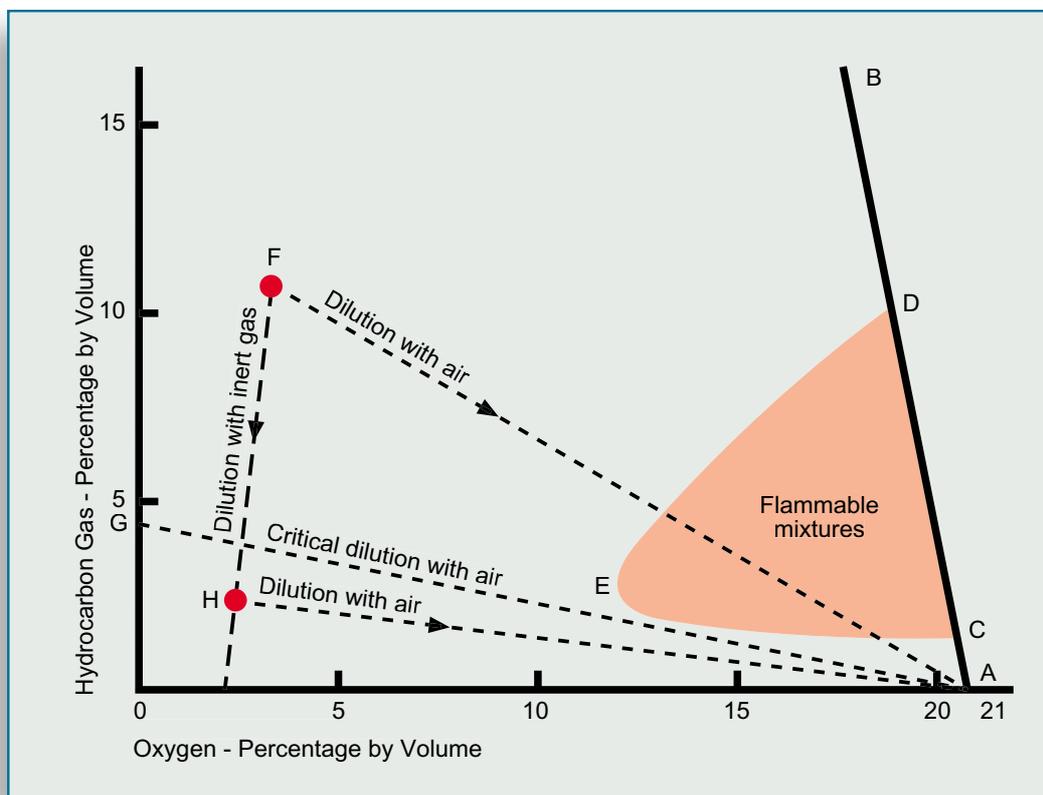


Figure 1.1 – Flammability composition diagram – hydrocarbon gas/air/inert gas mixture

This diagram is illustrative only and should not be used for deciding upon acceptable gas compositions in practical cases.

Non-volatile

Flashpoint of 60°C or above, as determined by the closed cup method of testing. These liquids produce, when at any normal ambient temperature, equilibrium gas concentrations below the Lower Flammable Limit. They include distillate fuel oils, heavy gas oils and diesel oils. Their RVPs are below 0.007 bar and are not usually measured.

Volatile

Flashpoint below 60°C, as determined by the closed cup method of testing. Some petroleum liquids in this category are capable of producing an equilibrium gas/air mixture within the flammable range when in some part of the normal ambient temperature range, while most of the rest give equilibrium gas/air mixtures above the Upper Flammable Limit at all normal ambient temperatures. Examples of the former are jet fuels and kerosenes and, of the latter, gasolines and most crude oils. In practice, gasolines and crude oils are frequently handled before equilibrium conditions have been attained and gas/air mixtures in the flammable range may then be present.

The choice of 60°C as the flashpoint criterion for the division between non-volatile and volatile liquids is to some extent arbitrary. Since less stringent precautions are appropriate for non-volatile liquids, it is essential that under no circumstances is a liquid capable of giving a flammable gas/air mixture ever inadvertently included in the non-volatile category. Therefore, the dividing line must be chosen to make allowance for such factors as the misjudging of the temperature, inaccuracy in the flashpoint measurement and the possibility of minor contamination by more volatile materials. The closed cup flashpoint figure of 60°C makes ample allowances for these factors and is also

compatible with the definitions adopted internationally by IMO and by a number of regulatory bodies throughout the world. (See Section 2.7 for information on the relationship between the flashpoint and flammability of residual fuel oils.)

1.3 Density of Hydrocarbon Gases

The densities of the gas mixtures evolved from the normal petroleum liquids, when undiluted with air, are all greater than the density of air. Layering effects are therefore encountered in cargo handling operations and can give rise to hazardous situations.

Table 1.2 gives gas densities relative to air for the three pure hydrocarbon gases, propane, butane and pentane, which represent roughly the gas mixtures that are produced respectively by crude oils, by motor or aviation gasolines and by natural gasolines. These figures are not significantly changed if inert gas is substituted for air.

Gas	Density relative to air		
	Pure hydrocarbon	50% by volume hydrocarbon/ 50% by volume air	Lower flammable limit mixture
Propane	1.55	1.25	1.0
Butane	2.0	1.5	1.0
Pentane	2.5	1.8	1.0

Table 1.2 – Propane, butane and pentane: densities relative to air

It will be seen that the density of the undiluted gas from a product such as motor gasoline is likely to be about twice that of air, and that from a typical crude oil about 1.5 times. These high densities, and the layering effects that result from them, are only significant while the gas remains concentrated. As it is diluted with air, the density of the gas/air mixture from all three types of cargo approaches that of air and, at the Lower Flammable Limit, is indistinguishable from it.

Chapter 2

HAZARDS OF PETROLEUM

In order to appreciate the reasons for the practices adopted to ensure safety in tanker and terminal operations, all personnel should be familiar with the flammable properties of petroleum, the effects of the density of petroleum gases and their toxic properties. These are fully described in this Chapter.

Specific issues, including the handling of high vapour pressure cargoes, the formation of pyrophoric iron sulphides in cargo tanks, and the particular hazards associated with the handling, storage and carriage of residual fuel oils, are also discussed.

The Chapter also describes the principles, uses and limitations of gas detection equipment and addresses issues relating to gas evolution and dispersion. (Practical guidance for onboard gas testing operations is provided in Chapter 8.)

2.1 Flammability

Flammability is a primary risk in the handling of petroleum; this creates an ever present hazard.

For detailed information on flammability, see Section 1.2.

2.2 Density

The gases from most petroleum liquids are heavier than air and handling of petroleum cargoes should take account of the hazard that this property presents.

Information on the density of hydrocarbon gases is given in Section 1.3.

2.3 Toxicity

2.3.1 Introduction

Toxicity is the degree to which a substance or mixture of substances can harm humans. Toxic means the same as poisonous.

Toxic substances can harm humans in three main ways: by being swallowed (ingestion), through skin contact (absorption), and through the lungs (inhalation). Toxic substances can have local effects, such as skin or eye irritation, but can also affect other, more distant, parts of the body (systemic effects). The purpose of this Section is to describe the adverse effects associated with toxic substances to which personnel engaged in tanker operations are most likely to be exposed, to indicate the concentrations at which those adverse effects are expected to occur in humans through a single

or repeated exposure, and to describe procedures for reducing the risks of such exposure. Although not strictly a matter of toxicity, the effects of oxygen deficiency are also described.

2.3.2 Liquid Petroleum

2.3.2.1 Ingestion

Petroleum has low oral toxicity, but when swallowed it causes acute discomfort and nausea. There is then a possibility that, during vomiting, liquid petroleum may be drawn into the lungs and this can have serious consequences, especially with higher volatility products, such as gasolines and kerosenes.

2.3.2.2 Absorption

Many petroleum products, especially the more volatile ones, cause irritation and remove essential oils, possibly leading to dermatitis, when they come into contact with the skin. They can also cause irritation to the eyes. Certain heavier oils can cause serious skin disorders on repeated and prolonged contact.

Direct contact with petroleum should always be avoided by wearing the appropriate protective equipment, especially impermeable gloves and goggles.

2.3.3 Petroleum Gases

2.3.3.1 Inhalation

Comparatively small quantities of petroleum gas, when inhaled, can cause symptoms of diminished responsibility and dizziness similar to intoxication, with headache and irritation of the eyes. The inhalation of an excessive quantity can be fatal.

These symptoms can occur at concentrations well below the Lower Flammable Limit. However, petroleum gases vary in their physiological effects and human tolerance to these effects also varies widely. It should not be assumed that, because conditions can be tolerated, the gas concentration is within safe limits.

The smell of petroleum gas mixtures is very variable and in some cases the gases may dull the sense of smell. The impairment of smell is especially likely, and particularly serious, if the mixture contains hydrogen sulphide.

The absence of smell should never be taken to indicate the absence of gas.

2.3.3.2 Exposure Limits

The toxic hazards to which personnel are exposed in tanker operations arise almost entirely from exposure to gases of various kinds.

Several indicators are used to characterise the effects of toxic vapours in various concentrations, and many substances have been assigned

Threshold Limit Values (TLVs), sometimes referred to as Permissible Exposure Limits (PELs). However, this latter term has been discontinued in this publication as operational procedures should be aimed at reducing personnel exposure to a minimum and not to a permissible level.

Exposure limits set by international organisations, national administrations or by local regulatory standards should not be exceeded.

Industry bodies and oil companies often refer to the American Conference of Governmental Industrial Hygienists (ACGIH) which has established guidelines on limits that are expected to protect personnel against harmful vapours in the working environment. The values quoted are expressed as Threshold Limit Values (TLVs) in parts per million (ppm) by volume of gas in air.

In spite of the fact that serious health effects are not likely as a result of exposure to TLV concentrations, the values are only guidelines. Best practice is to maintain concentrations of all atmospheric contaminants as low as reasonably practicable (ALARP).

In the following text, the term TLV-TWA (Time Weighted Average) is used. Because they are averages, TWAs assume short-term exposures above the TLV-TWA that are not sufficiently high to cause injury to health and that are compensated by equivalent exposures below the TLV-TWA during the conventional 8 hour working day.

2.3.3.3 Effects

The main effects of low concentrations of petroleum gas on personnel are headaches and eye irritation, with diminished responsibility and dizziness similar to intoxication. At high concentrations, these lead to paralysis, insensibility and death.

The toxicity of petroleum gases can vary widely depending on the major hydrocarbon constituents of the gases. Toxicity can be greatly influenced by the presence of some minor components such as aromatic hydrocarbons (e.g. benzene) and hydrogen sulphide (H₂S). A TLV-TWA of 300 ppm, corresponding to about 2% LFL, is established for gasoline vapours. Such a figure may be used as a general guide for petroleum gases but should not be taken as applicable to gas mixtures containing benzene or hydrogen sulphide.

2.3.4 Material Safety Data Sheets (MSDS)

To assist ships' crews in preparing for toxic cargoes, IMO has urged governments to ensure that ships are supplied with, and carry, Material Safety Data Sheets for significant cargoes. (See Bibliography for *'Recommendations for Material Safety Data Sheets for MARPOL Annex 1 Cargoes and Marine Fuel Oils'*.) The MSDS should indicate the type and probable concentrations of hazardous or toxic components in the cargo or bunkers to be loaded, particularly H₂S and benzene.

The MSDS should be based on the standard IMO format.

It is the responsibility of the supplier to provide the relevant MSDS to a tanker before it commences loading an oil cargo or bunker fuel. It is the ship's responsibility to provide the receiver with an MSDS for the cargo to be discharged. The ship should also advise the terminal and any tank inspectors

or surveyors whether the previous cargo contained any toxic substances. (See Section 26.3.3 – Ship/Shore Safety Check-List, Item 26.)

Provision of an MSDS does not guarantee that all of the hazardous or toxic components of the particular cargo or bunkers being loaded have been identified or documented. Absence of an MSDS should not be taken to indicate the absence of hazardous or toxic components. Operators should have procedures in place to determine whether any toxic components are present in cargoes that they anticipate may contain them.

2.3.5 Benzene and Other Aromatic Hydrocarbons

2.3.5.1 Aromatic Hydrocarbons

The aromatic hydrocarbons include benzene, toluene and xylene. These substances are components, in varying amounts, in many petroleum cargoes such as gasolines, gasoline blending components, reformates, naphthas, special boiling point solvents, turpentine substitute, white spirits and crude oil.

With the exception of benzene (see Section 2.3.5.2), the health hazards of aromatic hydrocarbons are not fully established, but it is recommended that personnel engaged in cargo operations involving products containing them follow the precautions and procedures described in Sections 11.1.6.6 (Closed Loading) and 11.8.4 (Measuring and Sampling) in order to minimise exposure due to cargo handling operations. The TLV of an aromatic hydrocarbon vapour is generally less than that of other hydrocarbons.

The supplier should advise the tanker of the aromatic hydrocarbon content of the cargo to be loaded (see Section 2.3.4 above).

2.3.5.2 Benzene

Exposure to concentrations of benzene vapours of only a few parts per million in air may affect bone marrow and may cause anaemia and leukaemia.

IMO has established minimum standards for ships carrying liquids in bulk with a benzene content of 0.5% or more. (See Bibliography for '*Revised Minimum Safety Standards for Ships Carrying Liquids in Bulk Containing Benzene*'.) They cover requirements for the transfer of information on the cargo by MSDS, occupational exposure limits, air quality monitoring, personal protective equipment and its maintenance, medical monitoring, and precautions during cargo operations. There is some crossover between cargoes containing benzene in MARPOL Annex I and some of the precautions to be followed as defined by MARPOL Annex II and the associated IBC and BCH Codes.

The following guidance uses the operational exposure limits in the IMO standards and provides general advice on precautions to be adopted by oil tankers carrying cargoes containing benzene at lesser concentrations.

Benzene primarily presents an inhalation hazard. It has poor warning qualities as its odour threshold is well above the TLV-TWA.

Exposure to concentrations in excess of 1,000 ppm can lead to unconsciousness and even death. Benzene can also be absorbed through the skin and is toxic if ingested.

Practical guidance on measures that can be taken to minimise the risks associated with loading cargoes containing benzene is given in Section 11.1.10.

Exposure Limits

IMO gives the TLV-TWA for benzene as 1 ppm over a period of eight hours. However, working procedures should aim at ensuring the lowest possible gas concentrations are achieved in work locations.

Personal Protective Equipment (PPE)

Personnel should be required to wear respiratory protective equipment under the following circumstances:

- Whenever they are at risk of being exposed to benzene vapours in excess of the TLV-TWA.
- When TLV-TWAs specified by national or international authorities are likely to be exceeded.
- When monitoring cannot be carried out.
- When closed operations cannot be conducted for any reason.

The respiratory protective equipment to be worn at any given time should be determined by the ship operator, but should not fall below that required in the IMO standards. The need to use respiratory protective equipment may be extended, by local regulations or by Company procedures, to personnel not directly involved in cargo operations. (See also Chapter 10.)

Ship operators should be aware that gas measuring equipment on board tankers will only provide spot readings and that personnel may experience concentrations of vapour in excess of the reading obtained. Careful consideration should therefore be given to the type of respiratory protective equipment employed for specific tasks.

Records should be kept by ship operators of all employees who are engaged in the handling of cargoes containing benzene. Personnel performing operations such as cargo gauging and sampling, or disconnection of cargo hoses after transfer, should be made aware of the benzene content.

Tank Entry

Prior to entry into a tank that has recently carried petroleum products containing benzene, the tank should be tested for benzene concentrations. This is in addition to the requirements for enclosed space entry detailed in Chapter 10.

2.3.6 Hydrogen Sulphide (H₂S)

Hydrogen Sulphide (H₂S) is a very toxic, corrosive and flammable gas. It has a very low odour threshold and a distinctive odour of rotten eggs. H₂S is colourless, is heavier than air, has a relative vapour density of 1.189, and is soluble in water.

2.3.6.1 Sources of Hydrogen Sulphide (H₂S)

Many crude oils come out of the well with high levels of H₂S, but a stabilisation process usually reduces this level before the crude oil is delivered to the ship. However, the amount of stabilisation may be temporarily reduced at times and a tanker may receive a cargo with an H₂S content higher than usual or expected. In addition, some crude oils are never stabilised and always contain high levels of H₂S.

H₂S can also be encountered in refined products such as naphtha, fuel oil, bunker fuels, bitumens and gas oils.

Cargo and bunker fuels should not be treated as free of H₂S until after they have been loaded and the absence of H₂S has been confirmed by both the results of monitoring and the relevant MSDS information.

2.3.6.2 Expected Concentrations

It is important to distinguish between concentrations of H₂S in the atmosphere, expressed in ppm by volume, and concentrations in liquid, expressed in ppm by weight.

It is not possible to predict the likely vapour concentration from any given liquid concentration but, as an example, a crude oil containing 70 ppm (by weight) H₂S has been shown to produce a concentration of 7,000 ppm (by volume) in the gas stream leaving the tank vent.

Precautions against high H₂S concentrations are normally considered necessary if the H₂S content in the vapour phase is 5 ppm by volume or above.

The effects of H₂S at various increasing concentrations in air are shown in Table 2.1.

The H₂S concentration in vapour will vary greatly and is dependent upon factors such as:

- Liquid H₂S content.
- Amount of air circulation.
- Temperature of air and liquid.
- Liquid level in the tank.
- Amount of agitation.

2.3.6.3 Exposure Limits

The TLV-TWA for H₂S is 5 ppm over a period of eight hours. However, working procedures should aim at ensuring that the lowest possible gas concentrations are achieved in work locations.

2.3.6.4 Procedures for Handling Cargo and Bunkers Containing H₂S

The following precautions should be taken when handling all cargoes and bunker fuels likely to contain hazardous concentrations of H₂S. They should also be taken when ballasting, cleaning or gas freeing tanks which previously contained a cargo with an H₂S content. Practical guidance on operational measures that can be taken to minimise the risks associated with loading cargoes containing H₂S is given in Section 11.1.9.

H ₂ S Concentration (ppm by volume in air)	Physiological Effects
0.1 – 0.5 ppm	First detectable by smell.
10 ppm	May cause some nausea, minimal eye irritation.
25 ppm	Eye and respiratory tract irritation. Strong odour.
50 – 100 ppm	Sense of smell starts to break down. Prolonged exposure to concentrations at 100 ppm induces a gradual increase in the severity of these symptoms and death may occur after 4–48 hours' exposure.
150 ppm	Loss of sense of smell in 2-5 minutes.
350 ppm	Could be fatal after 30 minutes' inhalation.
700 ppm	Rapidly induces unconsciousness (few minutes) and death. Causes seizures, loss of control of bowel and bladder. Breathing will stop and death will result if not rescued promptly.
700+ ppm	Immediately fatal.
<p>Note: Persons over-exposed to H₂S vapour should be removed to clean air as soon as possible.</p> <p>The adverse effects of H₂S can be reversed and the probability of saving the person's life improved if prompt action is taken.</p>	

Table 2.1 – Typical effects of exposure to hydrogen sulphide (H₂S)

Vapour Monitoring

Exposure levels in all work locations should be monitored by using suitable instrumentation for detecting and measuring the concentration of the gas.

High concentrations and the corrosive nature of the gas can have a damaging effect on many electronic instruments. Low concentrations of H₂S over time can also have a damaging effect on electronic instruments. Detector tubes should therefore be used if it becomes necessary to monitor a known high concentration.

Bunker fuel tanks should be monitored prior to, during and after bunkering. If H₂S has been detected, the bunker tank should be periodically tested. Although the concentration in the vapour space can be successfully lowered by forced air ventilation, it often increases again when the bunker fuel is heated, transferred or agitated by other means.

Bridge, control room, accommodation and engine spaces should be monitored if H₂S may be present. Ventilation systems should be operated as far as possible to prevent H₂S vapours entering the accommodation and engine spaces. Low concentrations of H₂S over time can cause discomfort to personnel.

The use of personal H₂S gas monitoring instruments for personnel engaged in cargo operations is strongly recommended. These instruments may provide either a warning alarm at a pre-set level or an H₂S reading and an alarm. It is further recommended that the alarms be set at a value of 5 ppm. Personnel should always carry personal monitors when working in enclosed spaces, gauging, sampling, entering a pumphoom, connecting and disconnecting loading lines, cleaning filters,

draining to open containments and mopping up spills if H₂S concentrations could exceed the TLV-TWA.

Passive sampling badges provide an immediate visual indication of when a specific chemical hazard is detected or when an established safe exposure level to such a chemical is exceeded. They should only be used for industrial hygiene purposes such as area sampling and for determining exposure of personnel over a period of time. They should never be used as an item of personal protective equipment.

Personal Protective Equipment (PPE)

Procedures should be defined for the use of respiratory protective equipment when concentrations of vapour may be expected to exceed the TLV-TWA (5 ppm by volume in air).

Consideration should be given to providing Emergency Escape Breathing Devices (EEBD) to personnel working in hazardous areas. These are very portable and can be donned quickly should gas be detected.

Personnel should be required to wear respiratory equipment under the following circumstances:

- Whenever they are at risk of being exposed to H₂S vapours in excess of the TLV-TWA.
- When TLV-TWAs specified by national or international authorities are exceeded or are likely to be exceeded.
- When monitoring cannot be carried out.
- When closed operations cannot be conducted for any reason and H₂S concentrations could exceed the TLV-TWA.

Company and Terminal Procedures

The tanker's Safety Management System (SMS) and the terminal's Operations Manual should contain instructions and procedures to ensure safe operations when handling cargo and bunker fuels that are likely to contain H₂S. The functional requirements should include, but not be limited to, the following:

- Training of all crew members in the hazards associated with H₂S and the precautions to be taken to reduce the risks to acceptable levels.
- Safe operating procedures for all operations.
- Gas testing/atmosphere monitoring procedures.
- Maintenance procedures for cargo related systems.
- PPE requirements.
- Contingency planning.
- Emergency response measures.
- Measures to protect visitors from exposure.

2.3.6.5 Additional Procedures when Handling Cargoes with Very High Concentrations of H₂S

Companies and terminals should develop additional procedures for use when handling cargoes with very high levels of H₂S. (100 ppm in the vapour space is considered to be a reasonable threshold.)

Whenever very high concentrations of H₂S are likely to be present, Emergency Escape Breathing Devices (EEBD) should be made available to all personnel working in hazardous areas who should already have a personal H₂S gas monitoring/alarm instrument.

Personnel should be instructed that, if their alarm activates, they should don the EEBD and immediately leave the area to an upwind location. They should advise the central control location of the presence of a high gas concentration in order that appropriate procedures can be initiated.

When H₂S is known to be present, self-contained breathing apparatus should always be worn if it is considered necessary to breach the integrity of the cargo system and a vapour free atmosphere cannot be guaranteed. This would include the following activities:

- Open gauging and sampling.
- Removing blanks for connecting the cargo hose or loading arm or disconnecting the hose and blanking after cargo handling.
- Cleaning filters.
- Draining lines to open containment.
- Mopping up spills.

Procedures should allow only for the use of air supplied by self-contained breathing apparatus. They should **not** include the use of chemical cartridge respirators for protection against H₂S vapours as the vapour concentrations in the atmosphere may exceed the operational capability of the respirator being used.

2.3.6.6 Corrosion

H₂S is very corrosive and enhanced inspection and maintenance regimes should be put in place if H₂S is likely to be present in high concentrations.

Pressure/vacuum valve seats made of brass are more likely to fail than stainless steel seats.

Mechanical tank gauges are more likely to fail since H₂S has a damaging effect on stainless steel tension springs and metals such as brass and bronze. An increase in the spare parts inventory may be necessary.

Computer and instrument components made of silver and gold are highly affected by even low H₂S concentrations.

2.3.6.7 General Nuisances

In addition to being a health hazard, the H₂S odour is also considered a public nuisance. Most local environmental regulations limit or ban the release of H₂S concentrations to the atmosphere and this is, in any case, good practice. It is therefore necessary to maintain cargo tank pressures within acceptably low limits.

The tank vapour pressure will rapidly increase if the vapour space is exposed to heat or the product is agitated.

Crude oil washing may rapidly increase the vapour pressure and should begin at a relatively low pressure, preferably while maintaining a relatively high discharge rate.

2.3.7 Mercaptans

Mercaptans are colourless, odorous gases generated naturally by the degradation of natural organisms. Their smell has been likened to rotting cabbage. Mercaptans may occur on ships where sea water has remained beneath an oil cargo or where oil residues are left in tanks that contain water, such as in a dirty ballast tank after it has been incompletely drained. They are also found in water treatment plants and ballast treatment facilities.

Mercaptans are also present in the vapours of pentane plus cargoes and in some crude oils. They are also used as an odourising agent in natural gas.

Mercaptans can be detected by smell at concentrations below 0.5 ppm, although health effects are not experienced until the concentration is several times higher than this.

The initial effects of mercaptans on people are similar to those caused by H₂S exposure, i.e. irritation to the lungs, eyes, nose and throat. If the concentration is very high, unconsciousness may occur and it may be necessary to administer oxygen.

2.3.8 Gasolines Containing Tetraethyl Lead (TEL) or Tetramethyl Lead (TML)

The amounts of Tetraethyl Lead (TEL) or Tetramethyl Lead (TML) normally added to gasolines are insufficient to render the gases from these products significantly more toxic than those from unleaded gasolines. The effects of the gases from leaded gasolines are therefore similar to those described for petroleum gases (see Section 2.3.3).

2.3.9 Inert Gas

2.3.9.1 General

Inert gas is principally used to control cargo tank atmospheres, thus preventing the formation of flammable mixtures. The primary requirement for an inert gas is low oxygen content. Its composition can, however, be variable. (Table 7.1 in Section 7.1.3 provides an indication of typical inert gas components expressed as a percentage by volume.)

2.3.9.2 Toxic Constituents

The main hazard associated with inert gas is its low oxygen content. However, inert gas produced by combustion, either in a steam raising boiler or in a separate inert gas generator (flue gas), will contain trace amounts of various toxic gases that may increase the hazard to personnel exposed to it.

Precautions necessary to protect personnel against the toxic components of inert gas during tank entry are given in Section 7.1.6.12. However, these precautions do not include requirements for the direct measurement of the concentration of the trace constituents of flue gas. This is because gas freeing the atmosphere of a cargo tank from a hydrocarbon gas concentration of about 2% by volume to 1% LFL, and until a steady 21% by volume oxygen reading is obtained, is sufficient to dilute these toxic constituents to below their TLV-TWA.

2.3.9.3 Nitrogen Oxides

Fresh flue gases typically contain about 200 ppm by volume of mixed nitrogen oxides. The majority is nitric oxide (NO), which is not removed by water scrubbing. Nitric oxide reacts slowly with oxygen, forming nitrogen dioxide (NO₂). As the gas stands in tanks, the total concentration of nitrogen oxide falls over a period of 1-2 days to a level of 10-20 ppm as the more soluble nitrogen dioxide goes into solution in free water, or by condensation, to give nitrous and nitric acids. Further decrease below this level is very slow.

Nitric oxide is a colourless gas with little smell at its TLV-TWA of 25 ppm. Nitrogen dioxide is more toxic with a TLV-TWA of 3 ppm.

2.3.9.4 Sulphur Dioxide

Flue gas produced by the combustion of a fuel oil that has a high sulphur content typically contains about 2,000 ppm of sulphur dioxide (SO₂). Inert gas system water scrubbers remove this gas with an efficiency that depends upon the design and operation of the scrubber, giving inert gas with a sulphur dioxide content of typically between 2 and 50 ppm.

Sulphur dioxide causes irritation of the eyes, nose and throat and may also cause breathing difficulties in sensitive people. It has a distinctive smell at its TLV-TWA of 2 ppm.

2.3.9.5 Carbon Monoxide

Carbon Monoxide (CO) is normally present in flue gas at a level of only a few parts per million. Abnormal combustion conditions and slow running can however give rise to levels in excess of 200 ppm. Carbon monoxide is an odourless gas with a TLV-TWA of 25 ppm. It is insidious in its attack, which is to restrict oxygen uptake by the blood, causing a chemically induced form of asphyxiation.

2.3.10 Oxygen Deficiency

The oxygen content of the atmosphere in enclosed spaces may be low for several reasons. The most obvious one is if the space is in an inert condition, and the oxygen has been displaced by the inert gas. Oxygen may also be removed from an atmosphere by chemical reactions, such as rusting or the hardening of paints or coatings.

As the amount of available oxygen decreases below the normal 21% by volume, breathing tends to become faster and deeper. Symptoms indicating that an atmosphere is deficient in oxygen may give inadequate notice of danger. Most people would fail to recognise the danger until they were too weak to be able to escape without help. This is especially so when escape involves the exertion of climbing.

While individuals vary in susceptibility, all will suffer impairment if the oxygen level falls to 16% by volume.

Exposure to an atmosphere containing less than 10% oxygen content by volume inevitably causes unconsciousness. The rapidity of onset of unconsciousness increases as the availability of oxygen diminishes, and death will result unless the victim is removed to the open air and resuscitated.

An atmosphere containing less than 5% oxygen by volume causes immediate unconsciousness with no warning other than a gasp for air. If resuscitation is delayed for more than a few minutes, irreversible damage is done to the brain, even if life is subsequently saved.

2.4 Gas Measurement

2.4.1 Introduction

This Section describes the principles, uses and limitations of portable instruments for measuring concentrations of hydrocarbon gas (in inerted and non-inerted atmospheres), other toxic gases and oxygen. Certain fixed installations are also described. For detailed information on the use of all instruments, reference should always be made to the manufacturer's instructions.

It is essential that any instrument used is:

- Suitable for the test required.
- Sufficiently accurate for the test required.
- Of an approved type.
- Correctly maintained.
- Frequently checked against standard samples.

2.4.2 Measurement of Hydrocarbon Concentration

The measurement of hydrocarbon vapours on tankers and at terminals falls into two categories:

1. The measurement of hydrocarbon gas in air at concentrations below the Lower Flammable Limit (LFL).

This is to detect the presence of flammable (and potentially explosive) vapours and to detect concentrations of hydrocarbon vapour that may be harmful to personnel. These readings are expressed as a percentage of the Lower Flammable Limit (LFL) and are usually recorded as % LFL. The instruments used to measure % LFL are Catalytic Filament Combustible Gas (CFCG) Indicators, which are usually referred to as Flammable Gas Monitors or Explosimeters. **A CFCG Indicator should not be used for measuring hydrocarbon gas in inert atmospheres.**

2. The measurement of hydrocarbon gas as a percentage by volume of the total atmosphere being measured.

On board a tanker, this is usually carried out to measure the percentage of hydrocarbon vapour in an oxygen deficient (inerted) atmosphere. Instruments used to measure hydrocarbon vapours in an inert gas atmosphere are specially developed for this purpose. The readings obtained are expressed as the percentage of hydrocarbon vapour by volume and are recorded as % Vol.

The instruments used to measure percentage hydrocarbon vapours in inert gas are the Non-Catalytic Heated Filament Gas Indicators (usually referred to as Tankscopes) and Refractive Index Meters. Modern developments in gas detection technology have resulted in the introduction of electronic

instruments using infra-red sensors that can perform the same function as the Tankscope.

2.4.3 Flammable Gas Monitors (Explosimeters)

Modern flammable gas monitors (Explosimeters) have a poison resistant flammable pellistor as the sensing element. Pellistors rely on the presence of oxygen (minimum 11% by volume) to operate efficiently and for this reason flammable gas monitors should not be used for measuring hydrocarbon gas in inert atmospheres.

2.4.3.1 Operating Principle

A simplified diagram of the electrical circuit incorporating a pellistor in a Wheatstone Bridge is shown in Figure 2.1.

Unlike early Explosimeters, the pellistor unit balances the voltage and zeros the display automatically when the instrument is switched on in fresh air. In general, it takes about 30 seconds for the pellistor to reach its operating temperature. However, the operator should always refer to the manufacturer's instructions for the start up procedure.

A gas sample may be taken in several ways:

- Diffusion.
- Hose and aspirator bulb (one squeeze equates to about 1 metre of hose length).
- Motorised pump (either internal or external).

Flammable vapours are drawn through a sintered filter (flashback arrestor) into the pellistor combustion chamber. Within the chamber are two elements, the Detector and the Compensator. This pair of elements is heated to between 400 and 600°C.

When no gas is present, the resistances of the two elements are balanced and the bridge will produce a stable baseline signal. When combustible gases are present, they will catalytically oxidise on the detector element causing its temperature to rise. This oxidation can only take place if there is sufficient oxygen present. The difference in temperature compared to the compensator element is shown as % LFL.

The reading is taken when the display is stable. Modern units will indicate on the display when the gas sample has exceeded the LFL.

Care should be taken to ensure that liquid is not drawn into the instrument. The use of an in-line water trap and a float probe fitted to the end of the aspirator hose should prevent this occurrence. Most manufacturers offer these items as accessories.

Only cotton filters should be used to remove solid particles or liquid from the gas sample when hydrocarbons are being measured. Water traps may be used to protect the instrument where the sampled gas may be very wet. Guidelines on the use of filters and traps will be found in the operating manual for the instrument. (See also Section 2.4.13.3)

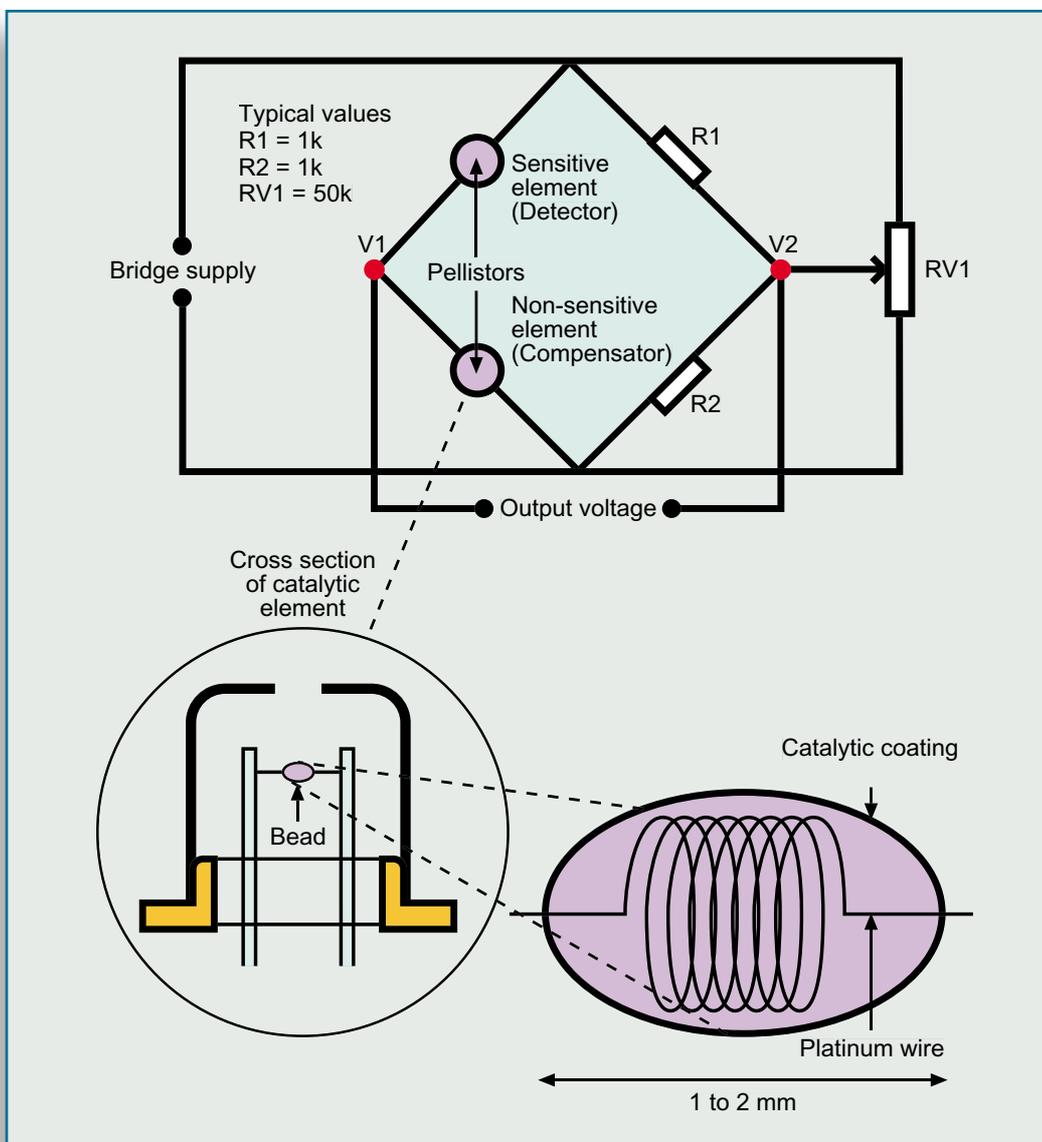


Figure 2.1 – Simplified diagram of a flammable gas monitor incorporating a pellistor

2.4.3.2 Cautions

Poisons and Inhibitors

Some compounds can reduce the sensitivity of the pellistor.

- Poisons – these are compounds that can permanently affect the performance of the pellistor and include silicone vapours and organic lead compounds.
- Inhibitors – these compounds act in a very similar way to poisons, except that the reaction is reversible. Inhibitors include hydrogen sulphide, freons and chlorinated hydrocarbons. If the presence of hydrogen sulphide is suspected, this should be tested for before any measurements of hydrocarbon vapours are carried out. (See Section 2.3.6.)

Pressure

Pellistor type instruments should not have their sensors subjected to pressure as this will damage the pellistor.

Such pressurisation may occur when testing for gas in the following conditions:

- Inert gas under high pressure or at high velocity, such as from a purge pipe or high velocity vent.
- Hydrocarbon gas mixtures at high velocity in vapour lines or from a high velocity vent.

The above is also relevant when using multi-gas instruments. For example, when an infra-red sensor is being utilised for taking a % Vol gas reading, any pellistor sensor in the instrument may suffer damage if the inlet gas stream into the instrument is at a pressure or has a high velocity.

Condensation

The performance of pellistors may be temporarily affected by condensation. This can occur when the instrument is taken into a humid atmosphere after it has been in an air conditioned environment. Time should be allowed for instruments to acclimatise to the operating temperature before they are used.

Combustible Mists

Pellistor instruments will not indicate the presence of combustible mists (such as lubricating oils) or dusts.

2.4.3.3 Instrument Calibration and Check Procedures

The instrument is set up in the factory to be calibrated using a specific hydrocarbon gas/air mixture. The hydrocarbon gas that should be used for calibration and testing should be indicated on a label fixed to the instrument.

Guidance on calibration and on operational testing and inspection of gas measuring instruments is given in Sections 8.2.6 and 8.2.7 respectively.

2.4.3.4 Precision of Measurement

The response of the instrument depends upon the composition of the hydrocarbon gas being tested and, in practice, this composition is not known. By using propane or butane as the calibration gas for an instrument being used on tankers carrying stabilised crude oil or petroleum products, the readings provided may be slightly in error by giving a slightly high reading. This ensures that any reading indicated will be "on the safe side". (See also Section 8.2.6.)

Factors that can affect the measurements are large changes in ambient temperature and excessive pressure of the tank atmosphere being tested, leading to high flow rates which in turn affect the pellistor temperature.

The use of dilution tubes, which enable catalytic filament indicators to measure concentrations in over rich hydrocarbon gas/air mixtures, is not recommended.

2.4.3.5 Operational Features

Older instruments are fitted with flashback arresters in the inlet and outlet of the detector filament chamber. The arresters are essential to prevent the possibility of flame propagation from the combustible chamber and a check should always be made to ensure that they are in place and fitted

properly. Modern pellistor type instruments have sintered filters usually built into the pellistor body.

Some authorities require, as a condition of their approval, that PVC covers be fitted around meters with aluminium cases to avoid the risk of incendive sparking if the case strikes rusty steel.

2.4.4 Non-Catalytic Heated Filament Gas Indicators (Tankscopes)

2.4.4.1 Operating Principle

The sensing element of this instrument is usually a non-catalytic hot filament. The composition of the surrounding gas determines the rate of loss of heat from the filament, and hence its temperature and resistance.

The sensor filament forms one arm of a Wheatstone Bridge. The initial zeroing operation balances the bridge and establishes the correct voltage across the filament, thus ensuring the correct operating temperature. During zeroing, the sensor filament is purged with air or inert gas that is free from hydrocarbons. As in the Explosimeter, there is a second identical filament in another arm of the bridge which is kept permanently in contact with air and which acts as a compensator filament.

The presence of hydrocarbon changes the resistance of the sensor filament and this is shown by a deflection on the bridge meter. The rate of heat loss from the filament is a non-linear function of hydrocarbon concentration and the meter scale reflects this non-linearity. The meter gives a direct reading of % volume hydrocarbons.

When using the instrument, the manufacturer's detailed instructions should always be followed. After the instrument has been initially set at zero with fresh air in contact with the sensor filament, a sample is drawn into the meter by means of a rubber aspirator bulb. The bulb should be operated until the meter pointer comes to rest on the scale (usually within 15-20 squeezes) then aspirating should be stopped and the final reading taken. It is important that the reading should be taken with no flow through the instrument and with the gas at normal atmospheric pressure.

The non-catalytic filament is not affected by gas concentrations in excess of its working scale. The instrument reading goes off the scale and remains in this position as long as the filament is exposed to the rich gas mixture.

2.4.4.2 Instrument Check Procedures

The checking of a non-catalytic heated filament instrument requires the provision of gas mixtures of a known total hydrocarbon concentration.

The carrier gas may be air, nitrogen or carbon dioxide or a mixture of these. Since this type of instrument may be required to measure accurately either low concentrations (1%-3% by volume) or high concentrations (greater than 10% by volume) it is desirable to have either two test mixtures, say 2% and 15% by volume, or one mixture between these two numbers, say 8% by volume. Test gas mixtures may be obtained in small aerosol type dispensers or small pressurised gas cylinders, or may be prepared in a special test kit.

2.4.4.3 Precision of Measurement

Correct response from these instruments is achieved only when measuring gas concentrations in mixtures for which the instrument has been calibrated and which remain gaseous at the temperature of the instrument.

Relatively small deviations from normal atmospheric pressure in the instrument produce significant differences in the indicated gas concentration. If a space that is under elevated pressure is sampled, it may be necessary to detach the sampling line from the instrument and allow the sample pressure to equalise with the atmosphere pressure.

2.4.4.4 Instruments with Infra-red Sensors

When selecting an instrument that uses an infra-red sensor for measuring the percentage by volume of hydrocarbon in an inert gas atmosphere, care should be taken to ensure that the sensor will provide accurate readings over the spectrum of gases likely to be present in the atmosphere to be measured. It may be prudent to make comparison readings with a Tankscope to verify the acceptability of the readings provided by the instrument under consideration.

2.4.5 Interferometer (Refractive Index Meter)

2.4.5.1 Operating Principle

An interferometer is an optical device that utilises the difference between the refractive indices of the gas sample and air.

In this type of instrument, a beam of light is divided into two and these are then recombined at the eyepiece. The recombined beams exhibit an interference pattern that appears to the observer as a number of dark lines in the eyepiece.

One light path is via chambers filled with air. The other path is via chambers through which the sample gas is pumped. Initially, the latter chambers are filled with air and the instrument is adjusted so that one of the dark lines coincides with the zero line on the instrument scale. If a gas mixture is then pumped into the sample chambers, the dark lines are displaced across the scale by an amount proportional to the change of refractive index.

The displacement is measured by noting the new position on the scale of the line that was used initially to zero the instrument. The scale may be calibrated in concentration units or it may be an arbitrary scale whose readings are converted to the required units by a table or graph.

The response of the instrument is linear and a one-point test with a standard mixture at a known concentration is sufficient for checking purposes.

The instrument is normally calibrated for a particular hydrocarbon gas mixture. As long as the use of the instrument is restricted to the calibration gas mixture, it provides accurate measurements of gas concentrations.

The measurement of the concentration of hydrocarbon gas in an inerted atmosphere is affected by the carbon dioxide present when flue gas is

used for inerting. In this case, the use of soda lime as an absorbent for carbon dioxide is recommended, provided the reading is corrected appropriately.

The refractive index meter is not affected by gas concentrations in excess of its scale range. The instrument reading goes off the scale and remains in this position as long as the gas chambers are filled with the gas mixture.

2.4.5.2 Instrument Check Procedures

A mixture of known hydrocarbon, e.g. propane in nitrogen at a known concentration, should be used to check the instrument. If the hydrocarbon test gas differs from the original calibration gas, the indicated reading should be multiplied by the appropriate correction factor before judging the accuracy and stability of the instrument.

2.4.6 Infra-red (IR) Instruments

2.4.6.1 Operating Principle

The infra-red (IR) sensor is a transducer for the measurement of the concentration of hydrocarbons in the atmosphere, by the absorption of infra-red radiation.

The vapour to be monitored reaches the measuring chamber by diffusion or by means of a pump. Infra-red light radiation from the light source shines through a window into the chamber, is reflected and focused by the spherical mirror, and then passes through another window and hits the beam splitter. The portion of the radiation that passes through the beam splitter passes through a broadband interference filter (measuring filter) into the housing cover of the measuring detector, and is converted into an electric signal.

The portion of the radiation reflected by the beam splitter passes through the reference filter to reach the reference detector.

If the gas mixture in the chamber contains hydrocarbons, a part of the radiation is absorbed in the wavelength range of the measurement filter, and a reduced electric signal is given. At the same time, the signal of the reference detector remains unchanged. Gas concentration is determined by comparing the relative values of the reference detector and the measuring detector.

Differences in the output of the IR light source, dirt on mirrors and windows as well as dust or aerosols contained in the air have an identical effect on both detectors and are therefore compensated.

2.4.6.2 Instrument Check Procedures

This instrument should be checked using a check gas of a known mixture of hydrocarbons. The IR sensor does not require the presence of air or inert gas in the gas concentration, as it is reliant solely on the hydrocarbon molecules. In general, these instruments are very stable and require little maintenance. Calibration should be checked frequently in accordance with the manufacturer's instructions and ship's Safety Management System procedures. (See also Section 2.4.4.4.)

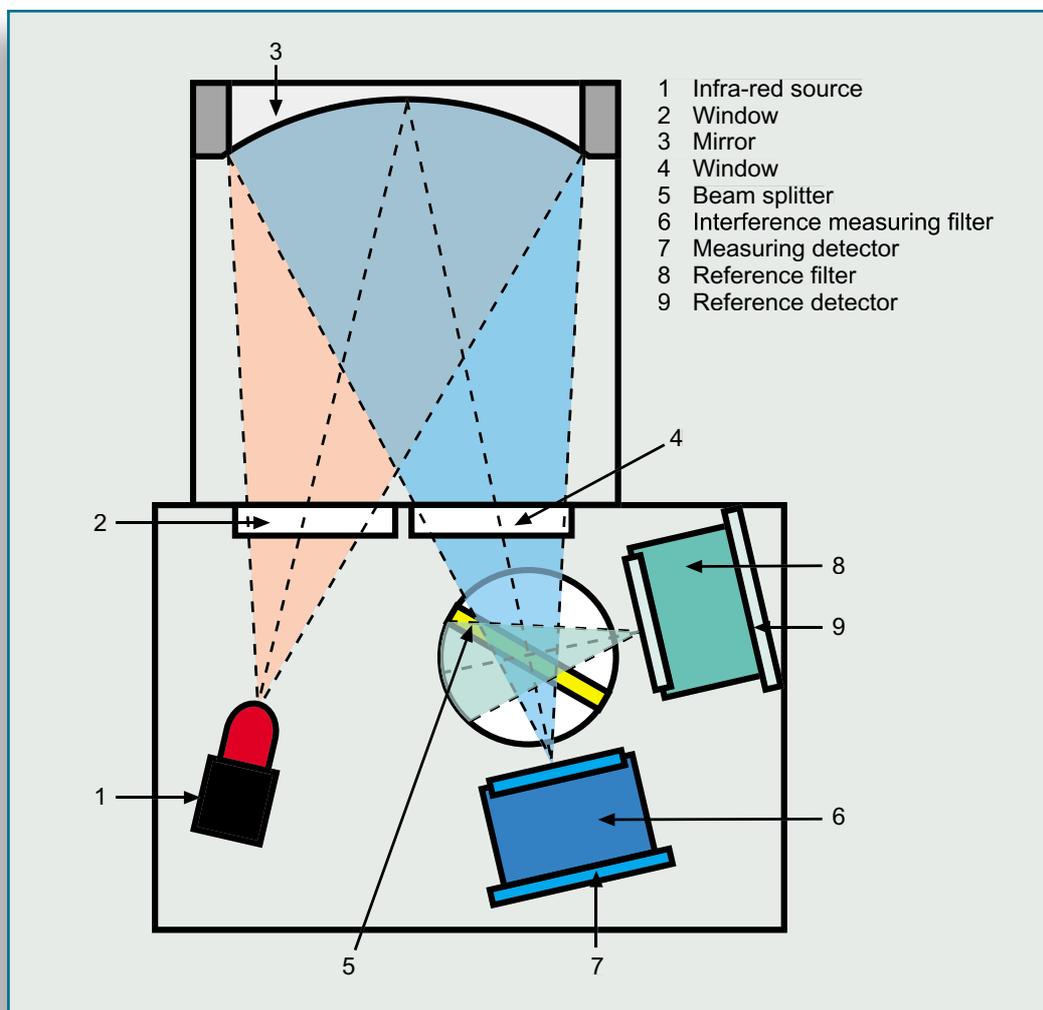


Figure 2.2 – Infra-red sensor

2.4.7 Measurement of Low Concentrations of Toxic Gases

2.4.7.1 Chemical Indicator Tubes

Probably the most convenient and suitable equipment for measuring very low concentrations of toxic gases on board tankers are chemical indicator tubes.

Measurement errors may occur if several gases are present at the same time, as one gas can interfere with the measurement of another. The instrument manufacturer's operating instructions should always be consulted prior to testing such atmospheres.

Chemical indicator tubes consist of a sealed glass tube containing a proprietary filling which is designed to react with a specific gas and to give a visible indication of the concentration of that gas. To use the device, the seals at each end of the glass tube are broken, the tube is inserted in a bellows-type fixed volume displacement hand pump, and a prescribed volume of gas mixture is drawn through the tube at a rate fixed by the rate of expansion of the bellows. A colour change occurs

along the tube and the length of discoloration, which is a measure of the gas concentration, is read off a scale integral to the tube.

In some versions of these instruments, a hand operated injection syringe is used instead of a bellows pump.

It is important that all the components used for any measurement should be from the same manufacturer. It is not permissible to use a tube from one manufacturer with a hand pump from another manufacturer. It is also important that the manufacturer's operating instructions are carefully observed.

Since the measurement depends on passing a fixed volume of gas through the glass tube, any use of extension hoses should be in strict accordance with the manufacturer's instructions.

The tubes are designed and intended to measure concentrations of gas in the air. As a result, measurements made in a ventilated tank, in preparation for tank entry, should be reliable.

For each type of tube, the manufacturers must guarantee the standards of accuracy laid down in national standards. Tanker operators should consult the ship's flag administration for guidance on acceptable equipment.

2.4.7.2 Electrochemical Sensors

Electrochemical sensors are based on the fact that cells can be constructed that react with the measured gas and generate an electric current. This current can be measured and the amount of gas determined. The sensors are low cost and are small enough to allow several to be incorporated into the same instrument, making them suitable for use in multi-gas detectors.

There are numerous electrochemical sensors available covering a number of gases which may be present in the shipboard environment, such as ammonia, hydrogen sulphide, carbon monoxide, carbon dioxide and sulphur dioxide.

Electrochemical sensors can be used in stand-alone instruments, which may provide a warning at a predetermined concentration of vapour, or they can be fitted in a multi-sensor instrument to provide a reading of the concentration of the vapour, usually in parts per million (ppm).

These sensors may give erroneous readings due to cross-sensitivity. This occurs, for example, when measuring toxic gases with hydrocarbon gases present, for example H₂S in the presence of nitric oxide and sulphur dioxide.

2.4.8 Fixed Gas Detection Installations

Fixed gas detection installations are used on some petroleum tankers to monitor the flammability of the atmosphere in spaces such as double hull spaces, pumprooms and pipe tunnels in double bottoms.

Three general arrangements have been developed for fixed monitoring installations, as follows:

- Sensing devices distributed throughout the spaces to be monitored. Signals are taken sequentially from each sensor by a central control.
- A gas measurement system installed in the central control room. Samples of the atmospheres to be checked are drawn sequentially, usually by vacuum pump, through sample lines to the central gas measurement system. It is important to ensure that there is no leakage of air into the system as that would dilute the samples and cause misleading readings.
- Infra-red sensors located in the space being monitored with the electronics necessary for processing the signals located in a safe location, usually the central control room.

Fixed gas detection units are usually fitted as a means of detecting leakage and not for gas testing prior to entry. Gas testing for entry should only be carried out using equipment that has been calibrated and tested and that has appropriate indicator scales. Some fixed gas detection units do meet these criteria. (See Section 10.10.2.)

2.4.9 Measurement of Oxygen Concentrations

Portable oxygen analysers are normally used to determine whether the atmosphere inside an enclosed space (cargo tank for example) may be considered fully inerted or safe for entry. Fixed oxygen analysers are used for monitoring the oxygen content of the boiler uptakes and the inert gas main.

The following are the most common types of oxygen analysers in use:

- Paramagnetic sensors.
- Electrochemical sensors.

All analysers, regardless of type, should be used strictly in accordance with the manufacturer's instructions. If so used, and subject to the limitations listed below, the analysers may be regarded as reliable.

2.4.10 Use of Oxygen Analysers

2.4.10.1 Paramagnetic Sensors

Oxygen is strongly paramagnetic (i.e. it is attracted by the poles of a magnet but does not retain any permanent magnetism) whereas most other common gases are not. This property means that oxygen content can be measured in a wide variety of gas mixtures.

One commonly used oxygen analyser of the paramagnetic type has a sample cell in which a lightweight body is suspended in a magnetic field. When sample gas is drawn through the cell, the suspended body experiences a torque proportional to the magnetic susceptibility of the gas. An electric current passing through a coil wound around the suspended body produces an equal and opposing torque. The equalising current is a measure of the magnetic force and is thus a measure of the magnetic susceptibility of the sample, i.e. related to its oxygen content.

Before use, the analyser should be tested with air for a reference point of 21% oxygen and with nitrogen or carbon dioxide for a 0% oxygen reference point.

Releasing nitrogen or carbon dioxide in a confined or unventilated area can lower the concentration of oxygen to a level that is immediately dangerous to life or health. Calibration should therefore only be carried out in well ventilated areas.

The analyser readings are directly proportional to the pressure in the measuring cell. The unit is calibrated to a specific atmospheric pressure and the small error due to atmospheric pressure variations can be corrected if required. Continuous samples should be supplied to the instrument by positive pressure. They should not be drawn through the analyser by negative pressure as the measuring pressure then becomes uncertain.

The filter should be cleared or replaced when an increase in sample pressure is required to maintain a reasonable gas flow through the analyser. The same effect is produced if the filter becomes wet due to insufficient gas drying. The need for filter cleaning or replacement should be checked regularly.

2.4.10.2 Electrochemical Sensors

Analysers of this type determine the oxygen content of a gas mixture by measuring the output of an electrochemical cell. In one commonly used analyser, oxygen diffuses through a membrane into the cell, causing current to flow between two special electrodes separated by a liquid or gel electrolyte.

The current flow is related to the oxygen concentration in the sample and the scale is arranged to give a direct indication of oxygen content. The cell may be housed in a separate sensor head connected by cable to the read out unit.

The analyser readings are directly proportional to the pressure in the measuring cell, but only small errors are caused by normal variations in atmospheric pressure.

Certain gases may affect the sensor and give rise to false readings. Sulphur dioxide and oxides of nitrogen interfere if they are present in concentrations of more than 0.25% by volume. Mercaptans and hydrogen sulphide can poison the sensor if their levels are greater than 1% by volume. This poisoning does not occur immediately but over a period of time; a poisoned sensor drifts and cannot be calibrated in air. In such cases, reference should be made to the manufacturer's instructions.

2.4.10.3 Maintenance, Calibration and Test Procedures

As these oxygen analysers are of vital importance, they should have a valid calibration certificate and should be tested strictly in accordance with the manufacturer's instructions before use.

It is essential that, each time an instrument is to be used, a check is made of batteries (if fitted) and zero point (21% oxygen) setting. During use, frequent checks should be made to ensure accurate readings are obtained at all times.

Testing is simple on all analysers using atmospheric air to test the reference point (21% oxygen) and an inert gas to test the 0% oxygen

reference point (nitrogen or carbon dioxide). (See also Sections 8.2.6 and 8.2.7.)

2.4.11 Multi-gas Instruments

Multi-gas instruments are now widely used and are usually capable of housing four different sensors. A typical configuration would comprise sensors for measuring:

- Hydrocarbon vapour as a % LFL (explosimeter function using a pellistor sensor).
- Hydrocarbon vapour in inert gas as a % Volume (tankscope function using an infra-red sensor).
- Oxygen (using an electrochemical sensor).
- Hydrogen Sulphide (using an electrochemical sensor).

Multi-gas instruments should be tested at regular intervals in accordance with the manufacturer's instructions.

Multi-gas instruments may be supplied for gas measurement use and be fitted with a data logging capability, but without an alarm function.

Care should be taken when using multi-gas instruments to check for hydrocarbons in an inerted atmosphere under pressure as the pellistor within the instrument could be damaged if subjected to pressure (see Section 2.4.3.2).

2.4.12 Personal Gas Monitors

Multi-gas instruments may be supplied as compact units fitted with an alarm function for personal protective use during tank entry. These personal monitors are capable of continuously measuring the content of the atmosphere by diffusion. They usually employ up to four electrochemical sensors and should automatically provide an audible and visual alarm when the atmosphere becomes unsafe, thereby giving the wearer adequate warning of unsafe conditions.

Disposable personal gas monitors are now available. They usually provide protection against a single gas and are available for low oxygen level, and high concentrations of hydrocarbons and other toxic vapours. The units should provide both audible and visual warning at specified levels of vapour concentration, which should be at or below the TLV-TWA for the monitored vapour. These monitors typically weigh less than 100 grams and have a life of about 2 years.

2.4.13 Gas Sample Lines and Sampling Procedures

2.4.13.1 Gas Sample Lines

The material and condition of sample lines can affect the accuracy of gas measurements.

Metal tubes are unsuited to most cargo tank gas measurements and flexible lines should be used.

The gases from crude oils and many petroleum products are composed essentially of paraffinic hydrocarbons and there are a number of suitable materials available for flexible sample tubing. The problem of material selection is more difficult for those gases containing substantial proportions of aromatic hydrocarbons, in particular xylene. It is recommended that in such cases suppliers of sample tubing should be asked to provide test data showing the suitability of their product for the purposes for which it will be employed.

Sample tubing should be resistant to hot wash water.

Sample tubing which is cracked or blocked, or which has become contaminated with cargo residues, greatly affects instrument readings. Users should check the condition of the tubing regularly and replace any found to be defective.

In order to prevent liquid from being drawn up the gas sampling line and causing contamination of the line, manufacturers provide a float termination or a probe termination to prevent the ingress of liquid. Operators should consider using these fittings, but should be aware of any limitations on their use to avoid static hazards.

2.4.13.2 Sampling Procedures

Every tank has 'dead spots' where the rate of change of gas concentration during ventilation or purging is less than the average in the bulk of the tank. The location of these dead spots depends on the positions of the inlet and outlet through which ventilating air or inert gas is admitted and expelled and also on the disposition of the structural members in the tank. Generally, but not invariably, the dead spots are to be found within the tank bottom structure. The sample line should be long enough to permit sampling in the bottom structure.

Differences in gas concentration between the bulk volume of the tank and the dead spots vary depending on the operating procedures in use. For example, the powerful water jets produced by fixed washing machines are excellent mixing devices which tend to eliminate major differences in gas concentration between one location in the tank and another. Similarly, the introduction of ventilating air or inert gas as powerful jets directed downwards from the deckhead produces good mixing and minimises variations in concentration.

Because of the hazards associated with these dead spots, it is important to refer to Chapter 10 before entering any cargo tank or other enclosed space.

2.4.13.3 Filters in Sample Lines

Cotton filters are used to remove water vapour in some hydrocarbon gas meters, of either the catalytic or non-catalytic filament types, and additional filters are not normally needed. In extremely wet conditions, e.g. during tank washing, excessive water can be removed from the gas sample using materials that retain water but do not affect the hydrocarbons. Suitable materials are granular anhydrous calcium chloride or sulphate. If required, soda asbestos selectively retains hydrogen sulphide without affecting the hydrocarbons. However, it also retains carbon dioxide and sulphur dioxide and should not be used in tanks inerted with scrubbed flue gas.

Water traps are often used in modern gas measurement instruments. These utilise a Polytetrafluoroethylene (PTFE) membrane that prevents liquid and moisture passing onto the sensors.

The use of water-retaining filters is essential with oxygen meters, particularly of the paramagnetic type, because the presence of water vapour in the sample can damage the measuring cell. Only manufacturer's recommended filters should be used.

2.5 Hydrocarbon Gas Evolution and Dispersion

2.5.1 Introduction

During many cargo handling and associated operations, petroleum gas is expelled from cargo tank vents in sufficient quantity to give rise to flammable gas mixtures in the atmosphere outside the tanks. In this Guide, a major objective is to avoid such a flammable gas mixture being exposed to a source of ignition. In many cases, this is achieved either by eliminating the source of ignition or by ensuring that there are barriers, such as closed doors and ports, between the gas and unavoidable potential sources of ignition.

However, it is impossible to cover every possibility of human error and every combination of circumstances. An additional safeguard is introduced if operations can be arranged so that petroleum gas issuing from vents is dispersed sufficiently well to prevent flammable gas mixtures reaching those areas where sources of ignition may exist.

There can be a flammability problem from gas concentrations external to cargo tanks in the case of high vapour pressure volatile cargoes, the main types of which are:

- Crude oil.
- Motor and aviation gasolines.
- Natural gasolines.
- Light Distillate Feedstocks (LDFs) and naphthas.

The gases from these petroleum liquids are denser than air and this has an important bearing on how they behave, both inside and outside the tanks (see Section 1.3).

The gas which is vented is formed within the tanks and the way in which it is formed affects both the concentration when vented and the length of time during which a high concentration is vented. Situations which lead to gas evolution include loading, standing of cargo in full or part filled tanks (including slop tanks), evaporation of tank residues after discharge, and crude oil washing.

The initial tank atmosphere, whether air or inert gas, has no bearing on gas evolution or venting.

2.5.2 Gas Evolution and Venting

2.5.2.1 Evolution During Loading

As a high vapour pressure petroleum cargo enters an empty gas free tank, there is a rapid evolution of gas. Because of its high density, the gas forms a layer at the bottom of the tank that rises with the oil surface as the tank is filled. Once it has been formed, the depth of the layer increases only slowly over the period of time normally required to fill a tank, although ultimately an equilibrium gas mixture is established throughout the ullage space.

The amount and concentration of gas forming this layer at the beginning of loading depend upon many factors, including:

- True Vapour Pressure (TVP) of the cargo.
- Amount of splashing as the oil enters the tank.
- Time required to load the tank.
- Occurrence of a partial vacuum in the loading line.

The hydrocarbon gas concentration in the layer varies with distance above the liquid surface. Very close to the surface, it has a value close to that corresponding to the TVP of the adjoining liquid. For example, if the TVP is 0.75 bar, the hydrocarbon gas concentration just above the surface is about 75% by volume. Well above the surface, the hydrocarbon gas concentration is very small, assuming that the tank was originally gas free. In order to consider further the influence of gas layer depth, it is necessary to define this depth in some way.

When considering dispersion of gases outside cargo tanks, only high gas concentrations in the vented gas are relevant. For this purpose therefore, the gas layer depth will be taken as the distance from the liquid surface to the level above it where the gas concentration is 50% by volume. It should be remembered that hydrocarbon gas will be detectable at heights above the liquid surface several times the layer depth defined in this way.

Most high vapour pressure cargoes give rise to a gas layer with a depth in these terms of less than 1 metre. Its precise depth depends upon the factors listed above and most of the advice with respect to vented gas given in this Guide is intended for such cargoes. However, gas layers greater than 1 metre in depth may be encountered if the cargo TVP is great enough. Cargoes giving rise to these deeper gas layers may require special precautions (see Sections 2.5.6.2 and 11.1.8).

2.5.2.2 Venting During the Loading of Cargo

Once the dense hydrocarbon gas layer has formed above the surface of the liquid, its depth, as defined in Section 2.5.2.1, increases only very slowly. As the liquid rises in the tank, the hydrocarbon gas layer rises with it. Above this layer, the atmosphere originally present in the tank persists almost unchanged and it is this gas that enters the venting system in the early stages of loading. In an initially gas free tank, the gas vented at first is therefore mainly air (or inert gas) with a hydrocarbon concentration below the LFL. As loading proceeds, the hydrocarbon content of the vented gas increases.

Concentrations in the range 30%-50% by volume of hydrocarbons are quite usual in the vented gas towards the end of loading, although the

very high concentration immediately above the liquid surface remains in the final ullage space on completion of loading.

Subsequently, evaporation continues until an equilibrium hydrocarbon gas concentration is established throughout the ullage space. This may be very high indeed, depending upon the cargo composition and temperature, and values as high as 90%-95% by volume have been observed with crude oils. However, this gas is only vented by breathing of the tank, and thus only intermittently. When the oil is discharged, this very dense gas mixture travels to the bottom of the tank with the descending liquid surface and may contribute to the gas vented during the next operation in the tank. If the tank is not initially gas free, the hydrocarbon gas concentration in the vented gas during loading depends upon the previous history of the tank. For example:

- In an unwashed crude oil tank that is to be loaded soon after discharge of a previous cargo, there is a layer of highly concentrated gas at the bottom of the tank, with hardly any hydrocarbon gas above it. This gas is expelled immediately ahead of the layer that is formed as fresh cargo enters the tank.
- In an unwashed crude oil tank after a long ballast voyage, there is a homogeneous hydrocarbon gas concentration of up to 10% by volume throughout the tank. When the tank is next loaded, this is the gas that is expelled until the concentrated gas layer immediately above the liquid surface begins to exert its influence. Thereafter, this concentrated layer dominates the composition of the vented gas.
- In a crude oil tank that has been crude oil washed but not subsequently purged with inert gas or gas freed, a uniform gas concentration exists throughout the tank. Depending on the crude oil used and its temperature, this concentration is usually well above the flammable range and may be as high as 40% by volume. This mixture is displaced from the tank throughout the subsequent loading until the possibly even richer gas adjacent to the liquid surface approaches the top of the tank.
- Shortly after the discharge of a motor or aviation gasoline cargo, there is a layer at the bottom of the tank where concentrations of 30%-40% by volume of hydrocarbons have been measured. If loaded at this stage, the gas enters the venting system immediately ahead of the concentrated layer formed by the next cargo.
- In motor or aviation gasoline tanks that have been battened down after discharge and not gas freed, uniform hydrocarbon gas concentrations as high as 40% by volume have been measured throughout the tanks. This concentration is expelled to the vent system throughout the next loading until the concentrated layer above the liquid surface approaches the top of the tank.

Note that in all loading operations, whether the tank is initially gas free or not, very high gas concentrations enter the venting system towards completion of loading.

2.5.2.3 Ballasting into a Cargo Tank

The atmosphere in cargo tanks before ballasting will be similar to that before the loading of oil cargo, given a similar tank history. The gas concentration expected to enter the venting system during ballasting will therefore be comparable to that in the examples given above. If it is necessary for ships using crude oil washing to load ballast into cargo tanks before departure, some ports require controls on vapour emissions

to the atmosphere. This is achieved by containing the vapour in empty cargo tanks, by simultaneous ballasting and cargo discharge, or by other approved means.

2.5.2.4 Inert Gas Purging

If inert gas purging is being carried out by the displacement method (see Section 7.1.4) any dense concentrated hydrocarbon layer at the bottom of the tank is expelled in the early stages, followed by the remainder of the tank atmosphere as it is pressed downwards by the inert gas. If there is a uniformly high concentration throughout the tank, for example after crude oil washing, the hydrocarbon concentration of the vented gas remains high throughout the purging process until the inert gas reaches the bottom of the tank.

If inert gas purging is being carried out by the dilution method (see Section 7.1.4), the gas concentration at the outlet is highest at the beginning of the operation and falls continuously as it proceeds.

2.5.2.5 Gas Freeing

In a gas freeing operation, air is delivered into the tank where it mixes with the existing tank atmosphere and where it also tends to mix together any layers that may be present. The resultant mixture is expelled to the outside atmosphere. Because the process is one of continuous dilution with the air, the highest hydrocarbon concentration is vented at the beginning of gas freeing and decreases thereafter. For example, on a non-inerted ship, gas freeing of a motor gasoline tank that has been battened down can give initial concentrations as high as 40% by volume, but in most circumstances the concentration in the vented gas is much lower, even at the start of the operations.

On inerted ships, after purging to remove hydrocarbon vapour before gas freeing, the initial concentration will be low, 2% by volume or less.

2.5.3 Gas Dispersion

Whether the hydrocarbon gas at the outlet is mixed with air or with inert gas will have no bearing on the dispersion of the gas after it has left the outlet.

As the hydrocarbon gas displaced during loading, ballasting, gas freeing or purging issues from the vent or vents on the tanker, it immediately starts to mix with the atmosphere.

The hydrocarbon concentration is progressively reduced until, at some distance from the vent, it passes below the LFL. At any point below the LFL, it ceases to be of concern as a flammability hazard because it cannot be ignited. However, there exists in the vicinity of any vent a flammable zone within which the gas concentration is above the LFL.

There is a potential danger of fire and explosion if this flammable zone reaches any location where there may be sources of ignition, such as:

- Superstructures and accommodation blocks into which the gas can enter through doors, ports or ventilation intakes.
- The cargo deck which, although it is usually regarded as free of sources of ignition, is a work area and thoroughfare.

- An adjacent jetty which, although it is usually regarded as free of sources of ignition, is a work area and thoroughfare.
- Adjacent vessels such as lightering ships, bunker and stores craft, pilot and crew transfer boats.

2.5.4 Variables Affecting Dispersion

2.5.4.1 The Dispersion Process

A mixture of hydrocarbon gas and air (or inert gas), issuing vertically from an outlet, rises under its own momentum as a plume above the outlet. If there is no wind, the plume remains vertical, but otherwise it is bent over in the downwind direction. The rise of the plume due to its momentum is opposed by a tendency to sink because its density is greater than that of the surrounding air.

The flow velocity of the issuing gas is at its maximum as it passes through the outlet, and decreases as air is drawn into the plume. This air decreases the hydrocarbon gas concentration and hence the gas density in the plume. The progressive decreases in velocity, hydrocarbon concentration and density, together with the wind speed and other meteorological factors, determine the final shape of the plume and hence of the flammable zone.

The type of vent being used affects the dispersion of the gas plume. During normal loading operations, the venting will be either via:

- A high velocity vent installed at a minimum height of 2 m above the deck, which causes the vapour to be vented at a speed of 30 m/second irrespective of the loading rate of the cargo, or
- A vent riser with a minimum height of 6 m above the deck.

These high velocity vents and risers may not be placed closer than 10 m to any accommodation house vent, to ensure that cargo vapours will be safely dispersed before they reach these locations.

2.5.4.2 Wind Speed

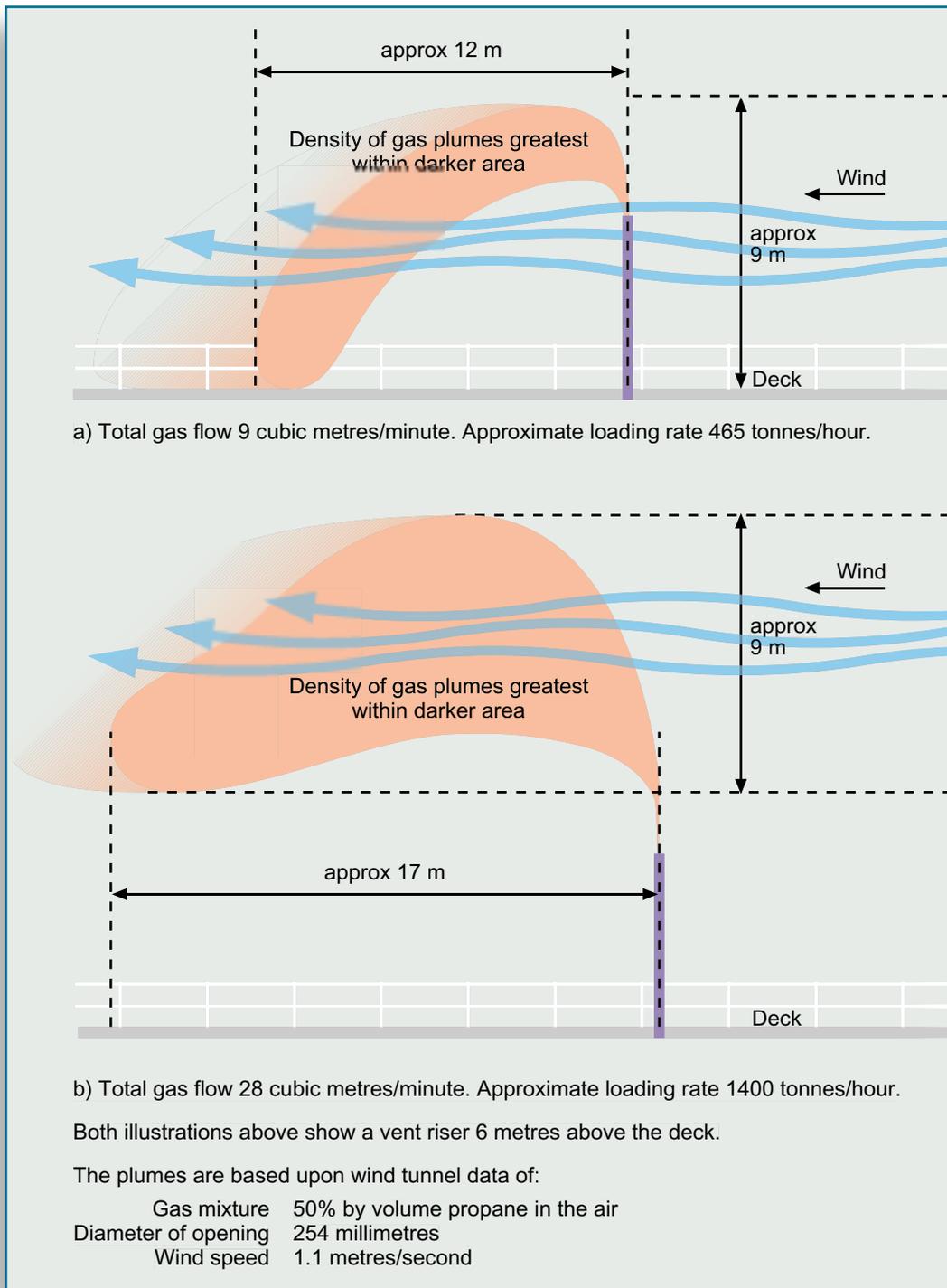
For many years, it has been recognised that the dispersion of hydrocarbon gas/air mixtures is inhibited by low wind speeds. This recognition is based upon experience on tankers and little experimental work has been done to obtain quantitative information on the effect of wind speed. Much depends upon the quantity of gas being vented and how it is vented, but experience at terminals seems to suggest that, at wind speeds above about 5 metres/sec (10 knots), dispersion is sufficient to avoid any flammability risk.

2.5.4.3 Rate of Flow of Gas

As the rate of flow of a hydrocarbon gas/air mixture of fixed composition is increased through a given opening, several effects come into play. In the first place, the rate of emission of the hydrocarbon constituent increases in proportion to the total gas flow rate and therefore the distance the plume travels before it is diluted to the LFL should be greater. On the other hand, the higher the velocity, the more efficient is the mixing of the initially hydrocarbon-rich gas with the air and this tends to counterbalance the first effect.

In addition, at low rates of total gas flow, the initial momentum of the plume may not be enough to counteract the tendency of the plume to sink because of its initially high density.

The results of the interaction of these different processes at low wind speed are illustrated in Figure 2.3. The gas mixture used in obtaining these diagrams was 50% by volume propane and 50% by volume air, and is typical of that to be expected when topping-off a crude oil cargo. At the lowest flow rate (Figure 2.3 (a)) the density effect predominates and the gas sinks back towards the deck. At the highest flow rate (Figure 2.3 (c)) mixing is far more efficient and there is no tendency for the plume to sink.



Figures 2.3 (a) and (b) – Indicative effect of gas flow rate on flammable zone

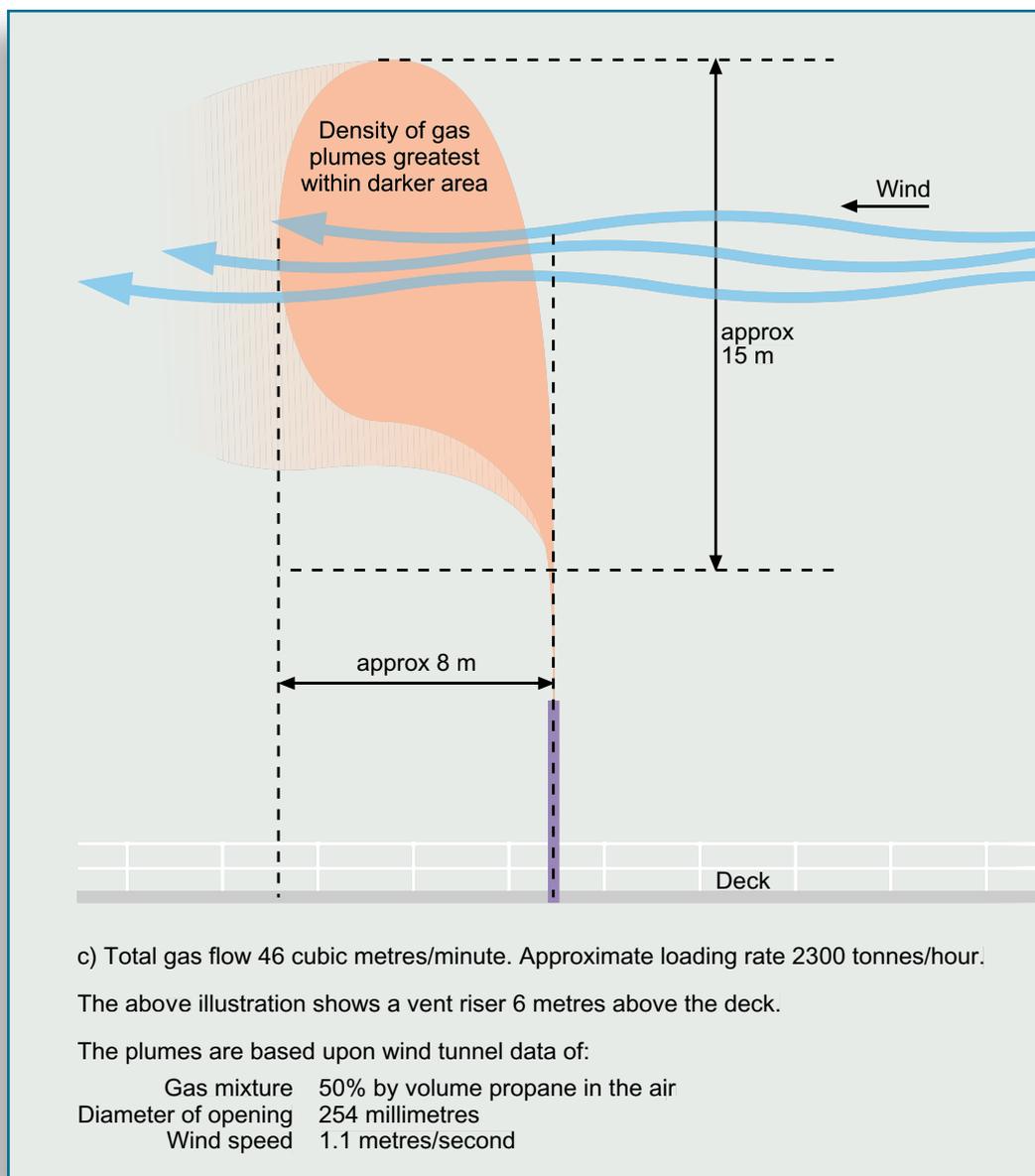


Figure 2.3 (c) – Indicative effect of gas flow rate on flammable zone

The flammable zones generated by the same operations with motor or aviation gasolines would be similar but with a more pronounced density effect, and this effect would be even more pronounced with a natural gasoline type cargo. Also, the greater dilution required to reach the LFL with motor or aviation gasolines (see Section 1.2.2) would tend to make the flammable zones larger than with crude oils, and this effect would be even more pronounced with the natural gasolines. Thus, the dispersion problem becomes progressively more pronounced as one goes from crude oils, through motor or aviation gasolines, to natural gasoline type cargoes.

2.5.4.4 Concentration of Hydrocarbon Gas

With a constant total rate of flow of gas, changes in hydrocarbon concentration have two effects. The rate of emission of hydrocarbon gas increases in proportion to the concentration so that, other things being equal, the extent of the flammable zone increases. Also, the initial density

of the gas mixture as it issues from the opening becomes greater so that there is a greater tendency for the plume to sink.

At low concentrations, therefore, a flammable zone similar in outline to that shown in Figure 2.3 (c) is to be expected, but it is likely to be small because of the relatively small amount of hydrocarbon gas. As the concentration increases, the flammable zone tends to assume such shapes as depicted in Figures 2.3 (b) and 2.3 (a) as the increasing density exerts its influence. In addition, the overall size of the zone becomes greater due to the greater rate of emission of hydrocarbon gas.

2.5.4.5 Cross-Sectional Area of the Opening

The area of the opening through which the hydrocarbon gas/air mixture issues determines, for a given volumetric rate of flow, the linear flow velocity and hence the efficiency of the mixing of the plume with the atmosphere. Effects of this kind occur, for example, in gas freeing. If fixed turbo-blower fans are used, the mixture is usually vented through a standpipe with a cross-sectional area small enough to give a high velocity and to encourage dispersion in the atmosphere. When using small portable blowers, which normally have to be operated against a low back pressure, it is usual to exhaust the gas through an open tank hatch. The outflow velocity is then very low with the outlet close to the deck; circumstances that encourage the gas to remain close to the deck.

2.5.4.6 The Design of the Vent Outlet

The design and position of a vent outlet must comply with current SOLAS requirements.

In certain operations, such as gas freeing, vapour may be vented from the tank through apertures other than these designated tank vents.

2.5.4.7 Position of the Vent Outlet

If vent outlets are situated near structures such as accommodation blocks, the shape of the flammable zone is influenced by turbulence produced in the air as it passes over the superstructure. A diagram illustrating the kind of eddies formed is given in Figure 2.4. This shows how, on the upwind side, there are downward eddies below a level indicated by the line X-X and how, above and in the lee of the structure, there is a tendency for turbulent air to form eddies close to the structure.

These movements can adversely affect the efficient dispersion of hydrocarbon gas.

If the exit velocity from an opening near a structure is high, it can overcome the influence of eddies.

For example, Figure 2.5 (a) shows the flammable zone from a tank opening situated only about 1.5 metres upwind of an accommodation block; the plume is almost vertical and only just touches the accommodation block. However, a somewhat lower rate of venting would have resulted in serious impingement of the zone upon the accommodation block.

Figure 2.5 (b) illustrates the effect of an additional opening which doubles the amount of gas released. Partly as the result of eddies and partly due

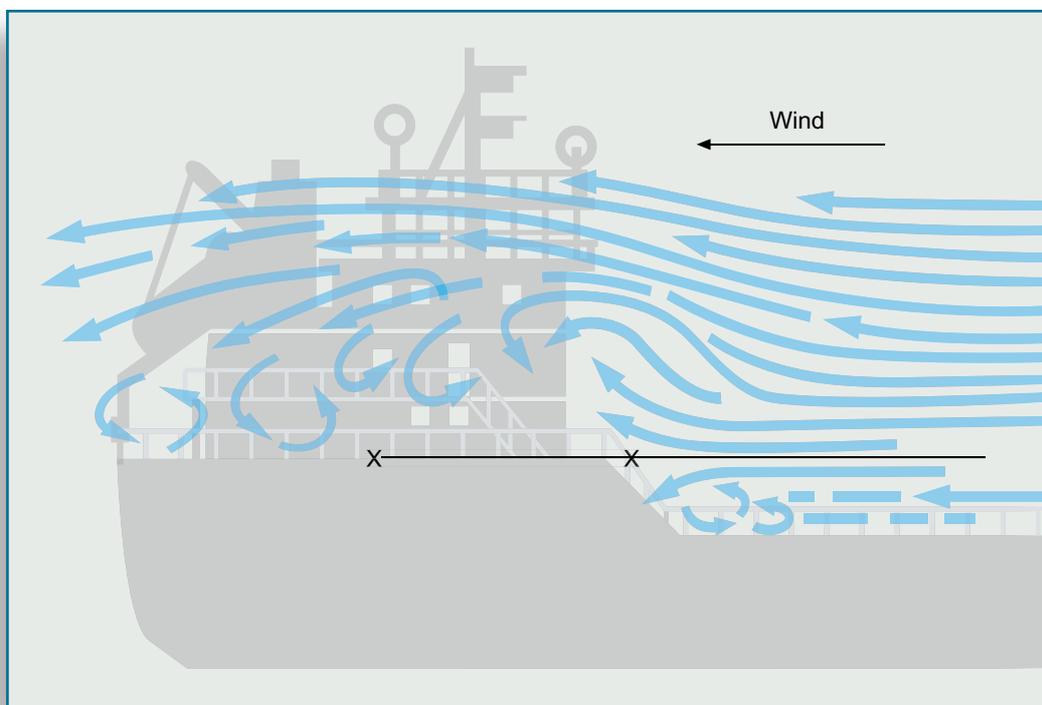


Figure 2.4 – Typical pattern of airflow around an accommodation block

to the denser combined plume, the flammable zone is in close contact with the top of the accommodation block.

2.5.5 Minimising Hazards from Vented Gas

The objective of venting arrangements and their operational control is to minimise the possibilities of flammable gas concentrations entering enclosed spaces containing sources of ignition, or reaching deck areas where, notwithstanding all other precautions, there might be a source of ignition. In previous Sections, means have been described of promoting rapid dispersion of gas and minimising its tendency to sink to the deck. Although this Section is concerned with flammability, the same principles apply to dispersion of gas down to concentrations that are safe to personnel.

The following conditions are required by SOLAS for any operation where flammable mixtures are displaced to the atmosphere or where mixtures are displaced which could become flammable on dilution with air, such as on inerted ships:

- An unimpeded vertical discharge at a high efflux velocity.
- Positioning the outlet sufficiently high above the deck.
- Placing the outlet at an adequate distance from the superstructure and other enclosed spaces.

When using a vent outlet of fixed diameter, usually designed for 125% of the maximum cargo loading rate, the efflux velocity will drop at lower loading rates. Vent outlets with automatically variable areas (high velocity vent valves) may be fitted to maintain a high efflux velocity under all loading conditions. The permitted height of the outlet above deck is dependent on whether venting is by a mast riser or through a high velocity vent valve.

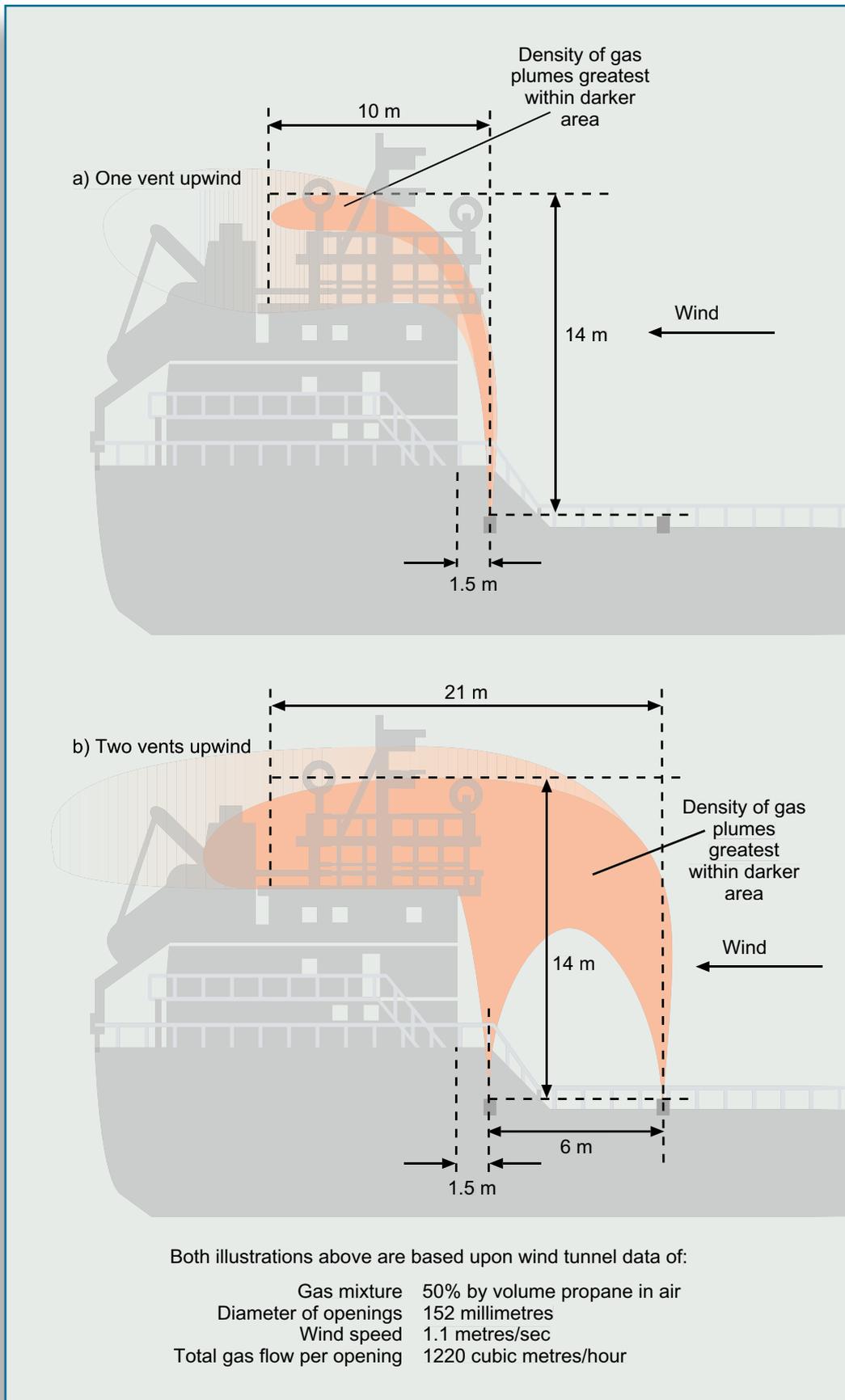


Figure 2.5 – Flammable zone from apertures near an accommodation block

The venting arrangements should always be used during cargo loading operations and during any ballasting into non-gas free cargo tanks.

When gas freeing by fixed mechanical blower, or purging with inert gas either by displacement or dilution through designated outlets, sufficiently high efflux velocities should be maintained to ensure rapid gas dispersion in any conditions.

When gas freeing by portable blowers, it may be necessary to open a tank hatch lid to act as a gas outlet, with a resulting low gas outlet velocity. Vigilance is then required to ensure that gas does not accumulate on deck. If an inerted tank is being gas freed through the open hatch, there may be localised areas where the atmosphere is deficient in oxygen. If practicable, it is preferable to gas free through a small diameter opening, such as a tank cleaning opening, with a temporary standpipe rigged.

In all operations where gas is being vented, great vigilance should be exercised, especially under adverse conditions (e.g. if there is little or no wind). Under such conditions, it may be prudent to stop operations until conditions improve.

2.5.6 Loading Very High Vapour Pressure Cargoes

2.5.6.1 Gas Evolution

This Section has so far dealt with gas evolution and dispersion from high vapour pressure cargoes which give rise to concentrated hydrocarbon gas layers of a depth of 1 metre or less when loaded (see Section 2.5.2.1). Cargoes yielding layers of greater depth are sometimes encountered. The main examples are crude oils, which may have their vapour pressures increased by the addition of extra gas (such as butane) and some natural gasolines (by-products of LNG/LPG production) which are sometimes known as Pentanes Plus.

Examples of the variation of gas layer depth (greater than or equal to 50% by volume concentration level) related to True Vapour Pressure (TVP) are shown in Figure 2.6 for typical natural gasolines and crude oils. There are some cargoes with intermediate properties, for example flash stabilised condensates, some distillation overhead products (which may be shipped as clean petroleum products such as naphtha, kerosene or even gas oil) and crude oils with abnormally low methane and ethane contents.

The natural gasoline curve in Figure 2.6 is for a series of blends of different TVPs and the crude oil curve is for a series produced by adding increasing amounts of butane to a crude oil. Below a gas layer depth of about 1 metre, the dependence of depth on TVP is not very marked for either type of cargo. At greater TVPs, the curve becomes progressively steeper, indicating that in this range a small increase in TVP can cause a very large increase in gas evolution.

Boiling commences when the TVP exceeds 1 bar. In the case of the natural gasoline blends, this coincides quite closely with the steep increase in gas layer thickness. However, with the crude oil/butane blends, the steep increase does not occur until a TVP significantly above 1 bar is reached. Crude oils may be stabilised so that their TVPs are near, or somewhat above, 1 bar as they enter the ship. In practice, therefore, some boiling may occur even without butanisation, but the gas evolution is not necessarily excessive.

In boiling, gas bubbles form below the surface of the liquid, but only down to a depth at which the total pressure (atmospheric plus hydrostatic) is equal to the TVP. The consequent loss of gas in this region may lead to a local fall in TVP. Moreover, the latent heat required to evaporate the gas results in cooling which also reduces the TVP. The reduction in TVP in the liquid near the surface from both these causes tends to delay boiling, despite the fact that the TVP of the bulk of the liquid is above 1 bar. That is why crude oils can be handled with their TVPs somewhat above 1 bar. It does not apply to the same extent to the natural gasoline type of product because the gaseous constituents in a crude oil are only a small proportion of the total, whereas a natural gasoline usually consists almost entirely of potentially gaseous compounds. This means that the availability of gas, where boiling is taking place, is far greater with the

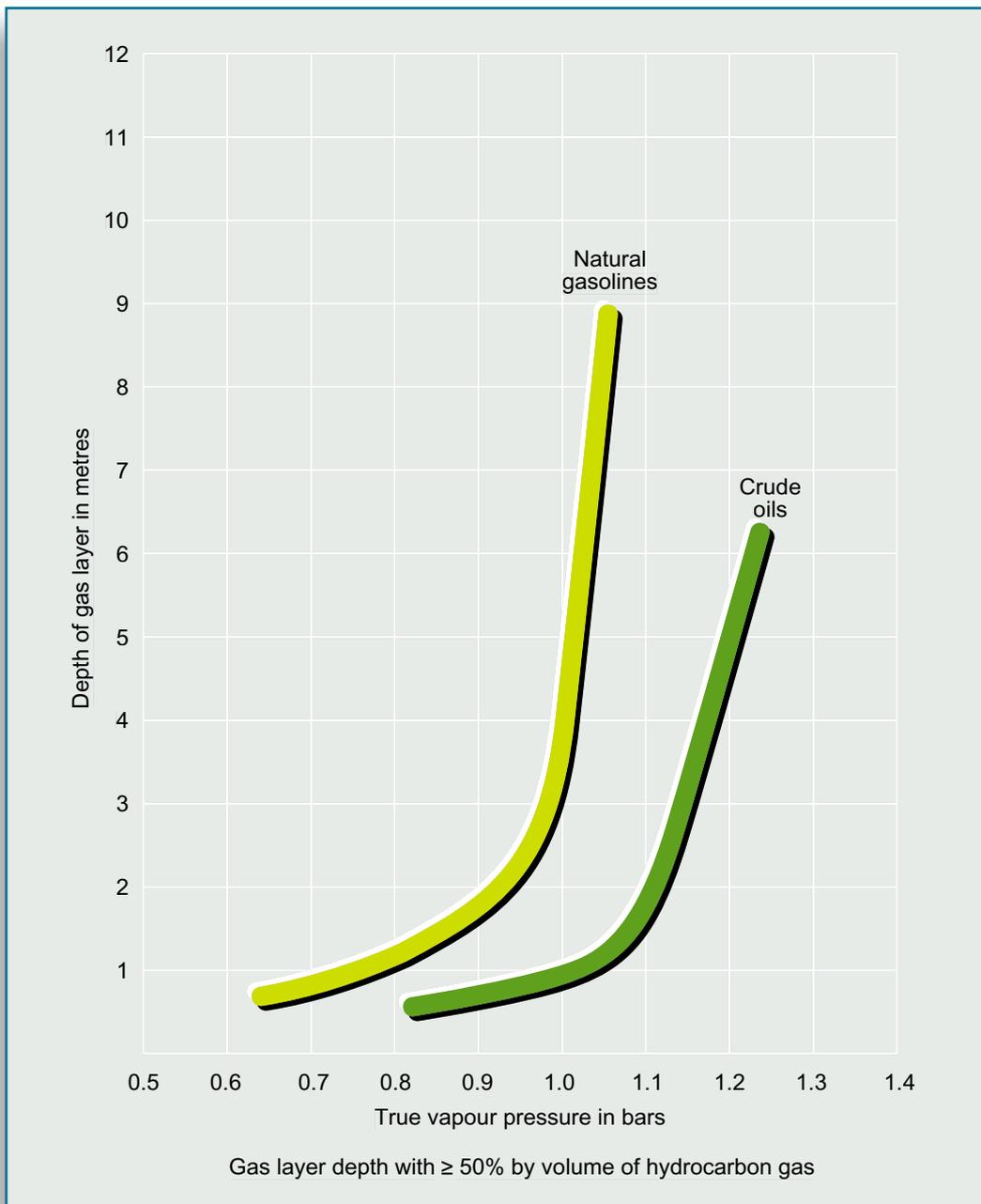


Figure 2.6 – Relationship between depth of gas layer and true vapour pressure

natural gasolines than with crude oils. Natural gasolines suffer hardly any decrease of TVP due to gas depletion when they begin to boil, and boiling is much more likely to continue in their case than in the case of crude oils.

2.5.6.2 Special Precautions with Very High Vapour Pressure Cargoes

When unusually deep gas layers are encountered, very high concentrations of gas, approaching 100% by volume, may be vented for prolonged periods during loading. Excessive amounts of gas may then be present on or around the tanker, which may call for special precautions to be taken.

Curves of the kind given in Figure 2.6 suggest that the TVP at the loading temperature of the cargo should be used as the criterion for determining when special precautions are necessary. The Reid Vapour Pressure of a cargo gives very little guidance unless the temperature of the cargo when loaded is also specified. However, it has proved to be difficult to select TVP criteria because they depend ultimately on subjective judgements of acceptable gas conditions on ships. As a general guide, the information available suggests that consideration should be given to the need for special precautions when the TVP is expected to exceed the following values:

- For natural gasoline type cargoes, for example pentanes plus (C5+), 0.75 bar.
- For crude oils, with or without added gas, 1.0 bar.
- For some intermediate cargoes, for example flash stabilised condensates, some distillation overhead products and crude oils with abnormally low methane and ethane contents, TVP limits between the above two values might be appropriate.

When cargo temperature, crude oil stabilisation conditions and Reid Vapour Pressures are known, True Vapour Pressures can be calculated for checking with the above criteria.

Precautions that might then be applied are given in Section 11.1.8.

2.6 Pyrophoric Iron Sulphide

2.6.1 Pyrophoric Oxidation

In an oxygen free atmosphere where hydrogen sulphide gas is present or, specifically, where the concentration of hydrogen sulphide exceeds that of the oxygen, iron oxide is converted to iron sulphide. When the iron sulphide is subsequently exposed to air, it is oxidised back to iron oxide and either free sulphur or sulphur dioxide gas is formed. This oxidation can be accompanied by the generation of considerable heat such that individual particles may become incandescent. Rapid exothermic oxidation with incandescence is termed Pyrophoric Oxidation.

Pyrophoric iron sulphide, i.e. iron sulphide capable of pyrophoric oxidation in air, can ignite flammable hydrocarbon gas/air mixtures.

2.6.2 Formation of Pyrophors

2.6.2.1 General

As described above, the formation of pyrophors is dependent on three factors:

- Presence of iron oxide (rust).
- Presence of hydrogen sulphide gas.
- Lack of oxygen.

However, it also depends on the comparative influence of these factors. The presence of oxygen will inhibit the conversion of iron oxide to iron sulphide. Also, while the concentration of hydrogen sulphide gas has a direct influence on the formation of pyrophors, the degree of porosity of the iron oxide and the rate of flow of the gas over its surface will influence the rate of sulphidation. Experiments have supported the view that there is no safe level of hydrogen sulphide below which a pyrophor cannot be generated.

2.6.2.2 In Terminal Operations

In terminal operations, pyrophoric iron sulphide is well recognised as a potential source of ignition. Pyrophoric deposits are apt to accumulate in storage tanks in sour crude service and in process equipment handling sour streams. When such tanks or equipment are taken out of service, it is normal practice to keep all internal surfaces thoroughly wet during ventilation so that there can be no pyrophoric reaction before the equipment is made hydrocarbon gas free.

Deposits and sludge should be kept wet until removed to a safe area where subsequent ignition will cause no damage. Numerous fires have occurred when deposits have dried out prematurely.

2.6.2.3 In Marine Operations

While pyrophoric iron sulphide is a widely recognised ignition source in shore based operations, it has rarely been cited as the cause of a marine ignition and in those few cases the hydrogen sulphide levels were very high. It is believed that marine operations have been free of this hazard because the cargo tanks of non-inerted ships normally contain some oxygen in the vapour space as a result of tank breathing.

However, the use of inert gas on crude carriers may, by decreasing the initial oxygen level as well as that of subsequent replenishments, increase the possibility of forming pyrophoric deposits. Although tanker flue gas normally contains 1-5% oxygen, this level can be further reduced by absorption into the crude cargo. Furthermore, as the cargo tanks are kept pressurised with inert gas with a low oxygen content, no air will enter the ullage space. If the pressure needs to be increased, it will again be done with inert gas having a low oxygen content.

2.6.3 Prevention of Pyrophoric Ignition in Inerted Cargo Tanks

As long as the cargo tanks remain inerted, there is no danger of ignition from a pyrophoric exothermic reaction. Therefore, it is imperative that the atmosphere in the tank is not allowed to become flammable. Flammable

atmospheres will inevitably arise if the tanks are discharged while the inert gas plant is inoperable.

However, various factors may inhibit pyrophor formation or a pyrophoric reaction, consequently reducing the risk of ignition. These factors include:

- Lack of sufficiently thick deposits of iron oxide.
- Inclusion of elemental sulphur and crude oil in tank deposits.
- Venting of tanks with air.

These inhibiting factors are not, however, predictable nor can anyone be confident that they will always be effective. Therefore, the degree of risk is judged to be high enough to require that atmosphere control is always maintained during and after discharge. To ensure that atmosphere control can be maintained, the following practices should be observed:

- Diligent maintenance of inert gas plants.
- Spares should be kept on hand for critical parts which cannot be obtained quickly or which can fail abruptly (e.g. the fans).
- In the event of an inert gas plant failure prior to or during discharge of cargo or ballast from cargo tanks, discharge should not commence or continue until the inert gas plant operation is restored, or an alternative source of inert gas is provided.

There is evidence that any pyrophoric deposit formed during the loaded passage will not necessarily be deactivated during the subsequent ballast passage. Therefore, the atmosphere in the cargo tanks should be maintained in an inert or non-flammable condition both throughout the voyage and during any discharge of ballast from them. The correct application of inert gas and gas freeing procedures, as described in Sections 7.1 and 11.4, should ensure that a flammable atmosphere is avoided.

2.7 The Hazards Associated with the Handling, Storage and Carriage of Residual Fuel Oils

2.7.1 General

The first part of this Section deals with the flammability hazards associated with residual fuel oils and provides information on flashpoint and vapour composition measurement, together with recommended precautionary procedures to be adopted when handling, storing or carrying residual fuel oils.

It should be noted that this guidance refers only to residual fuel oils and not to distillate fuels.

Reference should be made to Section 11.8.2 for precautions to be taken when measuring and sampling in non-inerted tanks when there is any possibility that a flammable gas/air mixture may be present.

The last part of this Section refers to the hydrogen sulphide hazard associated with fuel oil (see also Section 2.3.6).

2.7.2 Nature of Hazard

Residual fuel oils are capable of producing light hydrocarbons in the tank headspace, such that the vapour composition may be near to or within the flammable range. This can occur even when the storage temperature is well below the measured flashpoint. This is not normally a function of the origin or manufacturing process of the fuel, although fuels containing cracked residues may show a greater tendency to generate light hydrocarbons.

Although light hydrocarbons may be present in the headspaces of residual fuel oil tanks, the risk associated with them is small unless the atmosphere is within the flammable range and an ignition source is present. In such a case, an incident could result. It is therefore recommended that residual fuel oil headspaces be regarded as being potentially flammable.

2.7.3 Flashpoint and Headspace Flammability Measurement

2.7.3.1 Flashpoint

Fuel oils are classified for their safety in storage, handling and transportation by reference to their closed cup flashpoint (see also Section 1.2.5). However, information on the relationship between the calculated flammability of a headspace atmosphere and the measured flashpoint of the residual fuel oil has shown that there is no fixed correlation. A flammable atmosphere can therefore be produced in a tank headspace even when a residual fuel oil is stored at a temperature below its flashpoint.

2.7.3.2 Headspace Flammability

Traditionally, gas detectors such as explosimeters have been used to check that enclosed spaces are gas free, and they are entirely suited to this purpose (see Section 2.4.3). They have also been used to measure the "flammability" of headspaces in terms of percentage of the Lower Flammable Limit (LFL). Such detectors rely on a calibration carried out normally on a single hydrocarbon, such as methane, which may have LFL characteristics that are far removed from the hydrocarbons actually present in the headspace. When using an explosimeter to assess the degree of hazard in non-inerted residual fuel oil tank headspaces, it is recommended that the instrument is calibrated with a pentane/air or hexane/air mixture. This will result in a more conservative estimate of the flammability, but the readings should still not be regarded as providing a precise measurement of the vapour space condition.

When taking measurements, the manufacturer's operating instructions for the instrument should be closely followed and the instrument's calibration should be checked frequently as oxidation catalyst detectors (pellistors) are likely to be susceptible to poisoning when exposed to residual fuel oil vapours. For information on poisoning of pellistors, see Section 2.4.3.2.

In view of the problems associated with obtaining accurate measurements of the flammability of residual fuel tank headspaces using readily available portable equipment, the measured % LFL only ranks fuels broadly in terms of relative hazard. Care should be exercised therefore in interpretation of the figures obtained by such gas detectors.

2.7.4 Precautionary Measures

2.7.4.1 Storage and Handling Temperatures

When carried as fuel, temperatures of the residual fuel oil in the fuel system should conform to relevant codes of practice at all times and excessive local heating should be avoided.

2.7.4.2 Filling and Venting

When tanks are being filled, tank headspace gas will be displaced through vent pipes. Particular care should be taken to ensure that flame screens or traps are in good condition and that there are no ignition sources in the area immediately surrounding the venting system.

When filling empty or near empty tanks, the heating coils should be shut down and cool. Fuel oil contacting hot, exposed heating coils could possibly lead to the rapid generation of a flammable atmosphere.

2.7.4.3 Headspace Classification

All residual fuel oil tank headspaces should be classified as hazardous and suitable precautions taken. Electrical equipment within the space must meet the appropriate safety standards.

2.7.4.4 Hazard Reduction

The flammability of the headspace of residual fuel oil tanks should be monitored regularly.

If a measured value in excess of recommended levels is detected (IMO Resolution A.565(14) refers to a level in excess of 50% LFL), action should be taken to reduce the vapour concentration by purging the headspace with low pressure air. Gases should be vented to a safe area with no ignition sources in the vicinity of the outlet. On completion of venting, gas concentrations within the tank should continue to be monitored and further venting undertaken if necessary.

When residual fuel oil is carried as cargo on board tankers fitted with inert gas, it is recommended that the inert gas is utilised and that the headspace is maintained in an inert condition (see Section 2.5.4).

2.7.4.5 Ullaging and Sampling

All operations should be conducted such as to take due care to avoid the hazards associated with static electrical charges (see Section 11.8.2).

2.7.5 Hydrogen Sulphide Hazard in Residual Fuel Oils

Bunker fuels containing high H₂S concentrations may be supplied without advice being passed to the ship beforehand. Ship's personnel should always be alert to the possible presence of H₂S in bunker fuel and be prepared to take suitable precautions if it is present.

Before loading bunkers, the ship should communicate with the supplier to ascertain whether the fuel to be loaded is likely to have any H₂S content.

The design of bunker tank vents and their location makes managing the exposure to personnel more difficult, as closed loading and venting cannot usually be implemented.

If bunkering with fuel containing H₂S above the TLV-TWA cannot be avoided, procedures should be in place to monitor and control the access of personnel to exposure areas.

Ventilation to lower the concentration of vapour in the ullage space and in specific areas where vapours may accumulate should be carried out as soon as practicable.

Even after the tank has been ventilated to reduce the concentration to an acceptable level, subsequent transfer, heating and agitation of the fuel within a tank may cause the concentration to reappear.

Periodic monitoring of the concentration of H₂S should be continued until the bunker tank is refilled with a fuel oil not containing H₂S.

Chapter 3

STATIC ELECTRICITY

This Chapter describes hazards associated with the generation of static electricity during the loading and discharging of cargo and during tank cleaning, dipping, ullaging and sampling. Section 3.1 introduces some basic principles of electrostatics in order to explain how objects become charged and to describe the effect of those charges on other objects in close surroundings.

The risks presented by static electricity discharges occur where a flammable atmosphere is likely to be present. The main precaution for tankers against electrostatic risks is to conduct operations with the cargo tanks protected by inert gas. Section 3.2 describes, in general terms, precautions against electrostatic hazards in tanks that are not protected by inert gas; these are discussed in more detail in Chapter 11 (Shipboard Operations). Section 3.3 considers other likely sources of electrostatic hazards in tanker and terminal operations.

3.1 Principles of Electrostatics

3.1.1 Summary

Static electricity presents fire and explosion hazards during the handling of petroleum and during other tanker operations such as tank cleaning, dipping, ullaging and sampling. Certain operations can give rise to accumulations of electric charge that may be released suddenly in electrostatic discharges with sufficient energy to ignite flammable hydrocarbon gas/air mixtures. There is, of course, no risk of ignition unless a flammable mixture is present. There are three basic stages leading up to a potential electrostatic hazard:

- Charge separation.
- Charge accumulation.
- Electrostatic discharge.

All three of these stages are necessary for an electrostatic ignition of a flammable atmosphere.

Electrostatic discharges can occur as a result of accumulations of charge on:

- Liquid or solid non-conductors, for example a static accumulator oil (such as kerosene) pumped into a tank, or a polypropylene rope.
- Electrically insulated liquid or solid conductors, for example mists, sprays or particulate suspensions in air, or an unbonded metal rod hanging on the end of a rope.

The principles of electrostatic hazards and the precautions to be taken to manage the risks are described fully below.

3.1.2 Charge Separation

Whenever two dissimilar materials come into contact, charge separation occurs at the interface.

The interface may be between two solids, between a solid and a liquid or between two immiscible liquids. At the interface, a charge of one sign (say positive) moves from material A to material B so that materials A and B become respectively negatively and positively charged.

While the materials stay in contact and immobile relative to one another, the charges are extremely close together. The voltage difference between the charges of opposite sign is then very small, and no hazard exists. However, when the materials move relative to one another, the charges can be separated and the voltage difference increased.

The charges can be separated by many processes. For example:

- The flow of liquid petroleum through pipes.
- Flow through fine filters (less than 150 microns) that have the ability to charge fuels to a very high level, as a result of all the fuel being brought into intimate contact with the filter surface where charge separation occurs.
- Contaminants, such as water droplets, rust or other particles, moving relative to oil as a result of turbulence in the oil as it flows through pipes.
- The settling of a solid or an immiscible liquid through a liquid (e.g. water, rust or other particles through petroleum). This process may continue for up to 30 minutes after completion of loading into a tank.
- Gas bubbles rising up through a liquid (e.g. air, inert gas introduced into a tank by the blowing of cargo lines or vapour from the liquid itself, released when pressure is dropped). This process may also continue for up to 30 minutes after completion of loading.
- Turbulence and splashing in the early stages of loading oil into an empty tank. This is a problem in the liquid and in the mist that can form above the liquid.
- The ejection of particles or droplets from a nozzle (e.g. during steaming operations or injection of inert gas).
- The splashing or agitation of a liquid against a solid surface (e.g. water washing operations or the initial stages of filling a tank with oil).
- The vigorous rubbing together and subsequent separation of certain synthetic polymers (e.g. the sliding of a polypropylene rope through gloved hands).

When the charges are separated, a large voltage difference can develop between them. A voltage distribution is also set up throughout the neighbouring space and this is known as an electrostatic field. Examples of this are:

- The charge on a charged petroleum liquid in a tank produces an electrostatic field throughout the tank, both in the liquid and in the ullage space.
- The charge on a water mist formed by tank washing produces an electrostatic field throughout the tank.

If an uncharged conductor is present in an electrostatic field, it has approximately the same voltage as the region it occupies. Furthermore, the field causes a movement of charge within the conductor; a charge of one sign is attracted by the field to one end of the conductor and an equal charge of the

opposite sign is left at the opposite end. Charges separated in this way are known as 'induced charges' and, as long as they are kept separate by the presence of the field, they are capable of contributing to an electrostatic discharge.

3.1.3 Charge Accumulation

Charges that have been separated attempt to recombine and to neutralise each other. This process is known as 'charge relaxation'. If one or both of the separated materials carrying charge is a very poor electrical conductor, recombination is impeded and the material retains or accumulates the charge upon it. The period of time for which the charge is retained is characterised by the relaxation time of the material, which is related to its conductivity; the lower the conductivity, the greater the relaxation time.

If a material has a comparatively high conductivity, the recombination of charges is very rapid and can counteract the separation process, and consequently little or no static electricity accumulates on the material. Such a highly conductive material can only retain or accumulate charge if it is insulated by means of a poor conductor, and the rate of loss of charge is then dependent upon the relaxation time of this lesser conducting material.

The important factors governing relaxation are therefore the electrical conductivities of the separated materials, of other conductors nearby, such as ship's structure, and of any additional materials that may be interposed between them after their separation.

Refined clean products tend to have very low conductivity, such that the relaxation time is about half a minute. This is not to be confused with the 'settling time' referred to in Section 11.8.2.3.

3.1.4 Electrostatic Discharge

Electrostatic discharge occurs when the electrostatic field becomes too strong and the electrical resistance of an insulating material suddenly breaks down. When breakdown occurs, the gradual flow and charge recombination associated with relaxation is replaced by sudden flow recombination that generates intense local heating (e.g. a spark) that can be a source of ignition if it occurs in a flammable atmosphere. Although all insulating media can be affected by breakdowns and electrostatic discharges, the main concern for tanker operations is the prevention of discharges in air or vapour, so as to avoid sources of ignition.

Electrostatic fields in tanks or compartments are not uniform because of tank shape and the presence of conductive internal protrusions, such as probes and structure. The field strength is enhanced around these protrusions and, consequently, that is where discharges generally occur. A discharge may occur between a protrusion and an insulated conductor or solely between a conductive protrusion and the space in its vicinity, without reaching another object.

3.1.4.1 Types of Discharge

Electrostatic discharge can take the form of a 'corona', a 'brush discharge', a 'spark' or a 'propagating brush discharge', as described below:

Corona is a diffuse discharge from a single sharp conductor that slowly releases some of the available energy. Generally, corona on its own is incapable of igniting a gas, such as propane, or a vapour such as gasoline.

Brush Discharge is a diffuse discharge from a highly charged non-conductive object to a single blunt conductor that is more rapid than corona and releases more energy. It is possible for a brush discharge to ignite gases and vapours. Examples of a brush discharge are:

- Between a conductive sampling apparatus lowered into a tank and the surface of a charged petroleum liquid.
- Between a conductive protrusion (e.g. fixed tank washing machine) or structural member and a charged petroleum liquid being loaded at a high rate.

Spark is an almost instantaneous discharge between two conductors where almost all of the energy in the electrostatic field is converted into heat that is available to ignite a flammable atmosphere. Examples of sparks are:

- Between an unearthed conductive object floating on the surface of a charged liquid and the adjacent tank structure.
- Between unearthed conductive equipment suspended in a tank and the adjacent tank structure.
- Between conductive tools or materials left behind after maintenance when insulated by a rag or piece of lagging.

Sparks can be incendive if various requirements are met. These include:

- A discharge gap short enough to allow the discharge to take place with the voltage difference present, but not so short that any resulting flame is quenched.
- Sufficient electrical energy to supply the minimum amount of energy to initiate combustion.

Propagating Brush Discharge is a rapid, high energy discharge from a sheet of material of high resistivity and high dielectric strength with the two surfaces highly charged but of opposite polarity. The discharge is initiated by an electrical connection (short circuit) between the two surfaces. The bipolar sheet can be in 'free space' or, as is more normal, have one surface in intimate contact with a conducting material (normally earthed).

The short circuit can be achieved:

- By piercing the surface (mechanically or by an electrical break-through).
- By approaching both surfaces simultaneously with two electrodes electrically connected.
- When one of the surfaces is earthed, by touching the other surface with an earthed conductor.

A propagating brush discharge can be highly energetic (1 joule or more) and so will readily ignite a flammable mixture.

Scientific studies have shown that epoxy coatings greater than 2 mm thick on tanks, filling pipes and fittings may give rise to conditions whereby there is a possibility of a propagating brush discharge. In these cases, there would be a need to seek expert advice on requirements to explicitly earth the cargo. However, on most ships, the thickness of epoxy coatings is not generally greater than 2 mm.

3.1.4.2 Conductivity

Materials and liquid products that are handled by tankers and terminals are classified as being non-conductive, semi-conductive (in most electrostatic standards the term 'dissipative' is now preferred to 'semi-conductive') or conductive.

Non-Conductive Materials (or Non-Conductors)

These materials have such low conductivities that once they have received a charge they retain it for a very long period. Non-conductors can prevent the loss of charge from conductors by acting as insulators. Charged non-conductors are of concern because they can generate incendive brush discharges to nearby earthed conductors and because they can transfer a charge to, or induce a charge on, neighbouring insulated conductors that may then give rise to sparks.

Liquids are considered to be non-conductors when they have conductivities less than 50 pS/m (pico Siemens/metre). Such liquids are often referred to as static accumulators.

Petroleum products, such as clean oils (distillates), frequently fall into this category with a conductivity typically below 10 pS/m. Chemical solvents and highly refined fuels can have conductivities of less than 1 pS/m. The solid non-conductors include plastics, such as polypropylene, PVC, nylon and many types of rubber. They can become more conductive if their surfaces are contaminated with dirt or moisture. (Precautions to be taken when loading static accumulator oils are addressed in Section 11.1.7.)

Semi-Conductive Materials (or Dissipative Materials or Intermediate Conductors)

The liquids in this intermediate category have conductivities exceeding 50 pS/m and, along with conductive liquids, are often known as static non-accumulators. Examples of semi-conductive liquids are black oils (containing residual materials) and crude oils, which typically have conductivities in the range of 10,000-100,000 pS/m. The solids in this intermediate category generally include such materials as wood, cork, sisal and naturally occurring organic substances. They owe their conductivity to their ready absorption of water and they become more conductive as their surfaces are contaminated by moisture and dirt. However, when new or thoroughly cleaned and dried, their conductivities can be sufficiently low to bring them into the non-conductive range.

If materials in the intermediate conductivity group are not insulated from earth, their conductivities are high enough to prevent accumulation of an electrostatic charge. However, their conductivities are normally low enough to inhibit production of energetic sparks.

For materials with intermediate conductivities, the risk of electrostatic discharge is small, particularly if practices in this Guide are adhered to,

and the chance of their being incensive is even smaller. However, caution should still be exercised when dealing with intermediate conductors because their conductivities are dependent upon many factors and their actual conductivity is not known.

Conductive Materials

In the case of solids, these are metals and, in the case of liquids, the whole range of aqueous solutions, including sea water. The human body, consisting of about 60% water, is effectively a liquid conductor. Many alcohols are conductive liquids.

The important property of conductors is that they are incapable of holding a charge unless insulated, but also that, if they are insulated, charged and an opportunity for an electrical discharge occurs, all the charge available is almost instantaneously released into the potentially incensive discharge.

Table 3.1 provides information on the typical conductivity value and classification for a range of products:

Product	Typical Conductivity (picoSiemens/metre)	Classification
Non-Conductive		
Xylene	0.1	Accumulator
Gasoline (straight run)	0.1 to 1	Accumulator
Diesel (ultra-low sulphur)	0.1 to 2	Accumulator
Lube oil (base)	0.1 to 1,000*	Accumulator
Commercial jet fuel	0.2 to 50	Accumulator
Toluene	1	Accumulator
Kerosene	1 to 50	Accumulator
Diesel	1 to 100*	Accumulator
Cyclohexane	<2	Accumulator
Motor gasoline	10 to 300*	Accumulator
Semi-Conductive		
Fuel with anti-static additive	50 to 300	Non-accumulator
Heavy black fuel oils	50 to 1,000	Non-accumulator
Conductive crude	>1,000	Non-accumulator
Bitumen	>1,000	Non-accumulator
Alcohols	100,000	Non-accumulator
Ketones	100,000	Non-accumulator
Conductive		
Distilled water	1,000,000,000	Non-accumulator
Water	100,000,000,000	Non-accumulator

Table 3.1 – Typical conductivity of products

* Some additives used for performance improvement can increase conductivity significantly.

3.1.5 Electrostatic Properties of Gases and Mists

Under normal conditions, gases are highly insulating and this has important implications with respect to mists and particulate suspensions in air and other gases. Charged mists are formed during the ejection of liquid from a nozzle, for example:

- Petroleum products entering an empty tank at high velocity.
- Wet steam condensing.
- Water from tank washing machines.
- Crude oil during crude oil washing.

Although the liquid, for example water, may have a very high conductivity, the relaxation of the charge on the droplets is hindered by the insulating properties of the surrounding gas. Fine particles present in inert flue gas, or created during discharge of pressurised liquid carbon dioxide, are frequently charged. The gradual charge relaxation, which does occur, is the result of the settling of the particles or droplets and, if the field strength is high, of corona discharge at sharp protrusions. Under certain circumstances, discharges with sufficient energy to ignite hydrocarbon gas/air mixtures can occur. See also Section 3.3.4.

3.2 General Precautions Against Electrostatic Hazards

3.2.1 Overview

Whenever a flammable atmosphere could potentially be present, the following measures must be taken to prevent electrostatic hazards:

- The bonding of metal objects to the metal structure of the ship to eliminate the risk of spark discharges between metal objects that might be electrically insulated. This includes metallic components of any equipment used for dipping, ullaging and sampling.
- The removal from tanks or other hazardous areas of any loose conductive objects that cannot be bonded.
- Restricting the linear velocity of the cargo to a maximum of 1 metre per second at the individual tank inlets during the initial stages of loading, i.e. until:
 - a) the filling pipe and any other structure on the base of the tank has been submerged to twice the filling pipe diameter in order that all splashing and surface turbulence has ceased and
 - b) any water collected in the pipeline has been cleared. It is necessary to load at this restricted rate for a period of 30 minutes or until two pipeline volumes (i.e. from shore tank to ship's tank) have been loaded into the tank, whichever is the lesser.
- Continuing to restrict the product flow to a maximum of 1 m/s at the tank inlet for the whole operation unless the product is 'clean'. A 'clean' product, within this context, is defined as one which contains less than 0.5% by volume of free water or other immiscible liquid and less than 10 mg/l of suspended solids¹.
- Avoiding splash filling by employing bottom entry using a fill pipe terminating close to the bottom of the tank.

¹ CENELEC Technical Report CLC/TR 50404, "Electrostatics – Code of Practice for the Avoidance of Hazards Due to Static Electricity", June 2003.

The following additional precautions should be taken against static electricity during ullaging, dipping, gauging or sampling of static accumulator oils:

- Banning the use of all metallic equipment for dipping, ullaging and sampling during loading and for 30 minutes after completion of loading. After the 30 minute waiting period, metallic equipment may be used for dipping, ullaging and sampling, but it must be effectively bonded and securely earthed to the structure of the ship before it is introduced into the tank, and must remain earthed until after removal.
- Banning the use of all non-metallic containers of more than 1 litre capacity for dipping, ullaging and sampling during loading and for 30 minutes after completion of loading.

Non-metallic containers of less than 1 litre capacity may be used for sampling in tanks at any time, provided that they have no conducting components and that they are not rubbed prior to sampling. Cleaning with a high conductivity proprietary cleaner, a solvent such as 70:30% IPA:toluene mix, or soapy water, is recommended to reduce charge generation. To prevent charging, the container should not be rubbed dry after washing.

Operations carried out through a correctly designed and installed sounding pipe are permissible at any time. It is not possible for any significant charge to accumulate on the surface of the liquid within the sounding pipe and therefore no waiting time is required. However, the precautions to be observed against introducing charged objects into a tank still apply and if metallic equipment is used it should be bonded before being inserted into the sounding pipe.

Detailed guidance on precautions to be taken during ullaging, dipping and sampling of static accumulator oils is given in Section 11.8.2.3. These precautions should be rigidly adhered to in order to avoid hazards associated with the accumulation of an electrical charge on the cargo.

3.2.2 Bonding

The most important countermeasure that must be taken to prevent an electrostatic hazard is to bond all metallic objects together to eliminate the risk of discharges between objects that might be charged and electrically insulated. To avoid discharges from conductors to earth, it is normal practice to include bonding to earth ('earthing' or 'grounding'). On ships, bonding to earth is effectively accomplished by connecting metallic objects to the metal structure of the ship, which is naturally earthed through the sea.

Some examples of objects which might be electrically insulated in hazardous situations and which must therefore be bonded are:

- Ship/shore hose couplings and flanges, except for the insulating flange or single length of non-conducting hose required to provide electrical isolation between the ship and shore. (See Section 17.5.)
- Portable tank washing machines.
- Manual ullaging and sampling equipment with conducting components.
- The float of a permanently fitted ullaging device if its design does not provide an earthing path through the metal tape.

The best method of ensuring bonding and earthing will usually be a metallic connection between the conductors. Alternative means of bonding are available and have proved effective in some applications, for example semi-conductive (dissipative) pipes and 'O' rings, rather than embedded metallic layers, for GRP pipes and their metal couplings.

Any earthing or bonding links used as a safeguard against the hazards of static electricity associated with portable equipment must be connected whenever the equipment is set up and not disconnected until after the equipment is no longer in use.

3.2.3 Avoiding Loose Conductive Objects

Certain objects may be insulated during tanker operations, for example:

- A metal object, such as a can, floating in a static accumulating liquid.
- A loose metal object while it is falling in a tank during washing operations.
- A metallic tool, lying on a piece of old lagging, left behind after maintenance.

Every effort should be made to ensure that such objects are removed from the tank since there is evidently no possibility of deliberately bonding them. This necessitates careful inspection of tanks, particularly after shipyard repairs.

3.3 Other Sources of Electrostatic Hazards

3.3.1 Filters

Three classifications of filter may be used in tanker operations, as follows:

Coarse (greater than or equal to 150 microns).

These do not generate a significant amount of charge, and require no additional precautions provided that they are kept clean.

Fine (less than 150 microns, greater than 30 microns).

These can generate a significant amount of charge and therefore require sufficient time for the charge to relax before the liquid reaches the tank. It is essential that the liquid spends a minimum of 30 seconds (residence time) in the piping downstream of the filter. Flow velocity should be controlled to ensure that this residence time requirement is met.

Microfine (less than or equal to 30 microns).

To allow sufficient time for the charge to relax, the residence time after passing through microfine filters must be a minimum of 100 seconds before the product enters the tank. Flow velocity should be adjusted accordingly.

3.3.2 Fixed Equipment in Cargo Tanks

A metal probe, remote from any other tank structure but near a highly charged liquid surface, will have a strong electrostatic field at the probe tip. Protrusions of this type may be associated with equipment mounted from the top of a tank, such as fixed washing machines or high level alarms. During the loading of static accumulator oils, this strong electrostatic field may cause electrostatic discharges to the approaching liquid surface.

Metal probes of the type described above can be avoided by installing the equipment adjacent to a bulkhead or other tank structure to reduce the electrostatic field at the probe tip. Alternatively, a support can be added running from the lower end of the probe downward to the tank structure below, so that the rising liquid meets the support at earth potential rather than the insulated tip of a probe. Another possible solution, in some cases, is to construct the probe-like device entirely of a non-conductive material. These

measures are not necessary if the ship is limited to crude or black oil service or if the tanks are inerted.

3.3.3 Free Fall in Tanks

Loading or ballasting over the top (overall) delivers charged liquid to a tank in such a manner that it can break up into small droplets and splash into the tank. This may produce a charged mist as well as an increase in the petroleum gas concentration in the tank. Restrictions upon loading or ballasting overall are given in Section 11.1.12.

3.3.4 Water Mists

The spraying of water into tanks, for instance during water washing, gives rise to electrostatically charged mist. This mist is uniformly spread throughout the tank being washed.

The electrostatic levels vary widely from tank to tank, both in magnitude and in sign.

When washing is started in a dirty tank, the charge in the mist is initially negative, reaches a maximum negative value, then goes back through zero and finally rises towards a positive equilibrium value. It has been found that, among the many variables affecting the level and polarity of charging, the characteristics of the wash water and the degree of cleanliness of the tank have the most significant influence. The electrostatic charging characteristics of the water are altered by re-circulation or by the addition of tank cleaning chemicals, either of which may cause very high electrostatic potentials in the mist. Potentials are higher in large tanks than in small ones. The size and number of washing machines in a tank affect the rate of change of charge, but they have little effect on the final equilibrium value.

The charged mist droplets created in the tank during washing give rise to an electrostatic field, which is characterised by a distribution of potential (voltage) throughout the tank space. The bulkheads and structure are at earth (zero) potential and the space potential increases with distance from these surfaces and is highest at points furthest from them. The field strength, or voltage gradient, in the space is greatest near the tank bulkheads and structure, more especially where there are protrusions into the tank. If the field strength is high enough, electric breakdown occurs into the space, giving rise to a corona. Because protrusions cause concentrations of field strength, a corona occurs preferentially from such points. A corona injects a charge of the opposite sign into the mist and is believed to be one of the main processes limiting the amount of charge in the mist to an equilibrium value. The corona discharges produced during tank washing are not strong enough to ignite the hydrocarbon gas/air mixtures that may be present.

Under certain circumstances, discharges with sufficient energy to ignite hydrocarbon gas/air mixtures can occur from unearthed conducting objects already within, or introduced into, a tank filled with charged mist. Examples of such unearthed conductors are a metal sounding rod suspended on a rope or a piece of metal falling through the tank space.

An unearthed conductor within a tank can acquire a high potential, primarily by induction, when it comes near an earthed object or structure, particularly if the latter is in the form of a protrusion. The unearthed conductor may then discharge to earth giving rise to a spark capable of igniting a flammable hydrocarbon gas/air mixture.

The processes by which unearthed conductors give rise to ignitions in a mist are fairly complex, and a number of conditions must be satisfied simultaneously before an ignition can occur.

These conditions include the size of the object, its trajectory, the electrostatic level in the tank and the geometrical configuration where the discharge takes place.

As well as solid unearthed conducting objects, an isolated slug of water produced by the washing process may similarly act as a spark promoter and cause an ignition. Experiments have shown that high capacity, single nozzle, fixed washing machines can produce water slugs which, owing to their size, trajectory and duration before breaking up, may satisfy the criteria for producing incendive discharges. However, there is no evidence of water slugs capable of producing incendive discharges being produced by portable types of washing machine. This can be explained by the fact that, if the jet is initially fine, the length of slugs that are produced are relatively small so that they have a small capacitance and do not readily produce incendive discharges.

Following extensive experimental investigations and using the results of long-term experience, the tanker industry has drawn up the tank washing guidelines set out in Section 11.3. These guidelines are aimed at preventing excessive charge generation in mists and at controlling the introduction of unearthed conducting objects when there is charged mist in the tank.

Charged mists, very similar to those produced during tank washing, occur from time to time in partly ballasted holds of OBOs. Due to the design of these ships, there may be violent mist-generating impacts of the ballast against the sides of the hold when the ship rolls in even a moderate sea. The impacts also give rise to free flying slugs of water in the tank so that if the atmosphere of the tank is flammable all the elements for an ignition are present. The most effective countermeasure is to have tanks either empty or fully pressed up so that violent wave motion in the tank cannot take place.

3.3.5 Inert Gas

Small particulate matter carried in inert gas can be electrostatically charged. The charge separation originates in the combustion process and the charged particles are capable of being carried through the scrubber, fan and distribution pipes into the cargo tanks. The electrostatic charge carried by the inert gas is usually small, but levels of charge have been observed well above those encountered with the water mists formed during washing. Because the tanks are normally in an inert condition, the possibility of an electrostatic ignition has to be considered only if it is necessary to inert a tank which already contains a flammable atmosphere or if a tank already inerted is likely to become flammable because the oxygen content rises as a result of ingress of air. Precautions are then required during dipping, ullaging and sampling. (See Section 11.8.3.)

3.3.6 Discharge of Carbon Dioxide

During the discharge of pressurised liquid carbon dioxide, the rapid cooling which takes place can result in the formation of particles of solid carbon dioxide that become charged on impact and contact with the nozzle. The charge can be significant with the potential for incendive sparks. Liquefied carbon dioxide should not be used for inerting, or injected for any other reason into cargo tanks or pump rooms that may contain flammable gas mixtures.

3.3.7 Clothing and Footwear

People who are insulated from earth by their footwear or the surface on which they are standing can become electrostatically charged. This charge can arise from physical separation of insulating materials caused, for instance, by walking on a very dry insulating surface (separation between the soles of the shoes and the surface) or by removing a garment.

Experience over a very long period indicates that electrostatic discharges caused by clothing and footwear do not, however, present a significant hazard in the oil industry. This is especially true in a marine environment where surfaces rapidly become contaminated by deposits of salt and moisture that reduce electrical resistances, particularly at high humidity.

3.3.8 Synthetic Materials

An increasing number of items manufactured from synthetic materials are being offered for use on board ships. It is important that those responsible for their provision to tankers should be satisfied that, if they are to be used in flammable atmospheres, they will not introduce electrostatic hazards.

GENERAL HAZARDS FOR SHIP AND TERMINAL

This Chapter deals primarily with general hazards on board a tanker and/or at a terminal and the precautions to be taken to mitigate them. Reference should be made to the appropriate Chapters for precautions relating to specific operations such as cargo handling, ballasting, tank cleaning, inerting or entry into enclosed spaces.

4.1 General Principles

In order to eliminate the risk of fire and explosion on a tanker, it is necessary to prevent a source of ignition and a flammable atmosphere being present in the same place at the same time. It is not always possible to exclude both these factors simultaneously and precautions are therefore directed towards excluding or controlling one of them.

In the case of cargo compartments, pumprooms, and at times the tank deck, flammable gases are to be expected and the strict elimination of all possible sources of ignition in these locations is essential.

Cabins, galleys and other areas within the accommodation block inevitably contain ignition sources such as electrical equipment, matches and/or electric cigarette lighters. While it is sound practice to minimise and control such sources of ignition, for example by designation of approved smoking rooms, it is essential to avoid the entry of flammable gas.

Air conditioning intakes must be set to ensure that the atmospheric pressure inside the accommodation is always greater than that of the external atmosphere. Air conditioning systems must not be set to 100% recirculation, as this will cause the pressure of the internal atmosphere to fall to less than that of the external atmosphere, due to extraction fans operating in sanitary spaces and galleys.

In engine and boiler rooms, ignition sources such as those arising from boiler operations and electrical equipment cannot be avoided (see also Section 4.2.4). It is essential therefore to prevent the entry of flammable gases into such compartments. Residual fuel oils may present a flammability hazard (see Section 2.7) and the routine checking of bunker spaces for flammability by tanker and terminal personnel is to be encouraged.

It is possible, by good design and operational practice, for both flammable gases and ignition sources to be safely controlled in deck workshops, store rooms, forecastle, centre castle, dry cargo holds etc. However, the means for such control must be rigorously maintained.

Although the installation and the correct operation of an inert gas system provides an added measure of safety, it does not preclude the need for close attention to the precautions set out in this Chapter.

Oil spillage and leakage present a fire hazard and can lead to pollution. They can also cause slips and falls. Spills and leaks should therefore be avoided and, if they occur, immediate attention should be given to stopping the source and to cleaning contaminated areas.

4.2 Control of Potential Ignition Sources

4.2.1 Naked Lights

Naked lights must be prohibited on the tank deck and in any other place where there is a risk that petroleum gas may be present.

4.2.2 Smoking

Smoking is known to present significant risks on board ships and therefore requires careful management. While the text of this Section refers explicitly to smoking, the controls should also be applied to the burning of other products such as incense and joss sticks, a practice that has become common around the world. As with tobacco products, smouldering smoke-producing products should never be left unattended or allowed near bedding or other combustible materials.

4.2.2.1 Smoking at Sea

While a tanker is at sea, smoking should be permitted only at times and in places specified by the Master. Smoking must be prohibited on the tank deck or any other place where petroleum gas may be present. Criteria that should be taken into account when determining the location of designated smoking places are listed in Section 4.2.2.3.

4.2.2.2 Smoking in Port and Controlled Smoking

Smoking in port should only be permitted under controlled conditions. Difficulties perceived in introducing a restrictive smoking policy, including a total ban, should not impede the implementation of such a policy if it is in the interest of safe operations. Appropriate measures should be in place, both on the ship and the shore, to ensure full compliance.

Smoking should be strictly prohibited within the restricted area enclosing all tanker berths and on board any tanker while at a berth, except in designated smoking places.

Certain craft, such as barges designed without a permanent propulsion system, may have an accommodation block or lesser structure affixed directly to the tank deck. The spaces beneath such a structure may be designed for the carriage of non-explosive and non-flammable products, but this does not guarantee that such spaces remain gas free.

Some conventional vessels, typically smaller craft such as barges and inland watercraft, are similarly at risk through their inability to maintain positive pressure in the accommodation block and other spaces.

In such cases, the inherent difficulty in maintaining a gas free environment either within, immediately outside or below such an accommodation block or lesser structure makes the provision of a safe smoking area impossible. Smoking on board such craft should be strictly prohibited while they remain alongside the terminal or facility.

4.2.2.3 Location of Designated Smoking Places

The designated smoking places on a tanker or on shore should be agreed in writing between the Responsible Officer and the Terminal Representative before operations start. The Responsible Officer should ensure that all persons on board the tanker are informed of the selected places for smoking and that suitable notices, in addition to the tanker's permanent notices, are posted.

Certain criteria should be met in the selection of smoking places whenever petroleum cargoes are being handled or when ballasting into non-gas free cargo tanks, purging with inert gas, gas freeing or tank cleaning operations are taking place.

The criteria are:

- Smoking places should be confined to locations within the accommodation.
- Smoking places should not have doors or ports that open directly onto open decks.
- Account should be taken of conditions that may suggest danger, such as an indication of unusually high petroleum gas concentrations, particularly in the absence of wind, and when there are operations on adjacent tankers or on the jetty berth.

In the designated smoking places, all ports should be kept closed and doors into passageways should be kept closed except when in use.

While the tanker is moored at the terminal, even when no operations are in progress, smoking can only be permitted in designated smoking places or, after there has been prior agreement in writing between the Responsible Officer and the Terminal Representative, in any other closed accommodation.

When stern loading/discharge connections are being used, particular care must be taken to ensure that no smoking is allowed in any accommodation or space, the door or ports of which open onto the deck where the stern loading/discharge manifold is located.

4.2.2.4 Matches and Cigarette Lighters

Safety matches or fixed (car type) electrical cigarette lighters should be provided in approved smoking locations.

All matches used on board tankers should be of the safety type. The use of matches and cigarette lighters outside the accommodation should be prohibited, except in places where smoking is permitted. Matches should not be carried on the tank deck or in any other place where petroleum gas may be present.

The use of all mechanical lighters and portable lighters with electrical ignition sources should be prohibited on board tankers.

Disposable lighters present a significant risk as an uncontrolled ignition source. The unprotected nature of their spark producing mechanism allows them to be easily activated accidentally.

The carriage of matches and lighters through terminals should be prohibited. Severe penalties may be levied under local regulations for non-compliance.

4.2.2.5 Notices

Portable and permanent notices prohibiting smoking and the use of naked lights should be displayed conspicuously at the point of access to the ship and at the exits from the accommodation area. Within the accommodation area, instructions concerning smoking should be displayed conspicuously.

4.2.3 Galley Stoves and Cooking Appliances

The use of galley stoves and other cooking appliances that employ naked flames should be prohibited while a tanker is at a petroleum berth.

It is essential that galley personnel be instructed in the safe operation of galley equipment. Unauthorised and inexperienced persons should not be allowed to use such facilities.

A frequent cause of fires is the accumulation of unburnt fuel or fatty deposits in galley ranges, within flue pipes and in the filter cowls of galley vents. Such areas require frequent inspection to ensure that they are maintained in a clean condition. Oil and deep fat fryers should be fitted with thermostats to cut off the electrical power and so prevent accidental fires.

Galley staff should be trained in handling fire emergencies and appropriate responses. Appropriate fire extinguishers and fire blankets should be readily available.

The use of portable stoves and cooking appliances on board ship should be controlled and, when in port, their use should be prohibited.

Cookers and other equipment heated by steam may be used at all times.

4.2.4 Engine and Boiler Rooms

4.2.4.1 Combustion Equipment

As a precaution against funnel fires and sparks, burners, tubes, uptakes, exhaust manifolds and spark arresters should be maintained in good working condition. If there is a funnel fire or sparks are emitted from the funnel, the tanker should, if at sea, consider altering course as soon as possible to avoid sparks falling on the tank deck. Any cargo, ballasting or tank cleaning operations in progress must be stopped and all tank openings closed.

4.2.4.2 Blowing Boiler Tubes

Boiler tubes should be soot blown prior to arrival and after departure from a port. Boiler tubes should not be soot blown when the ship is in port. At sea, the officer on bridge watch should be consulted prior to the operation commencing and the vessel's course altered if necessary.

4.3 Portable Electrical Equipment

4.3.1 General

All portable electrical equipment, including lamps, for operation in hazardous areas must be of an approved type. Before use, portable equipment should be examined for possible defects such as damaged insulation and a check made that cables are securely attached and that they will remain so throughout the work. Special care should be taken to prevent any mechanical damage to flexible cables or wandering leads.

4.3.2 Lamps and Other Electrical Equipment on Flexible Cables (Wandering Leads)

The use of portable electrical equipment on wandering leads should be prohibited within cargo tanks and adjacent spaces or over the tank deck, unless, throughout the period the equipment is in use:

- The compartments within which, or over which, the equipment and the leads are to be used is safe for Hot Work (see Section 9.4).
- The adjacent compartments are also safe for Hot Work, or have been purged of hydrocarbon to less than 2% by volume and inerted, or are completely filled with ballast water, or any combination of these (see Section 9.4).
- All tank openings to other compartments not safe for Hot Work or purged as above are closed and remain so; or
- the equipment, including all wandering leads, is intrinsically safe; or
- the equipment is contained within an approved explosion-proof housing. Any flexible cables should be of a type approved for extra hard usage, have an earth conductor, and be permanently attached to the explosion-proof housing in an approved manner.

In addition, there are certain types of equipment that are approved for use over the tank deck only.

The foregoing does not apply to the proper use of flexible cables used with signal or navigation lights or with approved types of telephones.

4.3.3 Air Driven Lamps

Air driven lamps of an approved type may be used in dangerous/hazardous areas although, to avoid the accumulation of static electricity at the appliance, the following precautions should be observed:

- The air supply should be fitted with a water trap.
- The supply hose should be of a low electrical resistance.

Permanently installed units should be earthed.

4.3.4 Torches (Flashlights), Lamps and Portable Battery Powered Equipment

Only torches that have been approved by a competent authority for use in flammable atmospheres may be used on board tankers.

Handheld UHF/VHF portable transceivers must be of an intrinsically safe type.

Small battery powered personal items such as watches, miniature hearing aids and heart pacemakers are not significant ignition sources.

Unless approved for use in a flammable atmosphere, portable radios, tape recorders, electronic calculators, cameras containing batteries, photographic flash units, portable telephones and radio pagers, however, must not be used on the tank deck or in areas where flammable gas may be present.

Trimode gauging tapes are battery operated electronic units and should be certified as being suitable for use in flammable atmospheres.

4.3.5 Cameras

There is a wide range of photographic equipment available. Ships and terminals may encounter various types of camera in different situations – film crews with complex professional equipment and large batteries or the personal still or video equipment. The following general guidelines should be considered when deciding whether or not it is safe to use a particular camera. This guidance refers only to ignition hazards and does not consider security concerns that may require other restrictions on the use of cameras in some ports.

Camera equipment that contains batteries may produce an incendive spark from the flash or the operation of electrically powered items, such as aperture control and film winding mechanisms. This equipment should therefore not be used in a hazardous area (see Section 4.4.2) unless it is certified as being suitable for use in a hazardous area. Disposable cameras are available with a built-in flash capability and care must be taken to ensure that these are not used in hazardous areas.

Photographic equipment is available which does not have a flash, or any battery or power operated parts, such as the non-flash plastic disposable types. These cameras can be considered safe for use in hazardous areas.

Cameras that are operated by a clockwork mechanism, or with direct mechanical devices for aperture setting and film winding, are also available and can be considered safe for use in a hazardous area.

4.3.6 Other Portable Electrical Equipment

For guidance on the use of mobile telephones and pagers (see Sections 4.8.6 and 4.8.7.).

Any other electrical or electronic equipment of non-approved type, whether mains or battery powered, must not be active, switched on or used within hazardous areas. This includes, but should not be limited to, radios, calculators, photographic equipment, laptop computers, handheld computers and any other portable equipment that is electrically powered but not approved for operation in hazardous areas.

In view of the ready availability and widespread use of such equipment, appropriate measures should be taken to prevent its use within hazardous areas. Personnel must be advised of the prohibition of non-approved equipment, and terminals should have a policy for informing visitors of the potential dangers associated with the use of portable electrical equipment. Terminals should also reserve the right to require any non-approved items of equipment to be deposited at the entrance to the port area or other appropriate boundary within the terminal.

4.4 Management of Electrical Equipment and Installations in Dangerous Areas

4.4.1 General

This Section describes the different approaches to the classification of dangerous areas on board tankers and of hazardous areas in terminals with regard to electrical installations and equipment. General guidance is given on the safety precautions to be observed during maintenance and repair of electrical equipment. It should be noted that the standards for electrical equipment and its installation are considered to fall outside the scope of this Guide.

4.4.2 Dangerous and Hazardous Areas

4.4.2.1 Dangerous Areas in a Tanker

In a tanker, certain areas/spaces are defined by international convention, flag administrations and classification societies as being dangerous/hazardous for the installation or use of electrical equipment either at all times or during specific periods such as loading, ballasting, tank cleaning or gas freeing operations.

Definitions of dangerous areas on tankers, detailed in the classification society rules, are derived from recommendations by the International Electrotechnical Commission (IEC) as to the types of electrical equipment that can be installed in them. It should be noted that for terminals the IEC definitions follow a rigid classification based on a zonal concept (see Section 4.4.2.2 below).

4.4.2.2 Hazardous Areas at a Terminal

At a terminal, account is taken of the probability of a flammable gas mixture being present by grading hazardous areas into three zones. The IEC classifies hazardous areas into zones based upon the frequency of the occurrence and duration of an explosive gas atmosphere as follows:

- **Zone 0**
A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is present continuously or for long periods or frequently.
- **Zone 1**
A place in which an explosive atmosphere consisting of a mixture with air or flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally.

- **Zone 2**
A place in which an explosive atmosphere consisting of a mixture with air or flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will only persist for a short period.

4.4.2.3 Application of Hazardous Area Classifications to a Tanker at a Berth

When a tanker is at a berth, it is possible that an area in the tanker that is regarded as safe may fall within one of the hazardous zones of the terminal. If such a situation should arise and, if the area in question contains unapproved electrical equipment, then such equipment may have to be isolated whilst the tanker is at the berth.

4.4.3 Electrical Equipment

4.4.3.1 Fixed Electrical Equipment

Fixed electrical equipment in dangerous areas, even in locations where a flammable atmosphere is to be infrequently expected, must be of an approved type. This equipment should be properly maintained so as to ensure that neither the equipment nor the wiring become a source of ignition.

4.4.3.2 Closed Circuit Television

If closed circuit television is fitted on a tanker or on a jetty, the cameras and associated equipment must be of an approved design for the areas in which they are located. If they are of an approved design, there is no restriction on their use. When a tanker is at a berth, any servicing of this equipment should be subject to prior agreement between the ship's Responsible Officer and the Terminal Representative.

4.4.3.3 Electrical Equipment and Installations on board Ship

Fixed electrical equipment and installations in tankers will be in accordance with classification society or national requirements, based on the recommendations of the IEC. Additional recommendations in respect of the use of temporary electrical installations and portable electrical equipment are given in Sections 4.3 and 10.9.4.

4.4.3.4 Electrical Equipment and Installations at Terminals

At terminals, the types of electrical equipment and methods of installation will normally be governed by national requirements and, where applicable, by the recommendations of the IEC.

4.4.4 Inspection and Maintenance of Electrical Equipment

4.4.4.1 General

All apparatus, systems and installations, including cables, conduits and similar equipment, should be maintained in good condition. To this end, they should be inspected regularly.

Correct functional operation does not necessarily imply compliance with the required standards of safety.

4.4.4.2 Inspections and Checks

All equipment, systems and installations should be inspected when first installed. Following any repair, adjustment or modification, those parts of the installation that have been disturbed should be checked.

If at any time there is a change in the area classification or in the characteristics of the flammable material handled at a terminal, a check should be made to ensure that all equipment is of the correct group and temperature class and that it continues to comply with the requirements for the revised area classification.

4.4.4.3 Maintenance of Electrical Equipment

The integrity of the protection afforded by the design of explosion-proof or intrinsically safe electrical equipment may be compromised by incorrect maintenance procedures. Even the simplest of repair and maintenance operations must be carried out in strict compliance with the manufacturer's instructions in order to ensure that such equipment remains in a safe condition.

This is particularly relevant in the case of explosion-proof lights where incorrect closing after changing a light bulb could compromise the integrity of the light.

In order to assist with routine servicing and repair, ships should be provided with detailed maintenance manuals for the specific systems and arrangements fitted on board.

4.4.4.4 Insulation Testing

Insulation testing should only be carried out when no flammable gas mixture is present.

4.4.4.5 Alterations to Terminal Equipment, Systems and Installations

No modification, addition or removal should be made to any approved equipment, system or installation at a terminal without the permission of the appropriate authority, unless it can be verified that such a change does not invalidate the approval.

No modification should be made to the safety features of equipment that relies on the techniques of segregation, pressurising, purging or other methods of ensuring safety, without the permission of the engineer responsible.

When equipment in a terminal hazardous zone is permanently withdrawn from service, the associated wiring should be removed from the hazardous zone or should be correctly terminated in an enclosure appropriate to the area classification.

When equipment in a terminal's hazardous zone is temporarily removed from service, the exposed conductors should be correctly terminated as above, or adequately insulated, or solidly bonded together and earthed.

The cable cores of intrinsically safe circuits should either be insulated from each other or bonded together and insulated from earth.

4.4.4.6 Periodic Mechanical Inspections

During inspections of electrical equipment or installations, particular attention should be paid to the following:

- Cracks in metal, cracked or broken glasses, or failure of cement around cemented glasses in flame-proof or explosion-proof enclosures.
- Covers of flame-proof enclosures, to ensure that they are tight, that no bolts are missing, and that no gaskets are present between mating metal surfaces.
- Each connection to ensure that it is properly connected.
- Possible slackness of joints in conduit runs and fittings.
- Clamping of cable armouring.
- Stresses on cables that might cause fracture.

4.4.5 Electrical Repairs, Maintenance and Test Work at Terminals

4.4.5.1 General

All maintenance work on electrical equipment should be undertaken under the control of a permit or an equivalent safety management system, with procedures that ensure that electrical and mechanical isolations are effectively managed.

The use of mechanical lock-off devices and safety tags is strongly recommended.

4.4.5.2 Cold Work

Cold Work should not be carried out on any apparatus or wiring, nor should any flame-proof or explosion-proof enclosure be opened, nor the special safety characteristics provided in connection with standard apparatus be impaired, until all electrical power has been cut off from the apparatus or wiring concerned. The electrical power should not be restored until work has been completed and the above safety measures have been fully reinstated. Any such work, including changing of lamps, should only be done by an authorised person.

4.4.5.3 Hot Work

For the purpose of repairs, modifications or testing, the use of soldering apparatus or other means involving a flame, fire or heat, and the use of industrial type apparatus, is permitted in a hazardous area within a terminal, provided that the area has first been made safe and certified gas free by an authorised person and is then maintained in that condition as long as the work is in progress. When such Hot Work is considered necessary on a berth where a tanker is alongside or on the berthed tanker, the joint agreement of the Terminal Representative and the Responsible Officer should first be obtained and a Hot Work Permit issued.

It is also permissible to restore voltage to apparatus for testing during a period of repair or alteration, subject to the same conditions.

Before undertaking any Hot Work, reference should be made to Section 9.4.

4.5 Use of Tools

4.5.1 Grit Blasting and Mechanically Powered Tools

It should be noted that grit blasting and the use of mechanically powered tools are not normally considered as falling within the definition of Hot Work in the shipping industry. However, these activities have a significant potential for producing sparks and should be carried out under the control of a Permit to Work system, or under the control of the ship's Safety Management System.

The following precautions should be observed:

- The work area should not be subject to vapour release, or a concentration of combustible vapours, and should be free of combustible material.
- The area should be gas free and tests with a combustible gas indicator should give a reading of not more than 1% LFL.
- Mechanical tools should not be used when the ship is alongside a terminal, unless the express permission of the Terminal Representative has been granted.
- There must be no cargo, bunkering, ballasting, tank cleaning, gas freeing, purging or inerting operations in progress.
- Adequate fire-fighting equipment must be laid out and ready for immediate use.

The hopper and hose nozzle of a grit blasting machine should be electrically bonded and earthed to the deck or fitting being worked on.

There is a risk of perforation of pipelines when grit blasting or chipping, and great care must be taken when planning such work. Before commencing work on cargo lines on deck, they should be flushed. Drop line valves should be closed and bottom lines filled with water. The atmosphere inside the section to be worked on should be confirmed as either inerted to less than 8% oxygen by volume or gas free to not more than 1% LFL. Similar precautions should be adopted for inert gas and crude oil washing lines, as appropriate.

4.5.2 Hand Tools

The use of hand tools such as chipping hammers and scrapers for steel preparation and maintenance may be permitted without a Hot Work Permit. Their use must, however, be restricted to deck areas and fittings not connected to the cargo system.

The work area should be gas free and clear of combustible materials. The ship must not be engaged in any cargo, bunker, ballasting, tank cleaning, gas freeing, purging or inerting operations.

Non-ferrous, so called non-sparking, tools are only marginally less likely to give rise to an incendive spark and, because of their comparative softness, are not as efficient as their ferrous equivalents. Particles of concrete, sand or other rock-like substances are likely to become embedded in the working face or

edge of such tools, and can then cause incendive sparks on impact with ferrous or other hard metals. The use of non-ferrous tools is therefore not recommended.

4.6 Equipment Made of Aluminium

Aluminium equipment should not be dragged or rubbed across steel since it may leave a smear which, if subsequently struck by a hammer or falling object, can cause an incendive spark. It is therefore recommended that the undersides of aluminium gangways and other heavy portable aluminium structures are protected with a hard plastic or wooden strip to prevent smears being transferred to steel surfaces.

The use of other aluminium equipment in cargo tanks and on cargo decks should be subjected to a risk assessment and, where necessary, carefully controlled.

4.7 Cathodic Protection Anodes in Cargo Tanks

If magnesium anodes strike rusty steel, they are very likely to produce an incendive spark. Such anodes must not therefore be fitted in tanks where flammable gases can be present.

Aluminium anodes give rise to incendive sparking on violent impact and therefore should only be installed at approved locations within cargo tanks, and should never be moved to another location without proper supervision. Moreover, as aluminium anodes could easily be mistaken for zinc anodes and installed in potentially dangerous locations, it is advisable to restrict their use to permanent ballast tanks.

Zinc anodes do not generate an incendive spark on impact with rusty steel and therefore are not subject to the above restrictions.

The location, securing and type of anode installed in cargo tanks will be subject to approval by the appropriate authorities. Their recommendations should be observed and inspections made as frequently as possible to check the security of the anodes and mountings. Anodes have become more susceptible to physical damage with the advent of high capacity tank washing machines.

4.8 Communications Equipment

4.8.1 General

Unless certified as intrinsically safe or of other approved design, all communications equipment on board ships, such as telephones, talk-back systems, signalling lamps, search lights, loud hailers, closed circuit television cameras and electrical controls for ships' whistles, should neither be used nor connected or disconnected when the areas in which they are positioned come within the boundary of a shore hazardous zone.

4.8.2 Ship's Radio Equipment

The use of a tanker's radio equipment during cargo or ballast handling operations is potentially dangerous.

4.8.2.1 Medium and High Frequency Radio Transmissions

During medium and high frequency radio transmission (300 KHz-30 MHz), significant energy is radiated which can, at distances extending to 500 metres from the transmitting antennae, induce an electrical potential in unearthed 'receivers' (derricks, rigging, mast stays etc) that is capable of producing an incendive spark. Transmissions can also cause arcing over the surface of antenna insulators when they have a surface coating of salt, dirt or water.

Therefore, it is recommended that:

- All stays, derricks and fittings should be earthed. Bearings of booms should be treated with electrically conductive grease (such as graphite grease) to maintain electrical continuity or suitable bonding straps installed.
- Transmissions should not be permitted during periods when there is likely to be a flammable gas in the region of the transmitting antennae or if the antenna comes within the shore hazardous zone.
- Main transmitting antennae should be earthed or isolated whilst the ship is alongside the berth.

If it is necessary to operate the ship's radio in port for servicing purposes, there should be agreement between tanker and terminal on the procedures necessary to ensure safety. Among the precautions that might be agreed are operating at low power or the use of a dummy antenna load which will eliminate all radio transmissions to atmosphere. In any case, a safe system of work must be agreed and implemented before energising such equipment.

4.8.2.2 VHF/UHF Equipment

The use of permanently and correctly installed VHF and UHF equipment during cargo or ballast handling operations is considered safe. However, it is recommended that the transmission power be set to low power (one watt or less) when used in port operations.

The use of portable VHF/UHF radios within a terminal or on board ship presents no hazards as long as the equipment is certified and maintained to intrinsically safe standards and the power output is one watt or less.

The use of VHF/UHF radio equipment as a means of communication between ship and shore personnel should be encouraged.

4.8.2.3 Satellite Communications Equipment

This equipment normally operates at 1.6 GHz and the power levels generated are not sufficient to present an ignition hazard. Satellite communications equipment may be used therefore to transmit and receive messages whilst the ship is in port.

4.8.3 Ship's Radar Equipment

Marine radar systems operate in the high Radio Frequency (RF) and microwave range. Radiation from the scanner fans out in an almost horizontal, narrow beam as the scanner rotates. In port, it will pick up cranes, loading arm gantries and other such structures, but it will not normally spread down to the ship's deck or jetty.

Radar sets, operating on 3 cm and 10 cm wavelengths, are designed with a peak power output of 30 kW and, if properly sited, present no radio ignition hazard due to induced currents.

High Frequency (HF) radiation does not penetrate the human body, but at short ranges (up to 10 m) can cause heating of skin or eyes. Assuming sensible precautions are taken, such as not looking directly into the scanner at close range, there is no significant health risk from marine radar emissions.

Radar scanner motors are not rated for use in dangerous/hazardous areas but, apart from on smaller vessels, are generally situated well above shore hazardous zones. Any risk is reduced further on ships operating a closed loading system with vapour return. The testing of radars whilst alongside is therefore considered safe. However, it is good practice to switch the radar off or place it on standby when alongside a terminal and to consult with the terminal before testing radar equipment during cargo operations.

4.8.4 Automatic Identification Systems (AIS)

AIS is required to be operating while a ship is underway and while at anchor. Some port authorities may request that the AIS is kept on when a ship is alongside. The AIS operates on a VHF frequency and transmits and receives information automatically, and the output power ranges between 2 and 12.5 watts. Automatic polling by another station (e.g. by port authority equipment or another ship) could cause equipment to transmit at the higher (12.5 watt) level, even when it is set to low power (typically 2 watts).

When alongside a terminal or port area where hydrocarbon gases may be present, either the AIS should be switched off or the aerial isolated and the AIS given a dummy load. Isolating the aerial preserves manually input data that may be lost if the AIS is switched off. If necessary, the port authority should be informed.

When alongside terminal or port areas where no hydrocarbon gases are likely to be present, and if the unit has the facility, the AIS should be switched to low power.

If the AIS is switched off or isolated whilst alongside, it must be reactivated upon leaving the berth.

The use of AIS equipment may affect the security of the ship or the terminal at which it is berthed. In such circumstances, the use of AIS may be determined by the port authority, depending on the security level within the port.

4.8.5 Telephones

When there is a direct telephone connection from the ship to the shore control room or elsewhere, telephone cables should preferably be routed outside the dangerous zone.

When this is not feasible, the cable should be routed and fixed in position by qualified shore personnel and should be protected against mechanical damage so that no danger can arise from its use.

4.8.6 Mobile Telephones

Most mobile phones are not intrinsically safe and are only considered safe for use in non-hazardous areas. Mobile phones should only be used on board a ship with the Master's permission. Unless certified as being intrinsically safe (see below), their use should be restricted to designated areas of the accommodation space where they are unlikely to interfere with the ship's equipment.

Although transmission power levels of non-intrinsically safe mobile telephones are insufficient to cause problems with sparking from induced voltages, the batteries can contain sufficient power to create an incendive spark if damaged or short circuited. It should be borne in mind that equipment such as mobile telephones and radio pagers, if switched on, can be activated remotely and a hazard can be generated by the alerting or calling mechanism and, in the case of telephones, by the natural response to answer the call. When taken through a terminal, or on to or off a ship, they should therefore be switched off and should only be re-commissioned once they are in a non-hazardous area, such as inside the ship's accommodation or clear of the terminal.

Intrinsically safe mobile telephones are available and these may be used in hazardous areas. These telephones must be clearly identified as being intrinsically safe for all aspects of their operation. Terminal staff going on board a tanker, and ship's staff going into the terminal, carrying mobile telephones that are intrinsically safe should be prepared to demonstrate compliance if requested by the other party. Other visitors to the ship or terminal should not use mobile telephones unless prior permission has been obtained from the ship or terminal, as appropriate.

4.8.7 Pagers

Not all pagers are intrinsically safe. Non-intrinsically safe pagers are considered safe for use only in non-hazardous areas. When taken through a terminal, or onto or off a ship, they should be switched off and should only be re-commissioned once they are in a non-hazardous area, such as inside the ship's accommodation.

Intrinsically safe pagers may be used in hazardous areas. These pagers must be clearly identified as being intrinsically safe for all aspects of their operation. Terminal staff going on board a tanker, and ship's staff going into the terminal, carrying pagers that are intrinsically safe should be prepared to demonstrate compliance if requested by the other party. Other visitors to the ship or terminal should not use pagers unless prior permission has been obtained from the ship or terminal, as appropriate.

4.9 Spontaneous Combustion

Some materials when damp or soaked with oil, especially oil of vegetable origin, are liable to ignite without the external application of heat as the result of gradual heating within the material produced by oxidation. The risk of spontaneous combustion is smaller with petroleum oils than with vegetable oils, but it can still occur, particularly if the material is kept warm, for example by proximity to a hot pipe.

Cotton waste, rags, canvas, bedding, jute sacking, sawdust or any similar absorbent material therefore should not be stowed in the same compartment as oil, paint etc and should not be left lying on the jetty, on decks, on equipment, on or adjacent to pipelines

etc. If such materials become damp, they should be dried before being stowed away. If soaked with oil, they should be cleaned or destroyed.

Certain chemicals used for boiler treatment are also oxidising agents and, although carried in diluted form, are capable of spontaneous combustion if permitted to evaporate.

4.10 Auto-Ignition

Petroleum liquids when heated sufficiently will ignite without the application of a naked flame. This process of auto-ignition is most common where fuel or lubricating oil under pressure sprays onto a hot surface. It also occurs when oil spills onto lagging, vaporises and bursts into flame. Both instances have been responsible for serious fires. Oil feeder lines require particular attention to avoid oil being sprayed from leaks. Oil saturated lagging should be removed and personnel protected from any ignition or re-ignition of vapours during the process.

4.11 Asbestos

It is important to note that disturbance or removal of asbestos should be carried out by specialist contractors if possible. In cases where the crew is involved in urgent repair work at sea, measures should be in place to ensure that they are adequately protected from asbestos exposure. IMO MSC Circular 1045 provides the necessary guidance on how to handle asbestos safely on board ships.

Chapter 5

FIRE-FIGHTING

This Chapter describes the types of fire that may be encountered on a tanker or at a terminal, together with the means of extinguishing them. Descriptions of fire-fighting equipment to be found on tankers and in terminals are provided in Chapters 8 and 19 respectively.

5.1 Theory of Fire-Fighting

Fire requires a combination of fuel, oxygen, a source of ignition and a continuous chemical reaction, commonly referred to as combustion.

Fires are extinguished by the removal of heat, fuel or air, or by interrupting the chemical reaction of combustion. The main objective of fire-fighting is to reduce the temperature, remove the fuel, exclude the supply of air or interfere chemically with the combustion process with the greatest possible speed.

5.2 Types of Fire and Appropriate Extinguishing Agents

The classification of fires given below is that historically provided in ISGOTT. It conforms to the classifications used within Europe. Alternative classifications may be used elsewhere.

5.2.1 Class A – Ordinary (Solid) Combustible Material Fires

Class A fires are those involving solid cellulosic materials such as wood, rags, cloth, paper, cardboard, clothing, bedding, rope and other materials such as plastic etc.

Cooling by large quantities of water, or the use of extinguishing agents containing a large proportion of water, is of primary importance when fighting fires involving ordinary combustible material. Class A materials can support deep-seated and smouldering fires long after visible flames are extinguished. Therefore, cooling the source and surrounding area should continue long enough to ensure that no re-ignition of deep-seated fires is possible.

5.2.2 Class B – Fires Involving Flammable and Combustible Hydrocarbon Liquids

Class B fires are those that occur in the vapour/air mixture over the surface of flammable and combustible liquids such as crude oil, gasoline, petrochemicals, fuel and lubricating oils, and other hydrocarbon liquids. Fires involving flammable gases are generally included in this classification.

These fires are extinguished by isolating the source of fuel (stopping the flow of fuel), inhibiting the release of combustible vapours or by interrupting the chemical reaction of the combustion process. Since most Class B materials burn with greater intensity and re-ignite more readily than Class A materials, more effective extinguishing agents are generally required.

Class B liquids are generally divided into the two broad categories of non-volatile and volatile materials. This division is generally sufficient to ensure that proper precautions and measures can be specified for handling Class B liquids. In summary, non-volatile materials have a flashpoint of 60°C (140°F) or above, as determined by the closed cup method of testing. Volatile materials have a flashpoint below 60°C (140°F), as determined by the same method. Flammable gases are volatile materials that typically have flashpoints at temperatures at or below the ambient temperature range. Flammable gases have relatively high vapour pressures, when in the liquid state, compared to flammable (volatile) liquids.

Low expansion foam, defined and discussed in Section 5.3.2.1, is an effective agent for extinguishing most hydrocarbon liquid fires. It should be applied so as to flow evenly and progressively over the burning surface, avoiding undue agitation and submergence. This can best be achieved by directing the foam discharge against any vertical surface adjacent to the fire, both in order to break the force of discharge and to build up an unbroken smothering blanket. If there is no vertical surface, the discharge should be advanced in oscillating sweeps, in the direction of the wind when possible, taking care to avoid foam plunging into the liquid. Foam spray streams, while limited in range, are also effective.

Volatile liquid fires of limited size can be rapidly extinguished with dry chemical agents, but are subject to re-ignition when hot surfaces are in contact with flammable vapours.

Non-volatile liquid fires that have not been burning for an extended period can be extinguished by water fog or water spray if the whole burning surface is accessible. The surface of the burning oil transfers its heat rapidly to water droplets, which present a very large cooling surface area. The flame can be extinguished with advancing and oscillating sweeps of fog or spray across the complete width of the fire. Any oil fire that has been burning for some time is more difficult to extinguish with water, since the oil will have been heated to a progressively greater depth and cannot readily be cooled to a point where it ceases to give off gas.

Water should only be applied to oil fires as a spray or fog. The use of a water jet may spread the burning oil by splashing or overflow.

An aspect that must be borne in mind with liquid petroleum is the risk of re-ignition, so a continuing watch and preparedness should be maintained after the fire has been extinguished.

5.2.3 Class C – Electrical Equipment Fires

Class C fires involve energised electrical equipment. These fires may be caused by a short circuit, overheating of circuits or equipment, lightning or fire spread from other areas. The immediate action should be to de-energise the electrical equipment. Once de-energised, a non-conductive extinguishing agent such as carbon dioxide should be used. Dry chemical is an effective non-conductive extinguishing agent, but is difficult to clean up after use. **If the equipment cannot be de-energised, it is vital that a non-conductive agent be used.**

5.2.4 Class D – Combustible Metal Fires

Class D fires involve combustible metals such as magnesium, titanium, potassium and sodium. These metals burn at high temperatures and react violently with water, air and/or other chemicals. Fire extinguishers for use on Class D fires do not have a multi-purpose rating and must match the type of metal involved. Extinguishers rated for Class D fires have a label listing the metals that the extinguisher can be used on.

5.3 Extinguishing Agents

Extinguishing agents act by heat removal (cooling), by smothering (oxygen exclusion) or by flame inhibition (interfering chemically with the combustion process).

5.3.1 Cooling Agents

5.3.1.1 Water

The direct application of a water jet onto a fire is an effective fire-fighting method for Class A fires only. A wetting agent added to water may reduce the amount of water needed to extinguish fires in tightly packed Class A materials as it increases the effective penetration of water by lowering its surface tension.

For fires involving hydrocarbon liquids, water is used primarily to minimise escalation of a fire by cooling exposed surfaces. Water spray and water fog may be used for making a heat screen between the fire and fire-fighting personnel and equipment. If foam is not available, a water mist can be used to extinguish fires involving shallow pools of heavy oil.

Water in any form should not be applied to fires involving hot cooking oil or fat since it may cause the fire to spread.

Concentrated water streams should not be directed at fires involving liquefied gas as this will increase the hazard by increasing vapour cloud size as more cargo liquid is vaporised. However, water spray or water fog can be used on liquefied gas fires and spills. It will cool the area and control fire intensity as well as enhance vapour cloud dispersion.

Water jets should not be directed at energised electrical equipment as this could provide a path for electricity from the equipment with consequent danger of electric shock to fire-fighting personnel.

5.3.1.2 Foam

Foam has a limited heat absorbing effect and should not normally be used for cooling.

5.3.2 Smothering Agents

5.3.2.1 Foam

The primary extinguishing action of foam is by smothering. Foam is an aggregation of small bubbles, of lower specific gravity than oil or water, which flows across the surface of a burning liquid and forms a coherent smothering blanket. A good foam blanket seals against flammable vapour

loss, provides some cooling of the fuel surface by the absorption of heat, isolates the fuel surface from the oxygen supply, and separates the flammable vapour layer from other ignition sources (e.g. flames or extremely hot metal surfaces), thereby eliminating combustion. A good foam blanket will resist disruption due to wind and draught, or heat and flame impingement, and will reseal when its surface is broken or disturbed. Foam is an electrical conductor and should not be applied to energised electrical equipment.

There are several different types of foam concentrate available. These include standard protein foam, fluoro-protein foams and synthetic concentrates. The synthetics are divided into Aqueous Film Forming Foam (AFFF) for normal use, and hydrocarbon surfactant-type foam concentrates for use with alcohols and fuels blended with significant quantities of alcohol. Normally, the protein, fluoro-protein and AFFF concentrates are used at 3-6% by volume concentration in water. The hydrocarbon surfactant type concentrates are available for use at 1-6% by volume concentrations.

High expansion foam, made from hydrocarbon surfactant concentrates, is available, with expansion ratios from about 200:1 to 1,000:1. A foam generator, which may be fixed or mobile, sprays foam solution onto a fine mesh net through which air is driven by a fan. High expansion foam has limited uses. It is most often used to rapidly fill an enclosed space to extinguish a fire by displacing free air in the compartment. High expansion foam is generally unsuitable for use in outside locations as it cannot readily be directed onto a hot unconfined spill fire and is quickly dispersed in light winds.

High expansion foam systems are being enhanced with the introduction of a new development called "Hot Foam", which is now being increasingly used on ships as a replacement for halon. Heated water and foam are mixed to reduce possible damaging effects caused by rapid cooling.

Medium expansion foam has an expansion ratio from about 15:1 to 150:1. It is made from the same concentrates as high expansion foam, but its aeration does not require a fan. Portable applicators can be used to deliver considerable quantities of foam onto spill fires, but their throw is limited and the foam is liable to be dispersed in moderate winds.

Low expansion foam has an expansion ratio from about 3:1 to about 15:1. It is made from protein-based or synthetic concentrates and can be applied to spill or tank fires from fixed monitors or portable applicators. Good throw is possible and the foam is resistant to wind.

Foam applicators should be directed away from liquid petroleum fires until any water in the system has been flushed clear.

Foam should not come into contact with any electrical equipment.

The various foam concentrates are basically incompatible with each other and should not be mixed in storage. However, some foams separately generated with these concentrates are compatible when applied to a fire in sequence or simultaneously. The majority of foam concentrates can be used in conventional foam making devices suitable for producing protein foams. The systems should be thoroughly flushed out and cleaned before changing agents, as the synthetic concentrates may dislodge sediment and block the proportioning equipment.

Some of the foams produced from concentrates are compatible with dry chemical powder and are suitable for combined use. The degree of compatibility between the various foams, and between the different foams and dry chemical agents, varies and should be established by suitable tests.

The compatibility of foam compounds is a factor to be borne in mind when considering joint operations with other fire-fighters.

Foam concentrates may deteriorate with time depending on the storage conditions. Storage at high temperatures and in contact with air will cause sludge and sediment to form. This may affect the extinguishing ability of the expanded foam. Samples of the foam concentrate should therefore be returned periodically to the manufacturer for testing and evaluation.

5.3.2.2 Carbon Dioxide

Carbon dioxide is an effective smothering agent for extinguishing fires in enclosed spaces where it will not be widely diffused and where personnel can be evacuated quickly (e.g. machinery spaces, pumprooms and electrical switchboard rooms). Carbon dioxide is comparatively ineffective on an open deck or jetty area.

Carbon dioxide will not damage delicate machinery or instruments and, being a non-conductor, can be used safely on or around electrical equipment even when it is energised.

Due to the possibility of static electricity generation, carbon dioxide should not be injected into any space containing an un-ignited flammable atmosphere.

Carbon dioxide is asphyxiating and cannot be detected by sight or smell. All personnel should therefore evacuate the area before carbon dioxide is discharged. No one should then enter confined or partially confined spaces where carbon dioxide has been discharged unless supervised and protected by suitable breathing apparatus and a lifeline. Canister type respirators should not be used. Any compartment that has been flooded with carbon dioxide must be fully ventilated before entry without breathing apparatus.

5.3.2.3 Steam

Steam is inefficient as a total smothering agent because of the substantial delay that may occur before sufficient air is displaced from an enclosure to render the atmosphere incapable of supporting combustion. Steam should not be injected into any space containing an un-ignited flammable atmosphere due to the possibility of static electricity generation. However, steam can be effective for fighting flange or similar fires when discharged from a lance type nozzle directly at a flange or joint leak, or a vent or similar fire.

5.3.2.4 Sand

Sand is relatively ineffective as an extinguishing agent and is only useful for small fires on hard surfaces. Its primary use is to dry up small spills.

5.3.3 Flame Inhibiting Agents

Flame inhibitors are materials that interfere chemically with the combustion process and thereby extinguish the flames. However, cooling and removal of fuel is also necessary if re-ignition is to be prevented.

5.3.3.1 Dry Chemical

Dry chemical, as a flame inhibitor, is a material that extinguishes the flames of a fire by interfering chemically with the combustion process. Dry chemicals have a negligible cooling effect and, if re-ignition due to the presence of hot metal surfaces is to be prevented, the fuel must be removed or cooled using water.

Certain types of dry chemical can cause the breakdown of a foam blanket and only those labelled as being foam compatible should be used in conjunction with foam.

Dry chemical may be discharged from an extinguisher, a hose reel nozzle, a fire truck monitor, or a fixed system of nozzles as a free flowing cloud. It is most effective in dealing with a fire resulting from an oil spill by providing rapid fire knock-down, and can also be used in confined spaces where protection against the inhalation of powder may be necessary. It is especially useful on burning liquids escaping from leaking pipelines and joints. It is a non-conductor and is suitable therefore for dealing with electrical fires. It must be directed into the flames.

Dry chemical clogs and becomes unusable if it is allowed to become damp when stored or when extinguishers are being filled.

Dry chemical is prone to settlement and compaction caused by vibration. Maintenance procedures should include a schedule for inverting or rolling the extinguishers to keep the dry chemical powder in a free flowing state.

5.3.3.2 Vaporising Liquids (Halons)

Halon gases are known to have significant ozone depleting properties and, under the terms of the Montreal Protocol, production of halon was phased out in 2000. New halon fire-fighting installations have been prohibited on ships since July 1992. However, many installations will remain in service for the foreseeable future and, if correctly operated, will continue to provide adequate fire protection.

Vaporising liquids, in the same way as dry chemical powder, have a flame inhibiting effect and also have a slight smothering effect. There are a number of different liquids available, all halogenated hydrocarbons, often identified by a system of halon numbers.

The halons are most effective in enclosed spaces such as computer centres, storage rooms, engine rooms or pump rooms, generator enclosures and similar locations.

All halons are toxic to some degree because contact with hot surfaces and flames causes them to break down, yielding toxic substances. All personnel should therefore evacuate the area where halons are to be used, although it is possible to start the discharge of halons before the evacuation is complete because the normal concentrations encountered in extinguishing fires are tolerable for brief periods. After the fire has been extinguished, the area should be thoroughly ventilated. If it is necessary to enter the area before ventilation, suitable breathing apparatus should be used.

Chapter 6

SECURITY

This Chapter provides a brief summary of the major provisions of the International Ship and Port Facility Security (ISPS) Code.

6.1 General

Internationally trading ships, and terminals handling such ships, are required to take measures to enhance marine security and to be in compliance with the provisions of the *International Ship and Port Facility Security (ISPS) Code*, Parts A & B. The Code is detailed in Chapter XI-2 of the *International Convention for the Safety of Life at Sea (SOLAS)*.

Terminals should note that this is the first occasion on which the SOLAS Convention has been applied to shore-based facilities in states that are party to the Convention.

It is recommended that all ships and terminals should have a security plan with procedures to address all security aspects identified from a security assessment. Ships and terminals which are not required to comply with the SOLAS and ISPS Code are encouraged to consider the provisions of SOLAS and the ISPS Code when developing their security plans.

6.2 Security Assessments

The security assessment should include a risk analysis of all aspects of the ship's and terminal's operations in order to determine which parts of them are more susceptible and/or more likely to be the subject of a security incident. The risk is a function of the threat of a security incident, coupled with the vulnerability of the target and the consequences of the incident. The security assessment should, as a minimum, encompass the following items:

- Identification of existing security measures, procedures and operations in effect on board the ship or at the terminal.
- Identification and evaluation of key assets and infrastructure it is important to protect.
- Perceived threats to the ship or terminal facility and their likely occurrence.
- Potential vulnerabilities and consequences of potential incidents to ships, terminals, berths and ships at the berths.
- Identification of any weaknesses (including human factors) in the infrastructure, policies and procedures.

6.3 Responsibilities Under the ISPS Code

For a terminal, responsibility for the security plan rests with the terminal management and may, depending upon the circumstances at the terminal, require a designated security officer who has the necessary skills and training to ensure full implementation of the security measures at the terminal.

For a ship, the Company's responsibility for the plan rests with the Company Security Officer. However, the Master has overriding authority to make decisions regarding the safety and security of the ship. A designated Ship Security Officer should be appointed who has the necessary skills and training to ensure full implementation of the measures required to be in place on board the ship. This function may be conducted by the Master, although often one of the senior officers will be appointed.

6.4 Security Plans

The security plan will vary from terminal to terminal and from ship to ship depending on the particular circumstances identified by the security assessment, requirements for compliance with SOLAS and the ISPS Code, and local and national security considerations. The plan should describe:

- The security organisation on board the ship or at the terminal and port as appropriate.
- Basic security measures for normal operation and additional measures that will allow the ship and terminal to progress, without delay, to increased or lowered security levels as the threat changes.
- Procedures for interfacing the security activities of ships and terminals with those of local port authorities, other ships, terminals and dock facilities in the region and other local authorities and agencies (e.g. police and coast guard).
- Provision for regular reviews of the plan and for amendments based upon experience or changing circumstances.
- Measures designed to prevent unauthorised access to the ship and terminal and in particular, measures to restrict access to vulnerable areas of a terminal and to restrict access to ships when moored at the terminal, including the identification of tanker and terminal personnel (such as by identity documents or identification badges).
- Measures designed to prevent unauthorised weapons, dangerous substances or devices intended for use against persons, ships or terminals from being taken on board the ship or from being introduced to the terminal.
- Procedures for responding to security threats or breaches of security, which may include evacuation.

For ships, the ICS publication "*Model Ship Security Plan*" should be referred to. It can be adapted according to the security needs of individual ships.

PART 2

TANKER INFORMATION

Chapter 7

SHIPBOARD SYSTEMS

This Chapter describes the principal ship systems that are used during cargo and ballast operations in port.

7.1 Fixed Inert Gas Systems

This Section describes, in general terms, the operation of a fixed inert gas (IG) system that is used to maintain a safe atmosphere within a ship's cargo tanks. It also covers the precautions to be taken to avoid hazards to health resulting from the risks associated with operating IG plants.

Reference should be made to the ship's operations manual and the manufacturer's instructions and installation drawings, as appropriate, for details on the operation of a particular system. The IMO publication '*Guidelines for Inert Gas Systems*' should be consulted for a more comprehensive explanation of the design and operating principles and practices for typical inert gas systems.

7.1.1 General

Hydrocarbon gas normally encountered in petroleum tankers cannot burn in an atmosphere containing less than approximately 11% oxygen by volume. Accordingly, one way to provide protection against fire or explosion in the vapour space of cargo tanks is to keep the oxygen level below that figure. This is usually achieved by using a fixed piping arrangement to blow inert gas into each cargo tank in order to reduce the air content, and hence the oxygen content, and render the tank atmosphere non-flammable.

See Section 1.2.3 and Figure 1.1 for detailed information on the effect of inert gas on flammability.

7.1.2 Sources of Inert Gas

Possible sources of inert gas on tankers and combination carriers are:

- Uptake gas from the ship's main and auxiliary boilers.
- An independent inert gas generator.
- A gas turbine plant when equipped with an afterburner.

7.1.3 Composition and Quality of Inert Gas

The International Convention for the Safety of Life at Sea (SOLAS 1974), as amended, requires that inert gas systems be capable of delivering inert gas with an oxygen content in the inert gas main of not more than 5% by volume at any required rate of flow; and of maintaining a positive pressure in the cargo

tanks at all times with an atmosphere having an oxygen content of not more than 8% by volume except when it is necessary for the tank to be gas free.

When using flue gas from a main or auxiliary boiler, an oxygen level of less than 5% can generally be obtained, depending on the quality of combustion control and the load on the boiler.

When an independent inert gas generator or a gas turbine plant with afterburner is fitted, the oxygen content can be automatically controlled within finer limits, usually within the range 1.5% to 2.5% by volume.

In certain ports, the maximum oxygen content of inert gas in the cargo tanks may be set at 5% to meet particular safety requirements, such as the operation of a vapour emission control system. Where such a limitation is in place, the ship should be advised of the requirements in the pre-arrival information exchange.

Efficient scrubbing of the inert gas is essential, particularly for the reduction of the sulphur dioxide content. High levels of sulphur dioxide increase the acidic characteristic of the inert gas, which is harmful for personnel and may cause accelerated corrosion to the structure of a ship.

The table below provides an indication of the typical composition of inert gas generated from boiler flue gas, expressed as a percentage by volume.

Nitrogen	N	83%
Carbon Dioxide	CO ₂	12-14%
Oxygen	O	2-4%
Sulphur Dioxide	SO ₂	50 ppm
Carbon Monoxide	CO	Trace
Nitrogen Oxide	NO _x	200 ppm
Water Vapour	H ₂ O	Trace (high if not dried)
Ash and Soot	(C)	Traces
Density	1.044	

Table 7.1 – Typical composition of inert gas at the scrubber outlet

7.1.4 Methods of Replacing Tank Atmospheres

If the entire tank atmosphere could be replaced by an equal volume of inert gas, the resulting tank atmosphere would have the same oxygen level as the incoming inert gas. In practice, this is impossible to achieve and a volume of inert gas equal to several tank volumes must be introduced into the tank before the desired result can be achieved.

The replacement of a tank atmosphere by inert gas can be achieved by either inerting or purging. In each of these methods, one of two distinct processes, dilution or displacement, will predominate.

Dilution takes place when the incoming inert gas mixes with the original tank atmosphere to form a homogeneous mixture throughout the tank so that, as the process continues, the concentration of the original gas decreases progressively. It is important that the incoming inert gas has sufficient entry

velocity to penetrate to the bottom of the tank. To ensure this, a limit must be placed on the number of tanks that can be inerted simultaneously. Where this limit is not clearly stipulated in the operations manual, only one tank should be inerted or purged at a time when using the dilution method.

Displacement depends on the fact that inert gas is slightly lighter than hydrocarbon gas so that, while the inert gas enters at the top of the tank, the heavier hydrocarbon gas escapes from the bottom through suitable piping. When using this method, it is important that the inert gas has a very low velocity to enable a stable horizontal interface to be developed between the incoming and escaping gas. However, in practice, some dilution inevitably takes place owing to the turbulence caused in the inert gas flow. Displacement generally allows several tanks to be inerted or purged simultaneously.

Whichever method is employed, and whether inerting or purging (see Definitions), it is vital that oxygen or gas measurements are taken at several heights and horizontal positions within the tank to check the efficiency of the operation. A mixture of inert gas and petroleum gas, when vented and mixed with air, can become flammable. The normal safety precautions taken when petroleum gas is vented from a tank therefore should not be relaxed.

7.1.5 Cargo Tank Atmosphere Control

7.1.5.1 Inert Gas Operations

Tankers using an inert gas system should maintain their cargo tanks in a non-flammable condition at all times. It follows that:

- Tanks should be kept in an inert condition at all times, except when it is necessary for them to be gas free for inspection or work, i.e. the oxygen content should be not more than 8% by volume and the atmosphere should be maintained at a positive pressure.
- The atmosphere within the tank should make the transition from the inert condition to the gas free condition without passing through the flammable condition. In practice, this means that, before any tank is gas freed, it should be purged with inert gas until the hydrocarbon content of the tank atmosphere is below the critical dilution line (line GA in Figure 1.1).
- When a ship is in a gas free condition before arrival at a loading port, the tanks must be inerted prior to loading.

In order to maintain cargo tanks in a non-flammable condition, the inert gas plant will be required to:

- Inert empty cargo tanks (see Section 7.1.6.1).
- Be in operation, or be ready for immediate operation, during cargo discharge, deballasting, crude oil washing and tank cleaning (see Sections 7.1.6.6. and 7.1.6.9).
- Purge tanks prior to gas freeing (see Section 7.1.6.10).
- Top up the pressure in the cargo tanks when necessary during other stages of the voyage (see Sections 7.1.6.5 and 7.1.6.7).

It must be emphasised that the protection provided by an inert gas system depends on the proper operation and maintenance of the entire system.

7.1.5.2 Inert Gas System Maintenance

There should be close co-operation between the deck and engine departments to ensure proper maintenance and operation of the inert gas system. It is particularly important to ensure that non-return barriers function correctly, especially the deck water seal or block and bleed valves, so that there is no possibility of petroleum gas or liquid petroleum passing back to the machinery spaces.

To demonstrate that the inert gas plant is fully operational and in good working order, a record of inspection of the inert gas plant, including defects and their rectification, should be maintained on board.

7.1.5.3 Degradation of Inert Gas Quality

Tanker personnel should be alert to the possible degradation of inert gas quality within tanks as a result of air being drawn into the tanks due to inappropriate operation of the inert gas or cargo systems. For instance:

- Not topping up the inert gas promptly if the pressure in the system falls, due to temperature changes at night.
- Prolonged opening of tank apertures for tank gauging, sampling and dipping.

When water is drained from a non-inerted tank, air will be entrained into the drainings delivered to the slop tank and may ultimately enter into inerted tank atmospheres. The volume of air entrained in this manner can be particularly high if an eductor is used on recirculation to the slop tank. Therefore, when liquid is to be drained to the slop tank, the inert gas quality in all tanks should be closely monitored.

7.1.6 Application to Cargo Tank Operations

Before the inert gas system is put into service, the tests required by the operations manual or manufacturer's instructions should be carried out. The fixed oxygen analyser and recorder should be tested and proved to be in good order. Portable oxygen and hydrocarbon meters should also be prepared and tested.

7.1.6.1 Inerting of Empty Tanks

When inerting empty tanks that are gas free, for example following a dry docking or tank entry, inert gas should be introduced through the distribution system while venting the air in the tank to the atmosphere. This operation should continue until the oxygen content throughout the tank is not more than 8% by volume. Thereafter, the oxygen level will not increase if a positive pressure is maintained by using the inert gas system to introduce additional inert gas when necessary.

If the tank is not gas free, the precautions against static electricity given in Section 7.1.6.8 should be taken until the oxygen content of the tank has been reduced to 8% by volume.

When all tanks have been inerted, they should be kept common with the inert gas main and the system pressurised with a minimum positive pressure of at least 100 mm water gauge. If individual tanks have to be segregated from a common line (e.g. for product integrity), the segregated tanks should be provided with an alternative means of maintaining an inert gas blanket.

7.1.6.2 Loading Cargo or Ballast into Tanks in an Inert Condition

When loading cargo or ballast, the inert gas plant should be shut down and the tanks vented through the appropriate venting system. On completion of loading or ballasting, and when all ullaging is completed, the tanks should be closed and the inert gas system restarted and re-pressurised. The system should then be shut down and all safety isolating valves secured.

Local regulations may prohibit venting after crude oil washing (see Section 11.5.8).

7.1.6.3 Simultaneous Cargo or Ballast Operations

In the case of simultaneous loading and discharge operations involving cargo or ballast, venting to the atmosphere can be minimised, or possibly completely avoided, by interconnecting the tanks concerned through the inert gas main. Depending on the relative pumping rates, pressure in the tanks may be increased or a vacuum drawn, and it may therefore be necessary to adjust the inert gas flow accordingly to maintain tank pressures within normal limits.

7.1.6.4 Vapour Balancing During Ship-to-Ship Transfers

Vapour balancing is used to avoid the release of any gases to the atmosphere through vents and to minimise the use of the inert gas systems when transferring cargo from ship-to-ship. The inert gas mains of the ships are connected using a flexible hose. As a minimum, the following recommendations should be followed:

Before commencing cargo transfer:

- Equipment should be provided on at least one of the vessels to enable the oxygen content of the vapour stream to be monitored. This should draw samples continuously from a location close to the vapour manifold connection and should include the facility for audible and visual alarms in the event that the oxygen content of the vapour stream exceeds 8% by volume. The oxygen analyser and associated alarms should be tested for proper function prior to each cargo transfer operation.
- The oxygen content of the vapour space of each tank connected to the IG main of both ships should be checked and confirmed to be less than 8% by volume.
- The vapour transfer hose should be purged of air and inerted prior to commencing transfer of vapours.
- The vapour manifold valves should not be opened until the pressure in the cargo system of the receiving vessel exceeds that of the ship discharging cargo.

During the cargo transfer:

- The inert gas system on the discharging ship should be kept operational and on standby, with the inert gas main deck isolating valve closed. The inert gas system should be used if the inert gas pressure in the discharging vessel falls to a low level (300 mm WG).
- The inert gas pressure on both ships should be monitored and each ship advised of the other's pressure on a regular basis.

- No air should be allowed to enter the cargo tanks of the discharging ship.
- Transfer operations should be suspended if the oxygen content of the vapour stream exceeds 8% by volume and should only be resumed once the oxygen content has been reduced to 8% or less by volume.
- The cargo transfer rate must not exceed the design rate for the vapour balancing hose.

7.1.6.5 Loaded Passage

A positive pressure of inert gas should be maintained in the ullage space at all times during the loaded passage in order to prevent the possible ingress of air (see also Section 7.1.5.3). If the pressure falls below the low pressure alarm level, it will be necessary to start the inert gas plant to restore an adequate pressure in the system.

Loss of pressure is normally associated with leakages from tank openings and falling air and sea temperatures. In the latter cases, it is all the more important to ensure that the tanks are gas tight. Gas leaks are usually easily detected by their noise and every effort must be made to eliminate leaks at tank hatches, ullage lids, tank washing machine openings, valves etc.

Leaks that cannot be eliminated should be marked and recorded for sealing during the next ballast passage or at another suitable opportunity.

Certain oil products, principally aviation turbine kerosenes and diesel oil, can absorb oxygen during the refining and storage process. This oxygen can later be liberated into an oxygen deficient atmosphere such as the ullage space of an inerted cargo tank. Although the recorded incidence of oxygen liberation is low, cargo tank oxygen levels should be monitored so that any necessary precautionary measures can be taken prior to the commencement of discharge.

7.1.6.6 Discharge of Cargo or Ballast from Tanks in an Inert Condition

The inert gas supply must be maintained throughout cargo or ballast discharge operations to prevent air entering the tanks. If a satisfactory positive inert gas pressure can be safely maintained without a continuous supply of inert gas then it is acceptable to re-circulate or stop the supply of inert gas provided that the inert gas plant is kept ready for immediate operation.

If on arrival in port the inert gas has to be de-pressurised in order to measure or sample the cargo, it may be difficult, because of the low boiler load, to re-pressurise with inert gas having sufficiently low oxygen content. In this event, it may be necessary to create a load on the boiler by using the main cargo pumps to circulate the cargo around the ship's pipelines until the inert gas quality is satisfactory. Great care is necessary to ensure that the pumping arrangements used for circulating cargo do not give rise to an overflow.

Throughout the discharge of cargo, particularly when the boiler load is low or fluctuating, the oxygen content of the inert gas supply must be carefully monitored. Additionally, both the oxygen content and pressure of the inert gas main should be continuously recorded during discharge. For

action to be taken in the event of failure of the inert gas plant during discharge from inerted tanks, see Section 7.1.12.

If hand dipping of a tank is necessary, pressure may be reduced while dipping ports are open, but care must be taken not to allow a vacuum to develop since this would pull air into the tank. To prevent this, it may be necessary to reduce the cargo pumping rate, and discharge should be stopped immediately if there is a danger of the tanks coming under vacuum.

7.1.6.7 Ballast Passage

During a ballast passage, cargo tanks other than those required to be gas free should remain in the inert condition and under positive pressure to prevent ingress of air. Whenever pressure falls to the low pressure alarm level, the inert gas plant should be restarted to restore the pressure, with due attention being paid to the oxygen content of the inert gas delivered.

7.1.6.8 Static Electricity Precautions

In normal operations, the presence of inert gas prevents the existence of flammable gas mixtures inside cargo tanks. Hazards due to static electricity may arise however, mainly in the case of a failure of the inert gas system. To avoid these hazards, the following procedures are recommended:

- If the inert gas plant breaks down during discharge, operations should be suspended (see Section 7.1.12). If air has entered the tank, no dipping, ullaging, sampling or other equipment should be introduced into the tank until at least 30 minutes have elapsed since the injection of inert gas ceased. After this period, equipment may be introduced provided that all metallic components are securely earthed. This requirement for earthing should be applied until a period of five hours has elapsed since the injection of inert gas ceased.
- During any necessary re-inerting of a tank following a failure and repair of the inert gas system, or during initial inerting of a non-gas free tank, no dipping, ullaging, sampling or other equipment should be inserted until the tank is in an inert condition, as established by monitoring the gas vented from the tank being inerted. However, should it be necessary to introduce a gas sampling system into the tank to establish its condition, at least 30 minutes should elapse after stopping the injection of inert gas before inserting the sampling system. Metallic components of the sampling system should be electrically continuous and securely earthed. (See also Chapter 3 and Section 11.8.)

7.1.6.9 Tank Washing, Including Crude Oil Washing

Before each tank is washed, the oxygen content must be determined, both at a point 1 metre below the deck and at the middle level of the ullage space. At neither of these locations should the oxygen content exceed 8% by volume. Where tanks have a complete or partial swash bulkhead, the measurement should be taken from similar levels in each section of the tank. The oxygen content and pressure of the inert gas being delivered during the washing process should be continuously recorded.

If, during washing, the oxygen content in the tank exceeds 8% by volume or the pressure of the atmosphere in the tanks is no longer positive,

washing must be stopped until satisfactory conditions are restored (see also Section 7.1.12).

7.1.6.10 Purging

When it is required to gas free a tank after washing, the tank should first be purged with inert gas to reduce the hydrocarbon content to 2% or less by volume. This is to ensure that, during the subsequent gas freeing operation, no portion of the tank atmosphere is brought within the flammable range.

The hydrocarbon content must be measured with an appropriate meter designed to measure the percentage of hydrocarbon gas in an oxygen deficient atmosphere. The usual flammable gas indicator is not suitable for this purpose (see Section 2.4).

If the dilution method of purging is used, it should be carried out with the inert gas system set for maximum capacity to give maximum turbulence within the tank. If the displacement method is used, the gas inlet velocity should be lower to prevent undue turbulence (see Section 7.1.4).

7.1.6.11 Gas Freeing

Before starting to gas free, the tank should be isolated from other tanks. When either portable fans or fixed fans connected to the cargo pipeline system are used to introduce air into the tank, the inert gas inlet should be isolated. If the inert gas system fan is employed to draw air into the tank, both the line back to the inert gas source and the inert gas inlet into each tank that is being kept inerted should be isolated.

7.1.6.12 Preparation for Tank Entry

To ensure the dilution of the toxic components of inert gas to below their Threshold Limit Values (TLVs), gas freeing should continue until tests with an oxygen analyser show a steady oxygen reading of 21% by volume and tests with a flammable gas indicator show not more than 1% LFL.

If the presence of a toxic gas such as benzene or hydrogen sulphide is suspected, gas freeing should be continued until tests indicate that its concentration is below its TLV-TWA.

Positive fresh air ventilation should be maintained throughout the period that personnel are in a tank, and frequent tests should be made of both oxygen and hydrocarbon content of the tank atmosphere.

When other tanks in an inert condition are either adjacent or interconnected (e.g. by a pipeline) to the tank being entered, personnel should be alert to the possibility of inert gas leaking into the gas free tank through, for example, bulkhead fractures or defective valves. The risk of this occurring can be minimised by maintaining a small but positive inert gas pressure. When a gas free tank is re-connected to the inert gas main, it should immediately be re-inerted.

For general advice on entry into enclosed spaces see Chapter 10.

7.1.7 Precautions to be Taken to Avoid Health Hazards

7.1.7.1 Inert Gas on Deck

Certain wind conditions may bring vented gases back down onto the deck, even from specially designed vent outlets. Furthermore, if gases are vented at low level from cargo hatches, ullage ports or other tank apertures, the surrounding areas can contain levels of gases in harmful concentrations and may also be oxygen deficient. In these conditions, all non-essential work should cease and only essential personnel should remain on deck, taking all appropriate precautions.

When the last cargo carried was a sour crude, tests should also be made for hydrogen sulphide. If a level in excess of 5 ppm is detected, no personnel should be allowed to work on deck unless they are wearing suitable respiratory protection. (See Sections 2.3.6 and 11.1.9.)

7.1.7.2 Ullaging and Inspection of Tanks from Cargo Hatches

The low oxygen content of inert gas can cause rapid asphyxiation. Care should therefore be taken to avoid standing in the path of vented gas (see Section 11.8.3).

7.1.7.3 Entry into Cargo Tanks

Entry into cargo tanks should be permitted only after they have been gas freed, as described in Sections 7.1.6.10 and 7.1.6.11. The safety precautions set out in Chapter 10 should be observed and consideration given to the carriage of a personal oxygen deficiency alarm. If the hydrocarbon and oxygen levels specified in Section 7.1.6.12 cannot be achieved, entry should be permitted only in exceptional circumstances and when there is no practicable alternative. A thorough risk assessment should be carried out and appropriate risk mitigation measures put in place. As a minimum, personnel must wear breathing apparatus under such circumstances (see Section 10.7 for further details).

7.1.7.4 Scrubber and Condensate Water

Inert gas scrubber effluent water is acidic. Condensate water, which tends to collect in the distribution pipes, particularly in the deck main, is often more acidic than the scrubber effluent and is highly corrosive.

Care should be taken to avoid unnecessary skin contact with either effluent or condensate water. Particular care should also be taken to avoid accidental contact with the eyes, so protective goggles should be worn whenever there is a risk of such contact.

7.1.8 Cargo Tank Protection Against Over/Under-Pressure

Serious incidents have occurred on oil tankers due to cargo tanks being subjected to extremes of over or under-pressure. Whilst SOLAS regulations have been modified to require that tanks be fitted with full flow pressure relief devices or individual tank pressure monitoring, it is still essential that venting systems are thoroughly checked to ensure that they are correctly set for the intended operation. Once operations have started, further checks should be made for any abnormalities, such as unusual noises of vapour escaping under pressure or pressure/vacuum valves lifting. (See Section 7.2.2 for detailed information on the likely causes of tank over-pressurisation and under-pressurisation and the precautions to be taken to avoid them.)

Ship's personnel should be provided with clear, unambiguous operating procedures for the proper management and control of the venting system and should have a full understanding of its capabilities.

7.1.8.1 Pressure/Vacuum Breakers

Every inert gas system is required to be fitted with one or more pressure/vacuum breakers or other approved devices. These are designed to protect the cargo tanks against excessive pressure or vacuum and must therefore be kept in good working order by regular maintenance in accordance with the manufacturer's instructions.

When these breakers are liquid filled, it is important to ensure that the correct fluid is used and the correct level is maintained. The level can normally only be checked when there is no pressure in the inert gas main line. Evaporation, condensation and possible ingress of sea water should be taken into consideration when checking the liquid condition and level. In heavy weather, the pressure surge caused by the motion of liquid in the cargo tanks may cause the liquid in the pressure/vacuum breaker to be blown out. This may be more liable to happen on combination carriers than on tankers.

7.1.8.2 Pressure/Vacuum Valves

These are designed to provide for the flow of the small volumes of tank atmosphere, caused by thermal variations, in a cargo tank and should operate in advance of the pressure/vacuum breakers. To avoid unnecessary operation of the pressure/vacuum breaker, the pressure/vacuum valves should be kept in good working order by regular inspection and cleaning.

7.1.8.3 Full Flow Pressure/Vacuum Venting Arrangements

In inert gas systems fitted with tank isolating valves, secondary protection from over and under-pressurisation of the cargo tanks may be provided by using high velocity vent and vacuum valves as the full flow protection device. Where this is the case, particular attention should be paid to ensuring that the valves operate at the required pressure and vacuum settings. Planned maintenance procedures should be established to maintain and test these safety devices. See Section 7.2.1 for details.

7.1.8.4 Individual Tank Pressure Monitoring and Alarm Systems

In inert gas systems fitted with tank isolating valves, indication of the possible over and under-pressurisation of the cargo tank is provided by using individual tank pressure sensors connected to an alarm system. Where such systems are used, planned maintenance procedures should be established to maintain and test these sensors and to confirm that they are providing accurate readings.

7.1.9 Emergency Inert Gas Supply

SOLAS requires that suitable arrangements are provided to enable the inert gas system to be connected to an external supply of inert gas.

These arrangements should consist of a 250 mm nominal pipe size bolted flange, isolated from the inert gas main by a valve and located forward of the

non-return valve. The design of the flange should be compatible with the design of other connections in the ship's cargo piping system.

7.1.10 Product Carriers Fitted with an Inert Gas System

7.1.10.1 General

The basic principles of inerting are exactly the same on product carriers as on crude carriers.

There are, however, some differences in operational detail, as outlined in the following Sections.

7.1.10.2 Carriage of Products Having a Flashpoint Exceeding 60°C

SOLAS implies that tankers may carry petroleum products having a flashpoint exceeding 60°C (i.e. bitumens, lubricating oils, heavy fuel oils, high flashpoint jet fuels and some diesel fuels, gas oils and special boiling point liquids) without inert gas systems having to be fitted or, if fitted, without tanks containing such cargoes having to be kept in the inert condition.

However, when cargoes with a flashpoint exceeding 60°C are carried at a cargo temperature higher than their flashpoint less 5°C, the tanks should be maintained in an inert condition because of the danger that a flammable condition may occur.

It is recommended that, if inert gas systems are fitted, cargo tanks are maintained in an inert condition whenever there is a possibility that the ullage space atmosphere could be within the flammable range. (See also Section 2.7 regarding the carriage of residual fuel oils.)

When a non-volatile cargo is carried in a tank that has not been previously gas freed, the tank should be maintained in an inert condition.

7.1.10.3 Additional Purging and Gas Freeing

Gas freeing is required on product carriers more frequently than on crude carriers, because of the greater need both for tank entry and inspection, especially in port, and for venting the vapours of previous cargoes. On inerted product carriers, any gas freeing operation has to be preceded by a purging operation (see Section 7.1.6.10).

It should be recognised, however, that purging is not essential before gas freeing when the hydrocarbon gas content of a tank is already below 2% by volume.

7.1.11 Cold Weather Precautions for Inert Gas Systems

The inert gas system may be subject to operational faults when operating in extreme cold weather conditions.

7.1.11.1 Condensation in Inert Gas Piping

SOLAS requires that the piping system shall be so designed as to prevent accumulation of cargo or water in the pipeline under all normal

conditions. However, in extreme cold conditions, residual water in the inert gas may freeze in the inert gas main. Operators should be aware of this and should therefore operate the system to minimise residual water and closely monitor the system's operation.

7.1.11.2 Control Air

Air operated control valves fitted to the inert gas system outside the engine room may not operate correctly if exposed to extremely low ambient temperatures if the control air has a high water vapour content.

Water separators in control air systems should be drained frequently and the control air dryers should be checked regularly for efficient operation.

7.1.11.3 Safety Devices

In extremely cold weather, ice may prevent the pressure/vacuum valves from operating and may block the flame screens on the pressure/vacuum valves and mast risers.

Water filled pressure/vacuum breakers should be filled to the appropriate level with anti-freeze liquid.

Deck water seals are fitted with heating coils and these coils should be put into operation prior to experiencing cold weather conditions.

7.1.11.4 Sea Chests

To ensure that the water supply to the scrubber and deck seal is maintained in ice conditions at sea or in estuaries, low sea water suctions should be used. This will reduce the probability of ice slurry being drawn into the sea chest. Steam injection connections to sea chests can be used to assist in clearing sea chests, if it becomes necessary.

7.1.12 Inert Gas System Failure

SOLAS requires that each ship fitted with an inert gas system be provided with detailed instruction manuals covering operations, safety and maintenance requirements, and the occupational health hazards relevant to the installed system and its application to the cargo tank system. The manual must include guidance on procedures to be followed in the event of a fault or failure of the inert gas system.

7.1.12.1 Action to be Taken on Failure of the Inert Gas System

In the event that the inert gas system fails to deliver the required quality and quantity of inert gas, or to maintain a positive pressure in the cargo tanks and slop tanks, action must be taken immediately to prevent any air being drawn into the tanks. All cargo and or ballast discharge from inerted tanks must be stopped, the inert gas deck isolating valve closed, the vent valve between it and the gas pressure regulating valve (if provided) opened, and immediate action taken to repair the inert gas system.

Masters are reminded that national and local regulations may require the failure of an inert gas system to be reported to the harbour authority, terminal operator and to the port and flag state administrations.

Section 11.8.3.1 gives guidance on special precautions to be taken in the event of a breakdown of the inert gas system when loading static accumulator oils into inerted cargo tanks.

7.1.12.2 Follow-up Action on Crude Oil Tankers

Pyrophoric iron sulphide deposits (pyrophors), formed when hydrogen sulphide gas reacts with rusted surfaces in the absence of oxygen, may be present in the cargo tanks of crude oil tankers and these deposits can heat to incandescence when coming into contact with air. In the case of tankers engaged in the carriage of crude oil, the failed inert gas system must therefore be repaired and restarted, or an alternative source of inert gas provided, before discharge from inerted tanks is resumed. (See also Section 2.6.3.)

7.1.12.3 Follow-up Action on Product Tankers

Tank coatings usually inhibit the formation of pyrophors in the cargo tanks of product tankers. If it is considered totally impracticable to repair the inert gas system, discharge may therefore be resumed with the written agreement of all interested parties, provided that an external source of inert gas is provided or detailed procedures are established to ensure the safety of operations. The following precautions should be taken:

- The manual referred to in Section 7.1.12 above should be consulted.
- Devices to prevent the passage of flame or flame screens (as appropriate) are in place and are checked to ensure that they are in a satisfactory condition.
- Valves on the vent mast risers are opened.
- No free fall of water or slops is permitted.
- No dipping, ullaging, sampling or other equipment is introduced into the tank unless essential for the safety of the operation. If it is necessary for such equipment to be introduced into the tank, it should be done after at least 30 minutes have elapsed since the injection of inert gas has ceased. (See Section 7.1.6.8 for static electricity precautions relating to inert gas and Section 11.8 for static electricity precautions when dipping, ullaging and sampling.)
- All metal components of any equipment to be introduced into the tank should be securely earthed. This restriction should be applied until a period of five hours has elapsed since the injection of inert gas has ceased.

7.1.13 Inert Gas Plant Repairs

As inert gas causes asphyxiation, great care must be taken to avoid the escape of inert gas into any enclosed or partly enclosed space.

No one should be allowed inside the scrubber or deck water seal until the atmosphere has first been tested and an oxygen level of 21% by volume obtained (see also Chapter 10 – Enclosed Space Entry). In addition, while personnel are working inside the scrubber tower, the atmosphere must be continuously monitored for oxygen content and the personnel should be under constant supervision.

Before opening the IG system, it should, if possible, be gas freed and any enclosed space in which the system is opened up should be ventilated to avoid any risk of oxygen deficiency.

Continuous positive ventilation must be maintained before and during the work.

7.2 Venting Systems

7.2.1 General

Venting systems are required to meet the requirements of SOLAS. They are necessary for achieving safety on board a tanker and it is essential that they are operated to meet their design intent and that they are properly maintained.

To facilitate dilution of the hydrocarbon vapours into the atmosphere clear of the tanker's deck, venting systems allow vapours to be released either:

- At a low velocity, high above the deck from a vent riser; or
- At high velocity from a high velocity valve closer to the deck. This facilitates dilution of the hydrocarbon vapours in the atmosphere clear of the tanker's deck.

Vents are sited in selected locations to prevent the accumulation of a flammable atmosphere on the tank deck or around any accommodation or engine room housings (see Section 2.5.4).

Ship's personnel should be fully conversant with the operation and maintenance of all components of the venting system and should be aware of its limitations in order to prevent over or under-pressurisation of the tank(s) the system is serving (see Section 7.2.2 below).

7.2.2 Tank Over-Pressurisation and Under-Pressurisation

7.2.2.1 General

Over-pressurisation of cargo and ballast tanks is due to compression of the ullage space by the inadequate release of vapour or by the overfilling of the tank. Under-pressurisation can be caused by not allowing inert gas vapour or air into the tank when liquid is being discharged. The resulting over or under-pressure in the tank may result in serious deformation or catastrophic failure of the tank structure and its peripheral bulkheads, which can seriously affect the structural integrity of the ship and could lead to fire, explosion and pollution. (See also Section 7.1.8.)

Structural damage can also be caused by not allowing inert gas, vapour or air into a tank whilst liquid is being discharged. The resulting under-pressure in the tank can result in deformation of the ship's structure, which could result in fire, explosion or pollution.

To guard against over and under-pressurisation of tanks, owners/operators should give serious consideration to fitting protection devices as follows:

- Individual pressure sensors with an alarm for each tank.
- Individual full flow pressure/release devices for each tank.

7.2.2.2 Tank Over-Pressurisation – Causes

Over-pressurisation usually occurs during ballasting, loading or internal transfer of cargo or ballast. It can be caused by one of the following:

- Overfilling the tank with liquid.
- Incorrect setting of the tank's vapour or inert gas isolating valve to the vapour line or inert gas line.
- Failure of an isolating valve to the vapour line or inert gas line.
- Failure or seizure of the venting valve or high velocity valve.
- A choked flame arrester or screen.
- Loading or ballasting the tank at a rate which exceeds the maximum venting capacity. (See Section 7.3.3.1.)
- Ice forming on the vents, or freezing of the pressure/vacuum or high velocity valves or ice on the surface of the ballast. (See Section 7.1.11.3.)
- Restriction in the vapour lines caused by wax, residues or scale.

7.2.2.3 Tank Over-Pressurisation – Precautions and Corrective Actions

The major safeguard against tank over-pressurisation is adherence to good operating procedures. These should include:

- On ships without an inert gas system, a procedure to control the setting of the isolating valves on the vapour lines. The procedure should include a method of recording the current position of the isolating valves and a method for preventing them from being incorrectly or casually operated.
- On ships with inert gas systems where isolating valves are fitted to the branch line to each tank, SOLAS requires these valves be "provided with locking arrangements which shall be under the control of the responsible ship's officer". This statement should be taken to mean that the valves must be locked to prevent the possibility of any change in the valve setting without application to the Responsible Officer to obtain the means of releasing the locking system on the valve.
- A method of recording the status of all valves in the cargo system and preventing them from being incorrectly or casually operated.
- A system for setting the valves in the correct position for the operation, and monitoring that they remain correctly set.
- Restricting the operation of the valves to authorised personnel only.

A process of regular maintenance, pre-operational testing and operator awareness of isolating valves, pressure/vacuum valves or high velocity vents can guard against failure during operation.

To protect against over-pressurisation through filling tanks too quickly, all ships should have maximum filling rates for each individual tank and these should be available for reference by ship's personnel (see also Section 7.3.3). Tank vents should be checked to ensure that they are clear when the operation commences and, during freezing weather conditions, they should be inspected at regular intervals throughout the operation.

Where over-pressurisation of a tank or tanks is suspected, the situation requires appropriate corrective action. Loading of liquid should cease immediately.

7.2.2.4 Tank Under-Pressurisation – Causes

The causes of under-pressurisation are similar to those of over-pressurisation, namely:

- Incorrect setting of the tank's isolating valve to the vapour line or inert gas line.
- Failure of an isolating valve on the vapour line or inert gas line.
- The inert gas fan not being run due to breakdown or failure to operate it.
- Failure in one of the inert gas supply valves.
- A choked flame screen on the vapour inlet line.
- Ice forming on the vents of ballast tanks during cold weather conditions.

7.2.2.5 Tank Under-Pressurisation – Precautions and Corrective Actions

The precautions to guard against under-pressurisation are the same as those relating to over-pressurisation (see Section 7.2.2.3).

Where under-pressurisation of a tank or tanks is suspected, the situation requires corrective action. Discharge of liquid should cease immediately.

The methods of reducing a partial vacuum in a tank are either to raise the liquid level in the tank by running or pumping cargo or ballast into the affected tank from another tank, or to admit inert gas or air into the tank ullage space.

Cautions

- On a ship with an inert gas system, there is a possibility that the quality of the inert gas may be compromised by air leaking past the seals in the tank access locations.
- Admitting inert gas at a high velocity to return the tank to a positive pressure could cause an electrostatic hazard.
- The precautions identified in Section 11.8.3 should be observed when measuring and sampling.
- On ships without an inert gas system where it is not possible to reduce the partial vacuum by raising the liquid level, care should be exercised to ensure that the rush of air does not draw into the tank foreign objects with a possible ignition capability, e.g. rust.

7.3 Cargo and Ballast Systems

This Section describes the pipelines and pumps used for the loading and discharging of cargo and ballast. For the purposes of this Guide, the cargo heating system and crude oil washing (COW) system, where fitted, are considered to be part of the cargo system.

7.3.1 Operation Manual

The ship's crew should have access to up to date drawings and information on the cargo and ballast systems, and be provided with an Operation Manual describing how the systems should be operated.

The cargo system is one of the prime locations where breaching of cargo containment may occur and care should be taken not to over-pressurise sections of the system or to subject it to shock loads.

Operation of the cargo and ballast systems should only be carried out by personnel who are familiar with the correct operation of the pumps and associated systems, as described in the Operation Manual.

7.3.2 Cargo and Ballast System Integrity

The cargo and ballast systems are subjected to many conditions that may ultimately lead to failure resulting in loss of containment. These include the following:

- Turbulence in the flow, caused by poor pipeline design or excessive flow rates, and abrasion due to solid particulates in the cargo or ballast, can result in local erosion and pitting in the pipelines.
- The main fore and aft pipeline runs are usually located at the bottom of the tanks and on the main deck where the effects of hogging, sagging and the cyclical motions of a ship in a seaway are most pronounced. These movements may result in damage to pipeline connections and bulkhead penetrations, and to local external damage at pipeline supports.
- Handling cargoes for which the system has not been designed. Particular care should be taken to prevent damage to cargo valve seals and pump seals that are not suited to aggressive cargoes such as spiked crude oils.
- Corrosion due to oxidation (rusting) when pipe systems are used for both water and oil service.

Preferential corrosion is found where internal coatings have failed and the corrosion is concentrated at a small location. This localised corrosion may be accelerated when water is allowed to lie in the bottom of pipelines, in association with sulphurous products from cargo or inert gas, or if electrolytic corrosion cells are set up when pipeline connections are not securely bonded.

The presence of any latent defect in the cargo system will usually reveal itself when the system is pressurised during the discharge operation. It is good practice to pressure test cargo lines on a periodic basis, depending on the trade of the ship. Although these pressure tests may provide an indication of the system's condition at the time of the test, they should not be considered a substitute for regular external inspection of the pipeline system and periodic internal inspections, particularly at known failure points, such as pump discharge bends and stub pipe connections.

The presence of any latent defect in the ballast system will usually reveal itself when the system is being used during the deballasting operation. The inability to fully discharge or drain ballast tanks may result in stability problems on double bottom or double hull ships and, in some instances, could result in the ship being in an overloaded condition.

7.3.3 Loading Rates

Masters should be provided with information on maximum permissible loading rates for each cargo and ballast tank and, where tanks have a combined venting system, for each group of cargo or ballast tanks. This requirement is aimed at ensuring that tanks are not over or under-pressurised by exceeding the capacity of the venting system, including any installed secondary venting arrangements.

Other considerations will also need to be taken into account when determining maximum loading rates for oil tankers. Precautions against static electricity hazards and pipeline erosion are described in Section 7.3.3.2.

7.3.3.1 Venting Arrangements

Venting capacity is based on the maximum volume of cargo entering a tank plus a 25% margin to account for gas evolution (vapour growth).

When loading cargoes having a very high vapour pressure, gas evolution may be excessive and the allowance of 25% may prove to be insufficient. Actions to consider in order to ensure that the capacity of the venting system is not exceeded include a close monitoring of vapour line pressures on inerted ships and limiting loading rates on non-inerted ships throughout the loading period or during crude oil washing during discharge operations. It should be noted that the vapour growth increases when the liquid levels in the tank are above 80%. On inerted ships, close attention should be given to monitoring inert gas system pressures, particularly when topping-off during loading operations or on commencing crude oil washing during discharge operations.

When calculating loading rates, a maximum venting line velocity of 36 metres per second should be considered. This flow rate should be calculated for each diameter of line used. The volume throughputs may be aggregated where a common vent riser is used, but the maximum flow rate should not be exceeded anywhere within the system.

7.3.3.2 Flow Rates in Loading Lines

Depending upon the trade of the tanker, a number of loading rates need to be determined for each cargo tank. These loading rates will be dependent on the maximum flow rates in the cargo lines for different products and loading operations. In general, the following flow rates may need to be calculated for each section of the cargo system.

- A loading rate based on a linear velocity of 1 metre/second at the tank inlet for the initial loading rate for static accumulator cargoes into non-inerted tanks.
- A loading rate based on a linear velocity of 7 metres/second for bulk loading static accumulator cargoes into non-inerted tanks.
- A loading rate based on a linear velocity of 12 metres/second for loading non-static accumulator cargoes and also for loading static accumulator cargoes into inerted tanks. This velocity is provided for guidance only and is generally considered as a rate above which pipeline erosion may occur at pipe joints and bends.

Where a number of tanks are loaded through a common manifold, the maximum loading rate may be determined by the flow rate through the manifold or drop lines. For this reason, it is important that a constant check is kept on the number of cargo tank valves that are open

simultaneously and that a suitable loading rate is determined for the particular loading operation.

Offshore floating hoses that meet OCIMF guidelines (see Bibliography) and having a nominal diameter of less than 400 mm are suitable for continuous operation at a flow velocity of 21 m/s. Offshore floating hoses having a diameter greater than 400 mm are suitable for continuous operations at a flow velocity of 15 m/s. However, the maximum loading rate may be controlled by the size of the ship's loading line inboard of where the hose is connected.

7.3.3.3 Rate of Rise of Liquid in the Cargo Tank

Small tanks, such as slop tanks, may have larger filling or suction valves than their size would normally require, to accommodate certain operations for which they may be used, such as recirculatory crude oil washing from slop tanks. In such instances, the limiting factors of the venting flow rate and the liquid line flow rate may not be suitable for assessing maximum loading rates. It is then also necessary to consider the rate of rise of the liquid in the tank if over-filling is to be avoided.

To exercise control over the rate of liquid rise in any cargo tank, it may be appropriate to set the loading rate to limit the rate of rise of liquid in a cargo tank to a maximum of 150 mm/minute.

7.3.3.4 Loading Rates for Ballast Tanks

Loading rates for ballast tanks should be determined in the same manner as for cargo tanks, taking into account the size of vent outlets using a vent velocity of 36 metres/second. Liquid filling rates can be calculated using a pipeline flow rate of 12 metres/second, and a similar rate of rise of liquid of 150 mm/minute should also be considered, where practical.

7.3.4 Monitoring of Void and Ballast Spaces

Void and ballast spaces located within the cargo tank block should be routinely monitored to check that no leakage has occurred from adjacent tanks. Monitoring should include regular atmosphere checks for hydrocarbon content and regular sounding/ullaging of the empty spaces (see also Section 11.8).

7.4 Power and Propulsion Systems

While a tanker is berthed at a terminal, its boilers, main engines, steering machinery and other equipment essential for manoeuvring should normally be kept in a condition that will permit the ship to be moved away from the berth in the event of an emergency. See Section 22.7.1.1 for advice about planned immobilisation.

A terminal may allow some degree of immobilisation of the propulsion plant whilst the ship is alongside. The tanker must, however, obtain permission from the Terminal Representative or local authority before taking any action affecting the readiness of the ship to move under its own power.

Any unplanned condition that results in the loss of operational capability, particularly to any safety system, should be immediately communicated to the terminal.

7.5 Vapour Emission Control (VEC) Systems

Shipboard Vapour Emission Control (VEC) systems tend to fall into two main categories:

- Those systems conforming to IMO guidelines that provide a system for returning cargo vapours to the shore for reclamation or incineration of the petroleum vapour. (See Section 11.1.13.)
- Proprietary systems for recovering petroleum liquid or vapour from the vapour that would otherwise be vented during the loading operation or during the loaded passage.

Operators of VEC systems should be trained in the use of the system fitted to their ship.

7.6 Stern Loading and Discharging Arrangements

The use of a stern manifold for cargo transfer operations introduces additional hazards and operational concerns. Procedures should address the following:

- The requirement to monitor simultaneously the stern manifold and the cargo tank deck area.
- Additional trip hazards from working in a mooring area.
- Spill containment arrangements on the aft deck area.
- Provision of drip trays beneath the stern manifold.
- Elimination of potential sources of ignition from accommodation openings and electrical fittings.
- Connection and disconnection of hoses where no lifting gear is available.

(See also Section 11.1.6.9.)

SHIP'S EQUIPMENT

This Chapter describes equipment that is provided on board for fire-fighting purposes, for gas measurement and for lifting operations. Reference is also made to the need for testing and maintenance procedures for this equipment.

8.1 Shipboard Fire-Fighting Equipment

8.1.1 General

The requirements for ships' fire-fighting equipment are laid down by the regulations of the particular country in which the tanker is registered. These regulations are generally based on the principles of SOLAS.

The theory of fire-fighting and the types of fire that may be encountered are discussed in Chapter 5.

8.1.2 Tanker Fixed Fire-Fighting Installations – Cooling

All tankers are provided with a water fire-fighting system consisting of pumps with a permanent sea connection, a fire-main with hydrant points, fire hoses complete with couplings, and jet nozzles or, preferably, jet/spray nozzles. A sufficient number of hydrants are provided and located so as to ensure that two jets of water can reach any part of the ship. Certain bulkheads are sometimes fitted with permanent water spray lines.

An International Shore Fire Connection must be provided on a tanker so that an external water supply can be coupled to any hydrant in the ship's fire main. This connection should be available for immediate use. (See Section 26.5.3.)

In cold weather, the freezing of fire-mains and hydrants should be prevented by continuously bleeding water over board from hydrants at the extreme end of each fire-main. Alternatively, all low points of the fire-main may be kept drained.

8.1.3 Tanker Fixed Fire-Fighting Installations – Smothering

One or more of the different smothering systems listed below may be installed on board tankers.

8.1.3.1 Carbon Dioxide Flooding System

This system is designed to fight fires in the engine room, boiler room and pumproom. The system normally consists of a battery of large carbon dioxide cylinders. The carbon dioxide is piped from the cylinder manifold to suitable points having diffusing nozzles. An alarm should be activated in the compartment before the carbon dioxide is released to give personnel time to evacuate the compartment.

8.1.3.2 Foam Systems

Foam systems are used for fighting fire in the cargo spaces, on the cargo deck, in the pumproom or in the engine spaces. A foam system has storage tanks containing foam concentrate. Water from the fire pumps picks up the correct proportion of foam concentrate from the tank through a proportioner and the foam solution is then conveyed through permanent supply lines to offtake points, fixed foam monitors or, in the case of engine room installations, to fixed dispersal nozzles.

8.1.3.3 Water Fog

A water fog system consists of high pressure water lines and special fog nozzles. A ring of nozzles around the inside of the tank opening effectively blankets a cargo tank hatch fire. Some ships are also fitted with fixed pressurised water fog systems for protecting specific parts of the engine room, such as oil fuel treatment spaces, boiler firing platforms, small machinery spaces and pumprooms.

8.1.3.4 Water Curtain

Some ships have a fixed system to give a protective water curtain between the cargo deck and the superstructure.

8.1.3.5 Inert Gas System

The purpose of an inert gas system is to prevent cargo tank fires or explosions. It is not a fixed fire-fighting installation but, in the event of a fire, the system may be of assistance in controlling the fire and preventing explosions.

8.1.4 Portable Fire Extinguishers

All tankers are provided with a range of portable fire extinguishers to meet the requirements of their flag administration. In addition to the fire extinguishers in use, tankers are also required to carry spare charges for refilling used extinguishers. In the case of CO₂ extinguishers, spare fully charged extinguisher cylinders are carried.

All fire extinguishers should at all times be in good order and available for immediate use. The ship's Safety Management System should contain procedures for onboard maintenance, including that provided by service agents. As a minimum, all fire extinguishers should be formally checked for proper location, charging pressure and condition annually. (Guidelines for the maintenance and inspection of fire protection systems and appliances are contained in IMO MSC Circular 850, as amended.)

Consideration should be given to providing portable extinguishers, suitable for use on Class A fires (see Section 5.2.1), and dedicated to deployment at the ship's manifold when in port.

8.1.4.1 Types of Portable Fire Extinguisher

In addition to fire hose reels for water extinguishing of Class A type fires involving combustible materials, such as wood, paper and fabrics, all tankers are provided with a range of portable fire extinguishers. Table 8.1 provides an overview of the types of extinguisher likely to be found on board a tanker and their uses. Class D type fires are included mainly for completeness. (See Section 5.2 for information on the Classification of Fires.)

Type of Fire	Class A	Class B	Class C	Class D		
Fire Extinguishing Medium	Combustible Materials (e.g. wood, paper, fabrics)	Flammable and Combustible Hydrocarbon Liquids	Electrical Equipment Fires	Combustible Metals (e.g. magnesium, titanium, potassium and sodium)	Flammable Gases	Cooking Oil and Fats
Water/Hose Reels	✓					
Water with Additive	✓					
Spray Foam	✓	✓				
Dry Chemical	✓	✓	✓		✓	
CO ₂ Gas		✓	✓			
Wet Chemical	✓					✓
Fire Blanket						✓
Designed to match a particular type of fire				✓		

Table 8.1 – Portable fire extinguishing media and their uses

8.2 Gas Testing Equipment

8.2.1 Introduction

This Section provides operational guidance on the use of the gas measuring instruments described in Section 2.4.

The safe management of operations on board tankers is often dependent upon the crew's ability to determine the composition of the ambient atmosphere or the atmosphere in an enclosed space.

Tanker crews need to measure the oxygen, hydrocarbon and toxic gas concentrations in an atmosphere. This will enable them to detect the presence of any explosive mixtures, toxic vapours or oxygen deficiency that may present a risk of explosion or hazard to personnel.

On tankers fitted with an inert gas system, there is the additional need to measure the oxygen content of inert gas as part of the safe management of cargo tank atmospheres.

8.2.2 Summary of Gas Testing Tasks

8.2.2.1 Atmosphere Monitoring

The external atmosphere should be monitored for:

- Hydrocarbon vapour when undertaking Hot Work. This is achieved by using a flammable gas indicator, capable of measuring gas to the Lower Flammable Limit (LFL) and with the scale graduated as a percentage of this limit (see Section 2.4.2).
- Toxic vapours when loading cargoes containing toxic components and when undertaking gas freeing operations following the carriage of such cargoes. This is achieved by using an instrument capable of measuring concentrations of toxic gases in the human toxicity range, usually calibrated in parts per million (see Section 2.4.7).

8.2.2.2 Enclosed Space Monitoring

Prior to permitting entry into an enclosed space, measurements must be taken to detect the presence of hydrocarbon gas, to confirm normal oxygen levels and, if applicable, to detect the presence of any toxic vapours. (For a full description of the tests required prior to entering an enclosed space, reference should be made to Section 10.3.)

Measurement to ensure that the atmosphere is free of harmful hydrocarbon vapour is undertaken using a flammable gas indicator capable of measuring gas to the Lower Flammable Limit (LFL) and with the scale graduated as a percentage of this limit (% LFL).

An oxygen analyser is used to determine that the normal level of oxygen in air of 21% by volume is present.

Where toxic vapour may be present in the space to be entered, the atmosphere should also be tested with an instrument capable of measuring concentrations of toxic gases in the human toxicity range, usually calibrated in parts per million.

8.2.2.3 Inert Gas Atmosphere Management

To ensure compliance with statutory requirements, ships fitted with an inert gas system must be equipped with an oxygen analyser for determining the quality of the inert gas and for measuring the levels of oxygen in the cargo tanks.

A gas indicator capable of measuring the percentage of hydrocarbon gas by volume (% Vol) in an inerted atmosphere is also required for safe management of operations that include the purging and gas freeing of cargo tanks (see Section 2.4.4).

8.2.3 The Provision of Gas Measuring Instruments

SOLAS requires that a ship carrying cargoes that are likely to emit a toxic or flammable gas, or to cause oxygen depletion in a cargo space, be provided with an appropriate instrument for measuring the concentration of gas or oxygen in the air, together with detailed instructions for its use.

Implicit in the above provision is the requirement that the ship operator provides the correct instrument for each gas test required. It should be noted

that the different gas testing functions can be incorporated into a multi-function gas measuring instrument.

For descriptions of the various types of gas measuring instruments and their uses, see Section 2.4.

The gas measurement instrumentation on board a tanker should form a comprehensive and integrated system that addresses all the necessary applications identified by the operator. The instruments should be fit for the task to which they are applied and users should be made aware of the particular applications and limitations of each instrument.

Users of gas measuring instruments should be trained in the proper use of the equipment, to a level suited to their work duties.

A sufficient number of gas measuring instruments should be available on board the ship to meet all the identified requirements, whilst allowing for instrument failures, servicing requirements and the capability of the ship's crew to undertake repair and certified re-calibration of the instruments.

8.2.4 Alarm Functions on Gas Measuring Instruments

Alarms should only be fitted to instruments that are to be used where an audible warning is necessary, such as a personal gas alarm monitor. Analytical instruments that are used to provide numerical values for gases and vapours for dangerous space entry certification do not need to have an alarm function.

Instruments with an alarm capability should be designed so that the alarm inhibit and activate function cannot be changed by the instrument operator. This is to avoid the possibility of inappropriate or accidental inhibition of the alarm function.

The use of different instruments for testing atmospheres for entry certification, and for monitoring atmospheres with a personal monitor during the entry operation, reduces the probability of an accident due to an instrument malfunction. It is therefore recommended that the testing instrument is not also used as the personal alarm instrument during the entry operation.

8.2.5 Sampling Lines

Sampling lines should be suitable for the intended service and be impervious to the gases present in the atmospheres being monitored. They should also be resistant to the effects of hot wash water (see Section 2.4.13).

8.2.6 Calibration

Calibration should not be confused with operational testing (see Section 8.2.7 below).

The accuracy of measurement equipment should be in accordance with the manufacturer's stated standards. Equipment should, on initial supply, have a calibration certificate, traceable where possible to internationally recognised standards. Thereafter, procedures for management of the calibration certification process should form part of the on board Safety Management System. These procedures may include on board calibration in line with the manufacturer's guidelines and/or equipment being periodically landed to a recognised testing facility for calibration, either on a timed basis, or during the

ship's refit, or when the accuracy of the equipment is considered to be outside the manufacturer's stated accuracy.

Calibration certificates, showing the instrument's serial number, the calibration date and the calibration gas or the method of calibration used, together with reference to applicable standards, should be provided for retention on board.

Instruments are typically calibrated using a calibration gas consistent with the use of the instrument, such as propane or butane. The calibration gas used should be marked on the instrument.

The use of an inappropriate gas for calibration could result in erroneous readings during operation, even though the instrument appears to be operating correctly.

Instruments should only be dismantled by persons who are qualified and certified to carry out such work.

8.2.7 Operational Testing and Inspection

Gas measuring instruments should be tested in accordance with the manufacturer's instructions before the commencement of operations requiring their use. Such tests are designed only to ensure that the instrument is working properly. They should not be confused with calibration (see Section 8.2.6 above).

Instruments should only be used if the tests indicate that the instrument is giving accurate readings and that alarms, if fitted, are operating at the pre-determined set points.

Physical checks should include:

- Hand pump.
- Extension tubes.
- Tightness of connections.
- Batteries.
- Housing and case.

Instruments not passing these operational tests should be re-calibrated before they are returned to operational use. If this is not possible, they should be removed from service and clearly labelled to denote that they are not to be used.

During operations, it is important to check the instrument and sample lines for leakage occasionally, since the ingress of air will dilute the sample and give false readings. Leak testing may be carried out by pinching the end of the sample line and squeezing the aspirator bulb. The bulb should not expand as long as the sample line is pinched.

During extended operations, the ship operator should determine the frequency at which operational checks should be made. The results of the tests and inspections should be recorded.

These procedures should be documented in the Safety Management System (see Section 9.2).

8.2.8 Disposable Personal Gas Monitors

Disposable personal gas monitors should be periodically tested in accordance with the manufacturer's recommendations to confirm that they are operating correctly.

Disposable gas detection monitors, which cannot be re-calibrated, should be safely disposed of when the calibration expiry date is reached. For this reason, it is important to record the date when disposable instruments are first commissioned in order to establish their expiry date.

8.3 Lifting Equipment

8.3.1 Inspection and Maintenance

All shipboard lifting equipment, such as is used for the handling of cargo transfer equipment and/or gangways, should be examined at intervals not exceeding one year and load tested at least every 5 years unless local, national or company regulations require more frequent examinations.

Lifting equipment includes:

- Cargo hose handling cranes, derricks, davits and gantries.
- Gangways and associated cranes and davits.
- Store cranes and davits.
- Chain blocks, hand winches and similar mechanical devices.
- Personnel lifts and hoists.
- Strops, slings, chains and other ancillary equipment.

All equipment should be tested by suitably qualified individuals or authorities and be clearly marked with its Safe Working Load (SWL), serial number and test date.

The ship should ensure that all maintenance of lifting equipment is carried out in accordance with manufacturer's guidelines. Routine checks should be included within the ship's planned maintenance system.

All records of tests and inspections should be recorded in the ship's Lifting Equipment Register. These records should be available for inspection by Terminal Representatives when their personnel are involved in lifting operations using ship's equipment.

8.3.2 Training

Lifting equipment should only be operated by personnel who are trained and proven to be competent in its operation.

MANAGEMENT OF SAFETY AND EMERGENCIES

This Chapter sets out the principles and recommended practices for controlling health and safety hazards on board a tanker. It introduces a risk based approach to the planning and execution of hazardous work, following the principles set out in the *International Safety Management (ISM) Code*.

Guidance is given on risk assessment and risk management processes and information is provided on the practical application of these processes with regard to the management of Hot Work and other hazardous tasks on board.

Safety on board ship also extends to the activities of contractors and repair teams working on board. Issues relating to the safe management of contractors and repair work outside a shipyard are addressed.

Finally, advice is provided on the emergency management structure and organisation to facilitate effective responses to shipboard emergencies.

9.1 The International Safety Management (ISM) Code

All tankers, as defined in the SOLAS and MARPOL Conventions, of 500 gross tonnage and over, are required to comply with the *International Safety Management (ISM) Code*. Ships to which the Code does not apply are encouraged to develop a management system that provides an equivalent standard of safe operations.

Under the ISM Code, safety management processes are based on risk assessments and risk management techniques. This is a significantly different approach from the strictly compliance based requirements previously observed.

The purpose of the ISM Code is to provide an international standard for the safe management and operation of ships and for pollution prevention.

The Code requires that ship operators should:

- Provide for safe practices in ship operation and a safe working environment.
- Establish safeguards against all identified risks.
- Continuously improve the safety management skills of personnel ashore and aboard ship, including preparing for emergencies related to safety and environmental protection.

The Code defines a ship operating company, and requires the Company to develop a Safety Management System (SMS), which should include certain functional requirements – particularly “instructions and procedures to ensure safe operation of ships and protection of the environment”.

The ISM Code is not prescriptive with regard to how a ship is managed. It is left to the Company to develop the SMS elements suitable to the operation of a specific ship.

In developing their SMS, Companies are encouraged to take into account applicable industry publications and guidelines.

The IMO guidelines to the ISM Code identify that cargo loading and discharge operations, including those related to dangerous goods, should be included within the scope of the Company's documentation.

9.2 Safety Management Systems

The Safety Management System (SMS) enables effective implementation of the Company's health, safety and environmental protection policy. The SMS is subjected to regular audit to verify its suitability to deliver the expectations of the ISM Code, and to confirm that it is effective and that stated procedures are being followed.

Although a range of safety management topics is specified in the Code, the Company should develop the content and form of its SMS. The SMS must demonstrate that acceptable levels of safety management are in place to protect the ship, personnel and the marine environment.

To deliver the required levels of safety, the SMS will need to address all activities undertaken in the operation of the ship together with possible situations that may arise which would affect the safety of the ship or its operation.

These activities and situations will involve varying degrees of hazard to the ship, its personnel and the environment. Careful assessment of these hazards, and the probability of their occurrence, will determine the severity of the risks involved. Risk management tools are then applied to accomplish safe completion of the work, to ensure compliance with the SMS and to provide the objective evidence needed for verification, such as:

- Documented policies, procedures and instructions.
- Documentation of the verification carried out by the Responsible Person of day to day operation, when relevant to ensure compliance.

The end result of an effective Safety Management System is a safe system of work.

ICS has developed comprehensive '*Guidelines on the Application of the IMO ISM Code*', and '*Guidelines on the Assessment and Development of Safety Management Systems*'.

9.2.1 Risk Assessment

A risk assessment should entail a careful examination of what, in the range of operations, could cause harm, with a view to deciding whether the precautions are adequate, or whether more should be done to minimise accidents and ill health on board ship.

The risk assessment should first establish the hazards that are present at the place of work and then identify the significant risks arising out of the work activity. The assessment should take into account any existing precautions to control the risk, such as permits to work, restricted access, use of warning signs, agreed procedures and personal protective equipment. The type of questions that should be answered when carrying out a risk assessment are as follows:

What can go wrong?

An identification of the hazards and accident scenarios, together with potential causes and outcomes.

How bad and how likely?

An evaluation of the risk factors.

Can matters be improved?

An identification of risk control options to reduce the identified risks.

What is the effort involved and how much better would the result be?

A determination of the benefit and effectiveness of each risk control option.

What action should be taken?

An identification of the appropriate course of action to deliver a safe activity based on the hazards, their associated risks and the effectiveness of alternative risk control options.

In summary, the risk assessment should ensure that protective and precautionary measures are taken which will reduce the risks associated with a task to a level that is considered to be as low as reasonably practicable (ALARP).

9.3 Permit to Work Systems

9.3.1 General

While companies will develop their own procedures for managing all aspects of operations and tasks undertaken, many operators choose to incorporate a Permit to Work system into their SMS in order to manage hazardous tasks.

A Permit to Work system is a formal written system that is used to control certain types of work. It delivers a risk based approach to safety management and requires personnel to undertake and record risk assessments in the development of a safe system of work.

Guidance for establishing a Permit to Work system is contained in a number of publications issued by industry organisations and national safety bodies.

The Permit to Work system may include one or more of the following documents to control hazardous activities:

- A work instruction.
- A maintenance procedure.
- A local procedure.
- An operational procedure.
- A check-list.
- A permit.

The measures to be employed when carrying out a particular task are determined by a risk assessment and recorded in the Permit to Work.

9.3.2 Permit to Work Systems – Structure

The structure of the system and the processes employed are very important in ensuring that the system delivers the necessary level of safety and operational integrity.

The Permit to Work system should define:

- Company responsibility.
- Responsibilities for all personnel operating the system.
- Training in the use of the system.
- A measure of the competency of personnel.
- Types of permit and their application.
- Levels of authority.
- Isolation processes.
- Permit issuing procedures.
- Permit cancelling procedures.
- Emergency actions.
- Record keeping.
- Auditing.
- System updating.

The system will determine the appropriate controls needed to manage the risk associated with each task and determine the appropriate management tool needed to manage the task, as listed in Section 9.3.1 above.

The system need not require that all tasks be undertaken under the control of a formal permit. However, it is important that the work instruction, procedure or permit used for managing a task is appropriate to the work being carried out and that the process is effective in identifying and managing the risks.

9.3.3 Permit to Work Systems – Principles of Operation

A Permit to Work system should comprise the following steps:

- Identify the task and location.
- Identify the hazards and assess the risks.
- Ensure appropriate competency of personnel who will carry out the work.
- Define the risk control measures – state the precautions and personal protective equipment needed.
- Determine communication procedures.
- Identify a procedure and initiate a Permit to Work.
- Obtain formal approval to perform the work.
- Carry out a pre-work briefing.
- Prepare the work.
- Carry out the work to completion.
- Return work site to a safe condition.
- Complete the process, keeping records for audit purposes.

9.3.4 Permit to Work Forms

The Permit to Work form is designed to lead the operator through an appropriate process in a logical, detailed and responsible manner. The permit is produced as a joint effort between those authorising the work and those performing the work. The permit should ensure that all safety concerns are fully addressed.

The structure and content of Permit to Work forms will be determined by the specific individual requirement of a ship's SMS, but are typically as follows:

- Type of permit.
- Number of permit.
- Supporting documents – e.g. details of isolations, gas test results.
- Location of work.
- Description of work.
- Hazard identification.
- Precautions necessary.
- Protective equipment to be used.
- Period of validity.
- Authorisation for the work including duration, endorsement by the Master or department head.
- Acceptance by those performing the work.
- Management of changes to workforce or conditions.
- Declaration of completion.
- Cancellation.

The issue of a permit does not, by itself, make a job safe.

Adherence to the requirements of the permit, and the identification of any deviations from the specified controls or expected conditions, are essential in completing the task safely. The system should also identify any conflicts between tasks being carried out simultaneously on board.

9.3.5 Work Planning Meetings

Work planning meetings should be held to ensure that operations and maintenance tasks are correctly planned and managed with the aim of completing all tasks safely and efficiently. These meetings may include discussion of:

- Risk assessments.
- Work permits.
- Isolation and tagging requirements.
- The need for safety briefings, tool box talks and correct procedures.

The format and frequency of work planning meetings should be in accordance with the requirements of the company's SMS, and will be determined by the ship's activities.

It may be appropriate to have two levels of meetings – one on a management level and one that addresses the practical issues associated with carrying out specific tasks.

9.4 Hot Work

There have been a number of fires and explosions due to Hot Work in, on, or near cargo tanks or other spaces that contain, or that have previously contained, flammable substances or substances that emit flammable vapours.

Hot Work should only be considered if there are no practical alternative means of repair.

9.4.1 Control of Hot Work

The SMS should include adequate guidance on the control of Hot Work and should be robust enough to ensure compliance (see Figure 9.2). Absence of guidance should be regarded as prohibition rather than approval (IMO MSC/Circ. 1084).

9.4.2 Hot Work Inside a Designated Space

Whenever possible, a space such as the engine room workshop, where conditions are deemed safe, should be designated for Hot Work and first consideration should be given to performing any Hot Work in that space.

If the company designates such a place, it should be assessed for possible risks, and the conditions under which Hot Work can be undertaken in that place defined.

These conditions should include the need for additional controls, including consideration of the conditions under which Hot Work may be carried out in the designated space, when taking bunkers alongside or at anchor.

9.4.3 Hot Work Outside a Designated Space

9.4.3.1 General

Hot Work undertaken outside the designated space should be controlled under the SMS by means of a permit to work system.

The Master should decide whether the use of Hot Work is justified and whether it can be safely undertaken. The Master or Responsible Officer must approve the completed permit before any Hot Work can begin.

Consideration should be given to performing only one Hot Work operation at a time, due to the resource limitations usually present on board a tanker. A separate permit should be approved for each intended task and location.

A risk assessment should be carried out to identify the hazards and assess the risks involved. This will result in a number of risk reduction measures that will need to be taken to allow the task to be carried out safely.

The risk assessment should identify hazards associated with the risks to fire watch personnel and their means of exacuation in an emergency. The risk assessment should also include additional personal protective equipment required to ensure risk levels are acceptable.

A written plan for undertaking the work should be completed, discussed and agreed by all who have responsibilities in connection with the work.

This plan should define the preparations needed before work commences, the procedures for actually carrying out the work and the related safety precautions. The plan should also indicate the person authorising the work and the people responsible for carrying out the specified work, including contractors if appropriate. (See also Section 9.7.)

A Responsible Officer, who is not directly involved in the Hot Work, should be designated to ensure that the plan is followed.

The Hot Work permit should be issued immediately before the work is to be performed. In the event of a delay to the start of the work, all safety measures should be re-checked and recorded before work actually commences.

If the conditions under which the permit has been issued should change, Hot Work must stop immediately. The permit should be withdrawn or cancelled until all conditions and safety precautions have been checked and reinstated to allow the permit to be reissued or re-approved.

The work area should be carefully prepared and isolated before Hot Work commences.

Fire safety precautions and fire extinguishing measures should be reviewed. Adequate fire-fighting equipment must be prepared, laid out and be ready for immediate use.

Fire watch procedures must be established for the area of Hot Work and for adjacent spaces where the transfer of heat or accidental damage might create a hazard, e.g. damage to hydraulic lines, electrical cables, thermal oil lines etc. The fire watch should monitor the work and take action in case of ignition of residues or paint coatings. Effective means of containing and extinguishing welding sparks and molten slag must be established.

The atmosphere of the area should be tested and found to be less than 1% LFL.

The work area must be adequately and continuously ventilated and the frequency of atmosphere monitoring must be established. Times of atmosphere monitoring and results should be recorded on the Hot Work permit.

If it is necessary to carry out Hot Work in a dangerous or hazardous area (see Definition) the guidance given in Section 9.4.4 should also be followed.

When alongside a terminal, Hot Work should only be permitted in accordance with prevailing national or international regulations, port and terminal requirements and after all necessary approvals have been obtained.

Isolation of the work area and fire safety precautions should be continued until the risk of fire no longer exists.

Personnel carrying out the work should be adequately trained and have the competency required to carry it out safely and effectively.

A flow chart for guidance is shown in Figure 9.1.

Figure 9.2 depicts how guidance for Hot Work on an inerted ship may be presented within the SMS. This is provided as an example for operators to tailor to their own requirement.

9.4.3.2 Hot Work in a Gas Safe Area

A dedicated area outside the engine room, for example on the poop behind the accommodation and well clear of any oil tank vents, may be considered for Hot Work. Such an area should be marked accordingly. Any work intended at this location should be subject to a full risk assessment and the precautions set out in Section 9.4.3.1 should be taken.

9.4.3.3 Hot Work Inside the Machinery Space

Hot Work inside the main machinery space, when associated with fuel tanks and fuel pipelines, must take into account the possible presence of hydrocarbon vapours in the atmosphere and the existence of potential ignition sources.

No Hot Work should be carried out on bulkheads of bunker tanks, or within 500 mm of such bulkheads, unless that tank is cleaned to Hot Work standard.

The flow chart (Figure 9.1) assumes the work is considered essential for safety or the immediate operational capability of the ship, and that it cannot be deferred until the next planned visit to a repair yard.

9.4.4 Hot Work in Dangerous or Hazardous Areas

9.4.4.1 General

Dangerous or hazardous areas are locations on board or within the terminal where an explosive atmosphere could be present, as defined in Section 4.4.2. For ships, this effectively means an area slightly larger than the cargo tank deck, which includes cargo tanks and pumprooms, and the atmospheric space around and above them. No Hot Work should be undertaken in a dangerous or hazardous area until it has been made safe, and has been proved to be safe, and all appropriate approvals have been obtained.

Any Hot Work in a dangerous or hazardous area should be subject to a full risk assessment, and the guidance in Section 9.4.3 should also be followed. Account must be taken of the possible presence of hydrocarbon vapours in the atmosphere and the existence of potential ignition sources.

Hot Work in dangerous or hazardous areas should only be carried out when the ship is in ballast. Hot Work should be prohibited during cargo or ballast operations, and when tank cleaning, gas freeing, purging or inerting. If Hot Work needs to be interrupted to carry out any of these

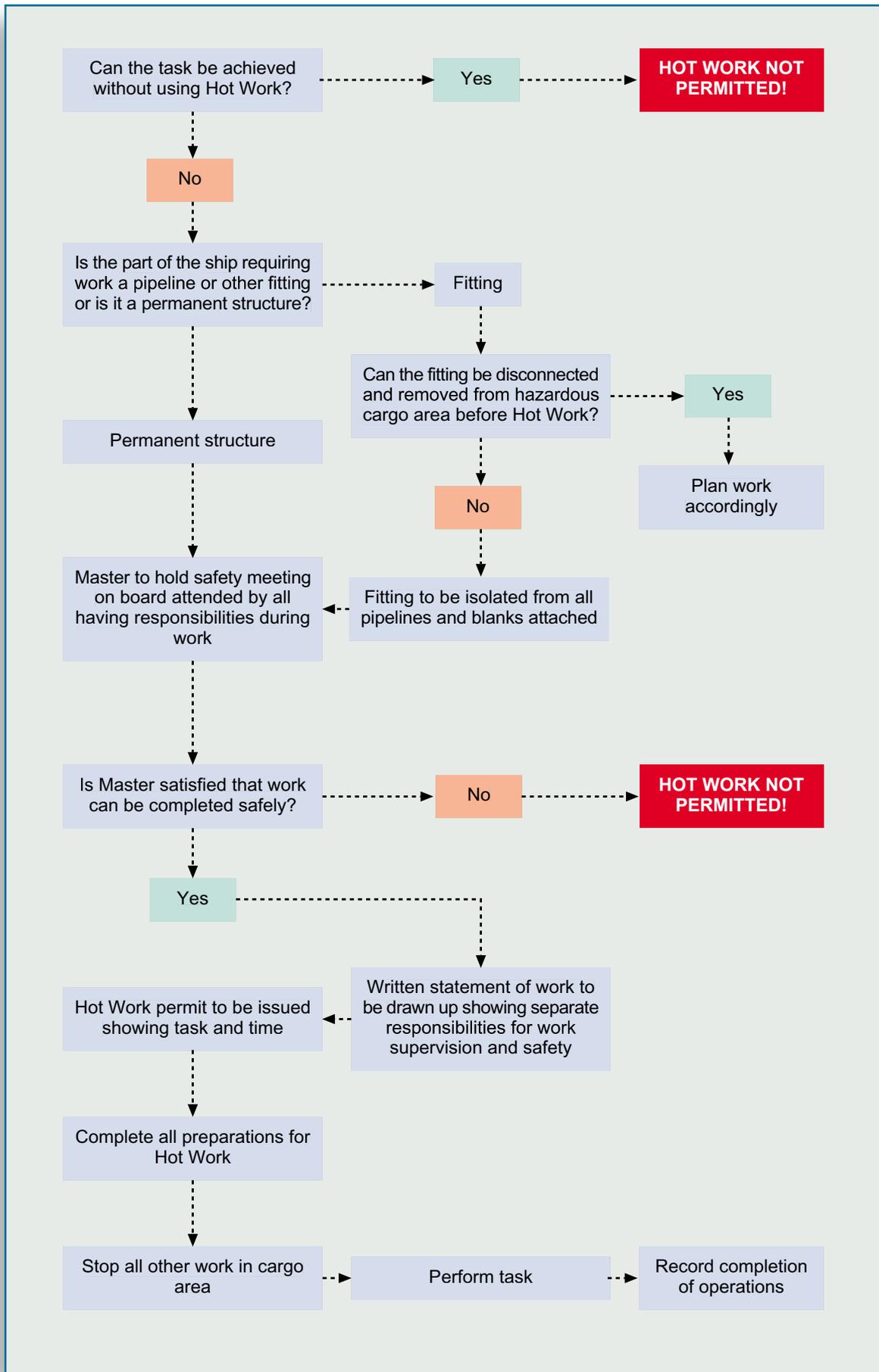


Figure 9.1 – Hot work flow chart

Work Location Minimum Requirements	Engine room workshop	Other parts of non-hazardous area	Open deck aft of accommodation	Enclosed spaces (other than pumprooms)	Main deck (deck plating)	Work on fixtures/fittings in the main deck area	Work on any cargo-related pipelines incl. heating coils in a cargo tank	Cargo pumprooms	Cargo or ballast tanks
Work planning meeting to be held and risk assessment completed	✓	✓	✓	✓	✓	✓	✓	✓	✓
Work in designated space with shield or curtain erected	✓								
Adequate ventilation	✓	✓		✓			✓	✓	✓
Confirmation from Master or designate that work is OK to proceed	✓								
Tank atmosphere checks carried out and entry permit issued				✓			✓		✓
Tank to be washed and gas freed					✓		✓		✓
Cargo tanks to be purged and inerted to not more than 8% O ₂ and not more than 2% HC					✓	✓	✓	✓	✓
Work to be carried out further than 500 mm from the tank deck or bulkheads				✓		✓		✓	
Work to be carried out more than 500 mm from a fuel oil tank deck or bulkheads			✓	✓		✓		✓	
Local cleaning to be carried out as per requirements				✓			✓	✓	✓
All interconnecting pipelines flushed and drained							✓	✓	✓
Tank valves isolated							✓	✓	✓
Hot Work permit to be issued on board		✓							
Hot Work permit issued in agreement with Company			✓	✓	✓	✓	✓	✓	✓
Hot Work permit approved by Master or Responsible Officer		✓	✓	✓	✓	✓	✓	✓	✓

Figure 9.2 – Example of SMS guidance for Hot Work on an inerted ship

operations, the permit should be withdrawn or cancelled. On completion of the operation, all safety checks should be carried out once more and the permit re-approved or a new procedure developed.

Where Hot Work involves entry into an enclosed space, the procedures outlined in Chapter 10 for enclosed space entry should be followed. A compartment in which Hot Work is to be undertaken should be cleaned and ventilated. Particular attention should also be given to the condition of any adjacent spaces.

Adjacent fuel oil bunker tanks may be considered safe if tests give readings of less than 1% LFL in the vapour space of the bunker tank. No Hot Work should be carried out on bulkheads of bunker tanks, or within 500 mm from such bulkheads, unless that tank has been cleaned for Hot Work.

Adjacent ballast tanks and compartments, other than cargo tanks, should be checked to ensure they are gas free and safe for Hot Work. If adjacent ballast tanks and compartments are found to contain hydrocarbon liquid or vapours, they should be cleaned and gas freed or inerted.

9.4.4.2 Hot Work in Cargo Tanks

To clean the work area, all sludge, cargo-impregnated scale, sediment or other material likely to give off flammable vapour should be removed. The extent of the cleaned area should be established following a risk assessment of the particular work to be carried out. Special attention must be given to the reverse side of frames and bulkheads. Other areas that may be affected by the Hot Work, such as the area immediately below the work location, should also be cleaned.

Table 9.1 provides guidance on the safe distance for areas to be cleaned and represents minimum requirements that may need to be extended, based on the output of the risk assessment. Cleaning distances are based on the type of work being carried out and the height above the tank bottom.

Consideration should be given to using fire resistant blankets or putting a water bottom in the tank to prevent falling sparks coming into contact with paint coatings.

All interconnecting pipelines to other compartments should be flushed through with water, drained, vented and isolated from the compartment where Hot Work will take place. Cargo lines may be subsequently inerted or completely filled with water, if considered necessary.

Height of Work Area	Operator's Side			Opposite Side		
	Gas Cut	Welding	Gouging	Gas Cut	Welding	Gouging
0-5 metres	1.5 m	5.0 m	4.0 m	7.5 m	2.0 m	2.0 m
5-10 metres	1.5 m	5.0 m	5.0 m	10.0 m	2.0 m	2.0 m
10-15 metres	1.5 m	5.0 m	7.5 m	15.0 m	2.0 m	2.0 m
>15 metres	1.5 m	5.0 m	10.0 m	20.0 m	2.0 m	2.0 m

Table 9.1 – Radius of areas to be cleaned in preparation for Hot Work in tanks

Heating coils should be flushed or blown through with steam and proved clear of hydrocarbons.

An adjacent fuel oil bunker tank may be considered safe if tests give a reading of less than 1% LFL in the vapour space of the bunker tank, and no heat transfer through the bulkhead of the bunker tank will be caused by the Hot Work.

Non-inerted Ships

The compartment in which the Hot Work is to be carried out should be cleaned, gas freed to Hot Work standard and be continuously ventilated.

Adjacent cargo tanks, including diagonally positioned cargo tanks, should either have been cleaned and gas freed to Hot Work standard or completely filled with water.

All slops should be either removed from the ship or securely isolated in a closed and non-adjacent tank at least 30 metres from the Hot Work location. For this purpose, tanks located diagonally should be regarded as adjacent tanks. A non-adjacent slop tank should be kept closed, securely isolated from the IG main and isolated from the piping system for the duration of the Hot Work.

Vapour or vent lines to the compartment should also be ventilated to not more than 1% LFL and isolated.

The possibility of using an external source of inert gas should be considered.

Inerted Ships

The compartment in which the Hot Work is to be carried out should be cleaned, gas freed to Hot Work standard and be continuously ventilated.

Adjacent cargo tanks, including diagonally positioned cargo tanks, should either be:

- Cleaned and gas freed, with hydrocarbon vapour content reduced to not more than 1% LFL and maintained at that level; or
- Emptied, purged and the hydrocarbon vapour content reduced to less than 2% by volume and inerted; or
- Completely filled with water.

All other cargo tanks should be inerted and their deck openings closed.

When Hot Work is to be carried out on a cargo tank bulkhead, or within 500 mm of such a bulkhead, then the space on the other side should also be cleaned to Hot Work standard.

Consideration should be given to reducing the inert gas pressure for the duration of the Hot Work to prevent uncontrolled venting.

Inert gas lines to the compartment should be purged with inert gas to not more than 2% hydrocarbon by volume and isolated.

All slops should be either removed from the ship or securely isolated in a non-adjacent tank at least 30 metres from the Hot Work location. For this purpose, tanks located diagonally should be regarded as adjacent tanks. A non-adjacent slop tank should be kept closed, securely isolated from

the IG main and isolated from the piping system for the duration of the Hot Work.

9.4.4.3 Hot Work Within the Cargo Tank Deck Area

On the Tank Deck

If Hot Work is to be undertaken on the tank deck or at a height of less than 500 mm above the tank deck, it should be classed as Hot Work within that tank and the appropriate measures complied with (see 9.4.4.2).

Above the Tank Deck

If Hot Work is to be undertaken above the tank deck (higher than 500 mm), cargo and slop tanks within a radius of at least 30 metres around the working area should either be:

- Cleaned and gas freed, with hydrocarbon vapour content reduced to not more than 1% LFL and maintained at that level; or
- Emptied, purged and the hydrocarbon vapour content reduced to less than 2% by volume and inerted; or
- Completely filled with water.

All other cargo tanks must be inerted with openings closed.

All slops should be either removed from the ship or isolated in a tank as far as practicable from the Hot Work location.

Additionally, on Non-Inerted Ships

All cargo tanks within 30 metres of the work location, including diagonally positioned cargo tanks, should either have been cleaned and gas freed to Hot Work standard, or completely filled with water.

All slops should be either removed from the ship or securely isolated in the tank furthest (and at least 30 metres) from the Hot Work location. Vapour or vent lines to the compartment should also be ventilated to not more than 1% LFL and isolated.

The possibility of using an external source of inert gas should be considered.

9.4.4.4 Hot Work in the Vicinity of Bunker Tanks

Hot Work in the vicinity of bunker fuel tanks should, in general, be treated in the same manner as Hot Work over the tank deck. No Hot Work should be carried out on the deck, or within 500 mm from such a deck, unless the tank has been cleaned to Hot Work standard.

Bunker fuel tanks should be clearly identified to avoid any misunderstanding as to their location and extent.

9.4.4.5 Hot Work on Pipelines

Wherever possible, sections of pipelines and related items, such as strainers and valves, should be removed from the system and repaired in the designated space. (See Section 9.4.2.)

Where Hot Work on pipelines and valves needs to be carried out with the equipment in place, the item requiring Hot Work must be disconnected by Cold Work, and the remaining pipework blanked off. The item to be

worked on should be cleaned and gas freed to a 'safe Hot Work' standard, regardless of whether or not it is removed from the hazardous cargo area.

If the location where the Hot Work is to be carried out is not in the immediate vicinity of the disconnected pipeline, consideration should be given to continuous through ventilation of the pipeline with fresh air and monitoring the exhaust air for hydrocarbon vapour.

Heating coils should be flushed or blown through with steam and proved clear of hydrocarbons.

9.5 Welding and Burning Equipment

Welding and other equipment used for Hot Work should be carefully inspected before each occasion of use to ensure that it is in good condition. Where required, it must be correctly earthed. When using electric arc equipment, special attention must be paid to ensure that:

- Electrical supply connections are made in a gas free space.
- Existing supply wiring is adequate to carry the electrical current demand without overloading, causing heating.
- Insulation of flexible electric cables is in good condition.
- The cable route to the work site is the safest possible, only passing over gas free or inerted spaces.
- The earthing connection is adjacent to the work site and the earth return cable leads directly back to the welding machine. The ship's structure should not be used as an earth return.

9.6 Other Hazardous Tasks

A hazardous task is defined as a task, other than Hot Work, which presents a hazard to the ship, terminal or personnel, the performance of which needs to be controlled by a risk assessment process, such as a Permit to Work system.

It follows that, for each hazardous task, a work permit or controlled procedure should be developed and approved. The permit or controlled procedure should follow the process outlined in Section 9.3 and should be discussed with the personnel who are performing the task.

The procedure, approval and record of compliance should be retained within the SMS records.

Hazardous tasks should only be carried out alongside a terminal with prior agreement of the Terminal Representative.

Examples of such tasks are:

- Enclosed space entry.
- Tank inspections.
- Diving operations.
- Blanking sea chests.

- Extended work aloft or over the side.
- Heavy or unusual lifting operations.
- Work on or adjacent to a pressurised system.
- Testing and launching of lifeboats.

9.7 Management of Contractors

The Master should satisfy himself that, whenever contractors or work gangs are employed, arrangements are made to ensure their understanding of, and compliance with, all relevant safe working practices. This is particularly important when they are to be involved in Hot Work or hazardous tasks. Contractors should be effectively supervised and controlled by a Responsible Officer.

The contractor should take part in relevant safety meetings to discuss the arrangements for work. Where applicable, the contractor should sign the formal approval relevant to work being undertaken, thereby verifying awareness of the hazards and safety precautions required to reduce the risks to an acceptable level.

9.8 Repairs at a Facility Other Than a Shipyard

9.8.1 Introduction

This Section deals with repairs that are to be carried out on board a tanker that is at a facility other than a shipyard. The guidance given in this Section is intended to supplement, not replace, the guidance given elsewhere in this publication. (Guidance on factors that should be addressed when a ship is at a shipyard is given in an OCIMF Information Paper entitled “*Health, Safety and Environment at New-building and Repair Shipyards and During Factory Acceptance Testing*” which can be downloaded from the OCIMF website.)

9.8.2 General

When a ship is operational at sea or in port, ship’s personnel carry out their duties in accordance with the ship’s Safety Management System (SMS). When a ship is at a shipyard, the ship is not operational and the work is primarily carried out and managed by the shipyard. While it may be monitored and checked by ship’s personnel, the safety of the ship and anyone on board is generally dependent on the shipyard’s safety management system. There will be occasions when a ship that is operational is required to carry out repairs using shore labour outside a shipyard or dry dock facility. In these cases, the safety of all on board will be dependent on the ship’s SMS and all activities should therefore be carried out in accordance with the SMS.

Repairs may be undertaken while the ship is:

- At anchor.
- Alongside at a lay-by berth, not normally used for cargo operations.
- Alongside a commercial jetty.
- At sea.

Such repair work is only carried out on an exceptional basis and attention will need to be paid to ensuring that the scope of the ship's SMS fully embraces the planned activities and the exposures to the shore labour employed.

9.8.3 Supervision and Control

The Master, Company Superintendent or other specifically appointed person should maintain full control of the repair work, ensuring that the ship is maintained in a safe condition at all times and that all work is carried out in a safe and proper manner.

Specific procedures will be required when the ship is to be repaired in a 'dead ship' condition or when there are limitations on the electrical power available.

9.8.4 Pre-Arrival Planning

Prior to arrival at the repair berth, anchorage or other facility, the following should be taken into consideration in the initial planning:

- Type and location of the berth or anchorage.
- Moorings – numbers, type.
- Condition of the ship – gas free or inert.
- Safe access – by launch, gangway or other means.
- Number of persons involved, including contractors.
- Location of work to be undertaken – engine room, cargo spaces, above deck, accommodation etc.
- Facilities for disposal of slops or sludge.
- Arrangements for permits and certification.
- Understanding of port or terminal requirements.
- Availability of main power or main engine(s).
- Emergency procedures, on board and ashore.
- Availability of assistance – fire-fighting, medical facilities etc.
- Connection to shore side services – water, power etc.
- Weather conditions.
- Draught and trim limitations (to avoid unnecessary ballast handling).
- Restrictions on smoking and other naked lights.

9.8.5 Mooring Arrangements

When moored to a repair berth, the number and size of mooring lines used should be adequate for all likely weather and tidal conditions.

Whenever practicable, an alternative power source should be provided for the deck machinery, in order that moorings can be adjusted if main power is not available.

On repair berths, the mooring pattern may be restricted due to crane movements or other activity on the dock side. Such restrictions should be taken into account when planning the berthing of the ship.

Moorings should be clear of Hot Work areas or other locations where the lines may be damaged by the repair work in progress.

When at anchor, it may be necessary to use additional cable, particularly if the main engine(s) will not be available at any time.

9.8.6 Shore Facilities

Whenever practicable, the ship should be physically isolated from regular terminal facilities or berths where other ships are being worked.

If any repairs are to be carried out concurrent with cargo handling operations, specific permission should be granted by the terminal operators.

The Master should establish whether any significant operations are to take place involving other vessels in the vicinity of the berth at which repairs are being undertaken, i.e. departure/arrival of other vessels, bunkering, fuel oil transfer etc.

The Master should be familiar with any specific safety requirements of the facility and/or harbour authorities.

There should be safe means of access at all times with guard rails and safety nets as appropriate. The number of access points should be sufficient to allow timely evacuation of all personnel on board. The gangway should be monitored at all times and a gangway watch should be posted to control access to the vessel (see also Chapter 6 – Security).

On a lay-by berth where the ship is not gas free, a sign should be placed at the foot of the gangway worded “**No Unauthorised Access. This Ship Is Not Gas Free.**”

Port security plans should be implemented and followed as may be appropriate.

Contractors should advise the Master of the number and movement of workers on board each day during the repair period.

Procedures for the use of cranes or other lifting equipment should be determined upon arrival.

Garbage disposal procedures should be agreed between the ship and the facility, with regular disposal of accumulated garbage being arranged.

Emergency alarm signals should be agreed and, whenever practicable, a drill held prior to commencing repair work. Subsequent drills should be arranged when the repairs are to be carried out over an extended period.

Any restrictions on activities such as bunkering, storing or taking luboils are to be agreed.

9.8.7 Pre-Work Safety Meeting

Work planning meetings should be held prior to the commencement of any work, and on each subsequent work day.

Work planning meetings will normally include representatives from the ship and all the contractors involved.

The prime function of these meetings is to ensure that all personnel involved are aware of the daily schedule, the interrelation between contractors, particular areas of concern and special precautions to be taken etc.

9.8.8 Work Permits

Permits should be issued for the relevant repair work jobs, including any repairs being carried out by ship's staff. In particular, permits should be issued for:

- Enclosed space entry.
- Hot Work.
- Electrical isolation.
- Other hazardous tasks.

Copies of all permits should be posted as may be necessary. Copies should also be retained by the person in charge of the operation.

All personnel involved should be made fully aware of the requirements for, and benefits of, the work permit system, and should be advised of restrictions on commencing any work until the appropriate permit has been issued.

9.8.9 Tank Condition

Whether the ship is gas free or not will depend on the work being undertaken and the specific port or facility regulations.

A certified chemist should test all cargo/ballast spaces for oxygen content and hydrocarbon content. The conditions of all tanks and void spaces should be included on the chemist's certificate.

As a minimum, gas free certificates should be issued on a daily basis.

If cargo tanks are not required to be gas free and the ship is inert, positive inert gas pressure should be maintained within the tanks at all times.

9.8.10 Cargo Lines

All cargo lines on deck, in the tanks and in the pumproom, including those lines and pumps which may not have been used for recent cargo or tank cleaning operations, should be thoroughly washed and drained. This includes any dead ends in the system.

In addition to the cargo suction and discharge lines (including stripping lines), slop tank balance lines or other similar fittings commonly found between slop tanks should also be cleaned and drained as part of the preparation for repair work.

The hydraulic valve system should be isolated in such a way as to prevent unintentional operation of cargo valves during the work process. Appropriate notices should be posted and the persons in charge of the relevant repair team(s) should be advised.

9.8.11 Fire-Fighting Precautions

9.8.11.1 Fire Water

Fire-mains should be continuously pressurised, either by ship's pumps or from a shore supply.

There should be an agreed pressure for the fire-main, which should be maintained at all times.

9.8.11.2 Fire patrols

There should be an agreed procedure for fire patrols on board.

Fire patrols can be provided either by ship's staff or by shore contractors.

Each member of the fire patrol should be fully aware of the procedure for raising the alarm and the action to be taken in the event of an emergency situation arising.

All areas where Hot Work is being carried out should be monitored by fire patrols at all times.

9.8.12 Safety Officer

A dedicated Safety Officer should be appointed by the Master to co-ordinate the permit and certification processes associated with the repair period.

The Safety Officer should be fully aware of all his duties and responsibilities.

9.8.13 Hot Work

The following supplements and does not replace the guidance given in Section 9.4, which should also be followed for any repair activities involving Hot Work.

Hot Work should be prohibited within or on the boundaries of cargo tanks, ballast tanks, slop tanks, bunker tanks, pumprooms and forward cofferdams, including the deck and ship's shell plating, except when special preparations have been made prior to entering the berth or facility and the necessary special conditions have been met.

Use of electrical welding equipment should be controlled and correct grounding cables should be used. Welding current should not be returned to the transformer via the ship's hull.

Hot Work should not be carried out within 30 metres of any non-gas free spaces unless specific permission has been received from the controlling authority.

Notices should be posted to indicate the current state of any tank or void space, e.g. stating whether it is either gas free and suitable for Hot Work, or only safe for entry.

Hot Work should be suspended immediately if any of the specific safety requirements cannot be complied with.

Any Hot Work on or above the weather decks should be stopped if the inert gas pressure reaches the relieving pressure of the pressure/vacuum valves. If it is found necessary to release tank pressure to atmosphere, all work should be suspended until the operation has been completed. Consideration may need to be given to clearing the deck area of personnel during venting, especially when there is the possibility of toxic gas (e.g. H₂S) being present. A new permit should be issued prior to resuming work.

9.9 Shipboard Emergency Management

9.9.1 General

The ISM Code requires that the Company establish procedures to identify, describe and respond to potential emergency shipboard situations. This Section provides guidance on meeting this responsibility by addressing those aspects covered by the scope of this Guide.

9.9.2 Tanker Emergency Plan

9.9.2.1 Preparation

Planning and preparation are essential if personnel are to deal successfully with emergencies on board tankers. The Master and other officers should consider what they would do in the event of various types of emergency, such as fire in cargo tanks, fire in the engine room, fire in the accommodation, the collapse of a person in a tank, the ship breaking adrift from her berth and the emergency release of a tanker from her berth.

They will not be able to foresee in detail what might occur in all such emergencies, but good advance planning will result in quicker and better decisions and a well organised reaction to the situation.

The following information should be readily available:

- Type of cargo, amount and disposition.
- Location of other hazardous substances.
- General arrangement plan.
- Stability information.
- Fire-fighting equipment plans.

9.9.2.2 Emergency Organisation

An emergency organisation should be set up for mobilisation in the event of an emergency. The purpose of this organisation will be to raise the alarm, locate and assess the incident and possible dangers, and organise manpower and equipment.

The following provides guidance for use in planning an emergency organisation, which should cover four elements:

Command Centre

There should be one group in control of the response to the emergency, with the Master or the Senior Officer on board in charge. The command centre should have means of internal and external communication.

Emergency Party

This group should be under the command of a senior officer and should assess the emergency and report to the command centre on the situation, advising what action should be taken and what assistance should be provided, either from on board or, if the ship is in port, from ashore.

Backup Emergency Party

The backup emergency party, under the command of an officer, should stand by to assist the emergency party as instructed by the command centre and should provide backup services, e.g. equipment, stores, medical services, including cardio-pulmonary resuscitation etc.

Engineering Group

This group should be under the command of the Chief Engineer or the Senior Engineering Officer on board, and should provide emergency assistance as instructed by the command centre. The prime responsibility for dealing with any emergency in the main machinery spaces will probably rest with this group. It may be called on to provide additional manpower elsewhere.

The plan should ensure that all arrangements apply equally well, whether the ship is in port or at sea.

9.9.2.3 Preliminary Action

The person who discovers the emergency must raise the alarm and pass on information about the situation to the officer on duty who, in turn, must alert the emergency organisation. While this is being done, those on the scene should attempt immediate measures to control the emergency until the emergency organisation takes effect. Each group in the emergency organisation should have a designated assembly point, as should those persons not directly involved as members of any group. Personnel not directly involved should stand by to act as required.

9.9.2.4 Ship's Fire Alarm Signal

When a ship is in port, the sounding of the ship's fire alarm system should be supplemented by a series of long blasts on the ship's whistle, each blast being not less than 10 seconds in duration, or by some other locally required signal.

9.9.2.5 Fire Control Plans

Fire control plans must be permanently displayed in prominent positions showing clearly, for each deck, the location and particulars of all fire-fighting equipment, dampers, controls etc. When the ship is in port, these plans should also be displayed, or be readily available, outside the accommodation block for the assistance of shore based fire-fighting personnel.

9.9.2.6 Inspection and Maintenance

Fire-fighting equipment should always be ready for immediate use and should be checked frequently. The dates and details of such checks should be recorded and indicated on the appliance, as appropriate. The inspection of all fire-fighting and other emergency equipment should be carried out by a Responsible Officer, and any necessary maintenance work completed without delay.

9.9.2.7 Training and Drills

Ship's personnel should be familiar with the theory of fire-fighting outlined in Chapter 5 and should receive instruction in the use of fire-fighting and emergency equipment. Practices and drills should be arranged at intervals to ensure that personnel retain their familiarity with the equipment.

If an opportunity arises for a combined fire practice or 'table-top' drill with shore personnel at a terminal (see Section 20.2.8), the Master should make an officer available to show the shore personnel the location of portable and fixed fire-fighting equipment on board and also to instruct them on any design features of the ship which may require special attention in case of fire.

9.9.3 Actions in the Event of an Emergency

9.9.3.1 Fire on a Tanker at Sea or at Anchor

Ship's personnel who discover an outbreak of fire must immediately raise the alarm, indicating the location of the fire. The ship's fire alarm must be operated as soon as possible.

Personnel in the vicinity of the fire should apply the nearest suitable extinguishing agent to attempt to limit the spread of the fire, to extinguish it, and thereafter to prevent re-ignition (see Section 5.3). If they are unsuccessful, their actions should very quickly be superseded by the activation of the tanker's emergency plan.

Any cargo, ballast, tank cleaning or bunkering operations should be stopped immediately and all valves closed. Any craft alongside should be removed.

Once all personnel have been evacuated from the vicinity, all doors, openings and tank apertures should be closed as quickly as possible and mechanical ventilation should be stopped. Decks, bulkheads and other structures in the vicinity of the fire, and adjacent tanks that contain petroleum liquids or are not gas free, should be cooled with water.

The tanker should be manoeuvred so as to resist the spread of the fire and to allow the fire to be attacked from windward.

9.9.3.2 Emergencies in Port

Emergencies occurring either on board or adjacent to the tanker when it is in a port are addressed in Section 26.5, as action taken will be the joint responsibility of the Master and the port or terminal authority.

9.9.3.3 Jettison of Cargo

The jettisoning of cargo is an extreme measure justified only as a means of saving life at sea or for the safety of the ship. A decision to jettison cargo should therefore not be taken until all the alternative options have been considered in the light of available information on stability and reserve buoyancy.

If it is necessary to jettison cargo, the following precautions should be taken:

- Engine room personnel should be alerted. Depending on the circumstances prevailing at the time, consideration should be given to changing over engine room intakes from high to low level.
- Discharge should take place through the sea valve and, where possible, on the side opposite to the engine room intakes.
- All non-essential inlets should be closed.
- If discharge must be from the deck level, flexible hoses should be rigged to extend below the water surface.
- All safety precautions relating to operations that involve the presence of flammable gas in the vicinity of the deck must be observed.
- A radio warning should be broadcast.

9.9.3.4 Follow-up

As soon as possible after an incident, there should be a thorough check of all the equipment used. Portable extinguishers should be re-filled, or replaced with spares from stock, and breathing apparatus bottles should be recharged. Foam systems should be flushed through with water.

Post-incident discussion should address how and which lessons can be learned and how contingency plans can be further developed.

ENCLOSED SPACES

This Chapter describes the hazards associated with entry into enclosed spaces and the tests to be carried out to determine whether or not an enclosed space has been made safe for entry. The conditions for entry are set out, as well as the precautions to be taken before entry and while work is being carried out in an enclosed space.

Masters should be aware that terminal requirements for enclosed space entry might differ from this guidance as a result of national legislation.

10.1 Definition and General Caution

For the purpose of this Guide, an 'Enclosed Space' is defined as a space that has the following characteristics:

- Limited openings for entry and exit.
- Unfavourable natural ventilation.
- Not designed for continuous worker occupancy.

Enclosed spaces include, but are not limited to: cargo tanks, double bottoms, fuel tanks, ballast tanks, pumprooms, cofferdams, void spaces, duct keels, inter-barrier spaces, engine crankcases and sewage tanks.

Although pumprooms come within the above definition of an enclosed space, they have their own particular equipment, characteristics and risks which require special precautions and procedures. These are explained in Section 10.10.

Many of the casualties that have occurred in enclosed spaces on ships have resulted from people entering an enclosed space without proper supervision or adherence to agreed procedures. In almost every case, the casualty would have been avoided if the simple guidance in this Chapter had been followed.

The rapid rescue of personnel who have collapsed in an enclosed space presents particular risk. It is a human reaction to go to the aid of a colleague in difficulties, but far too many additional and unnecessary casualties have occurred from impulsive and ill-prepared rescue attempts.

10.2 Hazards of Enclosed Spaces

10.2.1 Assessment of Risk

In order to ensure safety, a risk assessment should be carried out as described in Section 9.2.1. Gas tests carried out prior to entry into the space should reflect the contaminants that can reasonably be expected to be present within the space, taking into account the previous cargo carried, ventilation of the space, structure of the tank, coatings in the space and any other relevant factors.

When preparing for entry into a ballast tank or void space where hydrocarbon vapours may not normally be present, it is prudent to test the space for hydrocarbon vapour or H₂S if the space is adjacent to a cargo or bunker tank. This is particularly important if entry is being made to investigate the possibility of bulkhead defects.

10.2.2 Respiratory Hazards

Respiratory hazards from a number of sources could be present in an enclosed space. These could include one or more of the following:

- Hydrocarbon vapours, such as butane and propane.
- Toxic contaminants associated with organic vapours, such as aromatic hydrocarbons, benzene, toluene etc.
- Toxic gases, such as benzene, hydrogen sulphide and mercaptans.
- Oxygen deficiency caused by the presence of inert gas, oxidation (rusting) of bare steel surfaces, or by microbial activity.
- Solid residues from inert gas and particulates, such as those from asbestos, welding operations and paint mists.

10.2.3 Hydrocarbon Vapours

During the carriage and after the discharge of hydrocarbons, the presence of hydrocarbon vapour should always be suspected in enclosed spaces for the following reasons:

- Cargo may have leaked into compartments, including pumprooms, cofferdams, permanent ballast tanks and tanks adjacent to those that have carried cargo.
- Cargo residues may remain on the internal surfaces of tanks, even after cleaning and ventilation.
- Sludge and scale in a tank that has been declared gas free may give off further hydrocarbon vapour if disturbed or subjected to a rise in temperature.
- Residues may remain in cargo or ballast pipelines and pumps.

The presence of gas should also be suspected in empty tanks or compartments if non-volatile cargoes have been loaded into non-gas free tanks or if there is a common ventilation system which could allow the free passage of vapours from one tank to another.

Toxic contaminants could be present in the space as residues from previous cargoes, such as benzene or hydrogen sulphide.

To be considered safe for entry, whether for inspection, Cold Work or Hot Work, a reading of less than 1% LFL must be obtained on suitable monitoring equipment.

10.2.4 Toxic Gases

10.2.4.1 Benzene

See Section 2.3.5 for a description of the hazards associated with benzene. Checks for benzene vapour should be made prior to entering any compartment in which a cargo that may have contained benzene has recently been carried. Entry should not be permitted without appropriate personal protective equipment, if statutory or recommended TLV-TWAs are likely to be exceeded (see Section 2.3.3.2). Tests for benzene vapours can only be undertaken using appropriate detector equipment, such as detector tubes. Detector equipment should be provided on board all ships likely to carry cargoes in which benzene may be present.

10.2.4.2 Hydrogen Sulphide

See Section 2.3.6 for a description of the hazards associated with Hydrogen Sulphide (H_2S). H_2S is present in some crude oils and in some products in varying concentrations. Where the concentration is high, the oil is often referred to as being 'sour'.

H_2S is very soluble in water. General practice and experience indicates that washing a tank with water after carrying a cargo containing H_2S should eliminate the hydrogen sulphide vapour within the space.

However, prior to entry into an enclosed space which has previously carried oil containing H_2S , or where the presence of H_2S vapour may be expected, the space should be ventilated to a reading of less than 1% LFL on a combustible gas indicator and tested for the presence of H_2S using a gas detector tube. Care should be taken not to rely on the use of catalytic H_2S sensors which may have a cross-sensitivity with hydrocarbon vapour.

Since H_2S is heavier than air, it is very important that the bottom of any space is thoroughly tested.

When carrying a cargo containing H_2S , particular attention should be given to the possibility of the presence of H_2S in locations such as pumprooms, deck stores and in ballast tanks. There is a high probability of the presence of H_2S in ballast tanks due to the gas being drawn into the tank when deballasting during the loading operation.

10.2.4.3 Mercaptans

See Section 2.3.7 for a description of the hazards associated with Mercaptans. Mercaptans are present in the vapours of pentane plus cargoes and in some crude oils. They may also be present where oil residues have been in contact with water for extended periods.

The presence of Mercaptans can be detected by the use of chemical detector tubes. Their concentration should be reduced to 0.5 ppm to avoid discomfort to personnel and nuisance smells.

10.2.5 Oxygen Deficiency

Before initial entry is allowed into any enclosed space, the atmosphere should be tested with an oxygen analyser to check that the air contains 21% oxygen. This is of particular importance when considering entry into any space, tank or compartment that has been previously inerted. Lack of oxygen should always be suspected in all enclosed spaces, particularly if they have contained water, have been subjected to damp or humid conditions, have contained inert gas or are adjacent to, or connected with, other inerted tanks.

10.2.6 Products of Inert Gas

By-products of combustion when inert gas is produced from boiler flue gas or from an inert gas generator include carbon monoxide and carbon dioxide.

Carbon monoxide is a toxic gas that may be present in cargo tank atmospheres following gas freeing and in spaces containing components of the inert gas plant.

Carbon dioxide is not toxic, but presents a smothering hazard. Adequate ventilation is required to maintain a normal oxygen level in air of 21% by volume in the space and to eliminate any hazard.

10.3 Atmosphere Tests Prior to Entry

No decision to enter an enclosed space should be taken until the atmosphere within the space has been comprehensively tested from outside the space with test equipment that is of an approved type and that has recently been calibrated and checked for correct operation (see Section 8.2).

The appropriate atmosphere checks are:

- Oxygen content is 21% by volume.
- Hydrocarbon vapour concentration is less than 1% LFL.
- No toxic or other contaminants are present.

Care should be taken to obtain measurements from a representative cross-section of the compartment by sampling at various depths and through as many deck openings as practicable. When tests are being carried out from deck level, ventilation should be stopped and a minimum period of about ten minutes should be allowed to elapse before readings are taken.

Even when tests have shown a tank or compartment to be safe for entry, pockets of gas should always be suspected.

If extensive work is to be carried out within a large space, such as a cargo tank, it is recommended that a full assessment of the tank atmosphere is undertaken after the initial tests have been satisfactorily carried out and recorded. The person undertaking the full assessment should enter the tank carrying an emergency escape breathing device and a personal gas monitor, in addition to the gas testing instrument. The tank atmosphere should be checked frequently during this entry, with particular attention being placed on testing the work location(s) and places that are inaccessible for testing from the deck. On satisfactory completion of this additional atmosphere test, the results should be recorded as required by the appropriate safety procedure in the Safety Management System.

While personnel are in a tank or compartment, ventilation should be continuous.

Regeneration of hydrocarbon gas should always be considered possible, even after loose scale or sludge has been removed. Continual checks on the atmosphere in the space should be made as specified in the Safety Management System.

Atmosphere tests should always be made after any interruption or break in the work. Sufficient samples should be drawn to ensure that the resulting readings are representative of the condition of the entire space.

When entering cargo and bunker tanks, all the tanks and spaces adjacent to the space to be entered should also be tested for hydrocarbon gas and oxygen content and, where appropriate, the inert gas pressure should be lowered to reduce the possibility of any inter-tank leakage. Notwithstanding this precaution, personnel should remain alert to the possibility of leakage of hydrocarbon gas from adjacent spaces or from pipelines running through the tank.

10.4 Control of Entry into Enclosed Spaces

It is the responsibility of the Company to establish procedures for safe entry of personnel into enclosed spaces. The process of requesting, raising, issuing and documenting permits to enter into an enclosed space should be controlled by procedures in the ship's Safety Management System (SMS). It is the Master's responsibility to ensure that the established procedures for entry into an enclosed space are implemented.

The Master and Responsible Officer are responsible for determining whether entry into an enclosed space may be permitted. It is the duty of the Responsible Officer to ensure:

- That the space is ventilated.
- That the atmosphere in the compartment is tested and found satisfactory.
- That safeguards are in place to protect personnel from the hazards that are identified.
- That appropriate means for controlling entry are in place.

Personnel carrying out work in an enclosed space are responsible for following the procedures and for using the safety equipment specified.

Prior to entry into an enclosed space, a risk assessment should be completed to identify the potential hazards and to determine the safeguards to be adopted. The resulting safe working practice should be documented and approved by the Responsible Officer before being countersigned by the Master, who confirms that the practice is safe and in compliance with the ship's Safety Management System. The permit, or other enabling document, should be sighted and completed by the person entering the space, prior to entry.

The controls required for safe entry vary with the task being performed and the potential hazards identified during the risk assessment. However, in most cases, an Entry Permit System will provide a convenient and effective means of ensuring and documenting that essential precautions have been taken and, where necessary, that physical safeguards have been put in place. The adoption of an Entry Permit System, which may include the use of a check-list, is therefore recommended.

Permission to continue work should only be given for a period sufficient to complete the task. Under no circumstances should the period exceed one day.

A copy of the permit should be prominently displayed at the entrance to the space to inform personnel of the precautions to be taken when entering the space and of any restrictions placed upon the activities permitted within the space.

The permit should be rendered invalid if ventilation of the space stops or if any of the conditions noted in the check-list change.

Restricting the issue of approvals, such as entry permits, so that all cargo tanks which are safe to enter are shown on one document, may be found to simplify the paper administration, avoid overlapping and reduce the possibility of confusion as to which approval applies to which tank. However, if such a system is used, there must be rigorous control to ensure cancellation of existing permits, and that the atmospheres of all named tanks are correctly tested at the time of issue so that an effective extension of a period of validity does not occur by default. It will be particularly important to ensure that the permit process is supplemented by the marking of tank lids with notices indicating which tanks are safe to enter.

Inspection of cargo tanks after cleaning and before loading can require an independent surveyor to enter the tank. All relevant tank entry procedures must be observed.

10.5 Safeguards for Enclosed Space Entry

Before allowing access to the space, the Responsible Officer should ensure that:

- Appropriate atmosphere checks have been carried out.
- Piping, inert gas and ventilation systems have been isolated.
- Effective ventilation will be maintained continuously while the enclosed space is occupied.
- Fixed lighting, such as air-turbo lights, are ready for extended entry periods.
- Approved self-contained, positive pressure breathing apparatus and resuscitation equipment is ready for use at the entrance to the space.
- A rescue harness, complete with lifeline, is ready for immediate use at the entrance to the space.
- A fully charged approved safety torch is ready for immediate use at the entrance to the space.
- A responsible member of the crew is in constant attendance outside the enclosed space, in the immediate vicinity of the entrance and in direct contact with the Responsible Officer.
- All persons involved in the operation should be trained in the actions to be taken in the event of an emergency.
- Lines of communications have been clearly established and are understood by all concerned.
- Names and times of entry will be recorded and monitored by personnel outside the space.

The personnel undertaking the task should ensure that such safeguards are put into effect prior to entering the space.

The personal protective equipment to be used by people entering the space must be prescribed. The following items should be considered:

- Protective clothing including work clothing or protective suits, safety boots, safety helmet, gloves and safety glasses.
- For large spaces, or where climbing access will be undertaken, the wearing of safety harnesses may also be appropriate.
- Approved safety torches.
- Approved UHF radio.
- Personal gas detector or an area gas detector and alarm.
- Emergency Escape Breathing Device(s).

10.6 Emergency Procedures

10.6.1 Evacuation from Enclosed Spaces

If any of the conditions that are stated on the permit for entering the space change, or the conditions in the space are suspected of becoming unsafe after personnel have entered the space, personnel should be ordered to leave the space immediately and not be permitted to re-enter until the situation has been re-evaluated and the safe conditions stated on the permit have been restored.

10.6.2 Rescue from Enclosed Spaces

When an accident involving injury to personnel occurs in an enclosed space, the first action must be to raise the alarm. Although speed is often vital in the interests of saving life, rescue operations should not be attempted until the necessary assistance and equipment have been mustered. There are many examples of lives being lost through hasty, ill-prepared rescue attempts.

Prior organisation is of great value in arranging quick and effective response. Lifelines, rescue harness, breathing apparatus, resuscitation equipment and other items of rescue equipment should always be kept ready for use and a trained emergency team should be available. A means of communication should be agreed in advance.

Whenever it is suspected that an unsafe atmosphere has been a contributory factor to the accident, breathing apparatus and, where practicable, lifelines should be used by persons entering the space.

The person in charge of a rescue team should remain outside the space, from where the most effective control can be exercised.

It is imperative that every member of the rescue team should know what is expected of them. Regular drills and exercises in rescue from enclosed spaces should be carried out.

10.6.3 Resuscitation

Tanker and terminal personnel with safety responsibilities should be instructed in resuscitation techniques for the treatment of persons who have been overcome by toxic gases or fumes, or whose breathing has stopped from other causes such as electric shock or drowning.

Most tankers and terminals are provided with special apparatus for use in resuscitation. This apparatus can be of a number of different types. It is important that personnel are aware of its location and are trained in its proper use.

The apparatus should be stowed where it is easily accessible and not kept locked up. The instructions provided with it should be clearly displayed. The apparatus and the contents of cylinders should be checked periodically. Adequate spare bottles should be carried.

10.7 Entry into Enclosed Spaces with Atmospheres Known or Suspected to be Unsafe for Entry

It is stressed that entry into any space that has not been proved safe for entry should only be considered in an emergency situation when no practical alternative exists. In this highly hazardous situation, it is essential that permission is obtained from the Company and a safe system of work agreed.

Breathing apparatus, of the positive pressure type, should always be used whenever it is necessary to make an emergency entry into a space that is known to contain toxic vapours or gas, or to be deficient in oxygen, and/or is known to contain contaminants that cannot be effectively dealt with by air purifying equipment.

Entry into an enclosed space with an atmosphere known or suspected to be unsafe for entry should only be permitted in exceptional circumstances when no other practicable, safe alternative exists.

A written statement should be issued by the Master declaring that there is no practicable alternative to the proposed method of entry and that such entry is essential for the safe operation of the ship.

Where it is agreed that such an operation is necessary, a risk assessment should be carried out and a safe system of work developed in agreement with the Company.

A Responsible Officer must continuously supervise the operation and should ensure that:

- The personnel involved are well trained in the use of breathing apparatus and are aware of the dangers of removing their face masks while in the unsafe atmosphere.
- Personnel use positive pressure breathing apparatus.
- The number of persons entering the tank is kept to a minimum consistent with the work to be performed.
- Names and times of entry are recorded and monitored by personnel outside the space.
- Ventilation is provided where possible.

- Means of continuous communication are provided and a system of signals is agreed and understood by the personnel involved.
- Spare sets of breathing apparatus, a resuscitator and rescue equipment are available outside the space and a standby party, with breathing apparatus donned, is in attendance in case of an emergency.
- All essential work that is to be undertaken is carried out in a manner that will avoid creating an ignition hazard.
- If personnel are not connected to a lifeline, appropriate means should be in place to identify where the persons are whilst inside the space.

10.8 Respiratory Protective Equipment

A number of different types of respiratory protective equipment are available for use on board ship.

Some respiratory protective equipment is required to be carried to meet the fire safety provisions of SOLAS. However, under the provisions of the ISM Code, the Company is responsible for providing the level of equipment needed to safely manage all aspects of shipboard operational and safety activities. Respiratory protective equipment necessary to meet these provisions will, in most cases, exceed the minimum requirements under SOLAS.

10.8.1 Self-Contained Breathing Apparatus (SCBA)

This consists of a portable supply of compressed air contained in a cylinder or cylinders attached to a carrying frame and harness worn by the user. Air is provided to the user through a face mask, which can be adjusted to give an airtight fit. A pressure gauge indicates the pressure in the cylinder and an audible alarm sounds when the supply is running low. Only positive pressure type sets are recommended for use in enclosed spaces because, as their name implies, these maintain a positive pressure within the face mask at all times.

When using the equipment, the following should be noted:

- The pressure gauge must be checked before use.
- The operation of the audible low pressure alarm should be tested before use.
- The face mask must be checked and adjusted to ensure that it is airtight. In this regard, the presence of any facial hair may adversely affect the mask's seal and, should this be the case, another person should be selected to wear the apparatus. Alternatively, other specialist equipment may be provided that allows for facial hair.
- The pressure gauge should be monitored frequently during use to check on remaining air supply.
- Ample time should be allowed for getting out of the hazardous atmosphere. In any event, the user must exit immediately if the low pressure alarm sounds. It should be remembered that the duration of the air supply depends on the weight and fitness of the user and the extent of their exertion.

If the users suspect at any time that the equipment may not be operating satisfactorily or are concerned that the integrity of the face mask seal may be damaged, they should exit the space immediately.

10.8.2 Air Line Breathing Apparatus

Air line breathing apparatus enables compressed air equipment to be used for longer periods than would be possible using self-contained equipment.

This equipment consists of a face mask which is supplied with air through a small diameter hose leading outside the space where it is connected to either compressed air cylinders or an air line served by a compressor. If the ship's air supply is used, it is essential that it is properly filtered and adequately monitored for toxic or hazardous constituents. The hose is attached to the user by means of a belt or other arrangement, which enables rapid disconnection in an emergency. Air to the face mask is regulated by a flow control valve or orifice.

If the air supply is from a compressor, the arrangement will include an emergency supply of air cylinders for use in the event of the compressor failing. In such an emergency, the user should be signalled to vacate the space immediately.

A trained and competent person must be in control of the air line pressure and be alert to the need to change over to the alternative supply should normal working pressure not be maintained.

When using the air line breathing apparatus:

- Check and ensure that the face mask is adjusted to be airtight. The presence of facial hair may make this task harder to achieve.
- Check the working pressure before each use.
- Check the audible low pressure alarm before each use.
- To avoid damage, keep the air lines clear of sharp projections.
- Ensure that the air hose does not exceed 90 metres in length.
- Allow ample time to vacate the space when the low pressure alarm sounds. The duration of the emergency air carried by the user will depend on an individual's weight, fitness and level of exertion, and each user should be aware of their particular limitations.

Should there be any doubt about the efficiency of the equipment, the user should vacate the space immediately.

The user should carry a completely separate supply of clean air for use in emergency evacuation from the space in the event of the air line failing. It is recommended that the user should carry an Emergency Escape Breathing Device (EEBD) (see 10.8.3 below).

10.8.3 Emergency Escape Breathing Device (EEBD)

This is a compressed air or oxygen breathing device used for escape from a compartment where the atmosphere has become hazardous while a person is within it. It is primarily for use in accordance with the SOLAS requirements for escape from machinery or accommodation spaces in the event of a fire. Additional sets should be provided for use as emergency escape equipment during enclosed space entry. Each set has a duration of not less than 10 minutes. The device can be one of two types:

Compressed Air Type

These sets consist of an air bottle, reducing valve, air hose, face mask or

hood and a flame retardant high visibility bag or jacket. They are normally constant flow devices providing compressed air to the wearer at a rate of approximately 40 litres per minute, giving a duration of 10 (as a minimum) or 15 minutes, depending on the capacity of the bottle. Compressed air EEBDs can normally be recharged on board with a conventional SCBA compressor.

The pressure gauge, supply valve and hood should be checked before use.

Re-Breathing Type

These sets normally consist of a robust watertight carrying case, compressed oxygen cylinder, breathing bag, mouthpiece and a flame retardant hood. They are designed for single use by the wearer. When the hood is placed over the user's head and the set activated, exhaled air is mixed with compressed oxygen inside the breathing bag to allow the wearer to breath normally when escaping from a hazardous atmosphere.

It is stressed that EEBDs are for emergency escape, and should not be used as the primary means for entering oxygen deficient compartments, or while fighting fires.

10.8.4 Cartridge or Canister Face Masks

These units consist of a cartridge or canister attached to a face mask. They are designed to purify the air of specific contaminants. They do not supply any further air. It is important that they are only used for their designed purpose and within the limits prescribed by manufacturers. Such limits include an expiry date for the cartridge or canister.

Cartridge or canister face masks will not protect the user against concentrations of hydrocarbon or toxic vapours in excess of their design parameters, or against oxygen deficiency, and they should never be used in place of breathing apparatus.

10.8.5 Hose Mask (Fresh Air Breathing Apparatus)

This equipment consists of a mask supplied with air from a large diameter hose connected to a rotary pump or bellows. It is cumbersome and provides no seal against the entry of gases.

Although hose masks may be found on some ships, it is recommended that they are not used for enclosed space entry.

10.8.6 Equipment Maintenance

All respiratory protective equipment should be examined and tested by a Responsible Officer at regular intervals. Defects should be made good promptly and a record should be kept of inspections and repairs. Air bottles must be recharged as soon as possible after use.

Air bottles must not be in a damaged or corroded condition and should be tested hydraulically, in accordance with legislative requirements.

Masks and helmets should be cleaned and disinfected after use. Any repair or maintenance must be carried out strictly in accordance with the manufacturer's instructions.

10.8.7 Stowage

Breathing apparatus should be stowed fully assembled in a place where it is readily accessible. Air bottles should be fully charged and the adjusting straps kept slack. Units should be sited so as to be available for emergencies in different parts of the ship.

10.8.8 Training

Practical demonstrations and training in the use of breathing apparatus should be carried out to give personnel experience in its use. Only trained personnel should use self-contained and air line breathing apparatus, since incorrect or inefficient use can endanger the user's life.

10.9 Work in Enclosed Spaces

10.9.1 General Requirements

All work carried out in enclosed spaces should be conducted under the control of the Safety Management System. All conditions for entry, including the use of an entry permit, should be observed

Additional precautions may be necessary to ensure there is no loose scale, sludge or combustible material in the vicinity of the work site which, if disturbed or heated, could give off toxic or flammable gases. Effective ventilation should be maintained and, where practicable, directed towards the work area.

10.9.2 Opening Equipment and Fittings

Whenever cargo pumps, pipelines, valves or heating coils are to be opened, they should first be thoroughly flushed with water. However, even after flushing, there will always be a possibility of some cargo remaining, which could be a source of further flammable or toxic gas. Whenever such equipment is to be opened, the safe management procedure should identify the minimum safe working practices to be adopted, including any requirement for additional gas tests.

10.9.3 Use of Tools

Tools should not be carried into enclosed spaces, but should be lowered in a plastic bucket or canvas bag to avoid the possibility of their being dropped. Before any hammering or chipping is undertaken, or any power tool is used, the Responsible Officer should be satisfied that there is no likelihood of hydrocarbon vapour being present in the vicinity.

10.9.4 Use of Electric Lights and Electrical Equipment

Unless a compartment is designated safe for Hot Work by an approved safe system of work, such as a Hot Work permit, non-approved lights or

non-intrinsically safe electrical equipment must not be taken into an enclosed space.

Only approved safety lighting or intrinsically safe electrical equipment should be used in enclosed spaces that are liable to experience hydrocarbon vapour re-contamination.

In port, any local regulations concerning the use of electric lights or electrical equipment should be observed.

10.9.5 Removal of Sludge, Scale and Sediment

When removing sludge, scale or sediment from an enclosed space, periodic gas tests should be undertaken and continuous ventilation should be maintained throughout the period the space is occupied.

There may be increases in gas concentrations in the immediate vicinity of the work and care should be taken to ensure that the atmosphere remains safe for personnel. It is strongly recommended that personal gas monitors are provided to some or all of the persons engaged in the work.

10.9.6 Work Boats

Any work involving the use of work boats in cargo tanks presents additional hazards, which must be managed by the Company's Safety Management System.

Work boats used for tank repair work and tank inspections should be fit for the task for which they are to be employed. Before and during their use within an enclosed space, all conditions for entry, including the use of an entry permit should be observed (see Section 10.5). The following precautions should also be taken:

- All deck apertures, such as tank washing plates, should be opened and effective ventilation maintained continuously while persons are in the tank.
- The work boat should only be used when the water surface is calm.
- The work boat should only be used in tanks containing clean ballast water.
- The water level in the tank should be either stationary or falling. On no account must the level of the water be rising while the boat is in use.
- All personnel working in the compartment should wear a buoyancy aid.
- A Responsible Person should act as lookout at the top of the tank and if the boat is working at a point remote from the tank hatch, an additional lookout should be positioned a little way down the access ladder at a point where a clear view of the boat is provided.

10.10 Pumproom Entry Precautions

Cargo pumprooms are to be considered as enclosed spaces and the requirements of this Chapter should be followed to the maximum extent possible. However, because of their location, design and the operational need for the space to be routinely entered by personnel, pumprooms present a particular hazard and therefore necessitate special precautions, which are described in the following Sections.

10.10.1 Ventilation

Because of the potential for the presence of hydrocarbon gas in the pumproom, SOLAS requires the use of mechanical ventilation by extraction to maintain the atmosphere in a safe condition.

SOLAS requires that ships built from July 2002 be provided with continuous monitoring of the pumproom atmosphere and an audible and visual alarm system which will activate when the hydrocarbon gas concentration in the pumproom exceeds a pre-set level, which should not be more than 10% LFL.

Throughout cargo handling operations, the pumproom ventilation system must be in continuous operation and the gas detection system, if fitted, should be functioning correctly.

Ventilation should be continuous until access is no longer required, or cargo operations have been completed.

10.10.2 Pumproom Entry Procedures

Before anyone enters a pumproom, it should be thoroughly ventilated, the oxygen content of the atmosphere verified and the atmosphere checked for the presence of hydrocarbons and any toxic gas associated with the cargo being handled.

Only where a fixed gas detection system is correctly calibrated and tested and provides gas readings as a percentage LFL (% LFL) to a level of accuracy equivalent to portable gas instruments, at representative locations within the pumproom, should it be used to provide information for safe entry into the space.

Formal procedures should be in place to control pumproom entry. The procedure used should be based on a risk assessment, and should ensure that risk mitigation measures are followed and that entries into the space are recorded.

A communications system should provide links between the pumproom, navigation bridge, engine room and cargo control room. In addition, audible and visual repeaters for essential alarm systems, such as the general alarm and the fixed extinguishing system alarm, should be provided within the pumproom.

Arrangements should be established to enable effective communication to be maintained at all times between personnel within the pumproom and those outside. Regular communication checks should be made at

pre-agreed intervals and failure to respond should be cause to raise the alarm.

VHF/UHF communication should not be used as a primary communication method where it is known that reception may not be reliable or practicable due to noise. Where communication by VHF/UHF is difficult, it is recommended that a standby person is positioned on the pumproom top and that a visual and remote communication procedure is put in place.

The frequency of pumproom entry for routine inspection purposes during cargo operations should be reviewed with a view to minimising personnel exposure.

Notices should be displayed at the pumproom entrance prohibiting entry without formal permission.

10.11 Pumproom Operational Precautions

A pumproom contains the largest concentration of cargo pipelines of any space within the ship and leakage of a volatile product from any part of this system could lead to the rapid generation of a flammable or toxic atmosphere. The pumproom may also contain a number of potential ignition sources unless formal, structured maintenance, inspection and monitoring procedures are strictly followed.

10.11.1 General Precautions

Before starting any cargo operation:

- An inspection should be made to ensure that strainer covers, inspection plates and drain plugs are in position and secure.
- Drain valves in the pumproom cargo system, especially those on cargo oil pumps, should be firmly closed.
- Any bulkhead glands should be checked and adjusted or lubricated, as necessary, to ensure an efficient gas-tight seal between the pumproom and the machinery space.

During all cargo operations, including loading:

- The pumproom should be inspected at regular intervals to check for leakages from glands, drain plugs and drain valves, especially those fitted to the cargo pumps.
- If the pumps are in use, pump glands, bearings and the bulkhead glands (if fitted) should be checked for overheating. In the event of leakage or overheating, the pump should be stopped.
- No attempt should be made to adjust the pump glands on rotating shafts while the pump is in service.

10.11.2 Cargo and Ballast Line Draining Procedures

On some tankers, no provision is made for effective line draining and, in order to meet the demands of certain product trades, final line contents are drained to the pumproom bilge. This is an unsafe practice and it is recommended that cargo procedures be reviewed with the aim of preventing a volatile product being drained to the bilge.

It is strongly recommended that consideration is given to the provision of a comprehensive stripping arrangement to enable all lines and pumps to be drained effectively to a cargo tank, slop tank or dedicated reception tank, for subsequent discharge ashore.

Where lines that have been used for ballast have to be drained to the pumproom bilge on completion of deballasting, care must be taken to ensure that such drainings do not contain petroleum.

10.11.3 Routine Maintenance and Housekeeping Issues

It is important that the integrity of pipelines and pumps is maintained and that any leaks are detected and rectified in a timely fashion.

Pumproom bilges should be kept clean and dry. Particular care should be taken to prevent the escape of hydrocarbon liquids or vapour into the pumproom.

Pipelines should be visually examined and subjected to routine pressure tests to verify their condition. Other means of non-destructive testing or examination, such as ultrasonic wall thickness measurement, may be considered appropriate, but should always be supplemented by visual examination.

Procedures should be established to verify that mud boxes and filters are properly sealed after they have been opened up for routine cleaning or examination.

Valve glands and drain cocks should be regularly inspected to ensure that they do not leak.

Bulkhead penetrations should be routinely checked to ensure the effectiveness of seals.

Critical bolts on the cargo pumps and associated fittings, such as pedestal fixing bolts, pump casing bolts and bolts securing shaft guards, should be secure. In addition, requirements for their examination should be included in routine maintenance procedures.

The pumproom rescue harness and rope should be checked regularly to ensure it is fit for use and rigged for immediate operation.

Emergency escape routes should be checked regularly to ensure that they are properly marked and clear of obstructions. Where an escape trunk is fitted, doors should be checked for ease of operation, door seals should be effective and lighting within the trunk should be operational.

10.11.4 Maintenance of Electrical Equipment in the Pumproom

The integrity of the protection afforded by the design of explosion-proof or intrinsically safe electrical equipment may be compromised by incorrect maintenance procedures. Even the simplest of repair and maintenance operations must be carried out in strict compliance with the manufacturer's instructions in order to ensure that such equipment remains in a safe condition.

Maintenance of explosion-proof and intrinsically safe equipment should only be carried out by personnel qualified to undertake such work. This is particularly relevant in the case of explosion-proof lights, where incorrect closure after changing a lamp could compromise the integrity of the light.

In order to assist with such routine servicing and repair, ships should be provided with detailed maintenance instructions for the specific systems and arrangements as fitted on board.

10.11.5 Inspection and Maintenance of Pumproom Ventilation Fans

Pumproom ventilation fans are required to operate by drawing air out of the space. As a consequence, should gas be present in the pumproom, the vapours will be drawn through the blades of the fan impeller and could be ignited if the blades contact the casing or if the fan bearings or seals overheat.

Pumproom extractor fans, including impellers, shafts and gas seals, should be inspected on a regular basis.

The condition of the fan trunking should be inspected and the proper operation of changeover flaps and fire dampers confirmed.

Routine vibration monitoring and analysis should be considered as a means for providing early detection of component wear.

10.11.6 Testing of Alarms and Trips

Pump alarms and trips, level alarms etc, where fitted, should be tested regularly to ensure that they are functioning correctly, and the results of these tests should be recorded.

These tests should be as thorough as possible to verify the full and complete operability of the system and should not be limited to an electrical function test of the alarm itself.

10.11.7 Miscellaneous

There are a number of other ways to enhance the safety of pumprooms, some of which are mandatory for certain ships:

- A fixed gas detection system capable of continuously monitoring for the presence of hydrocarbon gas. Where such equipment is fitted, procedures should be developed to ensure it is regularly inspected and calibrated. Procedures should also be developed with regard to the action to be taken in the event of an alarm occurring, especially for vacating the space and stopping the cargo pumps. Whenever

practicable, gas detection should monitor a number of levels within the pumproom, not just the lower area.

- A fixed sampling arrangement to enable the oxygen content within the pumproom to be monitored from the deck by a portable meter prior to pumproom entry. Where such an arrangement is fitted, it should ensure that remote parts of the pumproom can be monitored.
- Temperature monitoring devices fitted to the main cargo pumps in order to provide remote indication of the temperature of pump casings, bearings and bulkhead seals. Where such equipment is fitted, procedures should be developed with regard to the action to be taken in the event of an alarm occurring.
- A high level alarm in pumproom bilges which activates audible and visual alarms in the cargo control room, engine room and the navigating bridge.
- Manually activated trips for the main cargo pumps provided at the lower pumproom level and at the top (main deck) level.
- Spray arrestors around the glands of all rotary cargo pumps in order to reduce the formation of mists in the event of minor leakage from the gland.
- Examining the feasibility of fitting a double seal arrangement to contain any leakage from the primary seal and to activate a remote alarm to indicate that leakage has occurred. However, the impact of any retrofit on the integrity of the pump will need to be clearly assessed in conjunction with the pump manufacturer.
- Particular attention to be given to the adequacy of fire protection in the immediate vicinity of the cargo pumps.
- Because of the problems associated with flashback re-ignition after the use of the primary fire-fighting medium, consideration should be given to the need to provide a backup system, such as high expansion foam or water drenching, to supplement the existing system.
- On ships fitted with an inert gas system, the provision of an emergency facility for inerting the pumproom could be an option, although careful attention must be paid to the safety and integrity of the arrangement.
- The provision of Emergency Escape Breathing Devices (EEBDs) located within the pumproom and readily accessible.

Chapter 11

SHIPBOARD OPERATIONS

This Chapter provides information on the full range of shipboard operations, including loading and discharging of cargo, hose clearing, tank cleaning and gas freeing, ballasting, ship-to-ship transfers and mooring.

The Chapter also includes information on the safe handling of particular cargoes, such as static accumulator oils, those having a high vapour pressure and those containing hydrogen sulphide.

Other operations that are addressed include the use of vapour emission control systems and crude oil washing.

11.1 Cargo Operations

11.1.1 General

All cargo operations should be carefully planned and documented well in advance of their execution. The details of the plans should be discussed with all personnel, both on the ship and at the terminal. Plans may need to be modified following consultation with the terminal and following changing circumstances, either on board or ashore. Any changes should be formally recorded and brought to the attention of all personnel involved with the operation. Chapter 22 contains details of cargo plans and communications regarding them.

11.1.2 Setting of Lines and Valves

Before commencement of any loading or discharging operation, the ship's cargo pipelines and valves should be set as per the required loading or discharging plan by a Responsible Officer and checked, independently, by other personnel.

11.1.3 Valve Operation

To avoid pressure surges, valves at the downstream end of a pipeline system should not be closed against the flow of liquid, except in an emergency. This should be stressed to all personnel responsible for cargo handling operations, both on the ship and at the terminal. (See Section 11.1.4 below.)

In general, where pumps are used for cargo transfer, all valves in the transfer system (both ship and shore) should be open before pumping begins, although the discharge valve of a centrifugal pump may be kept closed until the pump is up to speed and the valve then opened slowly. In the case of ships loading by gravity, the final valve to be opened should be that at the shore tank end of the system.

If the flow is to be diverted from one tank to another, either the valve on the second tank should be opened before the valve on the first tank is closed, or pumping should be stopped while the change is being made. Valves that control liquid flow should be closed slowly. The time taken for power operated valves to move from open to closed, and from closed to open, should be checked regularly at their normal operating temperatures.

11.1.4 Pressure Surges

The incorrect operation of pumps and valves can produce pressure surges in a pipeline system.

These surges may be sufficiently severe to damage the pipeline, hoses or metal arms. One of the most vulnerable parts of the system is the ship-to-shore connection. Pressure surges are produced upstream of a closing valve and may become excessive if the valve is closed too quickly. They are more likely to be severe where long pipelines and high flow rates are involved.

Where the risk of pressure surges exists, information should be exchanged and written agreement reached between the ship and the terminal concerning the control of flow rates, the rate of valve closure, and pump speeds. This should include the closure period of remotely controlled and automatic shutdown valves. The agreement should be included in the operational plan. (Generation of pressure surges in pipelines is discussed in more detail in Section 16.8.)

11.1.5 Butterfly and Non-Return (Check) Valves

Butterfly and pinned back non-return valves in ship and shore cargo systems have been known to slam shut when cargo is flowing through them at high rates, thereby setting up very large surge pressures which can cause line, hose or metal arm failures and even structural damage to jetties. These failures are usually due to the valve disc not being completely parallel to, or fully withdrawn from, the flow when in the open position. This can create a closing force that may shear either the valve spindle, in the case of butterfly valves, or the hold open pin, in the case of pinned back non-return valves. It is therefore important to check that all such valves are fully open when they are passing cargo or ballast.

11.1.6 Loading Procedures

11.1.6.1 General

The responsibility for safe cargo handling operations is shared between the ship and the terminal and rests jointly with the Master and the Terminal Representative. The manner in which the responsibility is shared should therefore be agreed between them so as to ensure that all aspects of the operations are covered.

11.1.6.2 Joint Agreement on Readiness to Load

Before starting to load cargo, the Responsible Officer and the Terminal Representative should formally agree that both the tanker and the terminal are ready to do so safely.

11.1.6.3 Emergency Shutdown Plan

An emergency shutdown procedure, and alarm, should be agreed between the ship and the terminal and recorded on an appropriate form.

The agreement should designate those circumstances in which operations must be stopped immediately.

Due regard should be given to the possible dangers of a pressure surge associated with any emergency shutdown procedure, (see Section 16.8).

11.1.6.4 Supervision

The following safeguards should be maintained throughout loading:

- A Responsible Officer should be on watch and sufficient crew should be on board to deal with the operation and security of the tanker. A continuous watch of the tank deck should be maintained.
- The agreed ship-to-shore communications system should be maintained in good working order.
- At the commencement of loading, and at each change of watch or shift, the Responsible Officer and the Terminal Representative should each confirm that the communications system for the control of loading is understood by them and by personnel on watch and on duty.
- The standby requirements for the normal stopping of shore pumps on completion of loading, and the emergency stop system for both the tanker and terminal, should be fully understood by all personnel concerned.

11.1.6.5 Inert Gas Procedures

Prior to the commencement of loading, the inert gas plant should be closed down and the inert gas pressure in the tanks to be loaded reduced unless simultaneous loading and discharge of cargo is to take place.

11.1.6.6 Closed Loading

For effective closed loading, cargo should be loaded with the ullage, sounding and sighting ports securely closed. The gas displaced by the incoming cargo should be vented to the atmosphere via the mast riser(s) or through high velocity or constant velocity valves, either of which will ensure that the gases are taken clear of the cargo deck. Devices fitted to mast risers or vent stacks to prevent the passage of flame should be regularly checked to confirm they are clean, in good condition and correctly installed.

In order to undertake closed loading, the vessel should be equipped with ullaging equipment that allows the tank contents to be monitored without opening tank apertures. (Closed gauging and sampling is discussed in detail in Section 11.8.1.)

There is a risk of overfilling a cargo tank when loading under normal closed conditions. Due to the reliance placed on closed gauging systems, it is important that they are fully operational and that backup is provided in the form of an independent overfill alarm arrangement. The alarm should provide audible and visual indication and should be set at a level that will enable operations to be shut down prior to the tank being overfilled. Under normal operations, the cargo tank should not be filled higher than the level at which the overfill alarm is set.

Individual overfill alarms should be tested at the tank to ensure their proper operation prior to commencing loading, unless the system is provided with an electronic self-testing capability which monitors the condition of the alarm circuitry and sensor and confirms the instrument set point.

On vessels without inert gas systems, this equipment should comply with the precautions highlighted in Section 11.8.2.

Vessels operating with inert gas are considered always to be capable of closed loading.

11.1.6.7 Commencement of Loading Alongside a Terminal

When all necessary terminal and tanker valves in the loading system are open, and the ship has signified its readiness, loading can commence. The initial flow should be at a slow rate. Whenever possible, this should be by gravity and to a single tank, with the shore pumps not being started until the system has been checked and the ship advises that cargo is being received in the correct tank(s). When the pumps have been started, the ship/shore connections should be checked for tightness until the agreed flow rate or pressure has been reached.

11.1.6.8 Commencement of Loading at Offshore Buoy Berths

Before commencing to load at a buoy berth offshore, the ship should confirm its full understanding of the communications system that will be used to control the operation. A secondary communications system should be provided and be ready to be brought into immediate action in the event of failure of the primary system.

After an initial slow loading rate to test the system, the flow rate may be brought up to the agreed maximum. A close watch should be kept on the sea in the vicinity of the seabed manifold so that leaks may be detected. During darkness, where safe and practical, a bright light should be shone on the water in the vicinity of the hoses.

11.1.6.9 Commencement of Loading Through a Stern Line

Before commencing loading through a stern line, the dangerous area extending not less than 3 metres from the manifold valve should be clearly marked and no unauthorised personnel should be allowed within this area during the entire loading operation.

A close watch should be maintained for any leakage and all openings, air inlets and doors to enclosed spaces should be kept tightly closed.

Fire-fighting equipment should be laid out ready for use in the vicinity of the stern manifold.

11.1.6.10 Commencement of Loading Through a Bow Line

Vessels involved in bow loading will necessarily be designed for use at particular terminals (normally single point moorings) for which detailed operating and safety procedures will be specified.

In general, however, the following checks should be carried out prior to loading:

- The mooring system should be inspected for security of connection and to ensure that any wear is within acceptable operational limits.
- The cargo hose connection should be carefully inspected for correct alignment and security of coupling. Where possible, a water pressure test of the coupling seals should be made.
- Any emergency release systems provided for the mooring and cargo connection should be operational. Tests of these systems should take place prior to mooring.
- Mooring load monitoring systems should be activated and tested.
- All primary and secondary means of communication with the loading terminal should be tested, including any telemetry control system.

A continuous watch by a responsible crew member should be maintained on the bow throughout loading. During darkness, the illumination on and around the vessel's bow should permit an effective visual watch to be maintained on the mooring point, mooring system, cargo hose connection, loading hoses and the area of water around the bow.

11.1.6.11 Loading Through Pumproom Lines

Due to the increased risk of leakage in the pumproom, it is not good practice to load cargo via pumproom lines. Whenever possible, cargo should be loaded through drop lines within the cargo tank area, with all pumproom valves closed.

11.1.6.12 Cargo Sampling on Commencement of Loading

Where facilities exist, a sample of the cargo should be taken as soon after the commencement of loading as possible. This will allow the product's visual quality to be checked to ensure the correct grade is being loaded. This should be done before opening up subsequent tanks for loading. (See Section 11.8.)

On non-inerted tankers loading static accumulator cargoes, precautions against static electricity hazards should be observed when taking the sample. (See Section 11.1.7.)

11.1.6.13 Periodic Checks During Loading

Throughout loading, the ship should monitor and regularly check all full and empty tanks to confirm that cargo is only entering the designated cargo tanks and that there is no escape of cargo into pumprooms or cofferdams, or through sea and over board discharge valves.

The ship should check tank ullages at least hourly and calculate a loading rate. Cargo figures and rates should be compared with shore figures to identify any discrepancy.

On ships where stress considerations may be critical, hourly checks should include, where possible, the observation and recording of the shear forces, bending moments, draught and trim and any other relevant stability requirements particular to the ship. This information should be checked against the required loading plan to confirm that all safe limits are adhered to and that the loading sequence can be followed, or amended, as necessary. Any discrepancies should be reported immediately to the Responsible Officer.

Any unexplained drop in pressures, or any marked discrepancy between tanker and terminal estimates of quantities transferred, could indicate pipeline or hose leaks, particularly in submarine pipelines, and require that cargo operations be stopped until investigations have been made.

The ship should carry out frequent inspections of the cargo deck and pumproom to check for any leaks. Overside areas should likewise be checked regularly. During darkness, where safe and practical, the water around the vessel should be illuminated.

11.1.6.14 Fluctuation of Loading Rate

The loading rate should not be substantially changed without informing the ship.

11.1.6.15 Cessation of Pumping by the Terminal

Many terminals require a standby period for stopping pumps and this should be understood and noted as discussed under item 24 of the guidelines for completing the Ship/Shore Safety Check-List before loading commences (see Section 26.4).

11.1.6.16 Topping-Off on board the Tanker

The ship should advise the terminal when tanks are to be topped-off and request the terminal, in adequate time, to reduce the loading rate sufficiently to permit effective control of the flow on board the ship. After topping-off individual tanks, master valves should be closed, where possible, to provide two-valve segregation of loaded tanks. The ullages of topped-off tanks should be checked from time to time to ensure that overflows do not occur as a result of leaking valves or incorrect operations.

The number of valves to be closed during the topping-off period should be reduced to a minimum.

The tanker should not close all its valves against the flow of oil.

Before topping-off operations commence at an offshore berth, the ship/shore communications system should be tested.

Where possible, the completion of loading should be done by gravity. If pumps have to be used to the end, their delivery rate during the 'standby' time should be regulated so that shore control valves can be closed as soon as requested by the ship. Shore control valves should be closed before the ship's valves.

11.1.6.17 Checks After Loading

After the completion of loading, a Responsible Officer should check that all valves in the cargo system are closed, that all appropriate tank openings are closed and that pressure/vacuum relief valves are correctly set.

11.1.7 Loading Static Accumulator Oils

11.1.7.1 General

Petroleum distillates often have electrical conductivities of less than 50 picoSiemens/metre (pS/m) and thus fall into the category of static accumulators.

Since the conductivities of distillates are not normally known, they should all be treated as static accumulators unless they contain an antistatic additive, which raises the conductivity of the product above 50 pS/m. (See Section 11.1.7.9 regarding cautions on the effectiveness of antistatic additives.) A static accumulator may carry sufficient charge to constitute an incendive ignition hazard during loading into the tank, and for up to 30 minutes after completion of loading.

Bonding (see Section 3.2.2) is an essential precaution for preventing electrostatic charge accumulation and its importance cannot be over-emphasised. However, while bonding assists relaxation, it does not prevent accumulation and the production of hazardous voltages. Bonding therefore should not be seen as a universal remedy for eliminating electrostatic hazards. This Section describes methods for controlling electrostatic generation, by preventing charge separation, which is another essential precaution (see Section 3.1.2).

11.1.7.2 Controlling Electrostatic Generation

Electrostatic discharge has long been known as a hazard associated with the handling of petroleum products.

FAILURE TO FOLLOW THE GUIDANCE GIVEN IN THIS SECTION WILL LEAD TO THE HAZARDOUS CONDITIONS REQUIRED FOR ELECTROSTATIC IGNITION ACCIDENTS TO OCCUR.

When a tank is *known to be* in an inert condition, no antistatic precautions are necessary.

If a flammable atmosphere is possible within the tank, then specific precautions will be required with regard to maximum flow rates and safe ullaging, sampling and gauging procedures when handling static accumulator products.

Mixtures of oil and water constitute a potent source of static electricity. Extra care should therefore be taken to prevent excess water and unnecessary mixing.

11.1.7.3 During Initial Filling of a Tank

The generally accepted method for controlling electrostatic generation in the initial stages of loading is to restrict the velocity of oil entering the tank to 1 metre/second until the tank inlet is well covered and all splashing and surface turbulence in the tank has ceased.

The 1 metre/second limit applies in the branch line to each individual cargo tank and should be determined at the smallest cross-sectional area including valves or other piping restrictions in the last section before the tank's loading inlet.

Minimum Diameter of Piping* (mm)	Approx. Flow Rate (m ³ /hour)
80	17
100	29
150	67
200	116
250	183
305	262
360	320
410	424
460	542
510	676
610	987
710	1,354
810	1,782

Table 11.1 – Rates corresponding to 1 metre/second

* Note that the diameters given are nominal diameters, which are not necessarily the same as the actual internal diameters.

Table 11.1 shows approximate volumetric flow rates that correspond to a linear velocity of 1 metre/second in piping of various diameters.

The reasons for such a low linear velocity as 1 metre/second are threefold:

1. At the beginning of filling a tank, there is the greatest likelihood of water being mixed with the oil entering the tank. Mixtures of oil and water constitute a most potent source of static electricity.
2. A low product velocity at the tank inlet minimises turbulence and splashing as oil enters the tank. This helps reduce the generation of static electricity and also reduces the dispersal of any water present, so that it quickly settles out to the bottom of the tank where it can lie relatively undisturbed when the loading rate is subsequently increased.
3. A low product velocity at the tank inlet minimises the formation of mists that may accumulate a charge, even if the oil is not considered to be a static accumulator. This is because the mist droplets are separated by air, which is an insulator. A mist can result in a flammable atmosphere even if the liquid has a high flashpoint and is not normally capable of producing a flammable atmosphere.

Figure 11.1 provides a flow chart to assist in deciding the precautions that need to be taken when loading static accumulator cargoes.

11.1.7.4 Minimising Hazards From Water

Because mixtures of oil and water constitute a potent source of static electricity, care should be taken to prevent excess water from operations such as water washing, ballasting or line flushing entering a tank that contains or will contain a static accumulator oil. For example, cargo tanks and lines that have been flushed with water should be drained before loading and water should not be permitted to accumulate in tanks. Lines should not be displaced with water back into a tank containing a static accumulator cargo. (For an explanation of line displacement, see Section 11.1.15.2.)

Any water remaining within the shore or ship pipeline system after the initial filling period might be flushed into the cargo tank when loading at the maximum rate. (The minimum product velocity for flushing water out of pipelines effectively is 1 metre per second.) The resulting mixing and agitating of the oil and water in the tank will increase the generation of static charge to a level that is unsafe in a flammable atmosphere. Before increasing to the bulk loading rate, it is therefore necessary to ensure that, so far as practicable, all excess water that may have been lying in low spots in the pipelines has been flushed out of the system either before loading commenced or during the initial filling of the tank (see Section 11.1.7.3 for advice on the process).

Under normal circumstances, and provided that the aforementioned precautions to prevent excess water have been taken, the amount of water still present in the system after the initial filling period will be insufficient to increase static separation

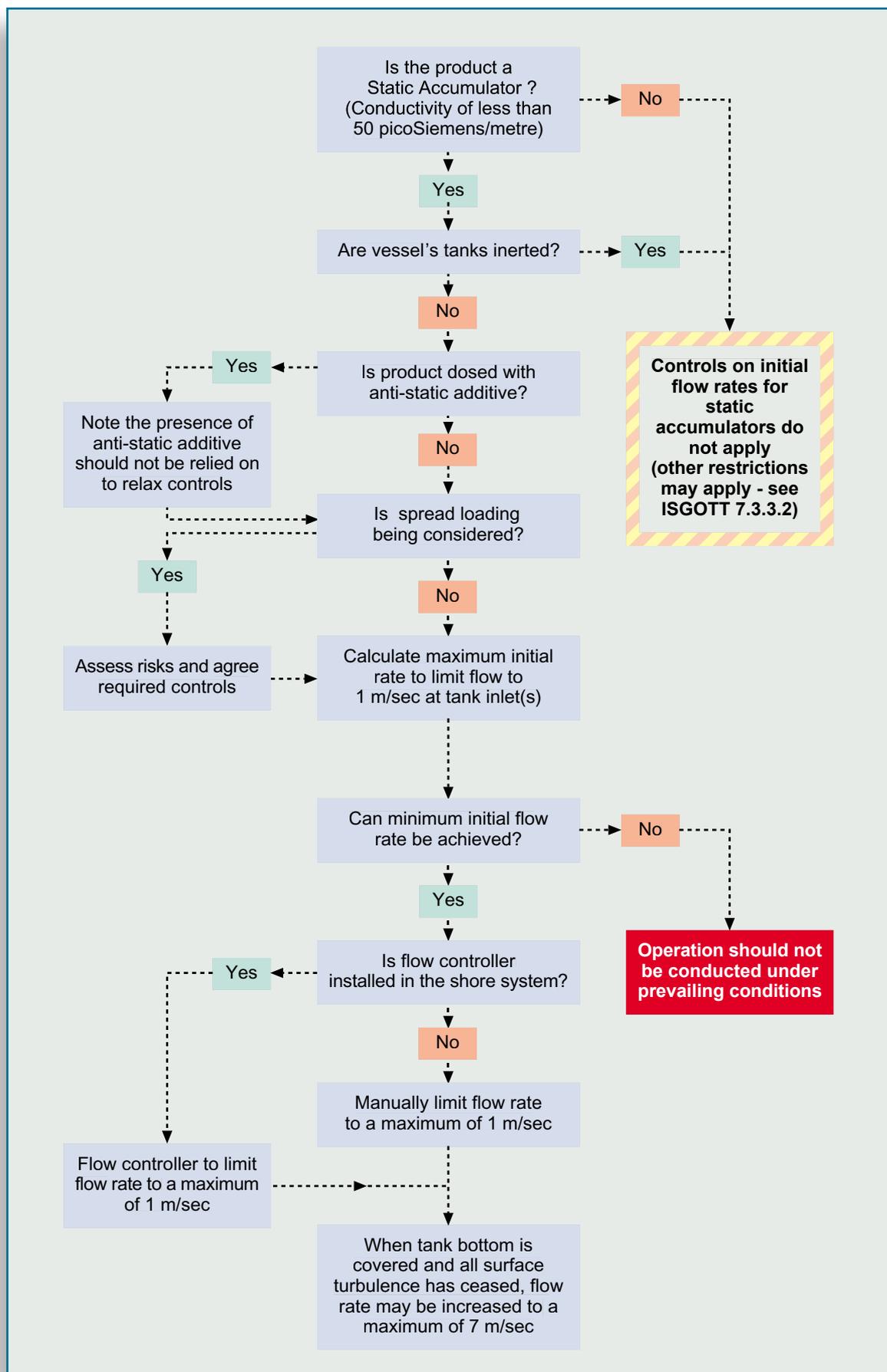


Figure 11.1 – The Control Hazards associated with the initial loading of static accumulator cargoes

when the loading rate is increased. However, if there is reason to believe that excess water may still be present in the shore pipeline, then the recommended action is to:

- Keep the product velocity in the shore line below 1 metre per second throughout loading to avoid flushing the water into the ship's tank(s); or
- Keep the product velocity at the tank inlet(s) below 1 metre per second throughout loading to avoid turbulence in the tank(s).

Whichever option gives the higher loading rate consistent with safety should be used.

11.1.7.5 Examples

Initial Loading Phase

Figure 11.2 shows the pipeline arrangements for a vessel loading a static accumulator product at a berth. The table defines the pipeline sizes and the volumetric flow rates at a velocity of 1 metre/second. For initial loading to two cargo tanks, the limitation will allow a loading rate of 366 m³/hour to be requested in the example given.

If the shore line were 510 mm diameter and water was suspected of being in the line, the vessel would need to load 4 tanks simultaneously to ensure the water content could be safely removed and an initial loading rate of 676 m³/hour should be requested. This will allow the water to be cleared from the shore line whilst keeping the velocity at the tank inlets below 1 metre/second.

11.1.7.6 Practical Considerations

In practice, not all terminals are equipped with flow control devices to regulate the loading rate and therefore may not be able to establish a loading rate to one cargo tank equivalent to a velocity of 1 metre/second. Some terminals achieve, or try to achieve, a low loading rate by commencing loading by gravity flow alone.

11.1.7.7 Spread Loading

Spread loading is the practice of commencing loading via a single shore line to several of the ship's cargo tanks simultaneously where it is necessary to mitigate a terminal's lack of flow control. The aim of this practice is to achieve a loading rate that will give a maximum velocity at each of the tank inlets of 1 metre per second.

Spread loading presents a number of potentially significant static generation risks that should be assessed and properly managed if this practice is to be used safely. For example:

- Uneven flow in the ship's cargo lines can create a backflow of vapour (gas or air) from other open tanks to the tank that is receiving product. This eductor effect will create a two-phase mixture of product and vapour that will result in increased turbulence and mist formation within the tank.

- The possibility of exceeding 1 metre/second product velocity at one tank inlet due to uneven distribution of product between the open tanks.

The following precautions should be taken to manage the risks associated with the spread loading of static accumulator cargoes:

- The overall loading rate should be selected so as to ensure a maximum product velocity of 1 metre/second into any one tank, assuming even distribution of cargo between tanks.
- Possible different flow distributions into different tanks should be considered and best efforts should be made to ensure equal flow distribution between cargo tanks.
- Not more than four cargo tanks should be loaded at any one time.
- Tank inlet valves should not be used to control cargo flow in the initial loading phase. Their use will reduce the cross-sectional area of the inlet, resulting in increased tank inlet velocity and greater turbulence and mist formation. If it is necessary to throttle valves in order to control flow rate, this should be done upstream of the tank valves.
- The management of the risks inherent in spread loading will require a risk assessment process to be followed. The risk assessment should consider:
 - The terminal's piping configuration, including flow control capability.
 - The ship's piping configuration.
 - Ship's cargo tank condition, for example previous cargo, tank atmosphere and physical condition (such as the integrity of heating coils).
 - The product to be loaded and the potential for generating a flammable atmosphere.

Spread loading should only be carried out when the ship and the terminal are both satisfied that the risks have been identified and that appropriate risk response measures have been taken to minimise, avoid or eliminate them.

11.1.7.8 Limitation of Product Velocity (Loading Rates) After the Initial Filling Period (Bulk Loading)

After the initial filling period, electrostatic generating processes such as mist formation and stirring up tank bottoms by turbulence are suppressed by the rising liquid level, and the concern changes to ensuring that excessive charge does not accumulate on the bulk liquid. This is also done by controlling the flow rate, but the maximum acceptable velocity is higher than for the initial filling period, provided the product is 'clean' as defined in Section 3.2.1.

Two-phase flows (i.e. through oil and water) give higher charging and may require that flow rate limitations have to be imposed throughout loading (see Section 11.1.7.4).

When the tank bottom is covered, after all splashing and surface turbulence has ceased and after all water has been cleared from the line, the rate can be increased to the lesser of the ship or

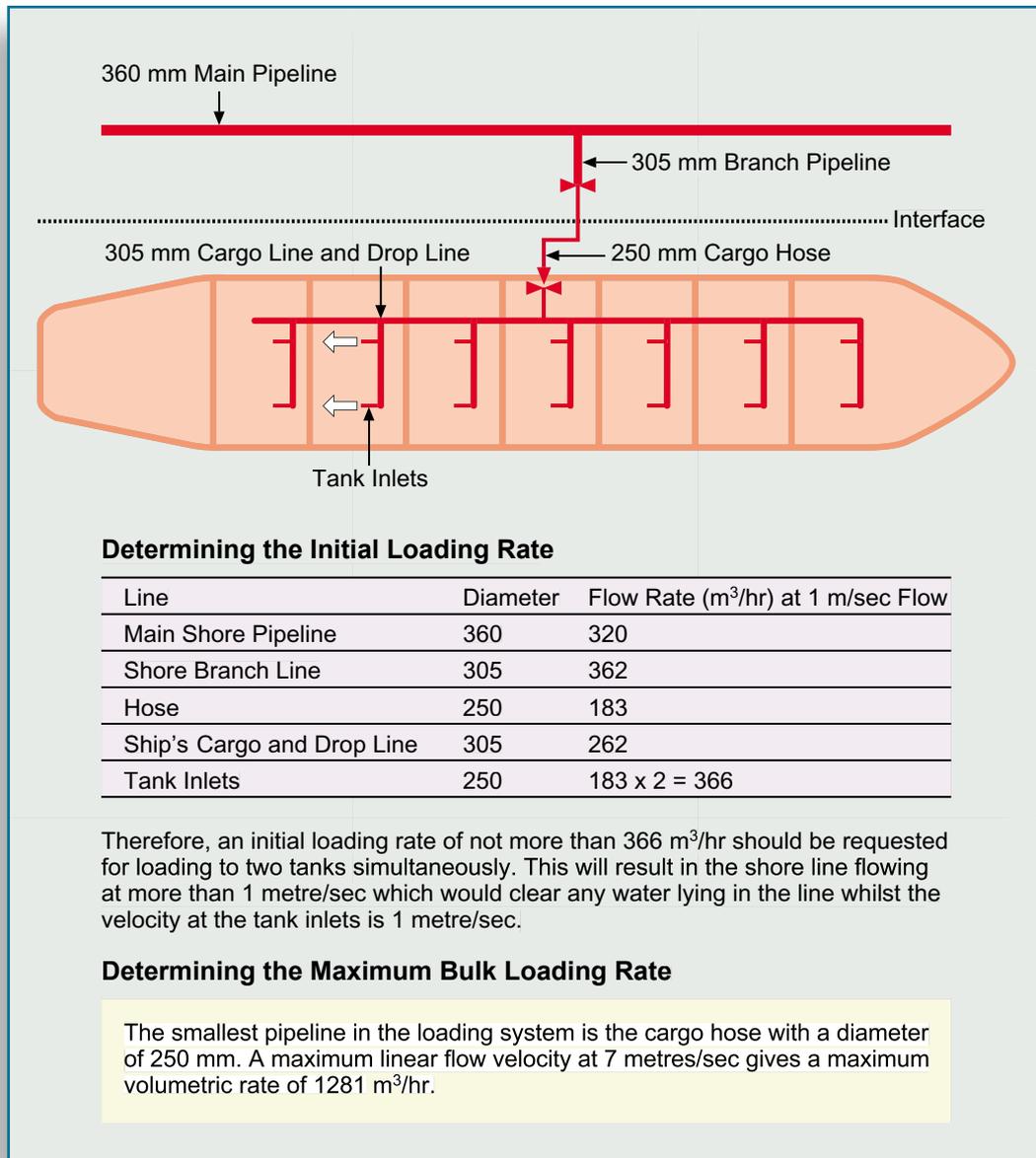


Figure 11.2 – Determining loading rates for static accumulator cargoes

shore pipeline and pumping system maximum flow rates consistent with proper control of the system. Established practice and experience indicate that hazardous potentials do not occur if the product velocity is less than 7 metres/second. Some national Codes of Practice also suggest 7 metres/second as a maximum value. However, a number of industry documents acknowledge that 7 metres/second is a precautionary limit and imply that higher speeds may be safe, without specifying what the real limits are. (All the empirical relationships for safe loading have been derived on the basis of experiments limited to a maximum flow of 7 metres/second.)

Only where well documented experience indicates that higher velocities can be safely used should the limit of 7 metres/second be replaced by an appropriate higher value.

Operators should be aware that the maximum velocity might not occur at the minimum diameter of the pipeline when the pipeline feeds multiple branch lines. Such configurations would be where a pipeline feeds multiple loading arms or hoses or, on a ship, where a main cargo line feeds multiple drop lines or tank inlets. For example, where a 150 mm diameter pipeline feeds three 100 mm branch lines, the highest velocity will be in the 150 mm pipeline, not in the branch lines.

Figure 11.2 also shows that the smallest diameter section of piping in the system is the cargo hose, which has a diameter of 250 mm. If a loading velocity of 7 metres/second is acceptable to the ship and shore, a maximum loading rate of 1,281 m³/hour should be requested.

11.1.7.9 Antistatic Additives

If the oil contains an effective antistatic additive, it is no longer a static accumulator. Although in theory this means that the precautions applicable to a static accumulator can be relaxed, it is still advisable to adhere to them in practice. The effectiveness of antistatic additives is dependent upon the length of time since the additive was introduced to the product, satisfactory product mixing, other contamination and the ambient temperature. It can never be certain that the product's conductivity is above 50 pS/m, unless it is continuously measured. (See Section 12.5.2.2.)

11.1.7.10 Loading of Different Grades of Product into Unclean Tanks (Switch Loading)

Switch loading is the practice of loading a low volatility liquid into a tank that previously contained a high volatility liquid. The residues of the volatile liquid can produce a flammable atmosphere even when the atmosphere produced by the low volatility liquid alone is non-flammable.

In this circumstance, it is important to reduce charge generation by avoiding splash loading and other charge generating mechanisms such as filters in the pipeline. The flow rate should be restricted as per Sections 11.1.7.3 and 11.1.7.8 during the initial and bulk loading periods respectively.

Product specification and quality requirements normally mean that switch loading does not arise on tankers handling finished products. This situation however may be encountered when handling cargo slops or off-grade product for which no tank preparation may be required as the grades can be mixed without a risk of product contamination. In this situation, the precautions outlined for switch loading described above should be implemented.

11.1.8 Loading Very High Vapour Pressure Cargoes

Cargoes with high vapour pressure (see Section 2.5.6.2) introduce problems of cargo loss due to excessive vapour release and can also cause discharge difficulties due to gassing-up of cargo pumps. Special precautions may therefore be necessary. These include:

- Permitting only closed loading methods (see Section 11.1.6.6).

- Avoiding loading when the wind speed is less than 5 knots.
- Using very low initial flow rates into tanks.
- Using very low topping-off rates.
- Avoiding a partial vacuum in the loading line.
- Avoiding loading oil that is hot due to lying in shore lines exposed to the sun. If this is unavoidable, this oil should be loaded to tanks that vent well clear of the superstructure (e.g. forward tanks).
- Providing additional supervision to see that gas dispersion is monitored and to ensure compliance with all safety requirements.
- Monitoring inert gas main pressure where this gives an indication of the cargo tank pressure. A maximum pressure in the order of 1,000 mm WG should be used and the loading rate adjusted accordingly.

To prevent gassing-up of cargo pumps, the expected True Vapour Pressure (TVP) of the cargo at the discharge port should, under normal circumstances, not exceed 0.7 bar for both crude oil and products. A TVP of up to 0.8 bar may be considered if the ship is fitted with an inert gas system, or if some other acceptable method of pressurisation is to be used during discharge.

11.1.9 Loading Cargoes Containing Hydrogen Sulphide (H₂S)

11.1.9.1 General

The number of cargoes containing significant quantities of Hydrogen Sulphide (H₂S) is increasing. In addition, levels of H₂S contained within the cargoes are also increasing. Guidance on H₂S toxicity is to be found in Section 2.3.6 and guidelines on gas measurement and gas testing are to be found in Sections 2.4 and 8.2.

This Section provides practical guidance on operational measures that can be taken to minimise the risks associated with loading cargoes containing H₂S, commonly referred to as 'sour' cargoes.

11.1.9.2 Precautions when Loading Cargoes Containing H₂S

The following precautions should be considered when preparing to load sour cargoes:

- Before arriving at the loading port, ensure that the cargo system is free of leaks from the cargo piping, tank fittings and the venting system. Test the heating coils to prevent possible transference of H₂S into the low pressure steam system.
- Any liquid filled pressure vacuum breakers should be checked to ensure that they are correctly filled.
- Check that all doors and ports can be securely closed to prevent any small gas ingress.

When loading a cargo containing H₂S:

- A safety plan should be produced for the loading operation which should include guidance on the venting procedure,

monitoring for vapour, personal protective equipment to be used, accommodation and engine room ventilation arrangements and emergency measures that have been put in place.

- Closed loading procedures described in Section 11.1.6.6 should be used.
- Venting to the atmosphere at a relatively low tank pressure should be avoided, particularly in calm wind conditions.
- Cargo loading should be stopped if there is no wind to disperse the vapours or if the wind direction takes cargo vapours towards the accommodation.
- Only personnel actively engaged in ship security and cargo handling should be permitted on open decks. Regular maintenance on deck should be limited or postponed until after the end of cargo operations. Visitors should be escorted to and from the accommodation spaces and briefed on the hazards of the cargo and emergency procedures.
- H₂S is very corrosive and mechanical gauges are therefore more likely to fail than usual. Their operational condition should be checked frequently. In the event of a gauge failure, repairs should not be undertaken unless an appropriate permit has been issued and all necessary precautions observed.
- H₂S is heavier than air. In ship-to-ship transfers, particular attention should therefore be given to the difference in freeboards of the ships and the possibility of vapour not being dispersed freely. Vent velocities should be kept high on the receiving ship and the ships should be turned so as to allow the wind to carry vapours away from the accommodation spaces.

11.1.10 Loading Cargoes Containing Benzene

Guidance on benzene toxicity is to be found in Section 2.3.5. Cargoes containing benzene should be loaded using the closed operation procedures described in Section 11.1.6.6 as this will significantly reduce exposure to benzene vapour. Where a Vapour Emission Control System (VECS) is available ashore, it should be used (see Section 11.1.13).

Operators should adopt procedures to verify the effectiveness of the closed loading system in reducing the concentrations of benzene vapours around the working deck. This will involve surveys to determine the potential for exposure of personnel to benzene vapour during all operations such as loading, discharging, sampling, hose handling, tank cleaning, gas freeing and gauging of cargoes containing benzene. These surveys should also be carried out to ascertain vapour concentrations when tank cleaning, venting or ballasting tanks whose previous cargo contained benzene.

Spot checks on vapour concentrations, using detector tubes and pumps, toxic analysers or an electronic detector tube, should be carried out by ship's personnel to ascertain if TLV-TWAs are being exceeded and therefore whether personal protective equipment should be worn.

In addition to the above, the precautions described in Section 11.8.4 should also be taken in order to minimise exposure when measuring and sampling cargoes containing benzene.

11.1.11 Loading Heated Products

Unless the ship is specially designed for carrying very hot cargoes, such as a bitumen carrier, cargo heated to a high temperature can damage a tanker's structure, the cargo tank coatings, and equipment such as valves, pumps and gaskets.

Some classification societies have rules regarding the maximum temperature at which cargo may be loaded and Masters should consult the ship operator whenever the cargo to be loaded has a temperature in excess of 60°C.

The following precautions may help to alleviate the effects of loading a hot cargo:

- Spreading the cargo throughout the ship as evenly as possible to dissipate excess heat and to avoid local heat stress.
- Adjusting the loading rate in an attempt to achieve a more reasonable temperature.
- Taking great care to ensure that tanks and pipelines are completely free of water before receiving any cargo that has a temperature above the boiling point of water.

11.1.12 Loading Over the Top (sometimes known as 'Loading Overall')

Volatile petroleum, or non-volatile petroleum having a temperature higher than its flashpoint minus 10°C, should never be loaded over the top into a non-gas free tank.

There may be specific port or terminal regulations relating to loading over the top.

Non-volatile petroleum having a temperature lower than its flashpoint minus 10°C may be loaded over the top in the following circumstances:

- If the tank concerned is gas free, provided no contamination by volatile petroleum can occur.
- If prior agreement is reached between the Master and the Terminal Representative.

The free end of the hose should be lashed inside the tank coaming to prevent movement.

Ballast or slops must not be loaded or transferred over the top into a tank that contains a flammable gas mixture.

11.1.13 Loading at Terminals Having Vapour Emission Control (VEC) Systems

11.1.13.1 General

The fundamental concept of a vapour emission control system is relatively simple. When tankers are loading at a terminal, the vapours are collected as they are displaced by the incoming cargo or ballast and are transferred ashore by pipeline for treatment or disposal. However, the operational and safety implications are

significant because the ship and terminal are connected by a common stream of vapours, thereby introducing into the operation a number of additional hazards which have to be effectively controlled.

Detailed guidance on technical issues associated with vapour emission control and treatment systems is available from a number of sources. IMO has developed international standards for the design, construction and operation of vapour collection systems on tankers and vapour emission control systems at terminals, and OCIMF has initiated and issued guidance on vapour manifold arrangements (see Bibliography).

It should be noted that Vapour Emission Control Systems (VECS) can serve tankers fitted with inert gas systems and also non-inerted tankers.

A summary of the terminal's VECS should be included in the terminal information booklet.

11.1.13.2 Misconnection of Liquid and Vapour Lines

To guard against the possible misconnection of the ship's vapour manifold to a terminal liquid loading line, the vapour connection should be clearly identified by painting the outboard 1 metre section with yellow and red bands and by stencilling the word 'VAPOUR' in black letters upon it.

In addition, a cylindrical stud should be permanently attached to each presentation flange face at the 12 o'clock position on the flange bolt circle. The stud should project 25.4 mm (1 inch) perpendicular to the flange face, and should be 12.7 mm (½ inch) in diameter, in order to prevent the connection of standard liquid transfer hoses. Blank flanges, inboard ends of reducers and hoses for the vapour line will have an extra hole to accommodate the stud on the presentation flange (see Figure 11.3).

Full details of vapour manifold arrangements, materials and fittings are contained in the OCIMF publication *'Recommendations for Oil Tanker Manifolds and Associated Equipment'*.

11.1.13.3 Vapour Over/Under-Pressure

Although all 'closed' cargo operations require in-tank pressures to be effectively monitored and controlled, the connection to a vapour emission control system results in pressures within the ship's vapour spaces being directly influenced by any changes that may occur within the terminal's system. It is therefore important to ensure that the individual cargo tank pressure/vacuum protection devices are fully operational and that loading rates do not exceed maximum allowable rates. In addition, pressures within vapour collection piping systems should be continuously monitored by sensors that incorporate high and low pressure alarm functions connected to audible and visual alarms.

11.1.13.4 Cargo Tank Overfill

The risk of overfilling a cargo tank when using a VEC system is no different from that when loading under normal closed

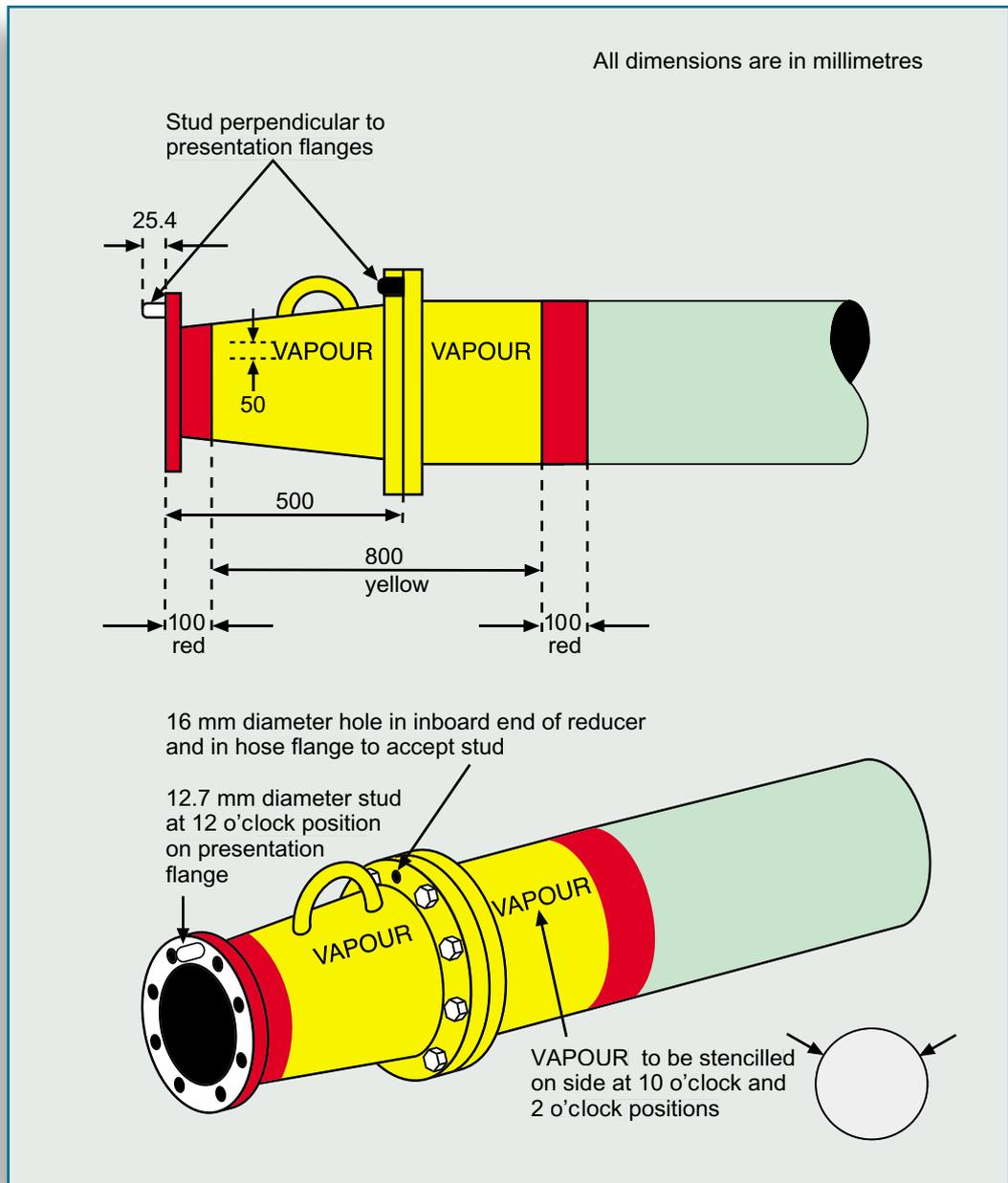


Figure 11.3 – Vapour manifold presentation flanges, orientation and labelling

conditions. However, owing to the reliance placed on closed gauging systems, it is important that they are fully operational and that backup is provided in the form of an independent overflow alarm arrangement. The alarm should provide audible and visual indication and should be set at a level that will enable operations to be shut down prior to the tank being overfilled. Under normal operations, the cargo tank should not be filled higher than the level at which the overflow alarm is set.

Individual overflow alarms should be tested at the tank to ensure their proper operation prior to commencing loading, unless the system is provided with an electronic self-testing capability which monitors the condition of the alarm circuitry and sensor, and confirms the instrument set point.

11.1.13.5 Sampling and Gauging

A cargo tank should never be opened to the atmosphere for gauging or sampling purposes while the ship is connected to the shore vapour recovery system unless loading to the tank is stopped, the tank is isolated from any other tank being loaded and precautions are taken to reduce any pressure within the cargo tank vapour space.

On non-inerted tankers, precautions against static hazards should also be followed. (See Section 11.8.)

11.1.13.6 Fire/Explosion/Detonation

The interconnection of ship and shore vapour streams, which may or may not be within the flammable range, introduces significant additional hazards that are not normally present when loading. Unless adequate protective devices are installed and operational procedures adhered to, a fire or explosion occurring in the vapour space of a cargo tank on board could transfer rapidly to the terminal and vice versa.

A detonation arrestor should be fitted in close proximity to the terminal vapour connection at the jetty head in order to provide primary protection against the transfer or propagation of a flame from ship to shore or from shore to the ship.

The design of the terminal vapour collection and treatment system will determine whether or not flammable vapours can be safely handled and, if they cannot, will include provisions for either inerting, enriching or diluting the vapour stream and continuously monitoring its composition.

11.1.13.7 Liquid Condensate in the Vapour Line

The ship's systems should be provided with means to effectively drain and collect any liquid condensate that may accumulate within vapour pipelines. Any build-up of liquid in the vapour line could impede the free passage of vapours and thus increase in-line pressures and could also result in the generation of significant electrostatic charges on the surface of the liquid. It is important that drains are installed at the low points in the ship's vapour piping system and that they are routinely checked to ensure that no liquid is present.

11.1.13.8 Electrostatic Discharge

The precautions contained in Section 11.1.7.3, with regard to initial loading rates, and in Section 11.8, with regard to measuring and sampling procedures, should be followed. In addition, to prevent the build-up of electrostatic charges within the vapour collection system, all pipework should be electrically bonded to the hull and should be electrically continuous. The bonding arrangements should be inspected periodically to check their condition. The terminal vapour connections should be electrically insulated from the tanker vapour connection by the use of an insulating flange or a single section of insulating hose.

11.1.13.9 Training

It is important that the Responsible Officer has received instruction on the particular vapour emission control system installed on the ship.

11.1.13.10 Communications

The introduction of vapour emission control reinforces the importance of good co-operation and communications between the ship and shore. Pre-transfer discussions should provide both parties with an understanding of each other's operating parameters. Details such as maximum transfer rates, maximum allowable pressure drops in the vapour collection system, and alarm and shutdown conditions and procedures must be agreed before operations commence (see Section 26.3 – Ship/Shore Safety Check-List).

11.1.14 Discharging Procedures

11.1.14.1 Joint Agreement on Readiness to Discharge

Before starting to discharge cargo, the Responsible Officer and the Terminal Representative must formally agree that both the tanker and the terminal are ready to do so safely.

11.1.14.2 Operation of Pumps and Valves

Throughout pumping operations, no abrupt changes in the rate of flow should be made.

Reciprocating main cargo pumps can set up excessive vibration in metal loading/discharging arms which, in turn, can cause leaks in couplers and swivel joints, and even mechanical damage to the support structure. Where possible, such pumps should not be used. If they are, care must be taken to select the least critical pump speed or, if more than one pump is used, a combination of pump speeds to achieve an acceptable level of vibration. A close watch should be kept on the vibration level throughout the cargo discharge.

Centrifugal pumps should be operated at speeds that do not cause cavitation. This effect may damage the pump and other equipment on the ship or at the terminal.

11.1.14.3 Closed Discharging

Ships correctly operating their inert gas systems are considered to be conducting 'closed' discharging operations.

On non-inerted ships, discharging, gauging and sampling should normally be carried out with all ullage, sounding and sighting ports closed. Air should be admitted to the tanks by the dedicated venting system.

When cargo is being run between tanks during discharge operations, care should be taken to ensure that vapours are vented to deck via deck apertures that are protected by flame screens.

Where the design of the ship does not allow admittance of air via the vapour system at a sufficient rate, air may be admitted via a sighting or ullage port, provided it is fitted with a permanent flame screen. In this situation, the ship is no longer considered to be closed discharging.

11.1.14.4 Inert Gas Procedures

Ships using an inert gas system (IGS) must have the system fully operational and producing good quality (i.e. low oxygen content) inert gas at the commencement of discharge. The IGS must be fully operational and working satisfactorily throughout the discharge of cargo or deballasting. Section 7.1 gives details on the operation of the IGS.

Cargo discharge must not be started until:

- All relevant cargo tanks, including slop tanks, are common with the inert gas (IG) main.
- All other cargo tank openings, including vent valves, are securely closed.
- The IG main is isolated from the atmosphere and, if a cross connection is fitted, also from the cargo main.
- The IG plant is operating.
- The deck isolating valve is open.

A low but positive inert gas pressure after completion of discharge will permit the draining of the manifold drip tray into a tank and, if required, allow manual dipping of each tank.

11.1.14.5 Pressurising of Cargo Tanks

When high vapour pressure petroleum (e.g. natural gasoline and certain crude oils) reaches a low level in cargo tanks, the head of liquid is sometimes insufficient to keep cargo pumps primed. If an inert gas system is installed, it can be used for pressurising cargo tanks in order to improve pump performance.

11.1.14.6 Crude Oil Washing

If the ship needs to crude oil wash all or some of its tanks during discharge, the Responsible Officer should incorporate a crude oil washing plan in the required discharge plan set out in Section 22.6.

A full description of the requirements relating to crude oil washing is given in Section 11.5.

11.1.14.7 Commencement of Discharge Alongside a Terminal

Shore valves must be fully open to receiving tanks before the tanker's manifold valves are opened. If there is a possibility that, owing to the elevation of the shore tanks above the level of the ship's manifold, pressure might exist in the shore line and no non-return (check) valves are fitted in the shore line, the ship must be informed and the tanker's manifold valves should not be opened until an adequate pressure has been developed by the pumps.

Discharge should start at a slow rate and only be increased to the agreed rate once both parties are satisfied that the flow of oil to and from designated tanks is confirmed.

11.1.14.8 Commencement of Discharge at an Offshore Terminal

Before commencing discharge at an offshore terminal, communications between ship and shore should be tested and fully understood. The ship must not open its manifold valves or start its pumps until a clear signal has been received from the shore that the terminal is ready. Discharge must be started slowly until the system has been tested and then gradually brought up to the maximum agreed flow rate or pressure. A close watch should be kept on the sea in the vicinity of the hoses to detect leaks. During darkness, a bright light should, where safe and practicable, be shone on the water in the vicinity of the hoses.

11.1.14.9 Commencement of Discharge Through a Stern Discharge Line

Before commencing discharge through a stern line, a dangerous area extending not less than 3 metres from the manifold valve should be clearly marked and no unauthorised personnel should be allowed within this area during the entire discharge operation.

A close watch must be maintained for any leakage and all openings, air inlets and doors to enclosed spaces should be kept tightly closed.

Fire-fighting equipment must be laid out and ready for use in the vicinity of the stern manifold.

11.1.14.10 Periodic Checks During Discharge

Throughout discharging, the ship should monitor and regularly check all full and empty tanks to confirm that cargo is only leaving the designated cargo tanks and that there is no escape of cargo into pumprooms or cofferdams, or through sea and overboard discharge valves.

The ship should check tank ullages at least hourly and calculate a discharge rate. Cargo figures and rates should be compared with shore figures to identify any discrepancy. These checks should, where possible, include the observations and recording of the shear forces, bending moments, draught and trim and any other relevant stability requirements particular to the ship. This information should be checked against the required discharging plan to see that all safe limits are adhered to and that the discharging sequence can be followed, or amended, as necessary. Any discrepancies should be immediately reported to the Responsible Officer.

Any drop in pressures or any marked discrepancy between tanker and terminal estimates of quantities could indicate pipeline or hose leaks, particularly in submarine pipelines, and require that cargo operations be stopped until investigations have been made.

The ship should carry out frequent inspections of the cargo deck and pumproom to check for any leaks. Overside areas should likewise be checked regularly. During darkness, where safe and practical, the water around the ship should be illuminated.

11.1.14.11 Fluctuations in Discharge Rate

During discharge, the flow of cargo should be controlled by the tanker in accordance with the agreement reached with the terminal.

The discharge rate should not be substantially changed without informing the terminal.

11.1.14.12 Simultaneous Ballast and Cargo Handling

If ballasting of cargo tanks is carried out simultaneously with the discharge of cargo, vapours may be emitted from the tanks being ballasted, in which case proper precautions should be taken.

Section 11.5.8 should be referred to for guidance on the control of emissions during and after crude oil washing.

11.1.14.13 Failure of the Inert Gas System During Cargo Discharge

Reference should be made to the guidance provided in Section 7.1.12 regarding actions to be taken in the event of failure of the inert gas system during cargo discharge.

11.1.14.14 Stripping and Draining of Cargo Tanks

If, during the discharge of the main bulk of cargo, a slop tank or other selected tank is used to receive the drainings of tanks being stripped, personnel should be alert to the fact that the ullage in the receiving tank will be decreasing. In these circumstances, great care should be taken to avoid an overflow and proper precautions taken in respect of any vapours emitted.

As air and/or gas bubbles in a liquid can generate static electricity, stripping pumps and eductors should be operated to avoid, as far as possible, the entrapment of air or gas into the liquid stream.

11.1.15 Pipeline and Hose Clearing Following Cargo Operations

11.1.15.1 General

The procedure for clearing the pipelines and hoses or arms between the shore valve and ship's manifold will depend on the facilities available and whether these include a slop tank or other receptacle. The relative heights of the ship and shore manifolds may also influence procedures.

11.1.15.2 Line Displacement with Water

On tankers that have a segregated ballast system, the practice of using cargo pumps on a sea suction should be avoided if at all

possible. However, some terminals will require the ship to displace the contents of the hoses or arms, and perhaps also the shore pipelines, with water on completion of cargo operations. Due to the added risk of pollution, this practice should only be undertaken if it is essential and must be carefully planned and executed. Prior to commencing the displacement, the ship and terminal should reach agreement on the procedures to be adopted, particularly the amount to be pumped and the pumping rate.

Particular attention must be paid to venting the cargo pumps and guaranteeing that no outflow of oil occurs when opening the sea valve.

Reference should be made to the ICS/OCIMF publication *'Prevention of Oil Spillages through Cargo Pumphouse Sea Valves'*.

11.1.15.3 Line Draining

On completion of loading, the ship's cargo deck lines should be drained into appropriate cargo tanks to ensure that thermal expansion of the contents of the lines cannot cause leakage or distortion. The hoses or arms, and perhaps a part of the pipeline system between the shore valve and the ship's manifold, are also usually drained into the ship's tanks. Sufficient ullage must be left in the final tanks to accept the cargo oil drained from hoses or arms and ship or shore lines.

On completion of discharge, the ship's cargo deck lines should be drained into an appropriate tank and then discharged ashore or into a slop tank.

When draining is complete, and before hoses or arms are disconnected, the ship's manifold valves and shore valves should be closed and the drain cocks at the ship's manifold should be opened to drain into fixed drain tanks or portable drip trays. Cargo manifolds and arms or hoses should be securely blanked after being disconnected. The contents of portable or fixed drip trays should be transferred to a slop tank or other safe receptacle.

11.1.15.4 Clearing Hoses and Loading Arms to the Terminal

If hoses or arms have to be cleared to the terminal using compressed air or inert gas, the following precautions should be strictly observed in order to avoid the possible creation of a hazardous static electrical charge or mechanical damage to tanks and equipment:

- The procedure to be adopted must be agreed between ship and terminal.
- There must be adequate ullage in the reception tank.
- To ensure that the amount of compressed air or inert gas is kept to a minimum, the operation must be stopped when the line has been cleared.
- The inlet to the receiving tank should be located well above any water that may be in the bottom of the tank.

- The line clearing operation must be continuously supervised by a Responsible Officer.

11.1.15.5 Clearing Hoses and Loading Arms to the Ship

The clearing of hoses and loading arms to the ship using compressed air should not be undertaken due to the risks of:

- Static charge generation.
- Compromising inert gas quality.
- Over-pressurisation of tanks or pipelines.
- Oil mists emanating from tank vents.

11.1.15.6 Clearing Ship's Cargo Pipelines

When compressed air or inert gas is used to clear ship's pipelines, for example when evacuating the liquid column above a submerged pump, sometimes referred to as 'purging', similar hazards to those identified above may arise and similar precautions must be observed. Line clearing operations must be undertaken in accordance with the operating procedures previously established for the particular ship.

11.1.15.7 Gas Release in the Bottom of Tanks

A strong electrostatic field can be generated by blowing air or inert gas into the bottom of a tank containing a static accumulator oil. If water or particulate matter is present in the cargo, the effect is made worse, as the rising gas bubbles will disturb the particulates and water droplets. The settling contaminants will generate a static charge within the cargo. Therefore, a settling period of 30 minutes should be observed after any blowing of lines has taken place into a non-inerted tank or into a tank that could possibly contain a flammable atmosphere.

Precautions should be taken to minimise the amount of air or inert gas entering tanks containing static accumulator oils. However, it is best to avoid the practice of blowing lines back to tanks containing such cargo.

Whenever possible, cargo lines should be drained by gravity.

11.1.15.8 Receiving Nitrogen from Shore

Personnel should be aware of the potential hazards associated with nitrogen and, in particular, those related to entering enclosed spaces or areas in way of tank vents or outlets which may be oxygen depleted. High concentrations of nitrogen are particularly dangerous because they can displace enough air to reduce oxygen levels to a point where people entering the area can lose consciousness due to asphyxiation. A problem not experienced with flue gas is that nitrogen cannot be detected by human senses, so smell cannot be relied upon and personnel may not be able to recognise the physical or mental symptoms of overexposure in time for them to take preventive measures.

If there is a requirement to use shore supplied nitrogen, for example for purging tanks, padding cargo or clearing lines, the ship should be aware that this may be at high pressure (up to 10 bar) and at a high flow rate and that it can therefore be potentially hazardous because of the risk of over-pressurisation of the cargo tanks. A risk assessment should be carried out and the operation should only proceed if appropriate risk responses are in place and operating. As a very minimum, the precautions detailed in Section 7.2.2 must be observed.

One method of reducing the risk of over-pressure is to ensure that the tank has vents with a greater flow rate capacity than the inlet, so that the tank cannot be over-pressurised. Where vapour control and emission regulations require closed operation, the incoming flow of nitrogen must be restricted to a rate equal to, or less than, the maximum flow of vapour possible through the vapour return line. Positive measures to ensure this should be agreed. A small hose or reducer prior to the manifold can be used to restrict the flow rate, but pressure must be controlled by the terminal. A gauge will permit the ship to monitor the pressure.

It is not appropriate to attempt throttling a gas flow by using a ship's manifold valve that is designed to control liquid flow. However, the manifold can, and should, be used as a rapid safety stop in an emergency. It should be noted that the effect of pressure surge in a gas is not as violent as in a liquid.

Sensitive cargoes, for example some highly specialised lubricating oils, may have to be carried under a pad or blanket of nitrogen supplied from ashore. In such cases, it is preferable to purge the entire cargo tank before loading. After such purging has been completed, loading the cargo in a closed condition will create the required pad within the tank. This significantly reduces the risk of over-pressurisation that is present when padding with shore supplied nitrogen as a separate procedure on completion of loading.

11.1.15.9 Pigging

Pigging is a form of line clearing in which an object, most often in the form of a rubber sphere or cylinder and known as a 'pig', is pushed through the line by a liquid or by compressed gas. A pig may be used to clear the line completely, in which case it will usually be propelled by water or by compressed gas, or to follow a previous grade to ensure that the pipeline remains as free of product as possible, in which case it is likely to be propelled by the next grade.

A common arrangement for catching the pig is for the shore terminal to provide a pig receiver, which is mounted outboard of the ship's manifold, and from which the pig may be removed.

A pressure of about 2.7 bar (40 psi) is considered to be the minimum necessary to drive the pig, but pressures of up to 7 bar (100 psi) may be used.

Before any pigging operations are carried out, the Responsible Officer and the Terminal Representative should agree the procedures and associated safeguards to be put in place. The

propelling gas or liquid volumes, pressures, time required for the pig to travel along the line, volume of residual cargo in the line, and the amount of ullage space available should be discussed and agreed.

During the pigging operation, the terminal should monitor the pressure upstream of the pig to ensure that it is not stuck in the line. Failure of the pig to arrive within the expected time period will also indicate that free movement of the pig has been restricted.

On completion of the pigging operation, the terminal should positively verify that the pig has arrived. Any residual pressure in the shore line must then be bled-off before opening the pig trap or disconnecting cargo arms or hoses.

Personnel at the receiving end should be aware that there may be sediment in the pig receiver unit and there should be means in place to deal with this, for example rags, absorbent material and drums.

11.2 Stability, Stress, Trim and Sloshing Considerations

11.2.1 General

Single hull oil tankers usually have such a high metacentric height in all conditions that they remain inherently stable. While tanker personnel have always had to take account of longitudinal bending moments and vertical shear forces during cargo and ballast operations, the actual stability of the ship has therefore seldom been a prime concern. However, the introduction of double hulls into tanker design has changed that situation.

11.2.2 Free Surface Effects

The main problem likely to be encountered is the effect on the transverse metacentric height of liquid free surface in the cargo and double hull ballast tanks.

Depending upon the design, type and number of these tanks, the free surface effect could result in the transverse metacentric height being significantly reduced. The situation will be most severe in the case of a combination of wide cargo tanks with no centreline bulkhead, and ballast tanks also having no centreline bulkhead ('U' tanks).

The most critical stages of any operation will be while filling the double bottom ballast tanks during discharge of cargo, and emptying the tanks during loading of cargo. If sufficient cargo tanks and ballast tanks are slack simultaneously, the overall free surface effect could well be sufficient to reduce the transverse metacentric height to a point at which the transverse stability of the ship may be threatened. This could result in the ship suddenly developing a severe list or angle of loll. A large free surface area is especially likely to threaten stability at greater soundings (innages), with associated high vertical centre of gravity.

It is imperative that tanker and terminal personnel involved in cargo and ballast operations are aware of this potential problem, and that all cargo and ballast operations are conducted strictly in accordance with the ship's loading manual.

Where they are fitted, interlock devices to prevent too many cargo and ballast tanks from being operated simultaneously, thereby causing an excessive free surface effect, should always be maintained in full operational order, and should never be overridden.

Ships that operate with limited metacentric height should be equipped with a loading computer that calculates metacentric height.

11.2.3 Heavy Weather Ballast

It is imperative that Masters and officers be aware that partially loading a cargo tank with heavy weather ballast may present a potential problem due to 'sloshing'. The combination of free surface and the flat tank bottom can result in the generation of wave energy of sufficient power to severely damage internal structure and pipelines.

11.2.4 Loading and Discharge Planning

Ballasting and deballasting must be planned and programmed around the cargo operations so as to avoid exceeding specified draught, trim or list requirements, while at the same time keeping shear force, bending moments and metacentric height within prescribed limits.

11.3 Tank Cleaning

11.3.1 General

This Section deals with procedures and safety precautions for cleaning cargo tanks after the discharge of volatile or non-volatile petroleum carried in non-gas free, non-inert or inert tanks. Guidance is also given on the cleaning of contaminated ballast spaces.

11.3.2 Tank Washing Risk Management

All tank washing operations should be carefully planned and documented. Potential hazards relating to planned tank washing operations should be systematically identified, risk assessed and appropriate preventive measures put in place to reduce the risk to as low as reasonably practicable (ALARP).

In planning tank washing operations, the prime risk is fire or explosion arising from simultaneous presence of a flammable atmosphere and a source of ignition. The focus therefore should be to eliminate one or more of the hazards that contribute to that risk, namely the sides of the fire triangle of air/oxygen, ignition source and fuel (i.e. flammable vapours).

Inert Tanks

The method that provides the lowest risk is washing the tank in an inert atmosphere. The inert condition provides for no ambiguity; by definition, to be deemed inert, the tank **MUST** meet the SOLAS requirement for inerting of the cargo tanks and reducing the oxygen content of the atmosphere in each tank to a level at which combustion cannot be supported.

Failure to prove through direct measurement that the tank is inert means, by default, that the tank **MUST** be considered to be in the non-inert condition.

Non-Inert Tanks

In ships that do not have access to inert gas, either through on board facilities (e.g. IGS plant) or shore supply, it is only possible to address the 'fuel' and the 'sources of ignition' sides of the fire triangle. In a non-inert condition, there are no physical barriers that will ensure elimination of these two hazards individually. Therefore, the safety of tank washing in the non-inert condition depends on the integrity of equipment, and implementation of strict procedures to ensure these two hazards are effectively controlled.

Non-inert cargo tank washing should only be undertaken when two sides of the fire triangle are addressed by a combination of measures to control both the flammability of the tank atmosphere **AND** sources of ignition.

It is recommended that all tankers that operate in the non-inert mode incorporate within their design and equipment the ability to mechanically ventilate cargo tanks concurrently with tank washing, in order to control tank atmosphere.

11.3.3 Supervision and Preparation

11.3.3.1 Supervision

A Responsible Officer must supervise all tank washing operations.

All crew involved in the operation should be fully briefed by the Responsible Officer on the tank washing plans, and their roles and responsibilities prior to commencement.

All other personnel on board should also be notified that tank washing is about to begin and this notification **MUST** in particular be extended to those on board not involved directly in the tank washing operation but who, by virtue of their own concurrent tasks, may impact upon the safety of the tank washing operation.

11.3.3.2 Preparation

Both before and during tank washing operations, the Responsible Officer should be satisfied that all the appropriate precautions set out in Chapter 4 are being observed. If craft are alongside the tanker, their personnel should also be notified and their compliance with all appropriate safety measures should be confirmed.

Before starting to tank wash alongside a terminal, the following additional measures should be taken:

- Relevant precautions described in Chapter 24 should be observed.
- The appropriate personnel ashore should be consulted to ascertain that conditions on the jetty do not present a hazard and to obtain agreement that operations can start.

The method of tank washing utilised on board a tanker is dependent on how the atmospheres in the cargo tanks are managed and will be determined by the equipment fitted to the vessel.

11.3.4 Tank Atmospheres

Tank atmospheres can be either of the following:

11.3.4.1 Inert

This is a condition where the tank atmosphere is known to be at its **lowest risk** of explosion by virtue of the atmosphere being maintained at all times non-flammable through the introduction of inert gas and the resultant reduction of the overall oxygen content in any part of any cargo tank to a level not exceeding 8% by volume while under a positive pressure (see Section 7.1.5.1).

The requirements for the maintenance of an inert atmosphere and precautions to be observed during washing are set out in Section 7.1.6.9 and provide the most certain level of control of an atmosphere during tank washing operations.

In fire triangle terms, this method **physically removes and controls** the 'oxygen' side of the fire triangle.

11.3.4.2 Non-Inert

For the purposes of this Chapter, a non-inert atmosphere is one in which the oxygen content has not been confirmed to be less than 8% by volume.

In recognition that tank washing and gas freeing operations in non-inert atmospheres are considered to present a likelihood of **increased risk**, additional control measures are required to reduce the risk of operations to as low as reasonably practicable (ALARP). These control measures **MUST** address two sides of the fire triangle namely:

- 'Fuel' and
- 'Sources of ignition'.

11.3.5 Tank Washing

11.3.5.1 Washing in an Inert Atmosphere

To satisfy the control measures for washing in inert atmospheres see Section 7.1.6.9.

During tank washing operations, measures must be taken to verify that the atmosphere in the tank remains non-flammable (oxygen content not to exceed 8% by volume) and at a positive pressure.

11.3.5.2 Washing in a Non-Inert Atmosphere

Non-inert cargo tank washing should only be undertaken when both the source of ignition and the flammability of the tank atmosphere are controlled. To achieve this, the following precautions to control 'sources of ignition' and 'fuel' **MUST** be taken for tank washing operations in a non-inert atmosphere condition.

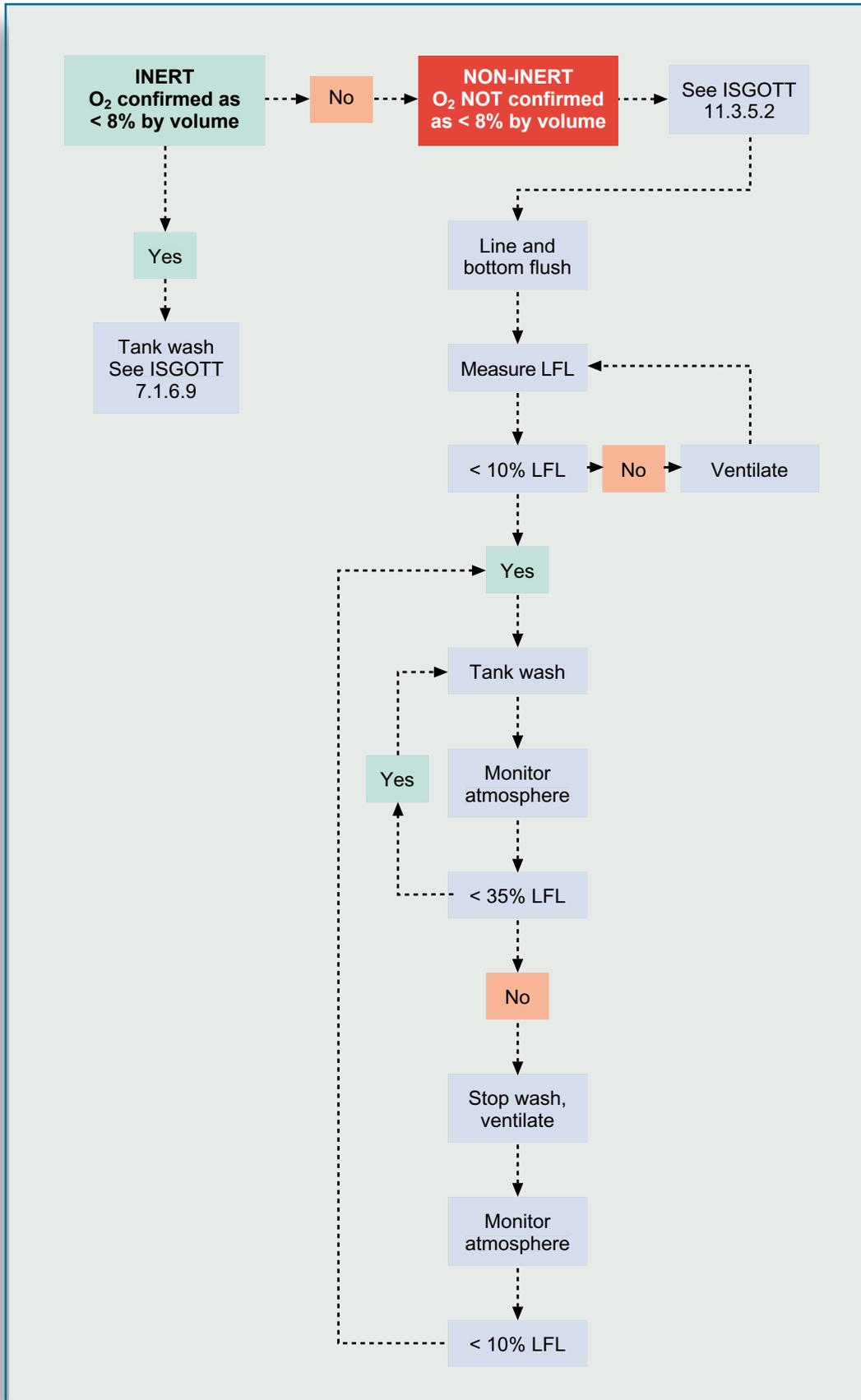


Figure 11.4 – Flow chart showing steps to control the ‘fuel’ while tank washing in the non-inert tank atmosphere method

To Control the 'Fuel' in the Tank Atmosphere

(See Figure 11.4 Non-inert tank washing flow chart.)

Before Washing:

- The tank bottom should be flushed with water, so that all parts are covered, and then stripped. This flush should be undertaken using the main cargo pumps and lines. Alternatively, permanent pipework extending the full depth of the tank should be used. This flush should not be undertaken using the tank washing machines.
- The piping system, including cargo pumps, crossovers and discharge lines, should also be flushed with water. The flushing water should be drained to the tank designed or designated to receive slops.
- The tank should be ventilated to reduce the gas concentration of the atmosphere to 10% or less of the Lower Flammable Limit (LFL). Gas tests must be made at various levels and due consideration should be given to the possible existence of pockets of flammable gas, in particular in the vicinity of potential sources of ignition such as mechanical equipment that might generate hot spots, e.g. moving parts such as found in in-tank (submerged) cargo pump impellers.
- Tank washing may only commence once the tank atmosphere reaches 10% or less of the LFL.

During Washing:

- Atmosphere testing should be frequent and taken at various levels inside the tank during washing to monitor the change in LFL percentage.
- Consideration should be given to the possible effect of water on the efficiency of the gas measuring equipment and therefore to suspension of washing to take readings.
- Mechanical ventilation should, whenever possible, be continued during washing and to provide a free flow of air from one end of the tank to the other.
- The ability to mechanically ventilate concurrent with tank washing is recommended but, where mechanical ventilation is not possible, the monitoring of the tank atmosphere should be more frequent as the likelihood of rapid gas build-up is increased.
- The tank atmosphere should be maintained at a level not exceeding 35% LFL. Should the gas level reach 35% LFL at any measured location within a tank, tank washing operations in that individual tank **MUST** immediately cease.
- Washing may be resumed when continued ventilation has reduced and is able to maintain the gas concentration at 10% or less of the LFL.
- If the tank has a venting system that is common to other tanks, the tank must be isolated to prevent ingress of gas from other tanks.

To Control the 'Sources of Ignition' in the Tank

- a) Individual tank washing machines should not have a throughput greater than 60 m³/h.
- b) The total water throughput per cargo tank should be kept as low as practicable and must not exceed 180 m³/hr.
- c) Different washing methods give rise to differing risks and the following should be followed for tank washing in non-inert conditions:
 - Recirculated wash water **MUST NOT** be used.
 - Heated wash water may be utilised, but use should be discontinued if the gas concentration reaches 35% of the LFL. A hot wash for a low flashpoint product should **ONLY** take place following a full (i.e. top to bottom) cold wash cycle.
 - If the hot wash water temperature is above 60°C, monitoring of the gas concentration level should be at an increased frequency.
 - Chemical additives may only be considered if the temperature of the wash water **DOES NOT** exceed 60°C.
 - Steam must never be injected into the tank when tank washing in non-inert conditions and **MUST NOT** be considered until the tank has been verified as gas free (see Section 3.1.2 and Definitions).
- d) The tank should be kept drained during washing. Washing should be stopped to clear any build-up of wash water.
- e) At all times, the discharge into the wash water reception/slop tank should be below the liquid level in that tank.
- f) If portable washing machines are used, all hose connections should be made up and tested for electrical continuity before the washing machine is introduced into the tank.

Portable washing machines should not be introduced into the tank until the LFL level is 10% or less.

Connections should not be broken until after the machine has been removed from the tank. To drain the hose, a coupling may be partially opened (but not broken) and then re-tightened before the machine is removed.

- g) The introduction of sounding rods and other equipment into the tank should be made utilising a full depth sounding pipe. If a full depth sounding pipe is not fitted, it is essential that any metallic components of the sounding rod or other equipment are bonded and securely earthed to the ship before introduction into the tank, and remain earthed until removed.

This precaution should be observed during washing and for five hours thereafter to allow sufficient time for any mist carrying a static charge to dissipate. If, however, the tank is continuously mechanically ventilated after washing, this period can be reduced to one hour. During this period:

- An interface detector of metallic construction may be used if earthed to the ship by means of a clamp or bolted metal connection.

- A metal rod may be used on the end of a metal tape if earthed to the ship by means of a clamp or bolted metal connection.
 - A metal sounding rod suspended on a fibre rope should **NOT** be used, even if the end at deck level is fastened to the ship because the rope cannot be relied upon to provide an earthing path.
 - Equipment made entirely of non-metallic materials may, in general, be used, for example a wooden sounding rod may be suspended on a natural fibre rope without earthing.
 - Ropes made of synthetic polymers should **NOT** be used for lowering equipment into cargo tanks.
- h) Measures should be taken to guard against ignition from mechanical defect of machinery, e.g. in-tank (submerged) cargo pumps, tank washing machines, tank gauging equipment etc.
- i) Precautions should be taken to eliminate the risk of mechanical sparks from, for example, metallic objects such as hand tools, sounding rods, sample buckets etc being dropped into the tank.
- j) The use of non-intrinsically safe equipment, for example, torches and inspection lamps, mobile phones, communications radios, handheld computers and organisers etc should **NOT** be allowed.

11.3.6 Precautions for Tank Washing

11.3.6.1 Portable Tank Washing Machines and Hoses

The outer casing of portable machines should be of a material that will not give rise to an incendive spark on contact with the internal structure of a cargo tank.

The coupling arrangement for the hose should be such that effective bonding can be established between the tank washing machine, the hoses and the fixed tank cleaning water supply line.

Washing machines should be electrically bonded to the water hose by means of a suitable connection or external bonding wire.

When suspended within a cargo tank, machines should be supported by means of a natural fibre rope and not by means of the water supply hose.

11.3.6.2 Portable Hoses for Use with Both Fixed and Portable Tank Washing Machines

Bonding wires should be incorporated within all portable tank washing hoses to ensure electrical continuity. Couplings should be connected to the hose in such a way that effective bonding is ensured between them.

Hoses should be indelibly marked to allow identification. A record should be kept showing the date and the result of electrical continuity testing.

11.3.6.3 Testing of Tank Cleaning Hoses

All hoses supplied for tank washing machines should be tested for electrical continuity in a dry condition prior to use, and in no case should the resistance exceed 6 ohms per metre length.

11.3.6.4 Tank Cleaning Concurrently with Cargo Handling

As a general rule, tank cleaning and gas freeing should not take place concurrently with cargo handling. If for any reason this is necessary, there should be close consultation with, and agreement from, both the Terminal Representative and the port authority.

11.3.6.5 Free Fall

It is essential to avoid the free fall of water or slops into a tank. The liquid level should always be such that the discharge inlets in the slop tank are covered to a depth of at least one metre to avoid splashing. However, this is not necessary when the slop and cargo tanks are fully inerted.

11.3.6.6 Spraying of Water

The spraying of water into a tank containing a substantial quantity of static accumulator oil could result in the generation of static electricity at the liquid surface, either by agitation or by water settling. Tanks that contain static accumulator oil should always be pumped out before they are washed with water, unless the tank is kept in an inert condition. (See Section 3.3.4.)

11.3.6.7 Exclusion of Cargo Oil from the Engine Room

If any part of the tank washing system extends into the engine room, it must be blanked off as soon as tank cleaning operations have been completed to prevent cargo oil from entering the engine room.

11.3.6.8 Special Tank Cleaning Procedures

After the carriage of certain products, tanks can only be adequately cleaned by steaming or by the addition of tank cleaning chemicals or additives to the wash water.

Steaming of Tanks

Because of the hazard from static electricity, the introduction of steam into cargo tanks should not be permitted where there is a risk of a flammable atmosphere. It should be borne in mind that a non-flammable atmosphere cannot be guaranteed in all cases where steaming might be thought to be useful.

Steaming can produce mist clouds, which may be electrostatically charged. The effects and possible hazards from such clouds are similar to those described for the mists created by water washing, but levels of charging are much higher. The time required to reach

maximum charge levels is also very much less. Furthermore, although a tank may be almost free of hydrocarbon gas at the start of steaming, the heat and disturbance will often release gases, and pockets of flammability may build-up.

Steaming may only be carried out in tanks that have been either inerted or water washed and gas freed. The concentration of flammable gas should not exceed 10% of the LFL prior to steaming. Precautions should be taken to avoid the build-up of steam pressure within the tank.

Strict observance of the static electricity precautions contained in Chapter 3 is essential.

Use of Chemicals in Tank Cleaning Wash Water

Constraints on the use of chemicals in tank cleaning wash water, will depend on the type of tank atmosphere (see Section 11.3.5.2).

If tank cleaning chemicals are to be used, it is important to recognise that certain products may introduce a toxicity or flammability hazard. Personnel should be made aware of the Threshold Limit Value (TLV) of the product. Detector tubes are particularly useful for detecting the presence of specific gases and vapours in tanks. Tank cleaning chemicals capable of producing a flammable atmosphere should normally only be used when the tank has been inerted.

Use of Chemicals for Local Cleaning of Tanks

Some products may be used for the local cleaning of tank bulkheads and blind spots by hand wiping, provided the amount of tank cleaning chemical used is small and the personnel entering the tank observe all enclosed space entry requirements.

In addition to the above, any manufacturer's instructions or recommendations for the use of these products should be observed. Where these operations take place in port, local authorities may impose additional requirements.

A Material Safety Data Sheet (MSDS) for tank cleaning chemicals should be on board the ship before they are used and the advice of any precautions to be taken should be followed.

11.3.6.9 Leaded Gasoline

Whereas shore tanks may contain leaded gasoline for long periods and therefore present a hazard from Tetraethyl Lead (TEL) and Tetramethyl Lead (TML), ships' tanks normally alternate between different products and thus present very little risk. However, ships employed in the regular carriage of leaded gasoline should flush the bottom of the tanks with water after every cargo discharge.

11.3.6.10 Removal of Sludge, Scale and Sediment

Before the removal by hand of sludge, scale and sediment, the tank atmosphere must be confirmed as safe for entry, with appropriate control measures implemented to protect the safety and health of personnel entering the space. The precautions described in Section 10.9 should be maintained throughout the period of work.

Equipment to be used for further tank cleaning operations, such as the removal of solid residues or products in tanks which have been gas freed, should be so designed and constructed, and the construction materials so chosen, that no risk of ignition is introduced.

11.3.6.11 Cleaning of Contaminated Ballast Spaces

Where leakage has occurred from a cargo tank into a ballast tank, it will be necessary to clean the tank for both MARPOL compliance and to effect repairs.

This task is difficult when the contamination is due to crude or black oils and particularly difficult if it occurs in a double hull or double bottom space.

As far as possible, tank cleaning, particularly in the initial stages, should be carried out by methods other than hand hosing. Such methods may include, but not be limited to, using portable machines, the use of detergents, or washing the bottom of the tank with water and detergent. Hand hosing should only be permitted for small areas of contamination or for final cleaning. Whichever method is used, the tank washings must always be handled in accordance with MARPOL regulations.

After a machine or detergent wash, prior to entry for final hand hosing, the tank must be ventilated in accordance with the procedures referred to in Section 11.4.7, until readings at each sampling point indicate that the atmosphere meets the 'safe for entry' criteria in Chapter 10. Suitable control measures should be implemented to protect the safety and health of personnel entering the space.

11.4 Gas Freeing

11.4.1 General

It is generally recognised that gas freeing is one of the most hazardous periods of tanker operations. This is true whether gas freeing for entry, for Hot Work or for cargo quality control. The cargo vapours that are being displaced during gas freeing are highly flammable, so good planning and firm overall control are essential. The additional risk from the toxic effect of petroleum gas during this period cannot be over emphasised and must be impressed on all concerned. It is therefore essential that the greatest possible care is exercised in all operations connected with gas freeing.

11.4.2 Gas Free for Entry Without Breathing Apparatus

In order to be gas free for entry without breathing apparatus, a tank or space must be ventilated until tests confirm that the hydrocarbon gas concentration throughout the compartment is less than 1% of the LFL, that the oxygen content is 21% by volume, and that there are no hydrogen sulphide, benzene or other toxic gases present, as appropriate (see Section 10.3).

11.4.3 Procedures and Precautions

The following recommendations apply to gas freeing generally:

- A Responsible Officer must supervise all gas freeing operations.
- All personnel on board should be notified that gas freeing is about to begin.
- Appropriate 'No Smoking' regulations should be enforced.
- Instruments to be used for gas measurement should be calibrated and tested in accordance with the manufacturer's instructions before starting operations.
- Sampling lines should, in all respects, be suitable for use with, and impervious to, the gases present.
- All tank openings should be kept closed until actual ventilation of the individual compartment is about to commence.
- Venting of flammable gas should be by the ship's approved method. Where gas freeing involves the escape of gas at deck level or through hatch openings, the degree of ventilation and number of openings should be controlled to produce an exit velocity sufficient to carry the gas clear of the deck.
- Intakes of central air conditioning or mechanical ventilation systems should be adjusted, if possible, to prevent the entry of petroleum gas, by recirculating air within the spaces. (See Section 4.1.)
- If at any time it is suspected that gas is being drawn into the accommodation, central air conditioning and mechanical ventilation systems should be stopped and the intakes covered or closed.
- Window type air conditioning units which are not certified as safe for use in the presence of flammable gas, or which draw in air from outside the superstructure, must be electrically disconnected and any external vents or intakes closed.
- Gas vent riser drains should be cleared of water, rust and sediment, and any steam smothering connections tested and proved satisfactory.
- If several tanks are connected by a common venting system, each tank should be isolated to prevent the transfer of gas to or from other tanks.
- If petroleum vapours persist on deck in high concentrations, gas freeing should be stopped.
- If wind conditions cause funnel sparks to fall on deck, gas freeing should be stopped.
- Tank openings within enclosed or partially enclosed spaces, such as under forecastles or in centrecastles, should not be opened until the compartment has been sufficiently ventilated by means of openings in the tank that are outside these spaces. When the gas level within the tank has fallen to 25% of the LFL or less, openings in enclosed or partially enclosed spaces may be opened to complete the ventilation. Such enclosed or partially enclosed spaces should also be tested for gas during this subsequent ventilation.

When undertaking gas freeing in port, the following should be observed:

- As a general rule, gas freeing should not take place concurrently with cargo handling. If for any reason this is necessary, there should be close consultation with, and agreement from, both the Terminal Representative and the port authority.

- The Terminal Representative should be consulted to ascertain that conditions on the jetty do not present a hazard and to obtain agreement that operations can start.
- If craft are alongside the tanker, their personnel should also be notified and their compliance with all appropriate safety measures should be checked.

Additional considerations that apply when tanks have been inerted are given in Section 7.1.6.12.

11.4.4 Gas Testing and Measurement

In order to maintain a proper control of the tank atmosphere and to check the effectiveness of gas freeing, a number of gas measuring instruments should be available on the ship. Section 2.4 provides details of these instruments and Section 8.2 contains information on their use.

Atmosphere testing should be undertaken regularly during the gas freeing operation to monitor progress.

Tests should be made at several levels and, where the tank is subdivided by a swash bulkhead, in each compartment of the tank. In large compartments, tests should be made at widely separate positions.

On the apparent completion of gas freeing of any compartment, a period of about 10 minutes should elapse before taking final gas measurements. This allows relatively stable conditions to develop within the space.

If satisfactory gas readings are not obtained, ventilation must be resumed.

On completion of gas freeing, all openings, except the tank hatch, should be closed.

On completion of all gas freeing, the gas venting system should be carefully checked, particular attention being paid to the efficient working of the pressure/vacuum valves and any high velocity vent valves. If the valves or vent risers are fitted with devices designed to prevent the passage of flame, these should also be checked and, if necessary, cleaned.

11.4.5 Fixed Gas Freeing Equipment

Fixed gas freeing equipment may be used to gas free more than one tank simultaneously, but must not be used for this purpose if the system is being used to ventilate another tank in which washing is in progress.

Where cargo tanks are gas freed by means of one or more permanently installed blowers, all connections between the cargo tank system and the blowers should be blanked, except when the blowers are in use.

Before putting a fixed gas freeing system into service, the cargo piping system, including crossovers and discharge lines, should be flushed through with sea water and the tanks stripped. Valves on the cargo piping system, other than those required for ventilation, should then be closed and secured.

11.4.6 Portable Fans

Portable fans or blowers should only be used if they are water, hydraulically, pneumatically or steam driven. Their construction materials should be such that no hazard of incendiary sparking arises if, for any reason, the impeller touches the inside of the casing. If steam driven fans are utilised, care should be taken to ensure that the exhaust does not vent into the cargo tank, in order to prevent possible build-up of static electricity.

The capacity and penetration of portable fans should be such that the entire atmosphere of the tank on which the fan is employed can be made non-flammable in the shortest possible time.

To assist in gas freeing deep cargo tanks and tanks with deep structural members in the tank bottom, the use of extension tubes for the fans is known to be effective. Where these extension tubes incorporate synthetic materials, care should be taken to ensure that they are effectively bonded to the ship's structure.

Portable fans should be placed in such positions, and the ventilation openings so arranged, that all parts of the tank being ventilated are equally and effectively gas freed.

Ventilation outlets should generally be as remote as possible from the fans.

Portable fans should be so connected to the deck that an effective electrical bond exists between the fan and the deck.

11.4.7 Ventilating Double Hull Ballast Tanks

The complexity of the structure in double hull and double bottom tanks makes them more difficult to gas free than conventional ballast tanks. It is strongly recommended that the Company develops guidelines and procedures relating to the ventilation of each tank. An efficient method is to fill each tank with ballast water and to then empty it. Account must be taken of the stress, trim and loadline factors. However, it must be borne in mind that any hydrocarbon leaks into the tank will mean that the ballast will be dirty ballast and must be handled in accordance with MARPOL regulations. When ballasting the tank, it should not be allowed to overflow onto the deck.

Whenever possible, these guidelines and procedures should be developed in conjunction with the shipbuilder and should be based on actual tests and experiments, as well as on calculation. They should give details of the configuration of each tank, the method of ventilation and the equipment to be used. Details should also include the time required for each method of ventilation to gas free the tank for entry. This should be the time to remove all contaminants, rather than a simple volume/rate calculation.

Where portable fans are used for ventilation purposes, the above information should be provided for a range of drive pressures and different numbers of fans.

Where tanks are identical in structure and size, and where the method of venting is identical, the data can be obtained from tests on a

representative tank. Otherwise, the tests referred to above should be carried out for each tank.

Consideration should be given to using purge pipes for inerting ballast tanks, to facilitate gas freeing the remoter corners of the tanks.

11.4.8 Gas Freeing in Preparation for Hot Work

In addition to meeting the requirements of Section 11.4.2, the requirements of Chapter 9 must also be complied with.

11.5 Crude Oil Washing

11.5.1 General

A crude oil tanker fitted with an inert gas system and approved fixed washing equipment in its cargo tanks can use crude oil from the cargo as the tank washing medium. This operation may take place either in port or at sea between discharge ports. It is most frequently carried out while the tanker is discharging cargo and permits the removal of oil fractions adhering to, or deposited on, tank surfaces. These deposits, which would normally remain on board after discharge, are then discharged with the cargo. As a consequence, the need to water wash the discharged tanks during the ballast voyage for the removal of residues is much reduced and, in some cases, entirely eliminated.

Reference should be made to the IMO publication '*Crude Oil Washing Systems*' and the tanker's approved '*Operations and Equipment Manual*' for further detailed guidance on the procedures involved.

11.5.2 Advance Notice

When it is required to carry out crude oil washing (COW) during cargo discharge, the Master should inform the competent authority and the terminal (or other ship when ship-to-ship transfer is involved) at least 24 hours in advance, or in such time as is required. Crude oil washing should only proceed when their approval is received.

11.5.3 Tank Washing Machines

Only fixed tank washing machines may be used for crude oil washing.

11.5.4 Control of Tank Atmosphere

The oxygen content of the tank must not exceed 8% by volume as described in Section 7.1.6.9.

11.5.5 Precautions Against Leakage from the Washing System

Before arriving in a port where it is intended to crude oil wash, the tank washing system should be pressure tested to normal working pressure and examined for leaks.

The system should be drained down after testing to avoid the risk of leaks due to thermal expansion.

Any leaks found should be made good, after which the system should be re-tested and proved leak free.

During crude oil washing, the system must be kept under constant observation so that any leak can be detected immediately and action taken to deal with it.

When tanks for crude oil washing are being changed over, the pressure in the COW line should be reduced to a minimum before any valves on the system are opened or closed, thereby minimising the potential for damage due to surge pressure.

11.5.6 Avoidance of Oil and Water Mixtures

Mixtures of crude oil and water can produce an electrically charged mist during washing with an electrical potential considerably in excess of that produced by 'dry' crude oil. The use of 'dry' crude oil is therefore important. Before washing begins, any tank that is to be used as a source of crude oil for washing should be partly discharged to remove any water that has settled out during the voyage. The discharge of a layer at least one metre in depth is necessary for this purpose.

For the same reason, if the slop tank is to be used as a source of oil for washing, it should first be completely discharged ashore and refilled with 'dry' crude oil.

11.5.7 Isolation of the Tank Cleaning Heater

If the tank washing water heater is fitted outside the engine room, it must be blanked off during crude oil washing to prevent oil from flowing through it.

11.5.8 Control of Vapour Emissions

During crude oil washing, hydrocarbon gas is generated within the cargo tanks beyond normally existing levels. Subsequent ballasting of such cargo tanks could lead to considerable hydrocarbon gas being expelled to the atmosphere. Some port authorities prohibit such discharges. The emission of hydrocarbon gas from ballasted cargo tanks can be avoided in one of four ways:

- a) By the use of permanent ballast tanks of sufficient capacity to provide the minimum departure draught.
- b) By containing gas in empty cargo tanks by simultaneous ballasting and cargo discharge, where the ullage spaces of the tanks being ballasted are directly connected to those of the tanks being discharged.
- c) By the gas compression method. This requires that, on completion of the discharge, the tank pressure is at a minimum and all cargo tanks are made common via the inert gas line. While ballasting, the gases from the ballasted cargo tanks are transferred through the inert gas lines into all available cargo tank spaces and, with all vent valves, ullage ports etc closed, the gases are compressed within the vessel up to a safe margin below pressure/vacuum valve and breaker

settings. The pressure/vacuum valves, deck water seal and filled liquid breaker must be in good operational condition. All non-return devices must be closed to prevent the backflow of inert gas into the inert gas plant.

d) By a suitable combination of any of these methods.

Generally, the ullage spaces of all cargo tanks are connected by the inert gas main line. If the ballasting of dirty tanks can be commenced while discharge continues from other tanks, judicious adjustments of ballast and discharge rates can prevent the gas pressure rising sufficiently to cause a discharge to the atmosphere. Where the ballast rate exceeds the discharge rate, it may be necessary to reduce or even temporarily stop the flow of inert gas to the tank system.

11.5.9 Supervision

The person in charge of crude oil washing operations must be suitably qualified in accordance with the requirements laid down by the flag administration of the ship and any port regulations that may be in force locally.

11.5.10 Cautionary Notice

A notice should be prominently displayed in the cargo and engine control rooms, on the bridge and on the notice boards of ships that have crude oil washing systems fitted. The following text is suggested:

**THE TANK WASHING LINES ON THIS SHIP MAY CONTAIN
CRUDE OIL.**

**VALVES MUST NOT BE OPERATED BY UNAUTHORISED
PERSONNEL.**

11.6 Ballast Operations

11.6.1 Introduction

This Section addresses routine ballast operations for both segregated ballast tankers and pre-MARPOL tankers. Additionally, it applies to tankers with Segregated Ballast Tanks (SBT) when taking extra ballast in cargo tanks as storm ballast, or to meet air draught restrictions for navigational purposes.

11.6.2 General

Before ballasting or deballasting in port, the operation should be discussed and agreed in writing between the Responsible Officer and the Terminal Representative.

The specific agreement of the Terminal Representative must be obtained before the simultaneous handling of cargo and non-segregated ballast takes place.

Ballast must be loaded and discharged in such a way as to avoid the ship's hull being subjected to excessive stress at any time during the operation.

11.6.3 Loading Cargo Tank Ballast

When loading ballast into cargo tanks, the following precautions should be observed:

- Before taking ballast into tanks containing hydrocarbon vapour, the Responsible Officer should consult with the Terminal Representative and all safety checks and precautions applicable to the loading of volatile petroleum must be observed. Closed loading procedures should be followed.
- On crude oil tankers, any tank to be ballasted should be crude oil washed beforehand.
- When taking ballast into cargo tanks that contain hydrocarbon vapour, gas is expelled which may be within the flammable range on mixing with air. This gas should therefore be vented through the recognised venting system.
- When taking ballast into tanks that previously contained cargoes that required closed operations, the ballast should also be loaded 'closed' by following the procedures in Section 11.1.6.6.
- Ballast should not be loaded over the top (overall) into tanks containing hydrocarbon vapour.
- The guidance given in Section 11.1.3 should be followed when operating ballast tank valves.

11.6.3.1 Operation of Cargo Pumps

When starting to ballast, cargo pumps should be operated so that no oil is allowed to escape over board when the sea suction valve is opened. Reference should be made to the ICS/OCIMF publication '*Prevention of Oil Spillages Through Cargo Pumproom Sea Valves*'.

11.6.3.2 Sequence of Valve Operations

The following procedures should be adopted when loading ballast into a non-inerted tank that contains hydrocarbon vapour:

- The tank valve should be the first valve opened and the sea valve should be the last.
- The initial flow of ballast should be restricted at the pump discharge, so that the entrance velocity into the tank is less than 1 metre/second until the longitudinals are covered or, if there are no longitudinals, until the depth of the ballast in the tank is at least 1.5 metres.

These precautions are required to avoid the spraying effect that may lead to a build-up of an electrostatic charge in a mist or spray cloud near the point where the ballast enters the tank (see Chapter 3). When a sufficient charge exists, there is always the possibility of a static discharge and ignition.

11.6.4 Loading Segregated Ballast

In general, there are no restrictions on ballasting Segregated Ballast Tanks (SBT) during the cargo discharge operation. However, the following considerations should be taken into account:

- Ballast should be taken as necessary to meet air draught requirements on the berth, particularly when hard cargo arms are connected.
- Ballast should not be loaded if it may cause the ship to exceed the maximum safe draught for the berth.
- Loading of ballast should not cause extreme shear forces or bending moments on the ship.
- Care should be taken to ensure that excessive free surface is not allowed to occur as this may result in the ship assuming an angle of loll, thereby jeopardising the integrity of the loading arms. This is particularly relevant to double hull tankers (see also Section 11.2).

11.6.5 Deballasting in Port

11.6.5.1 Oil Content Monitoring

The use of an oil content monitor for monitoring the discharge of clean or segregated ballast will give an early warning of any undiscovered contaminated ballast caused by, for example, inter-tank leakage when loading and deballasting are being carried out simultaneously.

11.6.5.2 Deballasting of a Ship Fitted with an Inert Gas System

Ships fitted with an inert gas system must replace the ballast discharged from cargo tanks with inert gas, so as to maintain the oxygen content of the tank atmosphere at not more than 8% by volume.

11.6.6 Discharging Segregated Ballast

To avoid pollution due to contaminated segregated ballast, the surface of the ballast should be sighted, where possible, prior to commencing deballasting. When segregated ballast is being discharged, it is prudent to monitor the ballast being discharged over board by means of a ballast water monitor. This may give the earliest warning of any inter-tank leakage between cargo and ballast tanks that may have been undetected, or even have been undetectable, before starting the ballast operation. As an additional precaution, on commencement of deballasting, a visual watch should be established to observe the ballast as it discharges into the sea. The operation should be stopped immediately in the event of contamination being observed.

11.6.6.1 Air Draught Management

Ballast carried in segregated tanks may be retained on board in order to reduce the freeboard. This may be necessary because of weather conditions or to keep within the restrictions of the terminal metal loading arms or shore gangway for example. Care must be taken, however, not to exceed the maximum draught for

the berth and to include the ballast weights in the hull stress calculations.

11.6.6.2 Discharging Segregated Ballast to Shore

Some terminals require that segregated ballast is discharged into shore tanks to meet environmental restrictions. On tankers with segregated ballast, this requires the cross-connection of the cargo and ballast systems, with the attendant risk of contamination between the systems unless a deck manifold for ballast is fitted.

Operators should produce carefully considered procedures for managing this operation, which should address the following issues:

- Fitting of cross-connection.
- Loading and deballasting sequence.
- Draught and air draught requirements.
- Hull stress management.
- Cargo line setting procedure.
- Cargo pump operation.
- Segregation of ballast and cargo.
- Ballast tank draining.
- Removal of cross-connection and isolation of the systems.

11.6.7 Ballast Water Exchange at Sea

The 2004 International Convention for the Control and Management of Ships' Ballast Water and Sediments has been adopted by IMO to prevent the spread of harmful aquatic organisms carried by ships' ballast water. Upon entry into force, this Convention will require all ships to implement a Ballast Water and Sediments Management Plan. Some countries have introduced specific requirements for ballast water management and reporting, within their national limits, prior to the Convention coming into force. Where ballast water exchange at sea is the method of compliance with regulations, the overall design, strength and stability of the ship should be sufficient to permit its safe execution in the weather conditions prevailing. Emptying and filling of tanks at sea, if not carefully managed, may lead to reduced stability, high stresses, sloshing, or excessive trim and reduced draughts. The ship's Ballast Water Management Plan should set out the procedures to be followed, and precautions to be taken, to allow this operation to be conducted safely.

11.6.8 Discharging Cargo Tank Ballast at Sea

All cargo tank ballast discharged at sea must be discharged in accordance with MARPOL.

11.7 Cargo Leakage into Double Hull Tanks

11.7.1 Action to be Taken

This Section addresses the actions to be taken in the event of a leak of hydrocarbons into a double hull or double bottom tank.

If a hydrocarbon leak is discovered, the first step should be to check the atmosphere in the tank to establish the hydrocarbon content. It should be noted that the atmosphere in the tank could be above the Upper Flammable Limit (UFL), within the flammable range, or below the Lower Flammable Limit (LFL). Regardless of the number of samples taken, any or all of these conditions may exist in different locations within the tank, due to the complexity of the structure. It is therefore essential that gas readings are taken at different levels, at as many points as possible, in order to establish the profile of the tank atmosphere.

If hydrocarbon gas is detected in a tank, there are a number of options which can be considered to maintain the tank atmosphere in a safe condition:

- Continuous ventilation of the tank.
- Inerting the tank.
- Filling or partially filling the tank with ballast.
- Securing the tank with flame screens in place at the vents.
- A combination of the above.

The option chosen will depend upon a number of factors, especially the degree of confidence in the hydrocarbon content of the atmosphere, bearing in mind the potential problems identified above.

It is strongly recommended that operators develop guidelines, taking into account the tank structure and any limitations of the available atmosphere monitoring system, which will assist ship's personnel to select the appropriate method of rendering the atmosphere safe.

Filling or partially filling the tank with ballast in order to render the atmosphere safe and/or stop any further leakage of cargo into the tank must take into account prevailing stress, trim, stability and loadline factors. It must also be borne in mind that all ballast loaded into a tank after a leak has been found, and all tank washings associated with cleaning the tank, will be classed as 'dirty ballast' as defined by the MARPOL regulations and must be processed in accordance with those regulations. This means that they must either be transferred directly to a cargo or slop tank for further processing in accordance with the requirements or, if discharged directly to sea, passed via the oil content monitor. The spool piece used to connect the ballast system to the cargo system should be clearly identified and stowed close to its working position and it should not be used for any other purpose.

If the tank is ventilated or inerted in lieu of filling, it should be sounded regularly to ascertain the rate of liquid build-up and thus of leakage.

If the quantity of cargo leaking into the space is determined to be pumpable, it should be transferred to another cargo tank via the emergency ballast/cargo spool piece connection (see above), or other emergency transfer method, in order to minimise contamination of the space and to facilitate subsequent cleaning and gas freeing operations.

Ships should have written procedures available on board which indicate the actions to be taken and the operations necessary for the safe transfer of the cargo.

Entry into the tank should be prohibited until it is safe for entry and there is no further possibility of hydrocarbon ingress. However, if it is deemed essential to enter the tank for any reason, such entry must be carried out in accordance with Section 10.7.

11.7.2 Inerting Double Hull Tanks

The complexity of the structure in double hull and double bottom tanks makes them more difficult to inert than conventional tanks. It is strongly recommended that the operator use these guidelines as a basis for developing procedures (similar to the guidelines and procedures mentioned in 11.4.7) relating to the inerting of such tanks. Whenever possible, these procedures should be developed in conjunction with the shipbuilder and should be based on actual tests/experiments as well as on calculation. They should describe for each tank the procedures to be followed, the equipment to be used and its configuration, and the time required to reduce the oxygen level in the tank to less than 8% by volume.

Where tanks are identical in structure and size, and where the method of inerting is identical, the data can be obtained from tests on a representative tank. Otherwise, the tests referred to above should be carried out for each tank.

The introduction of inert gas into a tank may give rise to electrostatic charging. The compartmentalised structure of the tanks means that this charge is unlikely to reach incendive levels. However, because there may be a flammable atmosphere in certain areas within the tank (see Section 11.7.1) it is essential that all electrostatic precautions detailed in Sections 3.2 and 7.1.6.8 are complied with throughout the inerting process and for 30 minutes thereafter.

Flexible hoses used for inerting double hull tanks should be clearly identified, be dedicated solely to this use and be stowed safely and correctly. The hose string should be electrically continuous, and this should be verified prior to putting hoses into service. It should be confirmed that the string is properly earthed before inerting commences.

In order to minimise the transfer of hydrocarbon vapour from cargo tanks, all cargo tank inert gas supply valves, where fitted, should be temporarily closed. Prior to connecting the hoses, the inert gas line should be purged with inert gas. The hoses should not be connected until required.

Once the tank has been inerted, consideration should be given to the benefits of keeping it permanently connected to the inert gas system (constant pressure monitoring, over-pressure protection via the deck water breaker, ease of topping-up, for example) against any potential problems of vapour transfer (vulnerability of the hose to heavy seas, for example). If the hoses remain connected, then all the cargo tank inert gas inlet valves must be re-opened. If the hoses are disconnected, the inert gas system must be returned to its original status. If leaked oil is to be transferred from a ballast space which has been inerted, it is important to ensure that further inerting is carried out during the operation in order to avoid the introduction of oxygen into the tank.

Once inerted, the tank should be kept topped-up as necessary to ensure that a positive pressure is maintained and the oxygen content does not exceed 8% by volume.

The exhaust vapour from the tank during inerting should be ventilated through an opening at least 2 metres above the deck. Portable standpipes should be used where necessary.

Double hull tanks are not usually fitted with devices such as P/V valves which allow a positive pressure to be maintained in the tank. The guidelines and procedures referred to above and in Section 11.4.7 should address the sealing of openings that might let air into the tank and the method for ensuring that the tank cannot be over-pressurised.

The progress of inerting can be monitored by measuring the oxygen content of the exhaust vapour. However, atmosphere measurements to determine when the tank is fully inert, and subsequent monitoring measurements, must be taken at all designated sampling points and with the inert gas supply stopped.

11.8 Cargo Measurement, Ullaging, Dipping and Sampling

11.8.1 General

Depending on the toxicity and/or volatility of the cargo, it may be necessary to prevent or minimise the release of vapour from the cargo tank ullage space during measurement and sampling operations.

Wherever possible, this should be achieved by the use of closed gauging and sampling equipment.

There are circumstances where it is considered essential to obtain clean samples for quality purposes, such as for high specification aviation fuels. The use of closed sampling equipment may cause cross-contamination of product samples and, where this is the case, the terminal operator may wish to undertake open sampling. A risk assessment should be carried out to ascertain whether open sampling can be achieved safely, taking into account the product volatility and toxicity. Risk mitigation measures, including the use of appropriate personal protective equipment if necessary, should be put in place before starting the operation.

Closed gauging or sampling should be undertaken using the fixed gauging system or by using portable equipment passed through a vapour lock. Such equipment will enable ullages, temperatures, water cuts and interface measurements to be obtained with a minimum of cargo vapours being released. This portable equipment, passed through vapour locks, is sometimes referred to as 'restricted gauging equipment'.

When it is not possible to undertake closed gauging and/or sampling operations, open gauging will need to be employed. This will involve the use of equipment passed into the tank via an ullage or sampling port or a sounding pipe, and personnel may therefore be exposed to concentrations of cargo vapour.

As cargo compartments may be in a pressurised condition, the opening of vapour lock valves, ullage ports or covers and the controlled release of any pressure should only be undertaken by authorised personnel.

When measuring or sampling, care must be taken to avoid inhaling gas. Personnel should therefore keep their heads well away from the issuing gas and stand at right angles to the direction of the wind. Standing immediately upwind of the ullage port might create a back eddy of vapour towards the operator. In addition, depending on the nature of the cargo being handled, consideration may have to be given to the use of appropriate respiratory protective equipment (see Sections 10.8 and 11.8.4).

When open gauging procedures are being employed, the tank opening should only be uncovered long enough to complete the operation.

11.8.2 Measuring and Sampling Non-Inerted Tanks

11.8.2.1 General

There is a possibility of electrostatic discharges whenever equipment is lowered into non-inerted cargo tanks. The discharges may come from charges on the equipment itself or from charges already present in the tank, such as in the liquid contents, on water or oil mists. If there is any possibility of the presence of a flammable mixture of hydrocarbon gas and air mixture, precautions must be taken to avoid incendive discharges throughout the system.

Precautions are necessary to deal with two distinct types of hazard:

- The introduction of equipment that may act as a spark promoter into a tank that already contains charged materials.
- The introduction of a charged object into a tank.

Each requires different mitigation measures.

Table 11.2 provides a summary of the precautions to be taken against electrostatic hazards when ullaging and sampling non-inerted cargo tanks.

11.8.2.2 Introduction of Equipment into a Tank

Measures to Avoid Introducing Spark Promoters

If any form of dipping, ullaging or sampling equipment is used in a possibly flammable atmosphere where an electrostatic hazard exists or can be created, precautions should be taken to ensure that they do not act as an unearthed conductor at any time during the operation. Metallic components of any equipment to be lowered into a tank should be securely bonded together and to the tank before the sampling device is introduced, and should remain earthed until after removal. Bonding and earthing cables should be metallic.

Equipment should be designed to facilitate earthing. For example, the frame holding the wheel on which a metal measuring tape is wound should be provided with a threaded stud to which a sturdy

Cargo tank operation when hazard can occur	Lowering of equipment with ropes or tapes of synthetic material	Loading clean oils	Tank washing
Electrostatic hazard [Chapter 3]	Rubbing together of synthetic polymers [Sections 11.8.2.2]	Flow of static accumulator liquids [Sections 11.1.7 & 11.8.2.3]	Water mist droplets [Section 3.3.4 & 11.8.2.5]
<p>Precautions necessary For dipping, ullaging and sampling with:</p> <p>(i) metallic equipment not earthed or bonded:</p> <p>(ii) metallic equipment which is earthed and bonded from before introduction until after removal:</p> <p>(iii) non-conducting equipment with no metallic parts:</p>	<p>[Sections 11.8.2.3 & 11.3.5.2 g)]</p> <p>Do not use ropes or tapes made of synthetic materials for lowering into cargo tanks at any time</p> <p>"</p> <p>"</p>	<p>[Section 11.8.2.3]</p> <p>Not permitted at any time</p> <p>Not permitted during loading and for 30 minutes thereafter</p> <p>No restrictions</p>	<p>[Sections 11.3.5.2 g) & 11.8.2.5]</p> <p>Not permitted during washing and for 5 hours thereafter</p> <p>No restrictions</p> <p>No restrictions</p>
Exceptions permitted if:	"	Sounding pipe is used	<p>a) Sounding pipe is used or</p> <p>b) Tank is continuously mechanically ventilated, when 5 hours can be reduced to 1 hour</p>

Table 11.2 – Summary of precautions against electrostatic hazards when ullaging and sampling non-inerted tanks

bonding cable is bolted. The stud should have electrical continuity through the frame to the metal measuring tape. The other end of the bonding cable should terminate in a spring-loaded clamp suitable for attachment to the rim of an ullage opening.

Those responsible for the supply of non-conductive and intermediate conductive equipment to ships must be satisfied that the equipment will not act as spark promoters. It is essential that non-conducting components do not lead to the insulation of any metal components from earth. For example, if a plastic sample bottle holder includes a metallic weight, the weight must be bonded as described above or fully encapsulated in a minimum of 10 mm thick plastic.

Measures to Avoid Introducing Charged Objects

The suitability of equipment made wholly of non-metallic components depends upon the volume and surface resistance of the materials employed and their manner of use. Non-conducting and intermediate conducting materials may be acceptable in some circumstances, for example plastic sample bottle holders can be lowered safely with natural fibre (intermediate conductivity) rope. Natural fibre rope should be used because synthetic rope generates significant static charge when sliding rapidly through an operator's gloved hand. This type of apparatus needs no special bonding or earthing.

A material of intermediate conductivity, such as wood or natural fibre, generally has sufficient conductivity as a result of water absorption to avoid the accumulation of electrostatic charge. At the same time, the conductivity of these materials is low enough to ensure that instantaneous release of a charge is not possible. There should be a leakage path to earth from such materials, so that they are not totally insulated, but this need not have the very low resistance normally provided for the bonding and earthing of metals. In practice, such a path usually occurs naturally on ships, either by direct contact with the ship or by indirect contact through the operator of the equipment.

11.8.2.3 Static Accumulator Oils

It is prudent to assume that the surface of a non-conducting liquid (static accumulator) may be charged and at a high potential during and immediately after loading. Metallic dipping, ullaging and sampling equipment should be bonded and earthed to avoid sparks. There remains, however, the possibility of a brush discharge between the equipment and the charged liquid surface as the two approach each other. Since such discharges can be incendiary, no dipping, ullaging or sampling with metallic equipment should take place while a static accumulator is being loaded, due to the possibility of the presence of a flammable gas mixture.

There should be a delay of 30 minutes (settling time) after the completion of loading of each tank before commencing these operations. This is to allow the settling of gas bubbles, water or particulate matter in the liquid and the dissipation of any electrical potential.

The situations in which these restrictions on the use of metallic equipment should be applied are summarised in Figure 11.5.

Non-Metallic Equipment

Discharges between the surface of a static accumulator oil and non-metallic objects have not in practice been found to be incendiary. Dipping, ullaging or sampling with non-metallic equipment lowered on clean natural fibre line is therefore permissible at any time.

Section 3.2.1 should be referred to regarding the use of non-metallic sampling containers.

Sounding Pipes

Operations carried out through sounding pipes are permissible at any time, because it is not possible for any significant charge to accumulate on the surface of the liquid within a correctly designed and installed sounding pipe. A sounding pipe is defined as a conducting pipe which extends the full depth of the tank and which is effectively bonded and earthed to the tank structure at its extremities. The pipe should be slotted in order to prevent any pressure differential between the inside of the pipe and the tank and to ensure that true level indications are obtained.

The electrostatic field strength within a metal sounding pipe is always low due to the small volume and to shielding from the rest

of the tank. Dipping, ullaging and sampling within a metal sounding pipe are therefore permissible at any time, provided that any metallic equipment is properly earthed. Non-metallic equipment may also be used in sounding pipes, although the precautions against introducing charged objects must be applied.

11.8.2.4 Static Non-Accumulator Oils

The possibility exists of a flammable atmosphere being present above a static non-accumulator oil in a non-inerted or non-gas free environment and therefore the precautions summarised in Section 11.8.2 and Figure 11.5 should be followed.

11.8.2.5 Ullaging and Dipping in the Presence of Water Mists

When tank washing operations are performed, it is essential that there should be no unearthed metallic conductor in the tank, and that none should be introduced while the charged mist persists, i.e. during washing and for 5 hours after the completion of the operation. Earthed and bonded metallic equipment can be used at any time because any discharges to the water mist take the form of a non-incendive corona. The equipment can contain or consist entirely of non-metallic components. Both intermediate conductors and non-conductors are acceptable, although the use of polypropylene ropes, for example, should be avoided. (See Section 3.3.4.)

It is absolutely essential, however, that all metallic components are securely earthed. If there is any doubt about earthing, the operation should not be permitted.

Ullaging and dipping operations carried out via a full-depth sounding pipe are safe at any time in the presence of a wash water mist.

11.8.3 Measuring and Sampling Inerted Tanks

Ships fitted with inert gas systems will have closed gauging systems for taking measurements during cargo operations. In addition, many ships will be provided with vapour locks to enable closed gauging and sampling to be undertaken for custody transfer purposes.

Ships equipped with a vapour lock on each cargo tank can measure and sample cargo without reducing the inert gas pressure. In many cases, the vapour locks are used in conjunction with specially adapted measurement devices, including sonic tapes, samplers and temperature tapes. When using the equipment, the valves of the vapour lock should not be opened until the instrument is properly attached to the standpipe. Care should be taken to ensure that there is no blow-back of vapour.

Sonic tapes, temperature tapes etc must be used in accordance with good safety practices and the manufacturer's instructions. The requirements for portable electrical equipment apply to these measurement devices (see Section 4.3).

On ships that are not equipped with vapour locks, special precautions need to be taken for the open measurement and sampling of cargo

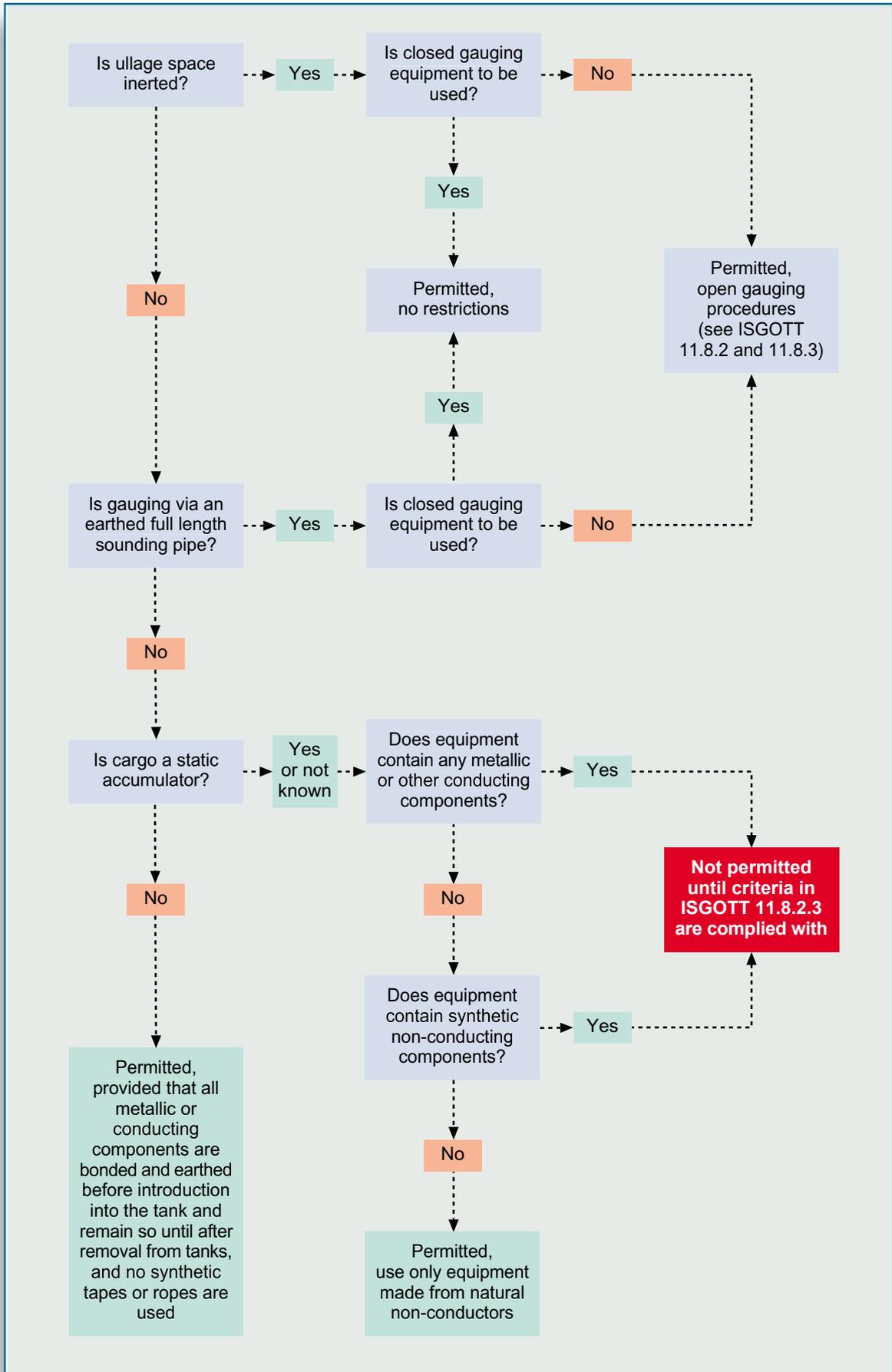


Figure 11.5 – Precautions required when using portable measuring and sampling equipment

carried in tanks which are inerted. When it is necessary to reduce the pressure in any tank for the purposes of measuring and sampling, the following precautions should be taken:

- A minimum positive inert gas pressure should be maintained during measurement and sampling. The low oxygen content of inert gas can rapidly cause asphyxiation and therefore care should be taken to avoid standing in the path of vented gas during measurement and sampling (see Section 11.8.1). No cargo or ballast operations are to be permitted in cargo compartments while the inert gas pressure is reduced to allow measuring and sampling.
- Only one access point should be opened at a time and for as short a period as possible. In the intervals between the different stages of cargo measurement (e.g. between ullaging and taking temperatures) the relevant access point should be kept firmly closed.
- After completing the operation and before commencing the discharge of cargo, all openings should be secured and the cargo tanks re-pressurised with inert gas. (See Section 7.1 for the operation of the ship's inert gas system during cargo and ballast handling.)
- Measuring and sampling which require the inert gas pressure to be reduced and cargo tank access points opened should not be conducted during mooring and unmooring operations or while tugs are alongside. It should be noted that, if access points are opened while a ship is at anchor or moored in an open roadstead, any movement of the ship might result in the tanks breathing. To minimise this risk in such circumstances, care should be taken to maintain sufficient positive pressure within the tank being measured or sampled.

If it is necessary to sound the tanks when approaching the completion of discharge, the inert gas pressure can again be reduced to a minimum safe operational level to permit sounding through sighting ports or sounding pipes. Care should be taken to avoid the ingress of air or an excessive release of inert gas.

11.8.3.1 Static Accumulator Cargoes in Inerted Cargo Tanks

Precautions are not normally required against static electricity hazards in the presence of inert gas because the inert gas prevents the existence of a flammable gas mixture. However, very high electrostatic potentials are possible due to particulates in suspension in inert gas. If it is believed that a tank is no longer in an inert condition, then dipping, ullaging and sampling operations should be restricted as detailed in Sections 7.1.6.8 and 11.8.2.

Restrictions would be required in the event of a breakdown of the inert gas system during discharge:

- In the event of air ingress.
- During re-inerting of a tank after such a breakdown.
- During initial inerting of a tank containing a flammable gas mixture.

Because of the very high potential that may be carried on inert gas particulates, it should not be assumed that corona discharges arising from conducting equipment introduced into the tank will be non-incendive if the tank contains a flammable atmosphere. Therefore, no object should be introduced into such a tank until the

initially very high potential has had a chance to decay to a more tolerable level. A wait of 30 minutes after stopping the injection of inert gas is sufficient for this purpose. After 30 minutes, equipment may be introduced, subject to the same precautions as for water mists caused by washing (see Section 11.8.2.5).

11.8.4 Measuring and Sampling Cargoes Containing Toxic Substances

Special precautions need to be taken when ships carry cargoes that contain toxic substances in concentrations sufficient to be hazardous.

Loading terminals have a responsibility to advise the Master if the cargo to be loaded contains hazardous concentrations of toxic substances. Similarly, it is the responsibility of the Master to advise the receiving terminal that the cargo to be discharged contains toxic substances. This transfer of information is covered by the Ship/Shore Safety Check-List (see Section 26.3).

The ship must also advise the terminal and any other personnel, such as tank inspectors or surveyors, if the previous cargo contained toxic substances.

Ships carrying cargoes containing toxic substances should adopt closed sampling and gauging procedures if possible.

When closed gauging or sampling cannot be undertaken, tests should be made to assess the vapour concentrations in the vicinity of each open access point, in order to ensure that concentrations of vapour do not exceed the Short Term Exposure Limit (TLV-STEL) of the toxic substances that may be present. If monitoring indicates the limit could be exceeded, suitable respiratory protection should be worn. Access points should be opened only for the shortest possible time.

If effective closed operations cannot be maintained, or if concentrations of vapour are rising because of defective equipment or due to still air conditions, consideration should be given to suspending operations and closing all venting points until defects in equipment are corrected, or weather conditions change and improve gas dispersion.

Reference should be made to Section 2.3 for a description of the toxicity hazards of petroleum and its products.

11.8.5 Closed Gauging for Custody Transfer

The gauging of tanks for custody transfer purposes should be effected by the use of a closed gauging system or via vapour locks. For the ullaging system to be acceptable for this purpose, the gauging system should be described in the ship's tank calibration documentation. Corrections for datum levels, and for list and trim, should be checked and approved by the ship's classification society.

Temperatures can be taken using electronic thermometers deployed into the tank through vapour locks. Such instruments should have the appropriate approval certificates and should also be calibrated.

Samples should be obtained by the use of special sampling devices using the vapour locks.

11.9 Transfers Between Vessels

11.9.1 Ship-to-Ship Transfers

In ship-to-ship transfers, both tankers should comply fully with the safety precautions required for normal cargo operations. If the safety precautions are not being observed on either vessel, the operations must not be started or, if in progress, must be stopped.

Ship-to-ship transfers undertaken in port or at sea may be subject to approval by the port or local marine authority and certain conditions relating to the conduct of the operation may be attached to such approval.

A full description of the safety aspects of transfer operations is contained in the ICS/OCIMF publication '*Ship-to-Ship Transfer Guide (Petroleum)*'.

11.9.2 Ship-to-Barge and Barge-to-Ship Transfers

In ship-to-barge or barge-to-ship transfers of petroleum, only authorised and properly equipped barges should be used. Precautions similar to those set out for ship-to-ship cargo transfers in the ICS/OCIMF '*Ship-to-Ship Transfer Guide (Petroleum)*' should be followed. If the safety precautions are not being observed on either the barge or the tanker, the operations must not be started or, if in progress, must be stopped.

Masters of ships should be aware that barge crews might not be conversant with the '*Ship-to-Ship Transfer Guide (Petroleum)*'.

The rate of pumping from ship to barge must be controlled according to the size and nature of the receiving barge. Communications procedures must be established and maintained, particularly when the freeboard of the ship is high in relation to that of the barge.

If there is a large difference in freeboard between the ship and the barge, the barge crew must make allowance for the contents of the hose on completion of the transfer.

Arrangements should be made to release the barge in an emergency, having regard to other shipping or property in the vicinity. If the tanker is at anchor, it may be appropriate for the barge to drop anchor clear of the tanker, where it could remain secured to wait for assistance.

Barges should be cleared from the ship's side as soon as possible after they have completed the loading or discharging of volatile petroleum.

11.9.3 Ship-to-Ship Transfers Using Vapour Balancing

Specific operational guidance should be developed to address the particular hazards associated with vapour emission control activities during ship-to-ship transfer operations using vapour balancing techniques. Such transfers should only be undertaken between inerted ships and the recommendations contained in Section 7.1.6.4 should be followed.

11.9.4 Ship-to-Ship Transfers Using Terminal Facilities

Where a tanker at a berth is transferring cargo to a tanker at another berth through the shore manifolds and pipelines, the two tankers and the terminal should comply with all regulations relating to ship-to-shore transfers, including written operating arrangements and communications procedures. The co-operation of the terminal in establishing these arrangements and procedures is essential.

11.9.5 Ship-to-Ship Electric Currents

The principles for controlling arcing during ship-to-ship transfer operations are the same as in ship-to-shore operations.

In ships dedicated to ship-to-ship transfers, an insulating flange or a single non-conducting length of hose should be used in the hose string. However, when transferring static accumulator oils, it is essential that these measures are not taken by both ships, leaving an insulated conductor between them upon which an electrostatic charge could accumulate. For the same reason, when such a dedicated ship is involved in ship-to-shore cargo transfers, care should be taken to ensure that there is no insulated conductor between the ship and shore through, for example, the use of two insulating flanges on one line.

In the absence of a positive means of isolation between the ships, the electrical potential between them should be reduced as much as possible. If both have properly functioning impressed current cathodic protection systems, this is probably best achieved by leaving them running. Likewise, if one has an impressed system and the other a sacrificial system, the former should remain in operation.

However, if one of the ships is without cathodic protection, or its impressed system has broken down, consideration should be given to switching off the impressed system on the other ship well before the two ships come together.

CARRIAGE AND STORAGE OF HAZARDOUS MATERIALS

This Chapter provides guidance on the carriage and storage of hazardous materials carried on board tankers as cargo, as ship's stores or as cargo samples.

ISGOTT does not attempt to give guidance on the many hazardous chemical cargoes that may be shipped from time to time.

General guidance on the properties of such cargoes may be obtained from the *ICS Tanker Safety Guide (Chemicals)*, and *Material Safety Data Sheets (MSDS)* on specific chemicals should be obtained from the shipper. Recommendations on handling and storage, necessary for compliance with the SOLAS Convention and any national requirements, are given in the *International Maritime Dangerous Goods (IMDG) Code*.

12.1 Liquefied Gases

In addition to the general precautions for handling packaged petroleum and other flammable liquids given in Section 12.5 below, the following safeguards should be observed when handling packaged liquefied gas cargoes:

- Pressurised receptacles should be suitably protected against physical damage from other cargo, stores or equipment.
- Pressurised receptacles should not be over-stowed with other heavy goods or other items.
- Pressurised receptacles should be stowed in such a position that the safety relief device is in contact with the vapour space within the receptacle.
- Valves should be protected against any form of physical damage with a suitable protection cap in place at all times when the cylinder is not in use.
- Cylinders stowed below deck should be in compartments or holds capable of being ventilated and away from accommodation and working areas and all sources of heat.
- Oxygen cylinders should be stowed separately from flammable gas cylinders.
- Temperatures should be kept down and hold temperatures should not be permitted to rise above 50°C. Hold temperatures should be checked constantly and, if they approach this level, the following measures should be taken:
 - The storage locations should be ventilated.
 - The liquefied gas containers should be sprayed with water if loading or discharge operations are carried out in direct sunlight.

- An awning should be rigged over the hold.
- The deck should be dampened down.

12.2 Ship's Stores

12.2.1 General

Any chemical or hazardous material placed on board a ship as stores should be accompanied by a Material Safety Data Sheet (MSDS). Where an MSDS is not provided for an item taken into ship's stores, the item should be isolated and stored in accordance with guidance provided on its container or packaging. It should not be put into use until satisfactory user information is provided.

Containers and packages should be stowed closed and the storage location kept clean and tidy.

12.2.2 Paint

Paint, paint thinners and associated cleaners and hardeners should be stowed in storage locations protected by fixed fire extinguishing arrangements approved by the administration. (SOLAS II-2 Regulation 10 Section 6.3 as amended covers Spaces Containing Flammable Liquid.)

12.2.3 Chemicals

All chemicals should be stowed in a designated and dedicated storage location. Care should be taken to ensure that incompatible chemicals are stowed separately. Information on the fire-fighting medium for each chemical should be readily available from the product's MSDS.

12.2.4 Cleaning Liquids

It is preferable to use cleaning liquids that are non-toxic and non-flammable. If flammable liquids are used, they should have a high flashpoint. Highly volatile liquids, such as gasoline or naphtha, should never be used in engine and boiler rooms.

Flammable cleaning liquids should be kept in closed, unbreakable, correctly labelled containers and should be stored in a suitable compartment when not in use.

Cleaning liquids should only be used in places where ventilation is adequate, taking into consideration the volatility of the liquids being used. All such liquids should be stowed and used in compliance with the manufacturer's instructions.

Direct skin contact with, or the contamination of clothing by, cleaning liquids should be avoided.

12.2.5 Spare Gear Storage

Spare gear is not inherently hazardous. There have, however, been cases where large items of spare gear stowed on deck have broken free of their

lashings with consequent damage to the vessel and risk of injury to personnel. When stowing spare gear, the following should be borne in mind:

- It should allow safe access to, and operation of, any safety equipment.
- It should not interfere with mooring or other operations.
- It should be properly lashed, taking into account expected weather on the voyage.

12.3 Cargo and Bunker Samples

All cargo samples should be stowed securely in lockers that have access external to the accommodation. Consideration should be given to storing samples in a location protected by a fixed fire-fighting system, such as a paint locker. The number of samples retained on board should be carefully managed and, when no longer required, they should be disposed of either to a slop tank on board or to a terminal's waste oil system.

The company should have a policy that addresses the disposal of samples; the aim should be to minimise the period of retention after the relevant cargo has been discharged. Unless the company advises to the contrary, it is suggested that samples are retained for a period of three months after the cargo has been discharged.

12.4 Other Materials

12.4.1 Sawdust, Oil Absorbent Granules and Pads

The use of sawdust for cleaning up small oil spills on board ship is discouraged. If sawdust is carried on board, care should be taken to ensure that, while unused, it is stowed in a dry condition and, if possible, in a cool location. Moist sawdust is susceptible to spontaneous combustion (see Section 4.9).

When sawdust has been used to clean up a minor oil spill, the contaminated sawdust should be stowed separately, in a sealed container and in a safe location, clear of the accommodation and hazardous areas.

Any oil-impregnated absorbent granules or pads should be stowed in dedicated containers on board, clear of the accommodation and hazardous areas.

Oil-impregnated sawdust and absorbent granules should be disposed of as early as possible, either ashore or via the ship's waste incinerator.

12.4.2 Garbage

The storage locations for garbage should be carefully selected to ensure that the garbage presents no potential hazard to adjacent spaces.

Particular consideration should be given to the storage of garbage that is designated as 'special waste', such as batteries, sensors and fluorescent tubes, to ensure that only compatible materials are stowed together.

The ICS publication '*Guidelines for the Preparation of Garbage Management Plans*' provides information on how to comply with Annex V of MARPOL 73/78.

12.5 Packaged Cargoes

12.5.1 Petroleum and Other Flammable Liquids

Packaged petroleum cargoes are usually shipped in steel drums of approximately 200 litres capacity. Products transported in this manner include gasoline, kerosene, gas oils and lubricating oil.

In addition to the general safety precautions for handling bulk petroleum, the following procedures should be observed when handling packaged petroleum products.

12.5.1.1 Loading and Discharging

Packaged petroleum and other flammable liquids should not be handled during the loading of volatile petroleum in bulk, except with the express permission of both the Responsible Officer and the Terminal Representative. When handling steel drums, the loading of bulk cargo should be suspended owing to the increased risk of spark generation.

12.5.1.2 Precautions During Handling

A Responsible Officer should supervise the handling of packaged petroleum and other flammable liquids. The following precautions should be taken:

- Stevedores must comply with smoking restrictions and other safety regulations.
- When permanent hatch protection is not fitted, temporary protection should be provided to avoid the risk of sparks being caused by hoists striking the hatch coamings, hatch sides or hold ladders.
- All hoists should be of a size suitable for passing through hatches with ample clearance.
- Fibre rope slings, cargo nets, or drum hooks on wire rope or chain slings, should be used for handling loose drums.
- Goods should preferably be palletted and secured. Pallets should be lifted with pallet lifting gear with safety nets. If goods are not presented on pallets, cargo trays or fibre rope slings may be used. The use of cargo nets for packaged goods is generally to be discouraged as they are liable to cause damage to the packaging.
- Loose gas cylinders should be handled with cargo nets of a sufficiently small mesh to prevent them falling through the net. Cylinders should never be handled by the valve or protection cap. Cylinders should never be lifted on board using lifting magnets, chains, slings or strops. A cylinder trolley or other appropriate device should be used when moving cylinders, even for short distances.

- Each package should be inspected for leakage or damage before being stowed, and any found defective to an extent likely to impair safety should be rejected.
- Packages should be placed on dunnage on the deck or in the hold.
- Packages should not be dragged across the deck or hold and should not be allowed to slide or roll free.
- Cans and drums should be stowed with caps and end plugs uppermost.
- When securing the cargo, each tier should be separated by dunnage. The height to which cargo can be safely stowed should be related to the nature, size and strength of the packages. Advice should be obtained from the terminal or shipper, as appropriate.
- Sufficient suitable dunnage should be used to prevent possible damage during the voyage.
- The cargo should be properly secured to prevent any movement during the voyage.
- During darkness, adequate approved lighting should be provided over the side and in the hold.
- Empty receptacles, unless gas free, should be treated as filled receptacles.
- No materials susceptible to spontaneous combustion should be used as dunnage or stowed in the same compartment as the packages. Attention is drawn to the combustible nature of certain protective packaging, such as straw, wood shavings, bituminised paper, felts and polyurethane.
- On completion of loading or discharge and prior to closing hatches, the hold should be inspected to check that everything is in order.

12.5.2 Dangerous Goods

Dangerous goods are classified in Chapter VII of the *International Convention for the Safety of Life at Sea (SOLAS), 1974*.

The Master should only permit aboard the ship packaged dangerous goods which have been properly identified by the shipper of the goods and declared as being properly packaged, marked and labelled in compliance with the appropriate provisions of the *International Maritime Dangerous Goods (IMDG) Code*, taking into consideration, as appropriate, the IMO '*Recommendations on the Safe Transport of Dangerous Cargoes and Related Activities in Port Areas*'.

Before accepting the cargo, the Master should check that he has received adequate advice on any special properties of the cargo, on procedures for entering an enclosed compartment containing the cargo, and for dealing with any leak, spill, inhalation, skin contact or fire.

Attention is drawn to the advice for dealing with spillage or fire contained in the IMO guide '*Emergency Procedures for Ships Carrying Dangerous Goods – Group Emergency Schedules*'.

The Master should ensure that the dangerous goods loaded in the ship are properly stowed and segregated as recommended in the IMDG Code, taking into consideration, as appropriate, the IMO *'Recommendations on the Safe Transport of Dangerous Cargoes and Related Activities in Port Areas'*.

12.5.2.1 Tetraethyl Lead (TEL) and Tetramethyl Lead (TML)

These anti-knock chemicals may be carried in small quantities on tankers as packaged cargo. Extreme care is necessary when handling anti-knock compounds because of the toxic hazards arising from skin contact or vapour inhalation. Before handling packaged cargoes of TEL and TML, it is essential that the Master is advised of the nature and properties of the substance and is provided with an appropriate Material Safety Data Sheet (MSDS) issued by the product's manufacturer.

12.5.2.2 Additives (Antistatic, Inhibitors, Dyes, H₂S Knockdown)

Additives for cargoes are frequently placed on board tankers in small containers, for delivery with the cargo. In order that these products can be stowed correctly, they should be accompanied by the appropriate MSDS.

Additives are routinely added to cargoes in an activity often described as either 'dosing' or 'doping'. This is usually undertaken ashore in well controlled and defined conditions. There are, however, occasions when it is necessary for this to be performed on board tankers. This is a non-standard and potentially hazardous activity.

It is therefore preferred that doping of cargoes be carried out 'in line' or in tanks ashore rather than on board the tanker.

However, where it is necessary to dope cargoes on a tanker, a 'cargo doping plan' should be drawn up by the supplier/contractor and communicated to the Master before arrival in port. On receipt of the plan, the Master should carry out a risk assessment and satisfy himself that all relevant items have been addressed and risks reduced to as low as reasonably practicable (ALARP). These measures may require the use of additional personal protective equipment. Finally, the supplier/contractor and Master should discuss and agree on the plan for on board doping.

All parties involved in the stowage and handling of the additive shall comply with the guidelines for the product, as detailed on the MSDS.

12.5.3 Entry into Holds

Before entry into any hold which contains, or which has contained, packaged petroleum and/or other flammable liquids, all the precautions for entry into enclosed spaces should be taken (see Chapter 10).

Holds should be ventilated during all cargo handling operations. If handling operations are interrupted and hatches are closed, the atmosphere should be re-tested before resuming work.

12.5.4 Portable Electrical Equipment

The use of portable electrical equipment, other than approved air driven lamps, should be prohibited in holds or spaces containing packaged petroleum or other flammable liquids, or on deck or in spaces over or adjacent to such holds or spaces, unless the ship complies with the conditions for the use of such equipment on tankers (see Section 4.3).

12.5.5 Smothering Type Fire Extinguishing Systems

When packaged petroleum or other flammable liquids are being handled, the control valves of any smothering system in the holds should be closed and precautions taken to prevent unauthorised or accidental opening of these valves. On completion of loading or discharge operations, and after hatches have been secured, any previously isolated fixed smothering system should be returned to operational readiness.

12.5.6 Fire-Fighting Precautions

In addition to the precautions outlined in Section 24.8, at least two dry chemical fire extinguishers, together with fire hoses equipped with spray nozzles, should be ready for use while cargo handling is taking place.

12.5.7 Forecastle Spaces and Midship Stores

Packaged petroleum or other flammable liquids should not be carried in the forecastle spaces, midship stores or any other space unless such spaces have been specifically designed and classified for the purpose.

12.5.8 Deck Cargo

When drums or other receptacles are carried on deck, they should be given protection against the sea and weather, and normally be stowed only one tier high.

All packages should be stowed well clear of all deck fittings, including tank and valve controls, fire hydrants, safety equipment, steam pipes, deck lines, tank washing openings, tank vents, hatches, doorways, emergency exits and ladders. They should be provided with adequate dunnage and be properly secured to strong points on the ship's structure.

12.5.9 Barges

Barge personnel should comply with the relevant requirements of Chapter 4, particularly with regard to restrictions on smoking, naked lights and the use of cooking appliances. If alongside a tanker, they should also comply with any requirements contained in Chapter 24. During the hours of darkness, barges containing packaged petroleum or other flammable liquids should only be allowed to remain alongside a tanker if adequate safe illumination is provided and there are means of ensuring compliance with smoking restrictions and other safety requirements.

Chapter 13

HUMAN ELEMENT CONSIDERATIONS

This Chapter describes, in general terms, some basic human element considerations for providing and maintaining a safe working environment on ships.

Guidance on manning levels, training, the management of fatigue and the control of drugs and alcohol is contained in this Chapter.

13.1 Manning Levels

The *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers* (STCW) and SOLAS 74/78, as amended, requires a flag state to issue each of its ships with a minimum safe manning document, in accordance with the provisions of IMO Resolution A.890.

It is the Company's responsibility to ensure that the minimum safe manning level of each ship is maintained at all times, in accordance with the minimum safe manning document. It is the Master's responsibility to ensure that the ship does not proceed to sea unless the manning level complies with at least the statutory minimum.

At all times during the ship's stay at a terminal, a sufficient number of personnel should be present on board to deal with any emergency.

13.2 Training and Experience

The STCW Convention and its 1995 amendments establish standards of training and competence for seafarers. STCW Chapter V contains specific requirements for personnel serving on oil tankers, chemical tankers and gas carriers, which define the training and experience needed by officers, ratings and personnel involved in cargo handling, which usually includes a tanker familiarisation course. STCW also establishes minimum levels of fire-fighting training for ship's personnel, according to their duties and responsibilities, with personnel on tankers being required to complete a high level, shore based, fire-fighting training course.

Personnel on tankers require an appropriate tanker endorsement on their STCW certificates of competence.

13.3 Hours of Rest

13.3.1 Statutory Requirements

The International Labour Organization (ILO) '*Convention on Seafarers' Hours of Work and the Manning of Ships*' (ILO 180) requires ships' personnel to have sufficient hours of rest to ensure that they are 'fit for duty' and are able to carry out their duties safely. The ILO requirements, which can be enforced by Port State Control, are stricter than similar

requirements contained in the STCW Convention. ILO 180 specifies the hours of rest that must be provided within any 24 hour and 7 day period (normally 10 or 77 hours respectively). However, a collective bargaining agreement with a seafarers' trade union may allow some additional flexibility for cargo handling operations, so long as compensatory rest is provided.

ILO Convention 180 requires the ship to maintain individual records of hours of work and rest for everyone on board which must follow a standard format agreed by ILO and IMO. Given that these records are difficult to maintain manually, the International Shipping Federation has developed a computer programme (*'ISF Watchkeeper'*) which ship operators may find helpful.

The senior staff on the tanker are responsible for managing the rest periods of ship's staff in the most efficient manner. However, when complex or protracted operations are undertaken, it may be necessary to suspend operations to provide an adequate rest period for those personnel most heavily engaged in the operation.

Where intense or prolonged operations are expected, the Company should consider the provision of additional personnel if this is necessary to avoid the suspension of operations. Any additional personnel involved with the operations must be competent and familiar with the risks associated with handling petroleum.

13.3.2 Fatigue

All parties involved with ship operations should be aware of the factors that can contribute to fatigue and take appropriate measures to reduce the potential for fatigue when planning and managing the activities and working times of ship's personnel.

Guidance on fatigue mitigation and management is contained in the IMO publication *'Guidelines on Fatigue'*. However, the most effective means of preventing fatigue is to ensure compliance with seafarers' hours of rest regulations.

13.4 Drug and Alcohol Policy

13.4.1 Industry Guidelines

The international oil tanker industry has operated a voluntary drug and alcohol policy for a number of years and guidance for operators is provided in publications such as:

- *Guidelines for the Control of Drugs and Alcohol Onboard Ship* (OCIMF).
- *Drug Trafficking and Drug Abuse: Guidelines for Owners and Masters on Prevention, Detection and Recognition* (ICS).

The implementation of policies and operating procedures aimed at providing a work place with personnel unaffected by drugs and alcohol will greatly improve operational safety and employees' health.

Drug and alcohol policies should be established and be clearly communicated to all personnel.

13.4.2 Control of Alcohol

The consumption of alcohol should be controlled to ensure no person is intoxicated while on board.

The standards that are used to define intoxication are laid down in published industry guidelines, which define alcohol limits and the method of determining them.

Controls on consumption should ensure that personnel are able to carry out scheduled duties free from the effects of alcohol.

Scheduled duties include, but are not limited to, standing of a deck or engine watch, the commencement of day work for day workers, arrival at a pilot station, going to mooring stations, or any other duty (including overtime work) scheduled at a specific time.

On ships operating with an Unmanned Machinery Space (UMS), the officer on standby duty, on call to answer UMS alarms, is considered to be on duty for the purposes of alcohol control.

No person should be allowed to consume alcohol while on watch or during the performance of any shipboard duties.

The issue of alcohol on board should be carefully controlled under the guidelines set out in the Company's policy and should be monitored by the Master.

13.4.3 Drug and Alcohol Testing Programmes

To ensure that the drug and alcohol policy is effective, operators should have a programme in place to prevent the use of illegal drugs and the misuse of alcohol.

Tests may be performed for the following reasons:

- Reasonable suspicion.
- After an accident.
- Pre-employment.
- Random testing programme.

A policy for random tests should be developed by the Company in conformity with the requirements/limitations of the country of jurisdiction.

13.5 Drug Trafficking

Companies should have procedures in place to prevent their ships being used for drug trafficking. For guidance, reference should be made to the ICS publication '*Drug Trafficking and Drug Abuse: Guidance for Owners and Masters on Prevention, Detection and Recognition*'.

Procedures should require the Master to notify the ship's owner/operator immediately, and the authorities at the next port of call:

- Of any suspicious circumstances during the voyage that can be related to the trafficking of drugs or other contraband.

- If any unauthorised persons have been found in areas on board that may be used to conceal drugs or other contraband.
- If any drugs or other contraband are found aboard. When drugs are discovered, the contraband and the area where it is found should be secured to ensure minimal handling and disturbance prior to appropriate action by the authorities when the ship arrives in port.

13.6 Employment Practices

The health and welfare of seafarers, which includes the provision of decent working conditions on board ship, has direct relevance to the safe operation of tankers. Guidance can be found in the International Shipping Federation publication '*Guidelines on Good Employment Practice*'.

Chapter 14

SPECIAL SHIP TYPES

This Chapter sets out safety measures to be taken on combination carriers in addition to those necessary for conventional tankers. For the purpose of this Guide, a combination carrier is a tanker designed to carry oil or solid cargoes in bulk, and is one of two main types, an Oil/Bulk/Ore ship or an Oil/Ore ship.

Other specialised types of combination carriers, which may for example carry oil in bulk as well as containers or general cargo, are not covered.

Some LPG carriers are certified to carry other petroleum products, such as light naphtha, jet fuel and motor gasolines (mogas). Section 14.2 provides guidance relating to LPG carriers when engaged in petroleum trades.

14.1 Combination Carriers

14.1.1 General Guidance

Petroleum and dry bulk cargoes should not be carried simultaneously.

Attention should be paid to the gas contents of wing tanks when the vessel is discharging bulk ore. Similarly, it should be realised that damaged bulkheads may lead to flammable gas mixtures in ore holds.

Between cargo holds, there may be a void space through which various piping systems can pass and which provide access to tank valves and double bottom tanks.

A single duct keel may be fitted along the centre line. On some ships, two duct keels are fitted, one on either side of the centre line. Some duct keels and pipe tunnels may be fitted with wheeled trolleys on rails to permit easier access for personnel and equipment. These spaces may be fitted with fixed lighting, fixed washing systems and a fixed gas monitoring system.

Because of their restricted natural ventilation, these spaces may be oxygen deficient. Furthermore, they are adjacent to cargo holds and ballast tanks, so both hydrocarbon vapour and inert gas may leak into them. The spaces should be regularly monitored for gas concentrations. Enclosed space entry requirements given in Chapter 10 should be strictly applied. The rescue of an unconscious or injured person from these confined spaces may be extremely difficult.

14.1.2 Types of Combination Carriers

14.1.2.1 Oil/Bulk/Ore (OBO)

The OBO ship is capable of carrying its full deadweight when trading as an ore carrier with cargoes of heavy ore concentrates. This type of ship is also designed to carry other types of dry bulk cargo, such as grain or coal.

On older ships, holds are usually arranged to extend the full breadth of the ship, with upper and lower hopper tanks and double bottom tanks. In some cases, holds may have wing tanks. Oil or dry bulk cargo is carried in the holds. In addition, oil may be carried in one or more sets of upper hopper tanks, and where there are wing tanks, these may also be used. Normally wing tanks for oily slops are fitted aft of the cargo holds. Ballast may be carried in top and bottom hopper tanks and some double bottom tanks designated as segregated ballast tanks. On more modern ships, side tanks and double bottom tanks used exclusively for ballast, or as voids, surround the cargo area.

Conventional bulk carrier hatches, normally of the side rolling type, are fitted with a special sealing arrangement.

Cargo and ballast pipelines are typically installed in a duct keel or in pipe tunnels.

14.1.2.2 Oil/Ore (O/O)

These ships were designed to carry their full deadweight when trading as tankers and also when carrying heavy ore concentrates. They were not usually designed to carry light bulk cargoes. With the advent of double hull requirements for the carriage of oil, vessels of this type are no longer being built, but several remain in service.

Heavy ore concentrates are carried only in the centre holds. When in oil service, cargo may be carried in both centre holds and cargo wing tanks.

Holds are constructed so as to extend for approximately half of the total breadth of the ship. Conventional wing tanks incorporate the main strengthening sections, allowing smooth sides in the centre holds. Holds are always constructed with double bottom spaces beneath them. Hatches are generally single piece side rolling with a sealing arrangement similar to that on OBO ships.

Cargo pipelines are usually installed in the wing tanks, whilst ballast pipelines are typically installed in the double bottom tanks. Where cargo pipelines pass through ballast tanks, the possibility of pollution caused by pipeline failure should be borne in mind.

14.1.3 Slack Holds in Combination Carriers

14.1.3.1 General

Because of the broad beam and size of the holds, the very large free surface in slack holds (i.e. holds not filled to within the coaming) permits substantial movement of liquid, which can result in both loss of stability and 'sloshing'.

14.1.3.2 Loss of Stability

Particular care should be taken when loading or discharging liquid cargo on combination carriers, and when handling ballast on such ships, to ensure that the total free surface effect of cargo and ballast tanks is kept within safe limits, otherwise a sudden, and possibly violent, list could occur.

In compliance with government requirements, all combination carriers are supplied with stability data and loading and unloading instructions. These instructions should be carefully studied and followed. Generally, these instructions will specify a maximum number of cargo holds or tanks which may be slack at any one time. Sometimes, it may be necessary to adjust the quantity of cargo to be loaded in order to avoid slack holds. Where double bottom ballast tanks extend across the whole width of the ship, the free surface effect of water when these tanks are slack will be as great as that of full cargo holds and account must be taken of this fact.

Some combination carriers have a valve interlocking system that limits the number of tanks which may be loaded or discharged simultaneously. Such systems may fail or can be bypassed, and it is a requirement that a conspicuous notice is displayed at the cargo control station warning of the danger of free surface effect and stating the maximum number of holds that can safely be slack at any one time.

Before arriving in port, a plan should be prepared for the anticipated loading or discharging sequence, bearing in mind the free surface effect and distribution of all cargo, fuel and ballast at all stages of the operation.

Terminal operators should appreciate that combination carriers may be subject to loading rate limitations and to specific discharge procedures. These arise from the danger of hatch seals leaking if placed under excessive pressure, as well as from the free surface effects.

If a loss of stability becomes evident during loading or discharge, all cargo, ballast and bunker operations must cease and it is prudent to disconnect the loading arms or hoses. A plan should be prepared for restoring positive stability. If the ship is at a terminal, this plan should be agreed by the Terminal Representative.

The specific action required to restore stability will be determined by the ship's detailed stability information in relation to a particular condition.

In general, the following principles apply:

- The vertical centre of gravity must be lowered in the most effective way.
- Where slack double bottom tanks exist, these should be filled ('pressed up'), starting with those on the low side, followed by those on the high side.
- No attempt should be made to correct a list by filling compartments on the high side as this is likely to result in a violent change of list to the opposite side.
- If the pressing up of slack double bottom tanks is insufficient to regain stability, it may be necessary to consider filling empty double bottom ballast tanks. It must be recognised that this will initially result in a further loss of stability caused by the additional free surface effect. However, this will soon be corrected by the effect of the added mass below the ship's original centre of gravity.
- The restraint provided by moorings should be considered. To attempt to control a list by adjusting mooring ropes' tension could be dangerous and is therefore not recommended.

On completion of loading, the number of slack holds should be at a minimum and, in any event, not more than that specified in the stability information book.

14.1.4 Sloshing

'Sloshing' is the movement of liquid within a hold when the ship is rolling or pitching.

It can give rise to:

- Structural damage caused by the slamming effect of the liquid against the ship's side or bulkheads.
- An electrostatically charged mist in the ullage space in holds partially filled with a mixture of oil and water, such as dirty ballast or retained tank washings. This can occur with only a slight rolling motion.

In order to eliminate these problems, slack holds should be avoided wherever possible. This may be difficult when loaded with an oil cargo, but may be more readily achieved when the vessel is in ballast.

14.1.5 Longitudinal Stress

Consideration should be given to the distribution of the weights along the ship, taking account of the ship's longitudinal strength.

14.1.6 Venting of Cargo Holds

The vent lines from the cargo holds may lead to either individual vent outlets, or to a main gas line venting system which expels the hydrocarbon vapour through a riser at a safe height above the deck, or to an inert gas pipeline system.

Owing to the greater movement of liquid within the cargo hold in rough sea conditions, the possibility of liquid entering the vent line is greater than on a conventional tanker. Various trap systems may be incorporated,

such as a U-bend or a special valve, but the possibility of a blockage should always be suspected after a rough voyage. A blockage may also occur if the vessel has been in very hot weather which has caused the cargo to expand above the gas line outlet.

Drains are normally fitted in each gas line and these should be checked before commencing cargo operations, in order to ensure that the cargo hold is able to 'breathe'. These drains may become blocked, particularly during the carriage of high pour point cargoes, and gas lines should be blown through with inert gas to ensure they are clear.

During the carriage of dry bulk cargoes, the holds should be sealed from the main oil cargo pumping and gas venting systems and alternative venting systems utilised as required. Wing tanks should be maintained either in a gas free or an inert condition.

14.1.7 Inert Gas

The basic principles of inerting are the same for a combination carrier as for a tanker. However, differences in design and operation give rise to certain particular considerations for combination carriers.

It is particularly important for combination carriers to maintain their holds in an inert condition. These holds may extend to the full width of the ship and, even at small angles of roll, agitation of clean or dirty ballast in a slack hold may result in the generation of static electricity. Slack holds should be avoided whenever possible.

The cargo holds of combination carriers are adjacent to ballast and void spaces. Leakages in pipelines or ducts in these spaces, or a fracture in the boundary plating, may cause oil, inert gas or hydrocarbon gas to leak into the ballast and void spaces. Consequently, gas pockets may form which, because of the complex structure of these spaces, could be difficult to disperse. Personnel should be alerted to this hazard.

If slops are retained on board due to the lack of reception facilities, the slop tank or tanks should be maintained in an inert condition and at a minimum pressure of 100 mm WG at all times. These tanks should be checked at intervals of not more than 2 days to ensure that the oxygen level does not exceed 8% by volume. The tanks should be re-inerted if the oxygen level is found to be more than 8%.

When the ship is in a 'dry' trade, the slop tanks containing oil or oil residues should be isolated from other tanks by blank flanges which should remain in position at all times when cargoes other than oil are being carried. (See the IMO *'Guidelines for Inert Gas Systems'*.)

14.1.8 Hatch Covers

The hatches of combination carriers are much larger than on oil tankers, but are required to remain gas and liquid tight at all times when carrying oil cargoes.

Regular attention should be paid to the closing devices, for example by adjusting the tension on them evenly and by lubrication of screw threads.

When closing hatch covers, the closing devices should be evenly and progressively pulled down in the correct sequence in accordance with the manufacturer's instructions.

A positive test of the efficiency of the sealing arrangements can be carried out by pressurising the holds with inert gas and applying a soapy solution to the sealing arrangements. Any leakage is readily detectable and should be rectified by further adjustment of the closing devices in the affected area.

The cover joints should be examined for gas leakage when the compartment is loaded with liquid cargo. Any gas or liquid leaks which cannot be stopped by adjusting the closing devices should be marked or noted, so that the jointing material can be examined when the opportunity next arises and the joint made good. Additional sealing by means of tape or compound may be necessary.

The gas tightness of the hatch covers will determine the frequency with which the inert gas requires to be topped up.

Most combination carriers use synthetic rubber for the hatch seals, and this material should be examined whenever a suitable opportunity occurs. It is also advisable to carry a reasonable stock of jointing material of the correct size, in order that repairs can be carried out at sea.

The hatch covers on combination carriers generally work, i.e. they move slightly against the coaming, when the ship is in a seaway, and it is thus possible for the steel hatch cover to rub on the steel coaming or remnants of a previous dry bulk cargo. Investigations have shown that this is unlikely to provide a source of ignition. However, in order to avoid unnecessary wear on the seals and in order to ease the opening and closing of hatches, it is important to keep hatch cover runways clear of foreign matter. After donning appropriate personal protective equipment, a compressed air hose with a suitable nozzle may be used to clean the trackways of foreign matter.

Owing to the height of hatch coamings, which are partially filled on completion of loading a liquid cargo, all main deck openings into cargo holds may have to withstand a positive pressure. Therefore, it is essential that all seals and gaskets on tank cleaning covers, access hatches, trimming hatches etc, provide an oil tight and gas tight seal. The seatings should be cleaned to ensure a proper seal and all securing bolts should be hardened down prior to loading a bulk liquid cargo.

14.1.9 Tank Washing

Any tank washing is to be carried out in accordance with the guidance given in Section 11.3 when carrying oil, or when converting from oil to dry bulk cargoes.

Cargo holds should not be used as slop tanks during cleaning because of the risk of sloshing. Holds containing dirty ballast should not be discharged when the ship is rolling or pitching. Hatch covers should not be opened until the hold is gas free. All closing devices should be kept secured to prevent movement of the hatch covers.

When cargoes other than oil are to be carried, it is essential that all holds and cargo tanks, other than slop tanks, are emptied of oil and oil residues and cleaned and ventilated to such a degree that the tanks are completely gas free. They should then be inspected internally to confirm this condition. The pumproom, cargo pumps, pipelines, duct keel and other void spaces should be checked to ensure that they are free of oil and hydrocarbon gas.

Most dry bulk ports require a gas free certificate to be issued in respect of a combination carrier presenting to load or discharge dry bulk cargo. Such certificates normally relate to holds and other spaces, but will not confirm that pumps and pipelines are free from oil and/or hydrocarbon gas.

14.1.10 Carriage of Slops when Trading as a Dry Bulk Carrier

Before a combination carrier is to be operated as a dry bulk carrier, every effort should be made to ensure that any oil contained in the slop tanks is discharged ashore. After discharging the slops, the empty tanks should be cleaned and either gas freed or inerted prior to loading any dry bulk cargo.

If, however, slops cannot be discharged and have to remain on board, the following precautions should be taken:

- All slops must be collected in the slop tank specially designated for this purpose.
- Blanking plates or other approved means of closure must be fitted in all pipelines, including common vent lines leading to or from the slop tank, to ensure that the contents and atmosphere of the slop tank are isolated from other compartments.
- The slop tank should be purged with inert gas and a positive pressure maintained within the tank at all times.
- Carbon dioxide must never be used in liquid form to provide inert gas to the ullage space of the dirty slop tank because of the risk of generating an electrostatic charge.
- Unless the tank is fully inerted, the slops should be handled in such a way as to avoid a free fall of slops into the receiving tank, as this may cause a build-up of an electrostatic charge.

Unless the ship reverts to carrying oil, oil slops should not be retained on board for more than one voyage. If, however, it is impossible to remove the slops because of a lack of shore reception facilities for oily residues, the slop tank should be treated as indicated above and appropriate reports forwarded to the Company and the relevant administration.

14.1.11 Leakage into Ballast Tanks on Combination Carriers

A serious problem occurs if there is leakage of oil from the cargo holds into the ballast tanks.

On combination carriers, the known weak structural points are as follows:

- On ships with vertically corrugated transverse bulkheads, cracks may occur in the welded seams between these bulkheads and the upper hopper tanks.
- In double hulled ships, leaks may be found in the upper welded seams of the longitudinal bulkhead between ballast tanks and cargo tanks abutting the sloped deckhead of the cargo tank.

Due attention should be given to ensuring the integrity of these seams.

14.1.12 Testing of Cargo Tanks and Enclosed Spaces on Dry Bulk Voyages

Before loading a dry bulk cargo, all spaces that have previously contained oil should be cleaned, gas freed and inspected internally. Once all tank cleaning has been completed, daily checks for hydrocarbon gas should be made in all empty cargo holds, empty cargo tanks and empty double bottom and ballast tanks, as well as pumprooms, pipe ducts, cofferdams, stool tanks and similar void spaces. If no hydrocarbon gas has been detected after 14 days, the frequency of the readings may be reduced to every two days, unless the ship passes through areas with higher sea or air temperatures, in which case the daily checks should continue.

If the following voyage is to continue in dry bulk cargoes, the readings on that voyage need be taken only every three days.

If hydrocarbon gas is detected during any dry cargo voyage, the space should be ventilated with air. If the hydrocarbon gas cannot be controlled by ventilation, the space should be inerted and remain so until it can be cleaned again.

14.1.13 Cargo Changeover Check-Lists

The following check-lists are of a general nature and each ship should use them as a guide when developing its own comprehensive check-lists.

Oil to Dry Bulk Cargo

- Wash cargo holds and tanks, including access trunks.
- Flush all main suction into cargo holds and tanks and strip dry.
- Gas free all cargo holds and tanks.
- Hose off, blow through, disconnect and stow portable heating coils as required. Plug securing sockets as necessary.
- Ensure fixed heating coils are free of oil before blanking ends.
- Complete hand hosing and digging of holds and sumps to the requirements of the next cargo.
- Drain cargo holds and suction wells.
- Blank off main suction to holds as necessary. Ensure the stripping discharge line to after hold is securely blanked.
- Ensure sounding pipes to bilge wells are open and clear of obstructions.
- Fit main and stripping suction recess doors as necessary. Also fit heating coil connecting pipe recess doors.
- Wash cargo pipeline system thoroughly, including pumps, deck lines, bottom lines and pumproom.
- Ensure gauging system, where fitted, is stowed or blanked as necessary to manufacturer's recommendations.
- Drain, vent and prove gas free all gas lines and risers.
- Blank off gas lines to holds as necessary.
- Set venting system to the requirements of the next cargo.
- Check hatch cover sealing arrangements and closing devices.
- Check ballast tanks, void spaces, cofferdams and pumprooms for flammable gas. Ventilate as necessary and prove gas free.

- If slops are retained, ensure designated pipeline segregations are fitted, slop tanks are fully inerted and the relevant venting system adopted, as necessary.

Dry Bulk Cargo to Oil

- Sweep holds clean and lift cargo remains out of hold for disposal.
- Wash cargo remains off bulkheads with a high pressure water jet, stripping slowly to remove water, leaving solid residues.
- Remove solid residues from the tank top and sumps, and prove that the stripping suction is clear.
- Remove suction doors and attach securely to stowage positions.
- Close off sounding pipes to sumps as required.
- Remove blanks from main cargo suctions and stripping discharges to after hold.
- Lower and secure heating coils in place, connect and prove tight, as necessary.
- Remove requisite blanks from gauging system and render fully operational.
- Wash all stripping lines thoroughly to remove solid residues. As far as possible, test stripping valves for tightness to ensure valve seats are not damaged by solid residues.
- Open, clean and check all strainers in cargo systems.
- Check and clean hatch cover sealing arrangements, trackways etc.
- Check hatch cover sealing arrangements and closing devices.
- Remove blanks from gas lines, as necessary.
- Set venting system for next cargo.
- Prove all valves and non-return valves in cargo system are operational.
- Inert holds prior to loading. During inerting, prove tightness of hatch covers, tank cleaning covers, access hatches and all openings into cargo spaces.

14.2 LPG Carriers Carrying Petroleum Products

14.2.1 General

Some LPG carriers are certified to carry other petroleum products, for example light naphtha, jet fuel and mogas.

The ship's Certificate of Fitness will identify the cargoes that can be carried. The vessel's classification society will also have laid down carriage criteria related to maximum tonnages in each tank, maximum densities and, where applicable, sloshing limits.

Some petroleum products are also classified as Noxious Liquid Substances (NLS). In this case, special rules apply in accordance with MARPOL Annex II, including the requirement to maintain a dedicated '*Cargo Record Book for Ships Carrying NLS in Bulk*'. Such ships are also provided with a '*Procedures and Arrangements Manual*'. Benzene precautions may need to be taken, as described in Section 2.3.5.

14.2.2 Product Limitations

The Master should be provided with the correct cargo specification and full carriage and handling details in the form of an MSDS. The specification should indicate the cargo quality and, where relevant, the potential to leave residues and/or the effect on cargo tank steelwork.

The specification should give details on colour, specific gravity, olefins, residues, lead, Methyl Tertiary Butyl Ether (MTBE) contents, copper strip corrosion test and final boiling point.

Naphtha derivatives can have a severe corrosion effect on synthetic flexible hoses used in gas freeing operations. For this reason, designated metal spool pieces should be used in areas where such corrosion can occur.

Petroleum product vapour, mixed with impurities from inert gas, can corrode the synthetic internals of tank safety valves, causing them to open due to broken or seized seals. Unless proper precautions are taken, cargo tank safety valves could lift at quite low pressures once the ship has reverted to LPG carriage, with potentially serious implications in terms of safety. Therefore, extreme vigilance and regular inspections are required to ensure that the integrity of tank safety valve components has not been compromised.

Products such as low density pentane derivatives can penetrate some gaskets. On changeover to LPG, these gaskets can freeze and subsequently will fail under pressure. Only gaskets compatible with the product should be used.

14.2.3 Pre-Loading Preparations

The stripping system should be carefully inspected before loading and, where portable pumps have to be fitted, these should be tested using fresh water prior to installation. Portable pumps, if made from aluminium, should be lowered into cargo tanks inside canvas bags to prevent 'aluminium grazing' on the steelwork structures (see Section 4.6).

To protect the diaphragms of air-driven portable pumps, a positive pressure should always be maintained on the 'drive' side of the pump throughout the period of cargo carriage. This can be achieved with air or nitrogen.

The cargo compressor room should be totally isolated from the cargo system. Some ships may require the use of a compressor for inert gas cooling and, if so, additional measures must be taken in order to ensure safe operation in the vicinity of the petroleum products.

Inert gas should be dry enough to prevent water residues. This is especially important with pentane derivatives, where water mixed with the product will create a noxious liquid.

Means of preventing hydrocarbon vapour passing back to the engine room or inert gas plant must be in place. This can take the form of a deck seal or similar arrangement. It should be cleaned and all alarms and associated shutdowns tested. The setting of the cargo tank safety valve must be such as to ensure that it lifts before the deck seal arrangement safety valve.

The ship should arrive at the loading port with all tanks inerted to less than 8% oxygen by volume, at ambient temperature and with no traces of the previous cargo. If ammonia was the previous cargo, the Company should be consulted regarding the maximum allowable ammonia vapour content (ppm).

14.2.4 Loading of Pentane Plus or Naphtha

Some terminals allow the ambient temperature loading of pentane plus or naphtha into a tank containing propane or butane vapour at ambient temperature and atmospheric pressure. Before conducting such an operation, it must be ensured that there is no heel of liquefied gas present in the tank. When pentane or naphtha is admitted at the bottom of the tank, the heel of liquefied gas would almost immediately be absorbed into the incoming liquid pentane with a consequent sudden drop in vapour pressure which would give rise to a possibly dangerous decrease in cargo tank pressure.

After the heel has been removed, loading the cargo will displace the gas remaining as the tank fills. Some further absorption of gas will occur during this process. When the tank is full of liquid cargo, the gas absorbed during the loading and the small quantity of gas remaining above the cargo will, in the absence of any other components, probably reach an equilibrium and may have no apparent effect on the pressure.

However, it must be kept in mind that some terminals do not allow this practice of loading cargo into tanks containing LPG vapour.

14.2.5 Cargo Sampling

Dependent upon owner's and charterer's requirements, various cargo samples and water dips will have to be taken from the tanks prior to and during cargo operations.

Closed loading and sampling are to be carried out at all times. Ships should ensure that vapour locks are fully functional.

14.2.6 Loading, Carriage and Discharge Procedures

During loading, carriage and discharge, a positive pressure must always be maintained in the cargo tanks. Special vapour recovery requirements may apply at certain terminals.

The holds or void spaces adjacent to the cargo tanks should always be inerted during the entire carriage period.

Petroleum product vapour may, over longer voyages, condense out in the vent lines. Regular inspections should be made of drains on these lines so as to ensure that there is no liquid build-up. This is especially true with lighter gasolines.

It is possible for paraffin waxes to crystallise if the cargo tank becomes too cold. If a vessel proceeds to a very cold climate, warming the hold/void spaces with inert gas may have some effect in preventing this phenomenon.

Petroleum products are normally very close to the maximum density that cargo pumps are rated to handle. Pump motor amperes must be carefully controlled during discharge.

During discharge, the inert gas generator should be run to maintain positive pressure in the cargo tanks.

Efficient stripping is essential to maximise discharge and to reduce time for subsequent tank cleaning.

14.2.7 Tank Cleaning and Changeover Procedures

Each ship will have specific changeover procedures. Issues to be addressed may include, but may not be limited to, the following:

- Personnel protection, in conjunction with strict tank entry procedures, must be rigidly enforced. In addition to checking for hydrocarbon vapour and oxygen content, it must be remembered that other hazardous vapours, such as benzene, may be present in varying quantities.
- Proper personal protective equipment, including compressed air breathing apparatus, must be used for all cargo tank entry. Tank atmospheres should be continuously monitored for all types of gas until traces of any by-products have been brought down to acceptable limits.
- Vapour and vent lines must be carefully inspected, because vapour from clean petroleum products is known to condense out and some liquids, such as kerosene, can take a considerable time to evaporate. This could pose serious problems later on, specifically in regard to future Hot Work or cargo contamination.
- Petroleum products liquid can sometimes remain trapped inside cargo pump chambers. Cargo pumps should be inspected and, if necessary, chambers should be drained.
- Diligent ventilation of smaller lines, especially stripping systems, is vital in order to ensure there is no future cargo contamination.

PART 3

TERMINAL INFORMATION

TERMINAL MANAGEMENT AND ORGANISATION

This Chapter describes the risk based systems and processes that should be in place to ensure the safe and efficient operation of the terminal. It covers the need for full supporting documentation, for example operating manuals, drawings and maintenance records for the facility and its equipment, copies of relevant legislation, and codes of practice. It also deals with the need for a clear, documented definition of the requirements for ship and berth compatibility.

Terminal manning is discussed with regard to ensuring effective supervision of operations and activities at the ship/shore interface.

15.1 Compliance

Terminals should comply with all applicable international, national and local regulations, and with company policy and procedures. Where a self-regulatory regime exists, terminals should meet the spirit and intent of any applicable codes and the guidelines for their implementation.

Terminal management should provide a healthy and safe working environment and ensure that all operations are conducted with minimum effect on the environment whilst complying with the regulatory system in force and recognised industry codes of practice. In this regard, reference should be made to the guidance contained in the OCIMF publication '*Marine Terminal Baseline Criteria and Assessment Questionnaire*'.

Terminals should maintain current copies of regulations and guidelines applicable to their operations (see Section 15.7).

Terminals should seek assurance that ships visiting their berths comply with applicable international, national and local marine regulations.

Terminals should have a management system in place, which is able to demonstrate and document proof of compliance with regulatory requirements and company policy and procedures. Terminal management should designate a person to be responsible for ensuring compliance with the regulations, company policy and procedures.

15.2 Hazard Identification and Risk Management

Terminals should have formal risk management processes in place, which demonstrate how hazards are identified and quantified, and how the associated risk is assessed and managed. This will usually be achieved by the use of a Permit to Work system (see Section 19.1.3).

The risk management should include formal risk assessments, which address any changes in design, manning or operation, and should follow on from the design case risk assessment for the facility. Risk assessments should be structured in order to identify potential hazards, assess the probability of occurrence, and determine the potential consequences of the event. The output of the risk assessment should provide recommendations on prevention, mitigation and recovery. Risk assessments should be undertaken as part of the process when modifications to the terminal equipment and facilities are proposed. They should also be carried out as part of the safety management process that is used to permit the conduct of operations whose scope is not covered in the current operational procedures.

Marine terminals should conduct reviews, typically annually, of their facilities and operations to identify potential hazards and the associated risks, which may demonstrate the need for additional or revised risk assessments. Reviews should also be carried out when there are changes to the terminal facilities or operations, for example, changes in equipment, organisation, the product being handled, or the type of ships visiting the terminal.

Terminal operating procedures should provide documentation and processes for ensuring the effective management and control of identified risks.

Records of all reviews and assessments should be kept.

15.3 Operating Manual

Terminals should have a written, comprehensive and up to date Terminal Operating Manual.

The Terminal Operating Manual is a working document and should include procedures, practices and drawings relevant to the specific terminal. The Manual should be available in the accepted working language to all appropriate personnel.

The Terminal Operating Manual should define the roles and responsibilities of the berth operating personnel and the procedures associated with emergencies such as fire, product spillage or medical emergency. A separate emergency response manual should be provided to cover such topics as emergency call out procedures and interaction with local authorities, municipal emergency response organisations, or other outside agencies and organisations. (See Chapter 20 for more detailed guidance on emergency planning and response.)

Terminals should also have a documented management of change process for handling temporary deviations and for making permanent changes to the procedures in the operating manual. It should define the level of approval required for such deviations and changes to a prescribed procedure.

15.4 Terminal Information and Port Regulations

Terminals should have procedures in place to manage the exchange of information between the ship and the terminal, before the ship berths. This will ensure the safe and timely arrival of the ship at the berth, with both parties ready to commence operations.

Detailed information on communications at the ship/shore interface is given in Chapter 22. Reference should also be made to Chapter 6 for information on security at the ship/shore interface.

15.5 Supervision and Control

15.5.1 Manning Levels

Personnel should be trained in the operations undertaken by them and have site specific knowledge of all safety procedures and emergency duties.

Terminals should provide sufficient manpower to ensure that all operational and emergency conditions can be conducted in a safe manner, taking into account:

- Effective monitoring of operations.
- Size of the facility.
- Volume and type of products handled.
- Number and size of berths.
- Number, type and size of ships visiting the terminal.
- Degree of mechanisation employed.
- Amount of automation employed.
- Tank farm duties for personnel.
- Fire-fighting duties.
- Liaison with port authorities and adjacent or neighbouring marine terminal operators.
- Personnel requirements for port operations including pilotage, mooring boats, line handling and hose handling.
- Fluctuations in manpower availability due to holidays, illness and training.
- Personnel involvement in emergency and terminal pollution response.
- Terminal involvement in port response plans, including mutual aid.
- Security.

When considering the effective monitoring of the ship/shore interface, good operating practice requires a competent member of the shore organisation to be on continuous duty in the vicinity of the ship-to-shore connections. This supervision should be aimed at preventing hazardous situations developing.

In establishing manning levels, due account should be taken of any local or national legal requirements. Consideration should be given to the avoidance of fatigue that may result from extended hours of work, or insufficient rest periods or time off between shifts.

15.5.2 De-Manning of Berths During Cargo Handling

Terminal operators may wish to reduce manning at the berth or de-man berths during cargo transfer operations. Where this happens, it should not result in a reduction of safe operational standards, operational surveillance or emergency response capability. The ship should always be informed before berth personnel depart, and the method of contact confirmed.

The ship/shore connections should remain under continual observation. This may be achieved by remote means, such as by a closed circuit television system, but sufficient numbers of personnel should always be available to take corrective action if a hazardous situation arises.

Supervision by systems incorporating television should only be used where they are continuously manned and give effective control over the cargo operations. Such systems cannot in themselves take corrective action and should not be regarded as a substitute for 'hands on' human supervision at the ship/shore interface when cargo operations are at a critical phase or during adverse weather conditions.

15.5.3 Checks on Quantity During Cargo Handling

The Terminal Representative should regularly check pressures in the pipeline and hose or metal arm and compare the estimated quantity of cargo loaded or discharged with the tanker's estimate. An unexpected drop in pressures, or any marked discrepancy between tanker and terminal estimates of quantities transferred, could indicate pipeline or hose leaks, particularly in submarine pipelines, and require that cargo operations be stopped until investigations have been carried out.

15.5.4 Training

Terminals should ensure that the personnel engaged in activities relating to the ship/shore interface are trained and competent in the duties that are assigned to them. They should be thoroughly familiar with those sections of this document that are applicable to their work location and duties.

Personnel should be aware of national and local rules and port authority requirements that affect the terminal operations and the manner in which they are implemented locally.

Terminals should consider adoption of the OCIMF '*Marine Terminal Training and Competence Assessment Guidelines for Oil and Petroleum Product Terminals*' in a manner appropriate to their operations. This document will assist in determining the training needs of the terminal.

15.6 Ship and Berth Compatibility

Terminals should have a definitive, comprehensive list of ship dimensional criteria for each berth within the terminal. This information should be made available to both internal and external contacts. Some typical examples of criteria are given in the following sections.

15.6.1 Maximum Draught

Maximum draught should preferably be determined in consultation with authorities and should be based upon the restricting depth at the berth or in the approaches, related to a specific datum, for example Chart Datum or Lowest Astronomical Tide.

A minimum Under Keel Clearance (UKC) should be defined taking into account speed, squat, ship motion (e.g. due to wave action) and the nature of the seabed.

Maximum draught should be defined for the usual water density at the berth.

When defining maximum draught, due regard should be given to unusual tidal or environmental conditions that may affect water depth.

15.6.2 Maximum Displacement

The full load displacement figure should be quoted to define the maximum size of ship allowed on the berth.

A maximum displacement figure may also be quoted for the berthing operation where there are restrictions on berthing energy or load limits on fendering systems. The use of deadweight as a parameter for setting ship size limitations is not recommended because this on its own is not a measure of size or of total weight of vessel for calculation of berthing energies.

15.6.3 Length Overall (LOA)

This is the maximum length of the ship and may be a limiting factor when ships have to transit locks or turn in a turning basin.

15.6.4 Other Criteria

In addition, terminals may specify further dimensional limitations, for example:

- **Minimum Length Overall (LOA):** This may be specified to ensure that small ships are not too small to tie up to or lie safely alongside the fendering at berths designed for much larger ships.
- **Maximum or Minimum Bow to Centre Manifold (BCM):** This is usually to ensure alignment between ship and shore manifold connections.
- **Minimum Parallel Body Length Forward and Aft of the Manifold:** This is to ensure that the ship will rest against the fenders when in position with the cargo connection made.
- **Maximum Beam:** This is required, for example, due to restrictions imposed by a lock, dock or river transit.
- **Maximum Allowable Manifold Height Above the Water:** This is to ensure that the ship can keep the cargo arms connected throughout the discharge and at all states of the tide. At some tidal locations, it may be necessary to disconnect the loading arms during the high water period.
- **Minimum Allowable Manifold Height Above the Water:** This is required, for example, to ensure that a loaded ship can be connected to the cargo arms. At some tidal locations, it may be necessary to disconnect the cargo arms during the low water period.
- **Maximum Air Draught:** This is specified to ensure that ships can pass beneath bridges and overhead obstructions, power cables etc. The local harbour authority may define a minimum safe clearance distance.

In defining these criteria, care should be taken in establishing the baseline data from which they are derived and ensuring that they are correctly reconciled. In addition, terminals should clearly identify the units of measurement used.

15.7 Documentation

Terminals should maintain a set of up to date documents to ensure compliance with regulations, procedures and good practice. This should provide comprehensive information on facilities and equipment associated with the management of the ship/shore interface.

Documentation should provide current information on topics that include the following:

- Legislation, including national and local operational requirements and health and safety legislation.
- Industry guidelines, Company policies, and health and safety policy.
- Operating manuals, maintenance and inspection procedures, and site plans and drawings.
- Records of internal and external audits, government inspections, health and safety meetings, permits to work and local procedures, for example.
- Certificates issued for equipment and processes.

Documentation available on site should include a comprehensive set of 'as built' construction drawings and specifications of the berth and associated terminal facilities, including all modifications made since they were first commissioned. This documentation should form the basis of any structural, water depth or other survey carried out to inspect the fabric of the facilities.

A record of the major equipment items should be kept. This will include, for example, specifications, purchase orders and inspection and maintenance data. Major equipment could include transfer arms, access towers, large valves, pumps, meters, fenders and mooring hooks.

Chapter 16

TERMINAL OPERATIONS

This Chapter provides information on a range of terminal operational procedures and activities that influence the safe receipt and handling of ships. These include the assessment of limiting environmental criteria for safe operations and issues associated with the provision of a safe means of access between the ship and shore.

Operations requiring special procedures are described, including the double banking of ships and the loading and discharging of cargo utilising tidal increases in depth of water, called 'over the tide'.

The Chapter also includes a brief explanation of the phenomenon of pressure surge in pipelines and discusses the manner in which it may be controlled.

The Section on pipeline flow rates provides guidance on precautions necessary to control static electricity generation in receiving tanks on board or ashore.

16.1 Pre-Arrival Communications

Terminals should provide ships visiting their berths with information on all pertinent local regulations and terminal safety requirements.

Detailed information on communications at the ship/shore interface is given in Chapter 22.

16.2 Mooring

Mooring equipment should be appropriate for the sizes of ship using the berths (see Section 15.6 for ship criteria). The equipment provided should allow the ship's mooring arrangements to hold the ship securely alongside the berth in the weather and tidal conditions expected at the berth (see Chapter 23).

16.2.1 Mooring Equipment

The terminal should provide mooring bollards, mooring bits or mooring hooks positioned and sized for the ships visiting the berth.

The Safe Working Load (SWL) of each mooring point or lead should be known to the berth operating personnel or marked on each mooring point.

Where shore mooring lines are provided, the terminal should have test certificates for the lines and the berth operating personnel should be aware of their SWL. (See Chapter 23 for information on ship's mooring equipment.)

16.3 Limiting Conditions for Operations

For each berth, terminals should establish weather operating limits defining the thresholds for stopping cargo transfer, disconnecting cargo (and bunker) hose connections and removing the ship from the berth, taking into account the SWL of the mooring system components and, if appropriate, the operating envelopes of the loading arms.

Operating limits will normally be based on ambient environmental conditions, such as:

- Wind speed and direction.
- Wave height and period.
- Speed and direction of the current.
- Swell conditions that may affect operations at the berth.
- Electrical storms.
- Environmental phenomena, for example river bores or ice movement.
- Extremes of temperature that might affect loading or unloading.

The environmental limits should define the thresholds for:

- Manoeuvring during arrival and berthing.
- Stopping loading or discharging.
- Disconnecting cargo hoses or hard arms.
- Summoning tug assistance.
- Removing the ship from the berth.
- Manoeuvring during unberthing and departure.

Information on environmental limits should be passed to the ship at the pre-cargo transfer conference and, where applicable, be formally recorded in the Ship/Shore Safety Check-List (see Sections 26.3 and 26.4). Routine local weather forecasts received by the terminal should be passed to the ship, and vice versa.

The terminal should, if possible, have its own locally installed anemometer for measuring wind speeds. Alternatively, other means may be used, for example wind reports from a reliable local source, such as a nearby airport or a ship.

Equipment for the measurement of other environmental factors should be considered, as appropriate.

16.4 Ship/Shore Access

16.4.1 General

Means of access between ship and shore are addressed by national regulation, usually by the port state or by the ship's flag state (see also Chapter 6 on Security). Any means of access must meet these regulated standards and should be correctly rigged by the ship or by the terminal, as appropriate.

Personnel should use only the designated means of access between the ship and shore.

16.4.2 Provision of Ship/Shore Access

Responsibility for the provision of safe ship/shore access is jointly shared between the ship and the terminal.

At locations that commonly handle ships, including barges, that are unable to provide a gangway due to the physical limitations of the berth or the nature of the ship's trade, the terminal should provide a shore based gangway or alternative arrangements to ensure safe ship/shore access. In any case, the preferred means for access between ship and shore is a gangway provided by the terminal.

When terminal access facilities are not available and a tanker's gangway is used, the berth must have sufficient landing area to provide the gangway with an adequate clear run in order to maintain safe, convenient access to the tanker at all states of tide and changes in freeboard.

Irrespective of whether it is provided by the terminal or the ship, the gangway should be subject to inspection as part of the ship/shore safety checks that are carried out at regular intervals throughout the vessel's stay at the berth (see Section 26.3).

All ship and shore gangways should meet the following criteria:

- Clear walkway.
- Continuous handrail on both sides.
- Electrically insulated to eliminate continuity between ship and shore.
- Adequate lighting.
- For gangways without self-levelling treads or steps, a maximum safe operating inclination should be established.
- Lifebuoys should be available with light and line on both ship and shore.

All shore gangways should also meet the following additional criteria, as appropriate:

- Remain within deflected fender face when in the stored position.
- Provide for locking against motion in the stored position.
- Permit free movement after positioning on the ship.
- Provide backup power or manual operation in the event of primary power failure.
- Be designed for specified operating conditions known to the berth operating personnel.

16.4.3 Access Equipment

16.4.3.1 Shore Gangway

When provided by the terminal, a gangway should allow safe access between the shore and the ship. This may be similar to a ship's gangway.

On berths for large ships, an automatic gangway may be provided consisting of a stairway tower with an adjustable bridge that

spans from the tower to the ship's deck. The bridge section is adjusted for height depending on the ship's freeboard.

At some berths, it may be necessary to provide access to small ships from an internal stairway below the working level of the berth.

16.4.3.2 Ship's Gangway

A ship's gangway consists of a straight, lightweight bridging structure provided with side stanchions and handrails. The walking surface has a non-slip surface or transverse bars to provide foot grips for when it is inclined. It is rigged perpendicular to the ship's side and spans between the ship's rail and the working deck of the berth.

16.4.3.3 Ship's Accommodation Ladder

The accommodation ladder consists of a straight lightweight structure fitted with side stanchions and handrails, mainly intended for access to boats from the main deck. The steps are self-levelling or formed as large radius non-slip treads. The ladder is rigged generally parallel to the ship's side on a retractable platform fixed to the ship's deck. The ladder is limited in its use as an access to the shore because it is fixed in its location and cannot be used if the ship's deck is below the level of the berth working deck.

16.4.4 Siting of Gangways

Means of access should be placed as close as possible to crew accommodation and as far away as possible from the manifold.

It should be borne in mind that the means of access also provides a means of escape. The location of any portable gangway should be carefully considered to ensure that it provides a safe access to any escape route from the jetty (see Chapter 21).

Particular attention to safe access should be given where the difference in level between the decks of the tanker and jetty becomes large. There should be special facilities at berths where the level of a tanker's deck can fall well below that of the jetty.

16.4.5 Safety Nets

Safety nets are not required if the gangway is fixed to the shore and provided with a permanent system of handrails made of structural members. For other types of gangway, and those fitted with rope or chain handrails or removable posts, correctly rigged safety nets should be provided.

16.4.6 Routine Maintenance

All gangways and associated equipment are to be routinely inspected and tested. This requirement should be included within the terminal's planned maintenance programme. Mechanically deployed gangways should also be function tested. Self-adjusting gangways should be fitted with alarms that should be routinely tested.

16.4.7 Unauthorised Persons

Persons who have no legitimate business on board, or who do not have the Master's permission, should be refused access to a tanker. The terminal, in agreement with the Master, should restrict access to the jetty or berth.

Terminal security personnel should be given a crew list and a list of authorised visitors to the ship (see also Section 6.4).

16.4.8 Persons Smoking or Intoxicated

Personnel on duty on a berth or jetty, or on watch on a tanker, must ensure that no one who is smoking approaches the berth or jetty or boards a tanker. Persons apparently intoxicated should not be allowed to enter the terminal area or board a tanker unless they can be properly supervised.

16.5 Double Banking

'Double banking' occurs when two or more ships are berthed at the same jetty in such a way that the presence or operations of one ship act as a physical constraint on the other. Double banking is sometimes used as a means of conducting multiple transfers between the shore and more than one ship at the same jetty at the same time. The outermost ship may be moored to an inner ship or to the shore, and hose strings led from shore, across the inner ship, to the outermost. This causes significant complication in respect of management of the ship/shore interface.

Double banking of ships on a berth for cargo operations should not be conducted unless a formal engineering study and risk assessment have been carried out and a formal procedure and safety plan produced. As a minimum, before such activities are agreed, consideration and agreement must be reached by all parties concerned regarding safe arrival and departure, strength of jetty construction, mooring fittings, mooring arrangements, personnel access, management of operational safety, liability, contingency planning, fire-fighting and emergency unberthing.

16.6 Over the Tide Cargo Operations

This is a procedure that utilises tidal changes in water depth, either finishing loading of a ship to its full draught as the water depth increases towards high tide, or discharging cargo to lighten a ship before the low tidal level is reached.

Terminals with draught limitations and significant tidal variations should have procedures in place if discharging or loading over the tide operations are to be permitted. These procedures should be agreed by all parties involved, prior to the arrival of the ship.

Procedures to control over the tide operations should be developed from a full risk assessment process with the aim of ensuring that the ship remains safely afloat, taking underkeel clearance requirements and contingency measures into account.

The terminal should seek assurance that the ship's equipment that is critical to the operation, for example cargo pumps and main engines, are operational prior to berthing and are kept available while the ship is alongside at the critical stage.

16.6.1 Discharging Over the Tide

Where a ship is required to use a berth when the nominated quantity of cargo will cause the ship to arrive alongside at a draught exceeding the maximum always afloat draught for the berth, it may be possible for the ship to berth and discharge sufficient cargo before the next low water, thus enabling her to remain afloat. This procedure may be adopted where all parties concerned accept the risk involved and agree to adopt mitigating procedures to ensure that the ship can be discharged in good time to remain afloat, or be removed from the berth to a position where it can remain afloat.

16.6.2 Loading Over the Tide

This may be undertaken where a ship cannot remain safely afloat during the final stages of loading during the low water period. The ship should stop loading at the draught at which it can remain always afloat and should recommence loading as the tide starts rising. Loading should not recommence unless equipment critical for the departure of the ship from the berth, main engine for example, is ready for use. The loading rate should allow the ship to complete loading and allow time for cargo measurements, sampling, documentation, clearance formalities and unberthing, while maintaining the required underkeel clearance.

16.7 Operations Where the Ship is not Always Afloat

A limited number of ports that have significant tidal ranges allow tankers to operate when they are unable always to remain afloat while alongside the cargo handling berth. This type of operation is considered exceptional and should only be permitted following a comprehensive risk assessment and the implementation of all safeguards identified to deliver a safe operation.

The type of operation that may be undertaken varies from the ship taking the ground for a brief period during its stay at the berth, to the ship being completely out of the water. In both cases, the following points are amongst those that need to be addressed:

- The seabed should be proved to be flat with no protuberances or high spots present that could result in local or general stresses on the hull.
- The slope of the seabed should not result in any excessive upthrust on the ship's structure or cause any loss of stability when the ship takes the ground.
- The ship's hull strength should be sufficient to take the ground without excessive stress being placed on the structure. This may require the ship's design and scantlings to be augmented to allow it to take the ground safely or dry out.
- The operation should not result in the ship losing any of its essential services, such as cooling water for the machinery or its fire-fighting capability. This may require the incorporation of special design features into the ship.
- As it will not be possible to remove the ship from the berth in the event of an emergency, port operations will need to address specific emergency procedures and the provision of appropriate fire-fighting equipment.
- Contingency plans will need to address the possibility of structural failure on the ship and the special nature and size of any resultant pollution.

16.8 Generation of Pressure Surges in Pipelines

16.8.1 Introduction

A pressure surge is generated in a pipeline system when there is an abrupt change in the rate of flow of liquid in the line. In tanker loading operations, it is most likely to occur as a result of one of the following:

- Closure of an automatic shutdown valve.
- Slamming shut of a shore non-return valve.
- Slamming shut of a butterfly type valve.
- Rapid closure of a power operated valve.

If the pressure surge in the pipeline results in pressure stresses or displacement stresses in excess of the strength of the piping or its components, there may be a rupture, leading to an extensive spill of oil.

16.8.2 Generation of a Pressure Surge

When a pump is used to convey liquid from a feed tank down a pipeline and through a valve into a receiving tank, the pressure at any point in the system while the liquid is flowing has three components:

- Pressure on the surface of the liquid in the feed tank. In a tank with its ullage space open to atmosphere, this pressure is that of the atmosphere.
- Hydrostatic pressure at the point in the system in question.
- Pressure generated by the pump. This is highest at the pump outlet, decreasing commensurately with friction along the line downstream of the pump and through the valve to the receiving tank.

Of these three components, the first two can be considered constant during pressure surge and need not be considered in the following description, although they are always present and have a contributory effect on the total pressure.

Rapid closure of the valve superimposes a transient pressure upon all three components, owing to the sudden conversion of the kinetic energy of the moving liquid into strain energy, by compression of the fluid and expansion of the pipe wall. To illustrate the sequence of events, the simplest hypothetical case will be considered, i.e. when the valve closure is instantaneous, there is no expansion of the pipe wall, and dissipation due to friction between the fluid and the pipe wall is ignored. This case gives rise to the highest pressures in the system.

When the valve closes, the liquid immediately upstream of the valve is brought to rest instantaneously.

This causes its pressure to rise by an amount P . In any consistent set of units:

$$P = wav$$

where: w is the mass density of the liquid
 a is the velocity of sound in the liquid
 v is the change in linear velocity of the liquid, i.e. from its linear flow rate before closure.

The cessation of flow of liquid is propagated back up the pipeline at the speed of sound in the fluid and, as each part of the liquid comes to rest, its pressure is increased by the amount P . Therefore, a steep pressure front of height P travels up the pipeline at the speed of sound, a disturbance known as a pressure surge.

Upstream of the surge, the liquid is still moving forward and still has the pressure distribution applied to it by the pump. Behind it, the liquid is stationary and its pressure has been increased at all points by the constant amount P . There is still a pressure gradient downstream of the surge, but a continuous series of pressure adjustments takes place in this part of the pipeline which ultimately results in a uniform pressure throughout the stationary liquid. These pressure adjustments also travel through the liquid at the speed of sound.

When the surge reaches the pump, the pressure at the pump outlet (ignoring the atmospheric and hydrostatic components) becomes the sum of the surge pressure P and the output pressure of the pump at zero throughput (assuming no reversal of flow), since flow through the pump has ceased. The process of pressure equalisation continues downstream of the pump.

Again taking the hypothetical worst case, if the pressure is not relieved in any way, the final result is a pressure wave that oscillates throughout the length of the piping system. The maximum magnitude of the pressure wave is the sum of P and the pump outlet pressure at zero throughput. The final pressure adjustment to achieve this condition leaves the pump as soon as the original surge arrives at the pump and travels down to the valve at the speed of sound. One pressure wave cycle therefore takes a time $2L/a$ from the instant of valve closure, where L is the length of the line and a is the speed of sound in the liquid. This time interval is known as the pipeline period.

In this simplified description, therefore, the liquid at any point in the line experiences an abrupt increase in pressure by an amount P followed by a slower, but still rapid, further increase until the pressure reaches the sum of P and the pump outlet pressure at zero throughput.

In practical circumstances, the valve closure is not instantaneous and there is then some relief of the surge pressure through the valve while it is closing. The results are that the magnitude of the pressure surge is less than in the hypothetical case and the pressure front is less steep.

At the upstream end of the line, some pressure relief may occur through the pump and this would also serve to lessen the maximum pressure reached. If the effective closure time of the valve is several times greater than the pipeline period, pressure relief through the valve and the pump is extensive and a hazardous situation is unlikely to arise.

Downstream of the valve, an analogous process is initiated when the valve closes, except that, as the liquid is brought to rest, there is a fall of pressure which travels downstream at the velocity of sound. However, the pressure drop is often relieved by gas evolution from the liquid so that serious results may not occur immediately, although the subsequent collapse of the gas bubbles may generate shock waves similar to those upstream of the valve.

16.9 Assessment of Pressure Surges

16.9.1 Effective Valve Closure Time

In order to determine whether a serious pressure surge is likely to occur in a pipeline system, the first step is to compare the time taken by the valve to close with the pipeline period.

The effective closure time, i.e. the period during which the rate of flow is in fact decreasing rapidly, is usually significantly less than the total time of movement of the valve spindle. It depends upon the design of the valve, which determines the relationship between valve port area and spindle position. Substantial flow reduction is usually achieved only during the closure of the last quarter or less of the valve port area.

If the effective valve closure time is less than, or equal to, the pipeline period, the system is liable to serious pressure surges. Surges of reduced, but still significant, magnitude can be expected when the effective valve closure time is greater than the pipeline period, but they become negligible when the effective valve closure period is several times greater than the pipeline period.

16.9.2 Derivation of Total Pressure in the System

In the normal type of ship/shore system handling petroleum liquids, where the shore tank communicates to the atmosphere, the maximum pressure applied across the pipe wall at any point during a pressure surge is the sum of the hydrostatic pressure, the output pressure of the pump at zero throughput and the surge pressure. The first two of these pressures are usually known.

If the effective valve closure time is less than or equal to the pipeline period, the value of the surge pressure used in determining the total pressure during the surge should be P , derived as indicated above in Section 16.8.2. If it is somewhat greater than the pipeline period, a smaller value can be used in place of P and, as already indicated, the surge pressure becomes negligible if the effective valve closure time is several times greater than the pipeline period.

16.9.3 Overall System Design

In practice, the design of a more complex system may need to be taken into account. In this Section, the simple case of a single pipeline has been considered. For example, the combined effects of valves in parallel or in series may have to be examined. In some cases, the surge effect may be increased. This can occur with two lines in parallel if closure of the valve in one line increases the flow in the other line before this line, in its turn, is shut down. On the other hand, correct operation of valves in series in a line can minimise surge pressure.

Transient pressures produce forces in the piping system which can result in large piping displacements, pipe rupture, support failure, and damage to machinery and other connected equipment. Therefore, the structural response of the piping system to fluid induced loads resulting from fluid pressures and momentum must be considered in the design. In addition, restraints are usually required to avoid damage ensuing from large movements of the piping itself. An important consideration in the selection of the restraints is the fact that the piping often consists of long runs of

straight pipe that will expand considerably under thermal loads. The restraints must both allow for this thermal expansion and absorb the surge forces without overstressing the pipe.

16.10 Reduction of Pressure Surge Hazard

16.10.1 General Precautions

If, as a result of the calculations summarised in Section 16.9, it is found that the potential total pressure exceeds or is close to the strength of any part of the pipeline system, it is advisable to obtain expert advice. Where manually operated valves are used, good operating procedures should avoid pressure surge problems. It is important that a valve at the end of a long pipeline should not be closed suddenly against the flow and all changes in valve settings should be made slowly.

Where motorised valves are installed, several steps can be taken to alleviate the problem:

- Reduce the linear flow rate, i.e. the rate of transfer of cargo, to a value that makes the likely surge pressure tolerable.
- Increase the effective valve closure time. In very general terms, total closure times should be of the order of 30 seconds, and preferably more. Valve closure rates should be steady and reproducible, although this may be difficult to achieve if spring return valves or actuators are needed to ensure that valves fail safe to the closed position. A more uniform reduction of flow may be achieved by careful attention to valve port design, or by the use of a valve actuator that gives a very slow rate of closure over, say, the final 15% of the port closure.
- Use a pressure relief system, surge tanks or similar devices to absorb the effects of the surge sufficiently quickly.

16.10.2 Limitation of Flow Rate to Avoid the Risk of a Damaging Pressure Surge

In the operational context, pipeline length and, very often, valve closure times are fixed and the only practical precaution against the consequences of an inadvertent rapid closure is correct operation of the valves and/or to limit the linear flow rate of the oil to a maximum value related to the maximum tolerable surge pressure.

16.11 Pipeline Flow Control as a Static Precaution

16.11.1 General

Safety procedures for the transfer of static accumulator cargoes require the linear flow rates of the cargo within the loading lines, both ashore and on board, to be managed to avoid the generation of static charges during the cargo transfer (see Chapter 3).

16.11.2 Flow Control Requirements

The generation of static is controlled by limiting the flow rate at the tank inlet at the commencement of loading to 1 metre/second. Transfer rates equivalent to flow rates of 1 metre/second through pipelines of various diameters, can be determined from Table 11.1. (See also Section 11.1.7.3.)

Once cargo has covered the tank inlet, the transfer rate can be increased to provide the maximum allowable linear flow rate as determined by the limiting pipe diameter in the ship or shore piping, whichever is the smaller (see Section 11.1.7.8).

16.11.3 Controlling Loading Rates

Due to the varying loading rates that different ships will require in order to comply with their maximum flow rate requirements, terminals should have the facility to control effectively the pumping rates to ships loading at its berths.

Similarly, if terminals expect ships to discharge to empty shore tanks, it may be necessary to use flow control or flow measuring equipment in order to determine that the flow rates in the shore lines and tank inlets are not exceeded, particularly in the initial phase of filling a tank.

16.11.4 Discharge into Shore Installations

When discharging static accumulator oils into shore tanks, the initial flow rate should be restricted to 1 metre/second unless or until the shore tank inlet is covered sufficiently to limit turbulence.

For a side entrance (horizontal entrance), the inlet is considered adequately covered if the distance between the top of the inlet and the free surface exceeds 0.6 metres. An inlet pointing downwards is considered sufficiently covered if the distance between the lower end of the pipe and the free surface exceeds twice the inlet diameter. An inlet pointing upwards may require a considerably greater distance to limit turbulence. In floating roof tanks, the low initial flow rate should be maintained until the roof is floating. Similar requirements apply to fixed roof tanks provided with inner floats.

TERMINAL SYSTEMS AND EQUIPMENT

This Chapter describes equipment that is provided by the terminal at the ship/shore interface, including fendering, lifting, lighting and bonding and earthing equipment.

Considerable emphasis is placed on ensuring that ship and shore remain electrically isolated, and on the means of achieving isolation.

17.1 Electrical Equipment

The classification of hazardous zones for the installation or use of electrical equipment within a terminal is described in Section 4.4.2.

Terminals should ensure that any electrical equipment is provided in accordance with a site specific area electrical classification drawing, which shows hazardous zones at the berths in plan and elevation.

Terminals should identify the zones and establish the type of equipment that is to be installed within each zone. National legislation, international standards and company specific guidelines, where available, are all to be complied with. A planned maintenance system should address the continued integrity of the equipment installed, and ensure it remains able to meet zone requirements.

Personnel carrying out maintenance on equipment within hazardous zones should be trained and certified as competent to carry out the work. Certification may be by internal process or as required by regulatory bodies. All electrical maintenance should be carried out under the control of a Permit to Work system (see Section 19.1.3).

17.2 Fendering

Fendering systems at each berth should be engineered to suit the range of ship sizes and types that use the berth and should be capable of withstanding expected loads without causing damage to the ship. The design should take account of the method of operating the berth, with particular reference to the use or non-use of tugs.

In calculating the berthing energy to be absorbed by the fendering system, the speed at which a ship closes with the berth is the most significant of all factors. Energy is calculated as a function of mass and the square of the speed ($E=1/2mV^2$). (See Section 15.6.2.)

The spacing of the fenders should allow the ship to lie alongside, with the fenders on the parallel sides of the ship, at all freeboards and all expected heights of the tide.

The terminal should advise the local pilots and berth operating personnel of the maximum permissible closing speed for each berth, recognising that this is often difficult to estimate. If speed of approach equipment is provided on the berth, it is strongly recommended that allowable approach speeds for each generic size of ship are included in the operating procedures.

17.3 Lifting Equipment

17.3.1 Inspection and Maintenance

All equipment used for the lifting of cargo transfer equipment and/or means of access should be examined at intervals not exceeding one year and load tested at intervals not exceeding five years, or more frequently if mandated by local regulation or Company requirements.

Equipment to be tested and examined includes:

- Cargo hose handling cranes, derricks, davits and gantries.
- Gangways and associated cranes and davits.
- Cargo loading arm cranes.
- Store cranes and davits.
- Slings, lifting chains, delta plates, pad eyes and shackles.
- Chain blocks, hand winches and similar mechanical devices.
- Personnel lifts and hoists.

Tests should be carried out by a suitably qualified individual or authority and the equipment should be clearly marked with its Safe Working Load (SWL), identification number and test date.

Terminals should ensure that all maintenance is carried out in accordance with manufacturers' guidelines and that it is incorporated into the terminal's planned maintenance system.

If certified equipment is modified or repaired, it should be re-tested and certified prior to being placed back in service.

Defective equipment should be withdrawn from service immediately and only reinstated after repair, examination and, where required, re-certification.

17.3.2 Training in the Use of Lifting Equipment

All personnel engaged in operating lifting equipment should be formally trained in its use.

17.4 Lighting

Terminals should have a level of lighting sufficient to ensure that all ship/shore interface activities can be safely conducted during periods of darkness.

Lighting levels should meet national or international engineering standards as a minimum. Particular consideration should be given to lighting of the following areas:

- Berth or jetty-head working areas.
- Access routes.
- Berth or jetty perimeters.
- Boat landings.
- Mooring dolphins and walkways.
- Stairways to elevated gantries.
- Emergency escape routes.
- Lighting of water around berth to detect spillage and possibly unauthorised craft.

17.5 Ship/Shore Electrical Isolation

17.5.1 General

Due to possible differences in electrical potential between the ship and the berth, there is a risk of electrical arcing at the manifold during connection and disconnection of the shore hose or loading arm. To protect against this risk, there should be a means of electrical isolation at the ship/shore interface. This should be provided by the terminal.

It should be noted that the subject of ship-to-shore electric currents is quite separate from static electricity, which is discussed in Chapter 3.

17.5.2 Ship-to-Shore Electric Currents

Large currents can flow in electrically conducting pipework and flexible hose systems between the ship and shore. The sources of these currents are:

- Cathodic protection of the jetty or the hull of the ship provided by either an impressed current system or by sacrificial anodes.
- Stray currents arising from galvanic potential differences between ship and shore or leakage effects from electrical power sources.

An all metal loading or discharge arm provides a very low resistance connection between ship and shore and there is a very real danger of an incendive arc when the ensuing large current is suddenly interrupted during the connection or disconnection of the arm at the tanker manifold.

Similar arcs can occur with flexible hose strings containing metallic connections between the flanges of each length of hose.

To prevent electrical flow between a ship and a berth during connection or disconnection of the shore hose or loading arm, the terminal operator should ensure that cargo hose strings and metal arms are fitted with an insulating flange. An alternative solution with flexible hose strings is to include, in each string, one length only of non-conducting hose without internal bonding. The insertion of such a resistance completely blocks the flow of stray current through the loading arm or the hose string. At the same time, the whole system remains earthed, either to the ship or to the shore. The above text is made with reference to conventional alongside

berths. OCIMF's *'SPM Hose System Design Commentary'* should be referred to for guidance on hose strings at offshore facilities.

All metal on the seaward side of the insulating section should be electrically continuous to the ship; all metal on the landward side should be electrically continuous to the jetty earthing system. This arrangement will ensure electrical discontinuity between the ship and shore, and prevent arcing during connection and disconnection.

The insulating flange or single length of non-conducting hose must not be short circuited by contact with external metal. For example, an exposed metallic flange on the seaward side of the insulating flange or hose length should not make contact with the jetty structure, either directly or through hose handling equipment.

It should be noted that the requirements for the use of insulating flanges or an electrically discontinuous length of hose also apply to the vapour recovery connection.

In the past, it was usual to connect the ship and shore systems by a bonding wire via a flameproof switch before the cargo connection was made and to maintain this bonding wire in position until after the cargo connection was broken. The use of this bonding wire had no relevance to electrostatic charging. It was an attempt to short circuit the ship/shore electrolytic/cathodic protection systems and to reduce the ship/shore voltage to such an extent that currents in hoses or in metal arms would be negligible. However, because of the large current availability and the difficulty of achieving a sufficiently small electrical resistance in the ship/shore bonding wire, this method has been found to be quite ineffective for its intended purposes but has itself created a possible hazard to safety. The use of ship/shore bonding wires is therefore not recommended. (See Section 17.5.4.)

While some national and local regulations still require mandatory connection of a bonding cable, it should be noted that the IMO *'Recommendations on the Safe Transport of Dangerous Cargoes and Related Activities in Port Areas'* (1995) urge port authorities to discourage the use of ship/shore bonding cables and to adopt the recommendation concerning the use of an insulating flange (see Section 17.5.5. below) or a single length of non-conducting hose as described above. Insulating flanges should be designed to avoid accidental short circuiting.

Current flow can also occur through any other electrically conducting path between ship and shore, for example mooring wires or a metallic ladder or gangway. These connections may be insulated to avoid draining the jetty cathodic protection system by the added load of the ship's hull. However, it is extremely unlikely that a flammable atmosphere would be present at these locations while electrical contact is made or interrupted.

Switching off cathodic protection systems of the impressed current type, either ashore or on the ship, is not in general considered to be a feasible method of minimising ship/shore currents in the absence of an insulating flange or hose. A jetty which is handling a succession of ships would need to have this cathodic protection switched off almost continuously and would therefore lose its corrosion resistance. Further, if the jetty system remains switched on, it is probable that the difference of potential between ship and shore will be less if the ship also keeps its cathodic protection system energised. In any case, the polarisation in an

impressed current system takes many hours to decay after the system has been switched off, so the ship would have to be deprived of full protection, not only while alongside but also for a period before arrival in port.

17.5.3 Sea Islands

Offshore facilities that are used for tanker cargo handling operations should be treated in the same way as shore terminals for the purpose of earthing and bonding, i.e. either an insulating flange or non-conducting hose should be used as appropriate.

It should be noted that switching off a cathodic protection system is not a substitute for the installation of an insulating flange or a length of non-conducting hose.

17.5.4 Ship/Shore Bonding Cables

A ship/shore bonding cable does not replace the requirement for an insulating flange or hose as described above. Use of ship/shore bonding cable may be dangerous and should not be used.

Although the potential dangers of using a ship/shore bonding cable are widely recognised, attention is drawn to the fact that some national and local regulations may still require a bonding cable to be connected.

If a bonding cable is insisted upon, it should first be inspected to see that it is mechanically and electrically sound. The connection point for the cable should be well clear of the manifold area. There should always be a switch on the jetty in series with the bonding cable and of a type suitable for use in a Zone 1 hazardous area. It is important to ensure that the switch is always in the 'off' position before connecting or disconnecting the cable.

Only when the cable is properly fixed and in good contact with the ship should the switch be closed. The cable should be attached before the cargo hoses are connected and removed only after the hoses have been disconnected.

17.5.5 Insulating Flange

17.5.5.1 Precautions

See Figure 17.1 for a schematic diagram of a typical insulating flange joint.

Points to be borne in mind when fitting an insulating flange are:

- When the ship-to-shore connection is wholly flexible, as with a hose, the insulating flange should be inserted at the jetty end where it is not likely to be disturbed. Then the hose must always be suspended to ensure the hose-to-hose connection

flanges do not rest on the jetty deck or other structure that may render the insulating flange ineffective.

- When the connection is partly flexible and partly metal arm, the insulating flange should be connected to the metal arm.
- For all metal arms, care should be taken to ensure that, wherever it is convenient to fit the flange, it is not short circuited by guy wires.
- The location of the insulating flange should be clearly labelled.

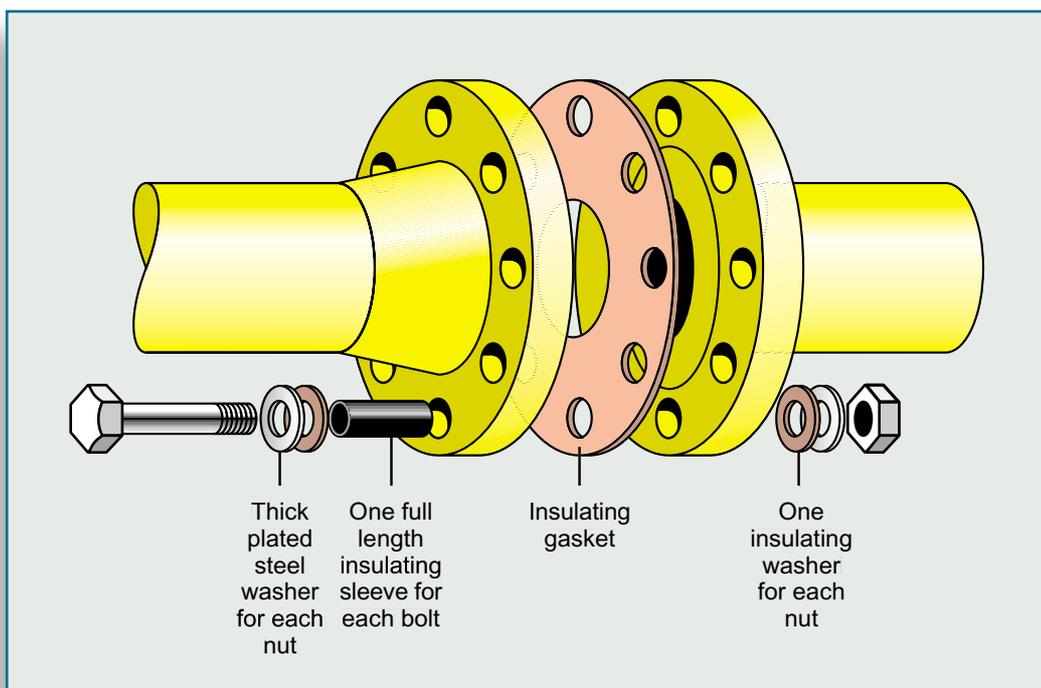


Figure 17.1 – Schematic diagram of insulating flange

17.5.5.2 Testing of Insulating Flanges

Insulating flanges should be inspected and tested at least annually, or more frequently if considered necessary. Factors to be taken into consideration when determining testing frequency should include risk of deterioration due to environmental exposure, usage, and damage from handling. It should be ensured that the insulation is clean, unpainted and in an effective condition. Readings should be taken between the metal pipe on the shore side of the flange and the end of the hose or metal arm when freely suspended. **The measured value after installation should be not less than 1,000 ohms.** A lower resistance may indicate damage to, or deterioration of, the insulation. The terminal should maintain records of all tests on all the insulating flanges within the terminal.

An insulating flange is designed to prevent arcing caused by low voltage but high current circuits (usually below 1 volt, but potentially up to around 5 volts and with currents rising to possibly several hundreds of amps) that exist between ship and shore due to stray currents, cathodic protection and galvanic cells. It is not intended to give protection against the high voltage but low current sparks associated with static discharge.

Therefore, even if the resistance of the flange drops below the 1,000 ohms quoted above due, for example, to ice, salt spray or product residue, any current flow will still be limited to a few milliamps as the potential difference across the flange will be far less than is required to initiate an arc during connection or disconnection of loading arms or hoses. Conversely, trying to earth (ground) a low voltage/high current circuit with a bonding cable is difficult, even if a very low resistance cable is used. The total resistances of the cable circuit connections and any switching device, combined with the availability of a very large current, will effectively prevent the potential difference between the ship and shore becoming zero and will render this circuit ineffective as a means of eliminating ship/shore currents in loading arms.

Typical DC insulation testers are often arranged with a user selectable test voltage (500/250/50 V etc) but are not normally accurately ranged or capable of adequately applying voltages to resistances as low as 1,000 ohms. These instruments are therefore not best suited for routine testing, but could be used for new installations where there will be no contamination of the flange and insulation readings will be many times higher. Routine testing should therefore be undertaken with an insulation tester specifically designed to have a typical driving voltage of 5 V or more when applied to a resistance of 1,000 ohms or greater.

It is recommended that handheld multimeters are not used for resistance testing of insulating flanges. Although it is understood that there may be multimeters with a capability to undertake this testing, they do not typically apply sufficient test energy to be effective in determining flange resistance, and may therefore falsely show a flange as having adequate resistance. However, should a potentially suitable multimeter be identified, it is recommended that users take care to verify that the equipment meets the strict interpretation of the recommendations contained in this Section before carrying out the tests.

17.5.5.3 Safety

Testing should be undertaken with instruments and methods selected to be compatible with any hazardous area associated with the location of the flange. Where testing of an insulating flange is carried out in a hazardous area with testing equipment not certified for use in such an area, the testing should be performed under the control of a Permit to Work (see Section 19.1.3).

17.6 Earthing and Bonding Practice in the Terminal

Earthing and bonding minimises the dangers arising from:

- Faults between electrically live conductors and non-current carrying metalwork.
- Atmospheric discharges (lightning).
- Accumulations of electrostatic charge.

Earthing is achieved by the establishment of an electrically continuous low resistance path between a conducting body and the general mass of the earth. Earthing may occur inherently through intimate contact with the ground or water, or it may be provided deliberately by means of an electrical connection between the body and the ground.

Bonding occurs where a suitable electrically continuous path is established between conducting bodies. Bonding may be achieved between two or more bodies without involving earthing, but more commonly earthing gives rise to bonding with the general mass of the earth acting as the electrical connection. Bonding may arise by construction through the bolting together of metallic bodies, thus affording electrical continuity, or may be by the provision of an additional bonding conductor between them.

Most earthing and bonding devices intended to protect against electrical faults or lightning are permanently installed parts of the equipment which they protect, and their characteristics must conform to the national standards in the country concerned, or to classification societies' rules, where relevant.

The acceptable resistance in the earthing system depends upon the type of hazard that it is required to guard against. To protect electrical systems and equipment, the resistance value is chosen so as to ensure the correct operation of the protective device (e.g. cut out or fuse) in the electrical circuit. For lightning protection, the value depends on national regulations, and is typically in the range of 5-25 ohms.

CARGO TRANSFER EQUIPMENT

This Chapter describes hard arms and flexible hoses used to make the ship/shore connection. The type of equipment is described, together with recommendations regarding its operation, maintenance, inspection and testing. If not properly engineered and maintained, this equipment will provide a weak link that may jeopardise the cargo system's integrity.

18.1 Metal Cargo Arms

18.1.1 Operating Envelope

All metal cargo arms have a designed operating envelope, which takes into account the following:

- Tidal range at the berth.
- Maximum and minimum freeboards of the largest and smallest tankers for which the berth has been designed.
- Minimum and maximum manifold setbacks from the deck edge.
- Limits for changes in horizontal position due to drift off and ranging.
- Maximum and minimum spacing when operating with other arms in a bank.

The limits of this operating envelope should be thoroughly understood by berth operators. Metal arm installations should have a visual indication of the operating envelope and/or be provided with alarms to indicate excessive range and drift.

The person in charge of operations on a berth should ensure that the tanker's manifolds are kept within the operating envelope during all stages of loading and discharging operations. To achieve this, the tanker may be required to ballast or deballast.

18.1.2 Forces on Manifolds

Most metal cargo arms are counterbalanced so that no weight, other than that of the liquid content of the arm, is placed on the manifold. Because the weight of oil in the arms can be considerable (particularly for larger diameter arms), it may be advisable for this weight to be relieved by a support or jack provided by the terminal.

Some arms have integral jacks that are also used to avoid overstressing of the tanker's manifold by the weight of the arm or other external forces such as the wind.

Terminals should have detailed information on the forces exerted on the tanker's manifold by each loading arm. This information should be readily available to the berth operator.

The berth operator's training should include the correct rigging and operation of cargo arms. Operators should be aware of the consequences of inappropriate operation that may cause excessive forces on the tanker manifold.

Where supports or jacks are utilised, they should be fitted in such a way that they stand directly onto the deck or some other substantial support. They should never be placed onto fixtures or fittings that are not capable of, or suitable for, supporting the load.

Some counterbalanced arms are made slightly tail heavy to compensate for clingage of oil and to facilitate the arm's return to the parked position without using power when released from the tanker's manifold. Additionally, in some positions of operation, there can be an upward force placed on the manifold. For both these reasons, manifolds should also be secured against upward forces.

18.1.3 Tanker Manifold Restrictions

The material of manufacture, support and cantilever length of a ship's manifold, together with the spacing intervals of adjacent outlets, must be checked for compatibility with the arms. Manifold flanges should be vertical and parallel to the ship's side. The spacing of the manifold outlets will sometimes dictate the number of arms that can be connected, while interference between adjacent arms is to be avoided. In most cases, cast iron manifolds will be subjected to excessive stress unless jacks are used. Cast iron reducers and spool pieces should not be used except by arrangement. (See Section 24.6.3.)

18.1.4 Inadvertent Filling of Arms while Parked

Loading arms are usually empty when parked and locked, but inadvertent filling may occur. The parking lock should only be removed after the arm has been checked and proven to be empty to avoid the possibility of an inadvertently filled loading arm falling onto the ship's deck.

18.1.5 Ice Formation

Ice formation will affect the balance of the arm. Any ice should therefore be cleared from the arm before the parking lock is removed.

18.1.6 Mechanical Couplers

Most mechanical couplers require that the ship's manifold flange face is smooth and free of rust for a tight seal to be achieved. Care should be taken when connecting a mechanical coupler to ensure that the coupler is centrally placed on the manifold flange and that all claws or wedges are pulling up on the flange. Where 'O' rings are used in place of gaskets, these should be renewed on every occasion.

18.1.7 Wind Forces

Wind loading of metal arms may place an excessive strain on the tanker manifolds, as well as on the arms, and the terminal should establish appropriate wind limits for operation. At terminals where wind loading is critical, a close watch should be kept on wind speed and direction. If wind limits are approached, operations should be suspended and the arms should be drained and disconnected.

18.1.8 Precautions when Connecting and Disconnecting Arms

Due to the risk of unexpected movements of both powered and unpowered arms during connection and disconnection, operators should ensure that all personnel stand well clear of moving arms and do not stand between a moving arm and the ship's structure. When connecting manually operated arms, consideration should be given to fitting two lanyards to control the movement of the connection end.

18.1.9 Precautions while Arms are Connected

The following precautions should be taken during the period that cargo arms are connected:

- The ship's moorings should be monitored frequently by ship and shore personnel and tended as necessary, so that any movement of the ship is restricted to within the operating envelope of the metal arm.
- If drift or range alarms are activated, all transfer operations should be stopped and remedial measures taken.
- The arms should be free to move with the motion of the ship. Care should be taken to ensure that hydraulic or mechanical locks cannot be inadvertently engaged.
- The arms should not foul each other.
- Excessive vibration should be avoided.

18.1.10 Powered Emergency Release Couplings (PERCs)

A Powered Emergency Release Coupling (PERC) is a hydraulically operated device to provide quick disconnection of a marine loading arm in an emergency, or when the operating envelope of a loading arm is exceeded. It has a valve on each side of the release point to minimise spillage. On release, the lower part of the coupling and its attendant valve remain attached to the ship's manifold while the upper part and its attendant valve remain attached to the cargo arm, which is then free to rise clear of the ship.

The Emergency Release System (ERS) is initiated in the following ways:

- Automatically, when the arm reaches the specified limit; alarms usually sound.
- Manually, using a push button on the central control panel.
- Manually, using hydraulic valves in the event of loss of electrical power supply ashore.

The Emergency Release System (ERS) valves above and below the Emergency Release Coupling (ERC) are hydraulically or mechanically interlocked to ensure they close fully prior to ERC operation.

Once the emergency disconnection has been initiated, the valves adjacent to the PERC will close rapidly (typically in less than 5 seconds) and therefore precautions need to be taken to avoid a pressure surge (see Section 16.8). It is usual for the terminal to provide surge control facilities for this purpose, but if these are not available then special operating procedures may be necessary.

18.2 Cargo Hoses

18.2.1 General

Oil cargo hose should conform to recognised standard specifications, or as recommended by OCIMF and confirmed by established hose manufacturers. Hose should be of a grade and type suitable for the service and operating conditions in which it is to be used.

Special hose is required for use with high temperature cargoes, such as hot asphalt, and also for use with low temperature cargoes.

The information on cargo hoses in the following Sections (18.2.2 to 18.2.5) is condensed from British Standards BS EN 1765 and BS 1435-2 ('*Rubber Hose Assemblies for Oil Suction and Discharge Services*'). It is provided to give a general indication of hoses that may be supplied for normal cargo handling duty, commonly referred to as 'dock hoses'.

Reference may also be made to the OCIMF publication '*Guide to Purchasing, Manufacturing and Testing of Loading and Discharge Hoses for Offshore Moorings*' for information on hoses commonly used at conventional buoy and single point mooring (SPM) facilities.

18.2.2 Types and Applications

For normal duty, there are three basic types of hose:

Rough Bore (R)

This type of hose is heavy and robust with an internal lining supported by a steel wire helix. It is used for cargo handling at terminal jetties. A similar hose is made for submarine and floating use (type R x M).

Smooth Bore (S)

Smooth bore hose is also used for cargo handling at terminal jetties, but is of lighter construction than the rough bore type and the lining is not supported by a wire helix. A similar hose is made for submarine and floating use (type S x M).

Lightweight (L)

Lightweight hose is for discharge duty or bunkering only, where flexibility and light weight are important considerations.

All of these types of hose may be supplied as either electrically continuous or electrically discontinuous.

There are a number of special hose types having the same basic construction, but which are modified for particular purposes or service. These include subsea hoses or hoses for use in floating hose strings.

18.2.3 Performance

Hose is classified according to its rated pressure and this pressure should not be exceeded in service. The manufacturer also applies a vacuum test to hoses supplied for suction and discharge service.

Standard hoses are usually manufactured for products having a minimum temperature of -20°C to a maximum of 82°C and an aromatic hydrocarbon content not greater than 25%. Such hoses are normally suitable for sunlight and ambient temperatures ranging from -29°C to 52°C .

18.2.4 Marking

Each length of hose should be marked by the manufacturer with:

- The manufacturer's name or trademark.
- Identification with the standard specification for manufacture.
- Factory test pressure.
- Month and year of manufacture.
- Manufacturer's serial number.
- Indication that the hose is electrically continuous or electrically discontinuous.

18.2.5 Flow Velocities

The maximum permissible flow velocity through a hose is limited by the construction of the hose and its diameter. The hose manufacturer's recommendations and certification should provide details. However, operators should take other factors into account when deciding flow velocities. These should include, but not be limited to, the following:

- The factor of safety being applied.
- Any limitations imposed by flow velocities in the ship's fixed piping system.
- Weather conditions causing movement of the hose.
- Age, service and condition of the hose.
- Amount of use and method of storing the hose.
- Other local considerations.

For conventional buoy and SPM facilities, the relevant OCIMF guidelines should be applied. For dock facilities, the BS 1435-2 or other equivalent standards are applicable.

The following tables are indicative of flow rates for hose supplied under the British Standard or the OCIMF guidelines.

Throughput at 12 metres/second Velocity			
Hose Nominal Inside Diameter		Throughput	
Inches	Millimetres	m ³ /hour	Barrels/hour
6	152	788	4,950
8	203	1,400	8,810
10	254	2,180	13,700
12	305	3,150	19,800
16	406	5,600	35,200
20	508	8,750	55,000
24	610	12,600	79,300
30	762	19,700	123,000

Table 18.1 – Throughput v. inside diameter at velocity of 12 m/s

Throughput at 15 metres/second Velocity			
Hose Nominal Inside Diameter		Throughput	
Inches	Millimetres	m ³ /hour	Barrels/hour
6	152	985	6,190
8	203	1,750	11,000
10	254	2,730	17,200
12	305	3,940	24,700
16	406	7,000	44,000
20	508	10,900	68,000
24	610	15,700	99,100
30	762	24,600	154,000

Table 18.2 – Throughput v. inside diameter at velocity of 15 m/s

18.2.6 Inspection, Testing and Maintenance Requirements for Dock Cargo Hoses

18.2.6.1 General

Cargo hoses in service should have a documented inspection at least annually to confirm their suitability for continued use. This should include:

- A visual check for deterioration/damage.
- A pressure test to 1.5 times the Rated Working Pressure (RWP) to check for leakage or movement of end fittings. (Temporary elongation at RWP should be measured as an interim step.)
- Electrical continuity test.

Hoses should be retired in accordance with defined criteria.

This guidance also applies to any ship's cargo hoses used for ship/shore connections and any other flexible hose connected to

ship or shore cargo systems, for example a jumper hose at the end of a ramp serving a pontoon berth.

A tanker should attest that any hoses that it provides are certified, fit for purpose, in good physical condition and have been pressure tested.

Details of the various inspections and tests are given in the following sections.

18.2.6.2 Visual Examination

A visual examination should consist of:

- Examining the hose assembly for irregularities in the outside diameter, e.g. kinking.
- Examining the hose cover for damaged or exposed reinforcement or permanent deformation.
- Examining the end fittings for signs of damage, slippage or misalignment.

A hose assembly exhibiting any of the above defects should be removed from service for more detailed inspection. When a hose assembly is withdrawn from service following a visual inspection, the reason for withdrawal and the date should be recorded.

18.2.6.3 Pressure Test (Integrity Check)

Hose assemblies should be hydrostatically tested to check their integrity. The intervals between tests should be determined in accordance with service experience, but in any case should not be more than twelve months. Testing intervals should be shortened for hoses handling particularly aggressive products or products at elevated temperatures.

Hoses for which the rated pressure has been exceeded must be removed and re-tested before further use.

A record should be kept of the service history of each hose assembly.

The recommended method of testing is as follows:

- (i) Lay out the hose assembly straight on level supports which allow free movement of the hose when the test pressure is applied. Conduct an electrical continuity test.
- (ii) Seal the hose by bolting blanking-off plates to both ends, one plate to be fitted with a connection to the water pump and the other to be fitted with a hand operated valve to release air through a vent. Fill the hose assembly with water until a constant stream of water is delivered through the vent.
- (iii) Connect the test pump at one end.
- (iv) Measure and record the overall length of the hose assembly. Slowly increase the pressure up to the Rated Working Pressure.

- (v) Hold the test pressure for a period of 5 minutes whilst examining the hose assembly for leaks at the nipples or for any signs of distortion or twisting.
- (vi) At the end of the 5 minute period and while the hose is still under full pressure, re-measure the length of the hose assembly. Ascertain the temporary elongation and record the increase as a percentage of the original length.
- (vii) Slowly raise the pressure to 1.5 times the Rated Working Pressure and hold this pressure for 5 minutes.
- (viii) Examine the hose assembly and check for leaks and any sign of distortion or twisting. Conduct an electrical continuity test with the hose at test pressure.
- (ix) Reduce the pressure to zero and drain the hose assembly. Re-test for electrical continuity.

If there are no signs of leakage or movement of the fitting while the used hose assembly is under test pressure, but the hose exhibits significant distortion or excessive elongation, the hose assembly should be scrapped and not returned to service.

If the integrity of the hose lining of smooth bore rubber hoses is in doubt, the hose should be additionally subjected to a vacuum test as follows:

- (i) Remove the blanks used for the pressure test and fit suitable plexiglas plates to the hose ends.
- (ii) Apply a vacuum of at least 510 mb gauge for a period of 10 minutes.
- (iii) Inspect the interior of the hose for blisters, bulges or separation of the lining from the carcass. Any damage to the lining should result in the hose being retired from service.
- (iv) Release the vacuum.
- (v) Re-test for electrical continuity or discontinuity as appropriate.

It should be noted that lightweight hoses, composite hoses and rough bore hoses should not be subjected to a vacuum test.

18.2.6.4 Electrical Continuity and Discontinuity Test

When using flexible hose strings, one length only of hose without internal bonding (electrically discontinuous) may be included in the hose string as an alternative to using the insulating flange (see Section 17.5.2). All other hoses in the hose string should be electrically bonded (electrically continuous). Since electrical continuity can be affected by any of the physical hose tests, a check on electrical resistance should be carried out prior to, during and after the pressure tests.

Electrically discontinuous hose should have a resistance of not less than 25,000 ohms measured between nipples (end flange to end flange). The testing of electrically discontinuous hoses should be carried out using a 500 V tester.

Electrically continuous hoses should not have a resistance higher than 0.75 ohms/metre measured between nipples (end flange to end flange).

18.2.6.5 Withdrawal from Service

In consultation with the hose manufacturer, retirement age should be defined for each hose type to determine when it should be removed from service, irrespective of meeting inspection and testing criteria.

The temporary elongations at which smooth bore rubber hose assemblies should be withdrawn from service will vary with the type of hose assembly construction, such that either:

- a) The temporary elongation, when measured as in Section 18.2.6.3 above, should not exceed 1.5 times the temporary elongation when the hose assembly was new.

For example:

Temporary elongation of new hose assembly: 4%

Temporary elongation at test: 6% maximum

or

- b) For hose assemblies where the temporary elongation of a new assembly was 2.5% or less, the temporary elongation at the test should not be more than 2% more than that of the new hose assembly.

For example:

Temporary elongation of new hose assembly: 1%

Temporary elongation of old hose assembly: 3% maximum.

18.2.6.6 Explanation of Pressure Ratings for Hoses

Figure 18.1 provides an illustration of the relationship between several definitions of pressure that are in common usage. The individual terms are briefly described below:

Operating Pressure

This is a common expression to define the normal pressure that would be experienced by the hose during cargo transfer. This would generally reflect the cargo pump operating pressures or hydrostatic pressure from a static system.

Working Pressure

This is generally considered to mean the same as 'Operating Pressure'.

Rated Working Pressure (RWP)

This is the common oil industry reference that defines the maximum cargo system pressure capabilities. This pressure rating is not expected to account for dynamic surge pressures but does include nominal pressure variations as expected during cargo transfer operations.

Maximum Working Pressure (MWP)

This is the same as Rated Working Pressure and is used by BS and EN Standards for designing hoses to these standards.

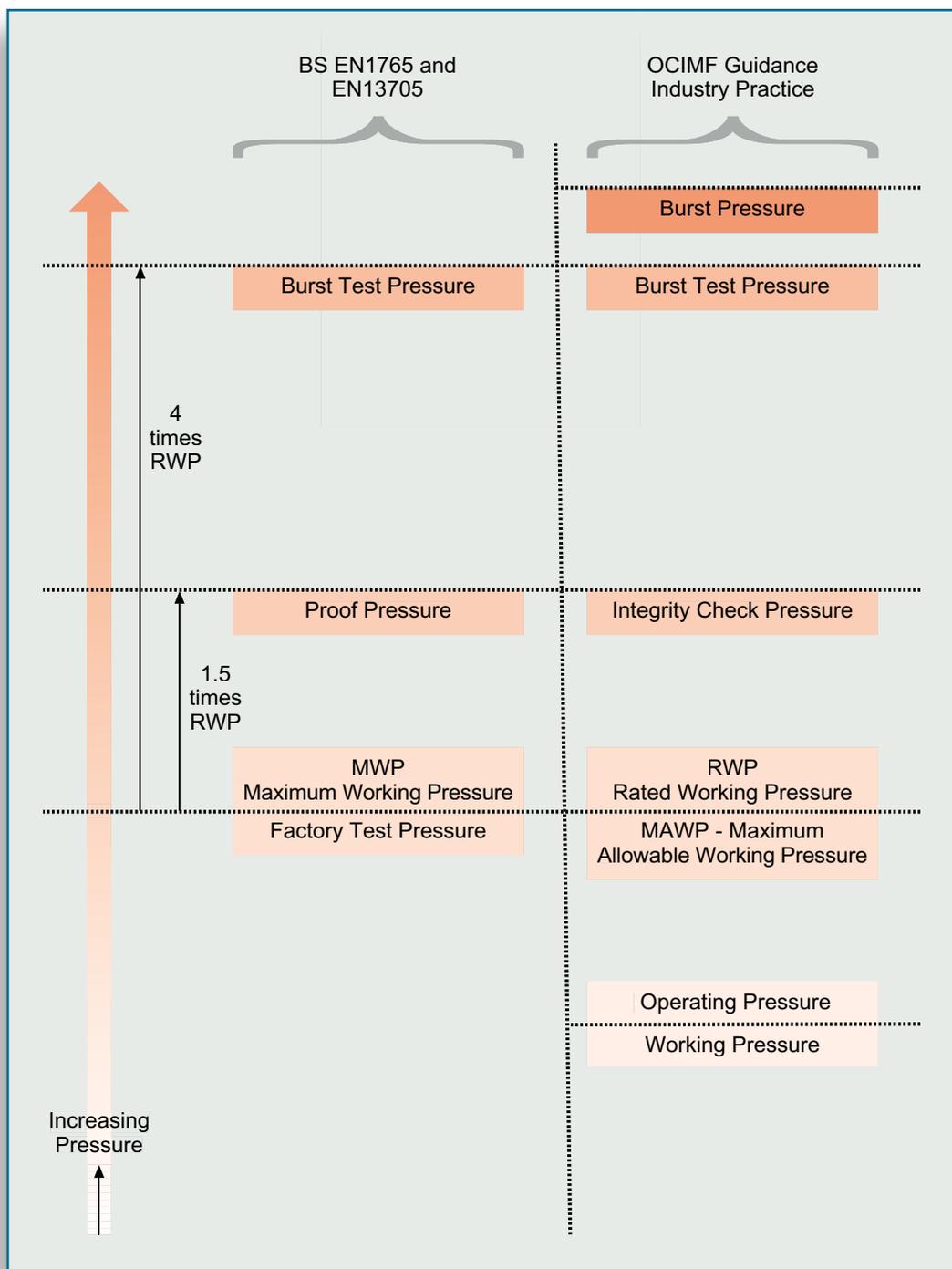


Figure 18.1 – Illustration of terminology used for defining hose pressures

Maximum Allowable Working Pressure (MAWP)

This is the same as Rated Working Pressure and Maximum Working Pressure. MAWP is used as a reference by the United States Coast Guard and is commonly used by terminals to define their system equipment limitations.

Factory Test Pressure

This is referenced in BS EN 1765 and is defined as equal to the Maximum Working Pressure, which in turn is the same as Rated Working Pressure.

Proof Pressure

This is a one time pressure that is applied to production hoses to ensure integrity following manufacture and is equal to 1.5 times the Rated Working Pressure.

Burst Test Pressure

This is a test requirement for a single prototype hose to confirm the hose design and manufacture of each specific hose type. The pressure is equal to a minimum of 4 times the Factory Test Pressure and must be applied in a specific manner and held for 15 minutes without hose failure.

Burst Pressure

This is the actual pressure at which a prototype hose fails. For a successful prototype hose, the Burst Pressure would exceed the Burst Test Pressure.

18.2.7 Hose Flange Standards

Flange dimensions and drilling should conform to the common standard of BS 1560 Series 150, or equivalent, as recommended for flanges on shore pipeline and ship manifold connections.

18.2.8 Operating Conditions

For oil cargo hose intended for use in normal duties:

- Oil temperatures in excess of those stipulated by the manufacturer, generally 82°C, should be avoided (see Section 18.2.3).
- The maximum permissible working pressure stipulated by the manufacturer should be adhered to and surge pressures should be avoided.
- The hose life will be shorter in white oil service than with black oils.

18.2.9 Extended Storage

New hoses in storage before use, or hoses removed from service for a period of two months or more, should as far as practicable be kept in a cool, dark, dry store in which air can circulate freely. They should be drained and washed out with fresh water and laid out horizontally on solid supports spaced to keep the hose straight. No oil should be allowed to come into contact with the outside of the hose.

If the hose is stored outside, it should be well protected from the sun.

Recommendations for hose storage are given in the OCIMF publication '*Guidelines for the Handling, Storage, Inspection and Testing of Hoses in the Field*'.

18.2.10 Checks Before Hose Handling

It is the responsibility of the terminal to provide hoses that are in good condition, but the Master of a tanker may reject any which appear to be defective.

Hose assemblies should be visually inspected on a regular basis. When hose assemblies are in constant or frequent use, the assembly should be inspected before each loading/unloading operation. Hose assemblies subject to infrequent use should be inspected each time they are brought into use.

18.2.11 Handling, Lifting and Suspending

Hoses should always be handled with care and should not be dragged over a surface or rolled in a manner that twists the body of the hose. Hoses should not be allowed to come into contact with a hot surface such as a steam pipe. Protection should be provided at any point where chafing or rubbing can occur.

Lifting bridles and saddles should be provided. The use of steel wires in direct contact with the hose cover should not be permitted. Hoses should not be lifted at a single point with ends hanging down, but should be supported at a number of places so that they are not bent to a radius less than that recommended by the manufacturer.

Excessive weight on the ship's manifold should be avoided. If there is an excessive overhang, or the ship's valve is outside the stool support, additional support should be given to the manifold. A horizontal curved plate or pipe section should be fitted at the ship's side to protect the hose from sharp edges and obstructions. Adequate support for the hose when connected to the manifold should be provided. Where this support is via a single lifting point, such as a derrick, the hose string should be supported by bridles or webbing straps. Some hoses are specifically designed to be unsupported.

18.2.12 Adjustment During Cargo Handling Operations

As the tanker rises or falls as a result of tide or cargo operations, the hose strings should be adjusted so as to avoid undue strain on the hoses, connections and ship's manifold and to ensure that the radius of curvature of the hose remains within the limits recommended by the manufacturer.

18.2.13 Submarine and Floating Hose Strings

Hoses in service at offshore mooring installations should be inspected periodically.

Particular attention should be paid to kinked or damaged sections, oil seepage from the hose flange areas, heavy marine growth and scuffing on the seabed. Where hose strings are lowered and raised repeatedly from the seabed, care should be taken to avoid damage caused by chains and lifting plates.

Particular care should be taken when lowering hose strings to avoid them coiling down. Dragging of hoses over the seabed should be minimised.

Before attempting to lift a hose string on board, the Responsible Officer should check that the total weight involved does not exceed the safe working load of the ship's derrick or crane. The terminal should advise the total weight of the hose string to be lifted in relation to the height of the lift, which could be as much as 8 metres above deck level for a

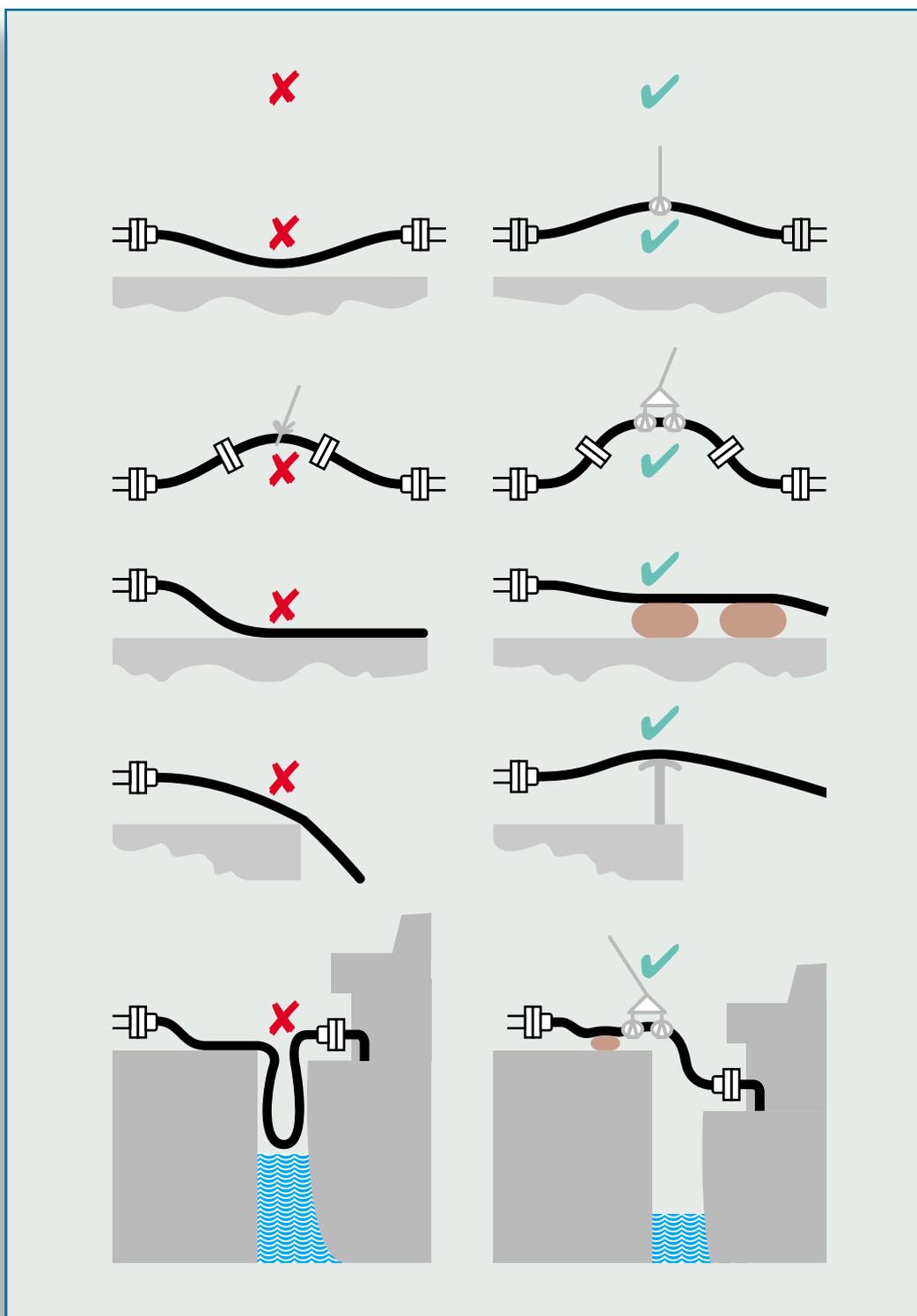


Figure 18.2 – Handling cargo hose

tanker's manifold connection situated 4.6 metres inboard. In wave and/or swell conditions greater than 1 metre significant height, the movement of the hose may also impose dynamic loads. In these circumstances, the load to be lifted may be as much as 1.5 times the static weight of the hose and its contents (see Section 18.2.13.1).

During the lifting of hose strings, contact with the ship's side and any sharp edges should be avoided.

Size of Tanker	Water Depth in Berth										
	180ft 54m	150ft 46m	120ft 37m	100ft 30m	90ft 27m	80ft 24m	70ft 21m	60ft 18m	50ft 15m	40ft 12m	30ft 9m
20 inch I.D. Hoses											
500,000 DWT	19.5	18.7	18.0	17.5	17.3						
333,000 "	16.9	16.2	15.4	14.9	14.7	14.5					
270,000 "	16.4	15.7	14.9	14.4	14.2	13.9	13.7				
200,000 "	15.9	15.1	14.4	13.9	13.7	13.4	13.2	12.9			
100,000 "	14.3	13.6	12.9	12.4	12.1	11.9	11.6	11.4	11.2		
70,000 "	13.8	13.1	12.4	11.9	11.6	11.4	11.1	10.9	10.6	10.4	
50,000 "	13.4	12.7	12.0	11.5	11.2	11.0	10.7	10.5	10.3	10.0	9.8
35,000 "	13.1	12.3	11.6	11.1	10.8	10.6	10.4	10.1	9.9	9.6	9.4
18,000 "	12.4	11.7	11.0	10.5	10.2	10.0	9.7	9.5	9.2	9.0	8.7
16 inch I.D. Hoses											
500,000 DWT	13.5	13.0	12.4	12.0	11.8						
333,000 "	11.8	11.2	10.7	10.3	10.1	9.9					
270,000 "	11.4	10.9	10.3	10.0	9.8	9.6	9.4				
200,000 "	11.1	10.5	10.0	9.6	9.4	9.2	9.1	8.9			
100,000 "	10.1	9.5	8.9	8.6	8.4	8.2	8.0	7.8	7.7		
70,000 "	9.7	9.2	8.6	8.2	8.1	7.9	7.7	7.5	7.3	7.1	
50,000 "	9.4	8.9	8.3	8.0	7.8	7.6	7.4	7.2	7.1	6.9	6.7
35,000 "	9.2	8.6	8.1	7.7	7.5	7.3	7.2	7.0	6.7	6.6	6.4
18,000 "	8.7	8.2	7.6	7.3	7.1	6.9	6.7	6.5	6.4	6.2	6.0
12 inch I.D. Hoses											
500,000 DWT	8.9	8.6	8.2	8.0	7.8						
333,000 "	7.8	7.4	7.0	6.8	6.7	6.6					
270,000 "	7.6	7.2	6.8	6.6	6.5	6.4	6.2				
200,000 "	7.3	7.0	6.6	6.4	6.2	6.1	6.0	5.9			
100,000 "	6.6	6.3	5.9	5.7	5.6	5.4	5.3	5.2	5.1		
70,000 "	6.4	6.1	5.7	5.5	5.3	5.2	5.1	5.0	4.9	4.7	
50,000 "	6.3	5.9	5.5	5.3	5.2	5.1	4.9	4.8	4.7	4.6	4.4
35,000 "	6.1	5.7	5.4	5.1	5.0	4.9	4.8	4.6	4.5	4.4	4.3
18,000 "	5.8	5.4	5.1	4.8	4.7	4.6	4.5	4.4	4.2	4.1	4.0
10 inch I.D. Hoses											
500,000 DWT	6.2	5.9	5.7	5.5	5.4						
333,000 "	5.4	5.1	4.9	4.7	4.6	4.5					
270,000 "	5.2	5.0	4.7	4.6	4.5	4.4	4.3				
200,000 "	5.1	4.8	4.6	4.4	4.3	4.2	4.1	4.0			
100,000 "	4.6	4.3	4.1	3.9	3.8	3.7	3.6	3.5	3.4		
70,000 "	4.4	4.2	3.9	3.8	3.7	3.6	3.5	3.4	3.3	3.2	
50,000 "	4.3	4.1	3.8	3.7	3.6	3.5	3.4	3.3	3.2	3.1	3.0
35,000 "	4.2	3.9	3.7	3.5	3.4	3.3	3.2	3.1	3.0	2.9	2.8
18,000 "	4.0	3.7	3.5	3.3	3.2	3.1	3.0	2.9	2.8	2.7	2.6
8 inch I.D. Hoses											
500,000 DWT	4.4	4.2	4.1	4.0	3.9						
333,000 "	3.9	3.7	3.5	3.4	3.3	3.2					
270,000 "	3.7	3.6	3.4	3.3	3.2	3.1	3.0				
200,000 "	3.6	3.5	3.3	3.2	3.1	3.0	2.9	2.8			
100,000 "	3.3	3.1	2.9	2.8	2.7	2.6	2.5	2.4	2.3		
70,000 "	3.2	3.0	2.8	2.7	2.6	2.5	2.4	2.3	2.2	2.1	
50,000 "	3.1	2.9	2.8	2.6	2.5	2.4	2.3	2.2	2.1	2.0	1.9
35,000 "	3.0	2.9	2.7	2.5	2.4	2.3	2.2	2.1	2.0	1.9	1.8
18,000 "	2.9	2.7	2.5	2.4	2.3	2.2	2.1	2.0	1.9	1.8	1.7

Table 18.3 – Weight of hose strings (in tonnes) for conventional buoy moorings
(See 18.2.13.1)

Size of Tanker	Inside Diameter of Hose in Inches				
	20	16	12	10	8
500,000 DWT	16.4	11.4	8.2	6.6	4.7
330,000 "	13.6	9.4	6.8	5.4	3.9
270,000 "	13.0	9.1	6.5	5.2	3.7
200,000 "	12.5	8.7	6.2	5.0	3.6
100,000 "	10.8	7.5	5.4	4.3	3.1
70,000 "	10.0	7.1	5.1	4.1	2.9
50,000 "	9.8	6.8	4.9	3.9	2.8
35,000 "	9.4	6.5	4.7	3.7	2.7
18,000 "	8.7	6.0	4.3	3.5	2.5

**Table 18.4 – Weight of hose strings (in tonnes) for single buoy moorings
(See 18.2.13.1)**

When the hose string has been lifted to the required height for connecting to the manifold, and while it remains connected, the vertical section of the hose string should be supported by hang-off chains or wires made fast to a strong point on the ship's deck.

In order to prevent spillage, precautions must be taken to ensure that, prior to the removal of blanks from submarine or floating pipelines, the section between the last valve and the blank does not contain oil under pressure.

A visual inspection of each floating hose string should be made before connecting it to the tanker manifold to determine if damage has been caused by, for example, contact with other ships or crossed lines and for possible kinking or oil seepage.

If any damage to the hose is found which is likely to affect its integrity, the hose should be withdrawn from use to allow further inspection and repair.

18.2.13.1 Hose String Weights

Tables 18.3 and 18.4 give the approximate weights of hose strings in tonnes (including fittings, floats and pick-up buoy) with all hoses full of crude oil having a specific gravity of 0.850. The assumed lift is 7.5 metres above deck level, with the tanker on light draught. These tables are for general guidance only and terminals should check their own arrangements.

18.3 Vapour Emission Control Systems

Some terminals are equipped with vapour emission control systems to receive and process vapours displaced from a ship during loading operations. The terminal's operating manual should include a full description of the system and the requirements for its safe operation. The terminal's information booklet, passed to visiting ships for information, should also include details of the vapour recovery system for the information of visiting vessels.

All shore personnel in charge of transfer operations should complete a structured training programme covering the particular vapour emission control system installed

in the terminal. The training should also include details of typical equipment installed on board ships and related operating procedures.

Ship and shore personnel should agree any constraints associated with the operation of the vapour emission control system during pre-transfer discussions. Confirmation that this information has been exchanged and agreed will be included within the Ship/Shore Safety Check-List (see Section 26.3.3, Question 32).

Section 11.1.13 should be referred to for information on the primary safety issues relating to cargo transfer operations using vapour recovery.

SAFETY AND FIRE PROTECTION

This Chapter contains general guidance on safety management at marine terminals and specific recommendations on the design and operation of fire detection and protection systems.

The guidance on fire-fighting equipment in this Chapter should be considered in conjunction with Chapter 5, which addresses fire-fighting theory.

19.1 Safety

19.1.1 Design Considerations

The layout and facilities at a terminal will be determined by many factors, including:

- Local topography and water depth.
- Access to the berth(s) – open sea, river channel or inlet.
- Types of cargo to be handled.
- Quantities of cargo to be handled.
- Local facilities and infrastructure.
- Local environmental conditions.
- Local regulations.

Most of the decisions regarding layout of facilities will have been decided at the initial planning and design stage for the terminal. However, many terminals have developed over time and may be required to handle a greater variety of products, larger quantities of cargoes and larger vessels than were anticipated when the terminal was originally designed. Terminals may also be subjected to reduced throughputs or changing environmental conditions, such as reduced water depths.

All terminals should be subjected to regular review to ensure that the facilities provided remain fit for purpose in the context of the operations being undertaken and current legislation. Such reviews should cover elements listed in the following sections, which will enable the terminal to maintain continuously the necessary level of safety.

19.1.2 Safety Management

Every terminal should have a comprehensive safety programme designed to deliver an appropriate level of safety performance. The safety programme should ensure that the following topics are addressed:

- Emergency management.
- Casualty response and casualty evacuation.

- Periodic fire and oil spill drills. These drills should address all aspects and locations of potential incidents and should include ships at a berth.
- Feedback from emergency drills and exercise.
- Hazard identification and risk assessment.
- Permit to Work systems.
- Incident reporting, investigation and follow-up.
- Near miss reporting, investigation and follow-up.
- Site safety inspections.
- Safe work practices and standards of housekeeping.
- Personal Protective Equipment. The equipment provided and requirements for its use should include associated third parties – tug and mooring boat crews, mooring gangs or cargo surveyors for example.
- Safety meetings across the terminal's manning structure encompassing all personnel.
- Work team safety briefings.
- Pre-task safety discussions.
- Safety management of visitors, contractors and ship's crew.
- On site training and familiarisation.

19.1.3 Permit to Work Systems – General Considerations

Permit to Work systems are widely used throughout the petroleum industry. The permit is essentially a document which describes the work to be done and the precautions to be taken in doing it, and which sets out all the necessary safety procedures and equipment. (Permit to Work systems are fully described in Section 9.3.)

For operations in hazardous and dangerous areas, permits should normally be used for tasks such as:

- Hot Work.
- Work with a spark potential.
- Work on electrical equipment.
- Diving operations.
- Heavy lifts.

The permit should specify clearly the particular item of equipment or area involved, the extent of work permitted, the conditions to be met and the precautions to be taken and the time and duration of validity. The latter should not normally exceed a working day. At least two copies of the permit should be made, one for the issuer and one for the person at the work site.

The layout of the permit should include a check-list to provide both the issuer and the user with a methodical procedure to check that it is safe for work to begin and to stipulate all the necessary conditions. If any of the conditions cannot be met, the permit should not be issued until remedial measures have been taken.

It is advisable to have distinctive Permit to Work systems for different hazards. The number of permits required will vary with the complexity of the planned activity. Care must be taken not to issue a permit for subsequent work that negates the safety conditions of an earlier permit. For example, a permit should not be issued to break a flange adjacent to an area where a Hot Work permit is in force.

Before issuing a permit, the Terminal Representative must be satisfied that the conditions at the site, or of the equipment to be worked on, are safe for the work to be performed, taking due account of the presence of any ships that will be alongside while the work is being carried out.

An entry permit should normally be issued prior to personnel entering an enclosed space (see Chapter 10).

19.2 Marine Terminal Fire Protection

19.2.1 General

Fire safety at marine terminals is provided through overlapping levels of protection as follows:

- Prevention and isolation.
- Detection and alarm facilities.
- Protection equipment.
- Emergency and escape routes.
- Emergency planning.
- Evacuation procedures.

Fire safety at marine terminals requires an appropriate balance between good design features, safe operational procedures and good emergency planning.

Fire protection alone will not provide an acceptable level of safety. Fire protection measures should not interfere with mooring or other operations.

Fire protection measures are not effective in limiting the frequency and size of spills or in minimising sources of ignition.

Automatic detection of fire, and the subsequent rapid response of emergency personnel and fire protection equipment, will limit the spread of fire and the hazard to life and property at unmanned locations or at locations with limited numbers of personnel.

Fire protection facilities should be designed to contain and control fires that may occur in defined areas and to provide time for emergency exit.

Emergency exit facilities are needed to ensure the safe evacuation of all personnel from the affected area in the event that fire protection facilities do not successfully control a fire.

19.2.2 Fire Prevention and Isolation

Safety at marine terminals begins with fire prevention features inherently designed into the overall facility. Terminal fire-fighting equipment is usually dispersed around the site and much of it is exposed to the weather. To ensure that it is fit for use, it is essential that all fire-fighting equipment is regularly inspected, maintained in a constant state of readiness and tested periodically to ensure reliable operation. Terminals should ensure that all fire-fighting equipment is maintained under the control of a planned maintenance system. Careful design of a marine terminal is no guarantee that a safe operation will be achieved. The training and competence of personnel are of critical importance. Periodic simulated emergency drills, both announced and unannounced, are recommended to ensure operability of the equipment, operator proficiency in the use of equipment and familiarity with emergency procedures.

19.2.3 Fire Detection and Alarm Systems

The selection and fitting of fire detection and alarm systems at a terminal is dependent upon the risk exposure presented by the product being handled, tanker sizes and terminal throughput. This topic is discussed in more detail in Section 19.4.1.

The location of all detectors should take into account natural and mechanical ventilation effects, since heat is carried and stratified by convection currents. Other considerations, such as the ability of flame detectors to 'see' flames, should be taken into account. The advice of manufacturers and fire and safety experts should be sought, along with a compliance check against local regulations, before installation.

In general terms, automatic detection and alarm systems have the purposes of alerting personnel and initiating a system to respond with the aim of reducing loss of life and property due to fires or other hazardous conditions. These systems may have one or more circuits to which automatic fire detectors, manual activation points, water flow alarm devices, combustible gas detectors and other initiating devices are connected. They may also be equipped with one or more indicating device circuits to which alarm indicating signals, such as control panel indicator and warning lamps, outdoor flashing lights, bells and horns are connected.

19.2.4 Automatic Detection Systems

Automatic detection systems consist of mechanical, electrical or electronic devices that detect environmental changes created by fire or by the presence of toxic or combustible gases. Fire detectors operate on one of three principles, sensitivity to heat, reaction to smoke or gaseous products of combustion, or sensitivity to flame radiation.

Heat Sensing Fire Detectors fall into two general categories, fixed temperature devices and rate-of-rise devices. Some devices combine both principles (rate-compensated detectors). Generally, heat detectors are best suited for fire detection in confined spaces subject to rapid and high heat generation, directly over hazards where hot flaming fires are expected, or where speed of detection is not the prime consideration.

Smoke Sensing Fire Detectors are designed to sense smoke produced by combustion and operate on various principles, including ionisation of

smoke particles, photo-electric light obscuration or light scattering, electrical resistance changes in an air chamber and optical scanning of a cloud chamber.

Gas (Product of Combustion) Sensing Fire Detectors are designed to sense and respond to one or more of the gases produced during the combustion of burning substances. These detectors are seldom a preferred option as fire tests have shown that detectable levels of gases are reached after detectable smoke levels.

Flame Sensing Fire Detectors are optical detection devices that respond to optical radiant energy emitted by fire. Flame detectors responsive to infra-red or ultraviolet radiation are available, but ultraviolet sensitive detectors are generally preferred.

19.2.5 Selection of Fire Detectors

When planning a fire detection system, detectors should be selected based on the types of fires that they are protecting against. The type and quantity of fuel, possible ignition sources, ranges of ambient conditions, and the value of the protected property should all be considered.

In general, heat detectors have the lowest cost and lowest false alarm rate, but are the slowest to respond. Since the heat generated by small fires tends to dissipate fairly rapidly, heat detectors are best used to protect confined spaces, or located directly over hazards where flaming fire could be expected. To avoid false alarms, the actuation temperature of a heat detector should be at least 13°C above the maximum expected ambient temperature in the area protected.

Smoke detectors respond faster to fires than heat detectors. Smoke detectors are best suited to protect confined spaces and should be installed either according to prevailing air current conditions or on a grid layout.

Photoelectric smoke detectors are best used in places where smouldering fires, or fires involving low temperature pyrolysis, may be expected. Ionisation smoke detectors are useful where flaming fires would be expected.

Flame detectors offer extremely fast response, but will warn of any source of radiation in their sensitivity range. False alarm rates can be high if this kind of detector is improperly used. Their sensitivity is a function of flame size and distance from the detector. They can be used to protect areas where explosive or flammable vapours are encountered because they are usually available in explosion-proof housings.

19.2.6 Location and Spacing of Fire Detectors

Fire detection at marine terminals is usually provided at remote, unmanned, high risk facilities, such as pumping stations, control rooms, and electrical switch gear rooms. Detectors may also be fitted at valve manifolds, loading arms, operator sheds and other equipment or areas susceptible to hydrocarbon leaks and spills, or that contain ignition sources.

To function effectively, fire detection devices must be properly positioned. Detailed requirements for spacing can be found in appropriate fire codes.

Heat, smoke and fire gas detectors should be installed in a grid pattern at their recommended spacing, or at reduced spacing for faster response. Each system should be engineered for the specific area being protected, with due consideration given to ventilation characteristics.

Detection systems for actuation of fire extinguishing systems should be arranged using a cross-zone array. In a cross-zone array, no two adjacent ionisation type detectors should be in the same detection circuit zone. The first detector actuated should activate the fire alarm system, while the actuation of a detector on an adjacent circuit should activate the fire extinguishing system.

19.2.7 Fixed Combustible and Toxic Gas Detectors

These gas detectors are designed to sense the presence of combustible or toxic gases to provide an early warning. They are used to provide continuous monitoring of potentially hazardous areas to safeguard against fire or explosion and for personnel protection from toxic gas leaks.

The operating principles of combustible and toxic gas detectors are similar to those for the product of combustion-gas sensing fire detectors. See also Sections 2.3 (Toxicity) and 2.4 (Gas Measurement).

Terminals that handle crude oil or products containing toxic components should consider installing fixed gas detection and alarm equipment in areas where personnel may be exposed. Consideration should be given to placing sensors in locations where leaks or spills could occur, for example loading arms, valve manifolds and transfer pumps, or where gas could accumulate due to inadequate ventilation. Toxic gas detectors may also be installed in the supply air intakes of pressurised control rooms and inside non-pressurised control rooms.

19.2.8 Locating Fixed Combustible and Toxic Gas Detectors

General considerations in positioning combustible and toxic gas detectors include the following:

- Elevations depending on relative density of air and any potential gas leakage.
- Possible flow direction of leaking gas.
- Proximity to potential hazards.
- Accessibility of detectors for calibration and maintenance.
- Sources of damage, such as water and vibration.
- Manufacturer's recommendations for sensors connected to analysers.

19.2.9 Fixed Combustible and Toxic Gas Analysers

Continuous analysers are typically permanently installed, electrically operated devices for the continuous analysis of air samples for detecting combustible and toxic gases, often using multiple sensors.

The analysers may be of the remote detection type in which individual diffusion sensors are connected to the analysers by electrical cable. In this case, the central equipment is available either for installation in

non-hazardous locations, such as pressurised control rooms, or in explosion-proof enclosures for location in hazardous areas.

The remote detection type, which uses remote diffusion detectors, provides rapid response and good reliability, making this the preferred design.

Alternatively, continuous analysers may also utilise a central detection unit in which samples are drawn from hazardous areas through tubing to the central location by means of a suction pump. Central diffusion detection units, utilising sample lines, are characterised by a relatively slow response time. Additionally, particulates must be taken into account and the lines must be heated to prevent condensation. Consequently, central detection units are not generally recommended.

Gas analysers should usually be provided with the following features and readout and alarm functions, in addition to continuous recording of data:

- a) Channels for connection to individual diffusion detection sensors so that each sampling circuit can analyse samples continuously. Thus, when an alarm condition occurs, the analyser will home on the sensor registering the alarm and the alarm will remain actuated until manually reset.
- b) The combustible gas analyser is calibrated in percentage of Lower Explosive Limit (LEL) and should be provided with a channel selector, indicator lamps to show the samples being analysed, and a meter. Visual and audible alarms should be provided for two levels of detection. The minimum level most frequently used is 20% LEL. The second or upper level of detection is usually 60% LEL. Silencing of the audible alarm should not extinguish the visual alarm until gas detection falls below the alarm level. Contacts are provided at the two levels of detection to permit automatic operation of a purging or fire prevention system.
- c) Alarm levels should be adjustable and alarms may be actuated by contact meters, recorder limit switches, solid-state signal level detectors, or optical meter relays. Multi-level alarms can be provided with means to actuate ventilation equipment, to effect transfer pump shutdown, or to actuate fire extinguishing systems.
- d) A means to disconnect the detectors safely from the actuating circuit. The disconnection capability is necessary for proper routine calibration and maintenance activities. A key-operated switch with supervisory alarm is recommended.
- e) On complicated or extensive systems, the indication of alarms on a graphic display, such as an outline plan of a facility, is recommended.
- f) Toxic gas analysers should be set to sound alarms at the monitored location and in the control room when the gas reaches the predetermined level, for example when an H_2S concentration reaches 5 ppm. Alarms should generally be both audible and visual.
- g) The gas detector head assembly should be suitable for the electrical classification of the hazardous area and, if installed outdoors, should be weatherproof and corrosion resistant.
- h) The detecting unit included in the head should provide adequate sensitivity and the necessary stability, under all conditions, to repeat any reading within $\pm 2\%$ of the full scale range.

19.2.10 Fire Extinguishing System Compatibility

Where a detection system is part of an automatic fixed fire extinguishing system, complete compatibility between the systems is essential. Detection devices and systems that are highly susceptible to false alarms should be avoided, especially when they are connected to fixed fire extinguishing systems for automatic activation (see Section 19.3.5).

19.3 Alarm and Signalling Systems

An alarm and signalling system must perform four significant functions. It should:

- Rapidly transmit an alarm or signal to indicate the detection of fire before there is significant damage.
- Initiate a sequence of events to evacuate personnel in the vicinity of fire.
- Transmit an alarm or signal to notify responsible parties or initiate an automatic extinguishing system.
- Have the capability to automatically self-test and warn of malfunction.

19.3.1 Types of Alarm Systems

Alarm systems are used to indicate an emergency and to summon assistance.

There are many different types ranging from a local system providing an alert signal at the protected facility, to one which alerts at a remote station attended by trained personnel 24 hours per day, such as a fire or police station or a third party answering service.

The type of system installed at a particular location should be based on a thorough risk assessment with input from competent personnel in the field of fire protection, taking due account of any applicable local regulations.

19.3.2 Types of Signal

Fire alarm systems provide several distinct types of signal which can be audible, visual or both. They range from relatively simple trouble signals, such as alarms for power interruptions, through supervisory signals, such as when critical equipment is in an abnormal condition, to either coded or non-coded alarm signals sounded when a fire alarm is activated either continuously or in the form of a prescribed pattern.

19.3.3 Alarm and Signalling System Design

Any variation or combination of the types of alarm and signalling systems previously described can be used to meet local circumstances.

In a large terminal facility, or where the terminal is an integral part of a large plant or processing facility, a coded signal system is usually preferred. The facility should be divided into a grid system, with each area of the grid identified by a numbered code. The coded signal system should include a code transmitter that triggers an alert at the specific location and also activates the general alarm.

Emergency reporting can also be achieved by using a dedicated emergency telephone system. Additionally, manual fire alarm stations can be installed instead of, or to supplement, the telephone reporting system.

When a dedicated telephone system is used, a special telephone should be installed in the control room or supervisory station to receive emergency calls. The telephone should be capable of receiving incoming calls only and extensions should also be provided at other locations which have preliminary emergency responsibility.

The general alarm system should, as a minimum, consist of one or more air horns, electric horns or steam whistles which are strategically located to ensure maximum coverage throughout the terminal. The alarm should be clear, audible and distinctive from signals used for other purposes, and should be capable of being heard in all areas of the terminal regardless of background noise.

Auxiliary alarm devices should be provided for indoor locations or remote areas where the general alarm cannot be heard. These alarms may be bells, or air or electric horns. Whichever devices are provided, they should be the same throughout the facility and should be distinct from other warning devices.

19.3.4 Alternative Alarm and Signalling System Design

Although a coded alarm system is generally preferable for large terminals, a non-coded, announcement type system can be used. Either system can consist of telephones or manual fire alarm stations at strategic locations. Coded manual fire alarm stations can be connected to the general alarm to sound a coded signal without manual intervention. Non-coded stations can be arranged to show fire location on a fire alarm indicator in the central control room or supervisory station so that the attendant can energise the code transmitter. Both the coded or non-coded announcement type systems should be controlled from a central fire alarm control panel.

19.3.5 Interface Between Detection Systems and Alarm or Fire Extinguishing Systems – Circuit Design

Actuation relays, where required between detectors and alarm or extinguishing systems, should consist of closed loops that are normally de-energised, and that require an input of sufficient electrical energy to activate the alarm or extinguishing system. This arrangement will prevent a false activation of an alarm or extinguishing system upon loss of power. It also allows for provision of a separate fault signal upon power loss.

19.3.6 Electric Power Sources

Electric power should be available from two highly reliable sources. The usual arrangement is an alternating current (AC) primary power supply, with a trickle charger supplying an emergency battery system for standby power. In some locations, authorities may require an engine driven generator as a secondary power supply in case the primary supply fails.

The capacity of secondary power supplies varies with the type of alarm system and the requirements of local regulatory authorities. For local or proprietary alarm systems where signals are registered only at the

terminal or plant central control room or central supervisory centre, battery size usually provides for loss of primary power for a minimum period of 8 hours and for at least 12 hours if the supply is not reasonably reliable.

In auxiliary and remote station systems where trouble signals from the loss of local operating power might not be transmitted to the receiving station, a 60 hour emergency power supply capacity is usually required in order that the emergency supply can operate the entire system if the power is cut over a weekend.

19.4 Detection and Alarm Systems at Terminals Handling Crude Oil and Petroleum Products

19.4.1 General

The specification for the detection and alarm systems on terminals transferring crude oil and flammable hydrocarbon liquids will depend on a number of factors that include the following:

- The commodities or products transferred.
- Tanker size and number berthed per year.
- Pumping rates.
- The proximity of hazardous equipment with respect to other equipment or hazards, i.e. equipment spacing, electrical area classification.
- The proximity of tankers to the terminal and to hazardous terminal equipment.
- The proximity of the terminal to residential, commercial or other industrial properties.
- The installation of emergency isolation valves.
- The number and nature of fixed fire extinguishing systems that are connected to detection and alarm systems.
- Whether the terminal is continuously manned or periodically unmanned.
- The ability of the emergency response unit at the terminal or within the terminal's organisation to provide a timely and effective response.
- Proximity to any outside emergency response units, and their capacity, availability and time of response.
- Requirements imposed by local regulatory bodies.
- The desired degree of protection beyond regulatory requirements.
- The degree of effective protection that a particular manufacturer's detection and alarm system offers.

The alarm system should have the capability to raise local audible and visual alarms and possibly a general alarm if the terminal is manned and depending upon local circumstances. It should indicate an alarm at a continuously attended central fire control panel showing the location of the activated detection and fire extinguishing system. Where fixed gas detection equipment is installed or the detection system covers more than a single detection zone, the panel should indicate the location of the activated gas detector.

Use of fire detection equipment that is designed to activate fixed fire-fighting equipment automatically may be advisable where a terminal extends away from shore in such a way that manual fire-fighting is difficult, dangerous or ineffective. This may also be advisable where fire-fighting boats are not available and accessibility with fire-fighting vehicles is poor, or at locations where trained fire-fighting personnel are limited in number and/or not always available for rapid response.

In most cases, a manually operated fire protection system is to be preferred. Upon actuation of a detector, the detection system should sound a local alarm and send a signal to a continuously attended control panel. If conditions warrant, the fire protection system may be manually activated by an operator, the fire brigade, or by personnel who monitor the alarm.

Equipment and terminal areas that are sometimes monitored with automatic fire or gas detection systems include transfer pumps, valve manifolds, loading arm areas, control rooms, electrical switch gear enclosures, operator's sheds, below deck areas, and other equipment or areas susceptible to hydrocarbon leaks and spills or that contain ignition sources.

19.4.2 Control Rooms/Control Buildings

When determining necessary detection and alarm equipment for control rooms, the first consideration should always be the requirements of local regulations. Once these have been met, the installation of additional gas and fire detection devices with associated alarm equipment depends on site specific factors such as control room pressurisation and attendance.

The following general detection and alarm facilities are suggested for all control rooms or buildings:

- Manual fire alarm stations should be provided at all exits. The operation of a manual fire station should sound a local alarm and should activate an alarm at the main fire control panel, if provided.
- A fire detection system should be installed in any area of a control building that is normally unattended. Each detector should raise a local alarm in the areas of the control room that are normally occupied and should activate an alarm at the main fire control panel located in a continuously attended area.
- Combustible gas detectors should be installed in the supply air intake vents of pressurised control rooms and inside non-pressurised control rooms. Each gas detector should sound a local alarm and should annunciate an alarm at a main fire control panel located in a continuously attended area.

Control rooms that are not continuously attended may sometimes be equipped with additional facilities. If the terminal handles volatile liquids, a fixed fire extinguishing system, activated automatically upon detection of combustible gas or fire, may be installed. The gas or fire detection system should then be arranged in a cross-zone array (see Section 19.2.6).

19.5 Fire-Fighting Equipment

Fire-fighting systems are required to protect potentially exposed equipment in order to avoid fire escalation and to minimise fire damage. Ideally, most fires should be controlled and extinguished by first isolating the source of the fuel and, if necessary and feasible, by extinguishing the fire with appropriate agents.

Where marine terminals have land connections with refineries or related installations, the fire-fighting system on the terminal is usually an integral part of the fire-fighting scheme for the whole of the complex.

Fixed fire-fighting systems should be capable of full operation by the personnel locally available within the first 5 minutes of the outbreak of a fire.

19.5.1 Terminal Fire-Fighting Equipment

In ports with many terminals or in congested industrial locations, the local authority or port authority may provide the main fire-fighting capability. The type and quantity of fire-fighting equipment should be related to the terminal size and location, the frequency of terminal use, and the additional factors identified in Section 19.1. Other relevant factors include the existence of reciprocal arrangements and the physical layout of the terminal.

Because of these many variables, it is impractical to make specific recommendations concerning fire-fighting equipment. Each terminal should be studied individually when deciding upon the type, location and use of the equipment.

In addition to national regulatory requirements, capability should be based on the general guidance contained within this Chapter and the outputs of a formal risk assessment. The risk assessment should take into account the following criteria for each berth:

- The sizes of ships that can be accommodated on the berth.
- Location of the terminal and the berth.
- Nature of the cargoes handled.
- Potential impact of oil spillage.
- Areas to be protected.
- Regional fire response capability.
- Level of training and experience of local emergency response organisations.

19.5.2 Portable and Wheeled Fire Extinguishers and Monitors

Portable and wheeled fire extinguishers should be provided at every marine terminal berth on a scale relative to the size, location and frequency of use of the berth (see Table 19.1).

Portable fire extinguishers should be located so that a fire extinguisher can be reached without travelling more than 15 metres. Wheeled extinguishers should normally be located in accessible positions at each end of loading arm gantries or at the berth approach access point.

Fire extinguisher locations should be permanent and conspicuously identified by luminous background paint or suitably coloured protective boxes or cabinets. The top or lifting handle of a fire extinguisher should normally not be at a height of more than one metre.

Dry chemical extinguishers are recognised as the most appropriate type of extinguisher for the quick knock-down of small hydrocarbon fires.

Carbon dioxide extinguishers have little value at berths or on jetties, except at points where minor electrical fires could occur. However, enclosed electrical sub-stations or switch rooms located on marine terminals should be equipped with an adequate number of carbon dioxide extinguishers or should have a fixed carbon dioxide system installed.

Foam extinguishers with a capacity in the order of 100 litres of pre-mix foam solution are suitable for use at berths. They are capable of producing approximately 1,000 litres of foam and provide a typical jet length of about 12 metres.

Small foam extinguishers with capacities of about 10 litres are, in most cases, too limited to be effective in the event of a fire at a terminal.

Where portable foam/water monitors are recommended in Table 19.1, they may be either portable or wheeled, but should have a discharge capacity of at least 115 m³/hr of foam and water in solution.

At least two portable foam/water monitors should be provided for each wharf or jetty, together with adequate lengths of foam induction hose and fire hose to facilitate deployment at their maximum range.

19.5.3 Terminal Fixed Fire-Fighting Equipment

19.5.3.1 Fire Water Supply

Fire water at marine terminals is often provided by the unlimited supply available from the sea, rivers or dock basin.

Where the fire water supply is obtained from static storage, such as a tank or reservoir, then the reserve for fire-fighting purposes should be equivalent to at least 4 hours continuous use at the maximum design capacity of the fire-fighting system. The reserve for fire-fighting would normally be additional to that required by any other user taking water from the same static storage. The piping arrangements at such storage facilities should be arranged to prevent use of the fire-fighting reserve for other purposes and the integrity of the make-up water supply to such a reserve would need to be assured.

Fire water flow rates and pressures should be sufficient to cover both extinguishing and cooling water requirements for a fire that might realistically occur. For typical flow rates, reference should be made to Table 19.1.

Installation	Minimum Provisions
<p>1. Barge berth or wharf or jetty handling liquids with a flashpoint at or below 60°C including materials in drums, and any product heated above its flashpoint.</p> <p>Tanker berth at a wharf or jetty handling ships of less than 20,000 tonnes deadweight and less than one ship per week.</p>	<p>Fire-main incorporating isolating valves and fire hydrants with a fire water supply of 100 m³/hr.</p> <p>Fire-fighting equipment consisting of: hand-held and wheeled fire extinguishers; fire hose; foam branch pipes; and portable or wheeled foam/water monitors designed for a minimum solution rate of 115 m³/hr.</p> <p>Static or trailer borne 3 m³ bulk supply of foam concentrate.</p> <p>Portable equipment:</p> <ul style="list-style-type: none"> • 2 x 9 kg portable dry chemical extinguishers • 2 x 50 kg wheeled dry chemical extinguishers.
<p>2. Tanker berth at a wharf or jetty handling ships of less than 50,000 tonnes deadweight, or more than one ship per week of less than 20,000 tonnes deadweight.</p>	<p>Fire-main incorporating isolating valves and fire hydrants with a water supply of 350 m³/hr.</p> <p>Portable and wheeled fire-fighting equipment.</p> <p>Fixed foam/water monitors and appropriate bulk concentrate supplies.</p> <p>Jetty support structure protection (optional).</p> <p>Portable equipment:</p> <ul style="list-style-type: none"> • 4 x 9 kg portable dry chemical extinguishers • 2 x 75 kg wheeled dry chemical extinguishers.
<p>3. Tanker berth at a wharf or jetty handling ships of 50,000 tonnes deadweight or larger, possibly VLCC size.</p>	<p>Fire-main incorporating isolating valves and fire hydrants with a fire water supply of 700 m³/hr.</p> <p>Portable and wheeled fire-fighting equipment.</p> <p>Fixed foam/water monitors and appropriate bulk concentrate supplies.</p> <p>Jetty support structure protection (optional).</p> <p>Portable equipment:</p> <ul style="list-style-type: none"> • 6 x 9 kg portable dry chemical extinguishers • 4 x 75 kg wheeled dry chemical extinguishers.
<p>4. Sea island berth.</p>	<p>Fire protection facilities as above according to use and size of ship.</p> <p>Portable equipment:</p> <ul style="list-style-type: none"> • 6 x 9 kg portable dry chemical extinguishers • 4 x 75 kg wheeled dry chemical extinguishers.

Table 19.1 – Fire protection guidelines for marine terminals handling crude oil and petroleum products (excluding liquefied hydrocarbon gases)

19.5.3.2 Fire Pumps

Where practical, permanently installed fire pumps should be provided on a scale which will ensure adequate reserve capacity to allow for contingencies, such as fire pump maintenance, repairs or breakdowns during emergencies.

Electric motor, diesel engine and steam turbine driven pumps are acceptable. However, the choice of steam turbine and electric drivers should take into account the reliability of the steam and power supplies at a particular installation. Typically, a combination of diesel and electric driven pumps is preferred.

When the fire pumps are to be located on a wharf or jetty, a safe and protected location is essential in order to ensure that the fire pumps will not become immobilised during a fire at the marine terminal, or do not in themselves present a potential ignition source. When selecting a location for the fire pumps, consideration should be given to the loading gantry and the nearest moored tanker or barge.

Where practical, fire pump installations should be protected from a sea surface fire penetrating the underside or below deck area of the installation. Protection may be achieved by structural barriers, booms or water spray systems. In this context, the fire pump should be installed on a solid deck. Whenever electric motor driven pumps are installed, the careful routing and fire protection of power cables should be considered.

19.5.3.3 Fire-Main Piping

Permanent fire water mains and/or foam-water solution mains should be installed on marine terminals and along the approach routes to berths. Mains should extend as near to the heads of marine terminals as possible and be provided with a number of accessible water take-off (hydrant) points.

The hydrant points generally consist of headers with individually valved outlets fitted with a fire hose connection suitable for the particular type of fire hose coupling in use locally. Isolating valves should be fitted so as to prevent the loss of all fire-fighting systems due to a single fracture or blockage of the fire-main network. The isolating valves should be positioned so that, in the event of fire-main failure in the berth area, there will still be a supply at the berth approach. Where the berth fire-main is extended from a shore installation, an isolating valve(s) should be provided at the shore side end of the wharf or jetty. Additional fire hydrants should then be provided upstream of an isolating valve.

In the case of sea island berths, isolating valves should be positioned on the fire-main grid so that at least 50% of the grid will continue to operate in the event of a single point failure, or during necessary maintenance, and still provide sufficient hydrants for the total fire water demand.

Fire-main construction materials should be compatible with the water supply.

The minimum capacities and pressures for fire water mains are dependent upon whether the system is to be used for cooling or for the production of foam, and upon the length of jet required.

Where freezing conditions are encountered, fire-mains which are not maintained in the dry mode should be protected from freezing. In particular, where the fire water supply is obtained from an on-shore grid, any wet section of the grid should be buried below the frost line or otherwise protected from freezing. Buried fire-mains need to be suitably coated and wrapped to prevent corrosion. Cathodic protection may also be necessary.

Drain valves should be conveniently and suitably located on the fire-mains, and flushing points should be provided at the extremities of the fire-main grid.

19.5.3.4 Fire Hydrants

The location and spacing of hydrants at marine terminals will generally be determined by the character of the facilities to be protected. At the berth or loading arm areas, it will often be difficult to achieve uniform spacing of fire hydrants, whereas on approach or access routes, uniform spacing can usually be achieved. For guidance purposes, hydrants should be spaced at intervals of not more than 45 metres in the berth or loading arm areas and not more than 90 metres along the approach or access routes.

Hose connections should be of a design compatible with those of the local or national fire authorities.

Hydrants should be readily accessible from roadways or approach routes and located or protected in such a way that they will not be prone to physical damage.

19.5.3.5 International Shore Fire Connection

All marine terminals and berths with a fire water system should have at least one International Shore Fire Connection, complete with nuts and bolts, through which water could be supplied to a tanker's fire-main if required for shipboard fire-fighting (see Section 26.5.3 and Figure 26.2).

The connection should be kept protected from the elements and located so as to be immediately available for use. The location and purpose of this connection should be made known to all appropriate staff and discussed during the joint completion of the Ship/Shore Safety Check-List. One 63 mm hose connection should be provided for every 57 m³/hr of required pumping capacity.

19.5.3.6 Pump-In Points for Fire-Fighting Boats

If tugs are used to berth or unberth tankers at a terminal, they may be equipped to pump fire-fighting water into the terminal's fire-main system.

Pump-in points should be provided at suitable, accessible locations near the extremities of the fire-mains and preferably where fire-fighting boats can be securely moored. In an extreme emergency, a fire boat can then be used to augment the fire water supply to the shore fire-main grid.

Pump-in points should comprise at least 4 x 63 mm hose inlets or equivalent. The hose inlets should have screw down valves and/or be fitted with non-return valves and be installed so as to minimise the possibility of hose kinking.

The location of these inlets should be highlighted, for example by appropriate signage and white painted hydrants.

19.5.3.7 Foam Systems

Foam concentrate should be properly proportioned and mixed with water at some point downstream of fire water pumps, and upstream of foam making equipment and application nozzles.

Fixed pipelines for expanded (aerated) foam are not recommended because the fully developed foam cannot be projected effectively due to loss of kinetic energy and high frictional losses through such systems.

The type of foam concentrate selected, i.e. protein, fluoro-protein, Aqueous Film Forming Foam (AFFF), or alcohol/polar solvent resistant type concentrate (hydrocarbon surfactant type concentrate), will depend upon the fuel type and formulation, whether aspirating or non-aspirating equipment is installed and ease of re-supply.

There are several systems that can be adopted for feeding foam concentrate into foam making equipment at the berths. Some of the principal systems are briefly described.

Direct Foam Pick-Up from Atmospheric Tanks

This method incorporates direct foam induction via a flexible pick-up tube connecting a monitor to an adjacent foam storage tank at atmospheric pressure, a tank truck, portable trailer or drum. One storage tank may be used to supply more than one fixed monitor. Such monitors would be positioned near ground or deck level.

Displacement Proportioner Foam Unit Utilising Pressure Vessels

This unit may comprise foam concentrate in one large pressure vessel, possibly of 4.5 cubic metres capacity, or two smaller pressure vessels of 2.3 cubic metres. The foam proportioner unit is positioned between the fire pumps and the downstream foam making equipment. The system functions by utilising by-passed fire-main water to pressurise the storage vessel and displace the foam concentrate from the storage vessel into a foam-main.

Sufficient hydrants should be provided on the foam-main from which portable foam making equipment, including monitors, can be operated.

Dedicated 'Foam Concentrate' Pipeline System Using Atmospheric Foam Tanks

This system comprises three main components:

- 1) Foam concentrate bulk storage in tanks or other vessels.
- 2) Foam pumps for delivering the foam concentrate into the foam pipeline grid. The pumps may be electric motor or water turbine driven using a bypass from the fire-main.
- 3) Pipeline grid, possibly of 75 mm diameter, traversing the berth approach and the berth, providing numerous take-off points for the attachment of foam induction hose for connecting portable or fixed equipment.

Where pipelines for foam solution or concentrate are provided, the lines should have a number of accessible take-off (hydrant) points

which should be spaced not more than two or three standard hose lengths apart. Isolating valves should be fitted so as to retain the utility of the line in the event of fracture. Suitable pipeline drain valves and wash out facilities should be provided. A foam solution pipeline of this type should be designed for a minimum solution rate of 115 cubic metres/hour.

Foam concentrate can also be distributed through a smaller bore pipe system to the tanks supplying the inductors of fixed or mobile foam making appliances.

Variable Flow Injection Incorporating Atmospheric Foam Tank and Foam Pump(s)

This system involves pumping foam concentrate into a foam-main via a metering device or variable flow injector. The foam pump(s) would normally be driven by an electric motor and would take suction from an atmospheric foam tank.

The bulk foam concentrate supplies associated with any fixed foam monitor or foam-water sprinkler system should be sufficient to ensure continuous foam application until the arrival of adequate backup fire-fighting resources, either water-borne or land based. In any case, the bulk foam concentrate supply should be sufficient to ensure not less than 30 minutes of continuous foam application at design flow conditions.

19.5.3.8 Monitors (or Cannons)

Monitors may be used for foam and water, although specific types may be designed solely for foam. Large capacity monitors would normally be on a fixed mounting or on a mobile unit. The provision of fixed monitors should be considered for tanker berths handling ships in excess of 20,000 tonnes deadweight. The scale of provision should be related to the size, location and frequency of use of each individual berth.

The number and capacity of foam monitors required will depend upon local circumstances and conditions, which will include the capacity of the fire water supply system. Where a single elevated foam monitor is provided for berth and shipboard fire-fighting duty, the discharge capacity of the monitor should not be less than 115 m³/hr, but could be as high as 350 m³/hr.

The monitors should be supplied from the berth fire-main and should either be manually activated individually at each monitor riser or be activated from a remote manual or motorised isolating valve controlling a group of monitors, depending upon the particular design.

Monitors may be situated at berth or wharf deck level (normally only suitable at small terminals) or may be mounted on fixed towers. The effective height of the liquid stream required from a monitor is dictated by the particular use envisaged. For example, if required to assist in the event of a fire involving the ship's manifold, the height of freeboard is important and with large tankers this can be in excess of 23 metres. Ideally, fixed monitors should be positioned on towers or on top of gangway access towers in order to ensure that foam discharge will be above maximum high tide and light ship deck height for adequate

coverage of the ship's manifold. Typically, monitors will provide a jet length of 30 metres and a jet height of 15 metres in still air.

Monitors may be manually controlled or remotely controlled either from the tower base or at a distance. Tower base controls may need special protection. Fixed tower installations may have the drawback that, for manual control, with the wind in the wrong direction, smoke can obscure vision and sighting. Remote control can be achieved by electronic means, hydraulically or with a mechanical linkage. The remote control point for elevated monitors should be sited in a safe location. However, the selection of a safe location will depend upon the character and size of the berth involved. Where practicable, the monitor control point should be at least 15 metres from the probable location of fire.

The water monitors should be mounted at berth or wharf deck level and be fitted with variable nozzles capable of discharging either a spray or a jet. They should be located so as to be capable of cooling the berth structure, as well as the adjacent hull of a tanker. In some cases, it may be necessary to provide elevated water monitors in place of, or additional to, deck mounted monitors to allow water discharge above maximum freeboard height.

19.5.3.9 Below Deck Fixed Protection Systems

Below deck fixed protection systems have been installed when the marine terminal extends over water and away from shore in such a way that fire-fighting would be difficult or dangerous, or when fire-fighting boats are not available. In these situations, this type of system may be required in order to provide a safe base for operations during a large tanker fire and is especially useful where large spill fires on the sea beneath the berth are a possibility.

When fire-fighting boats are available to provide a quick response, a fixed water spray system may be installed below deck for cooling non-fire resistant, unprotected supports and exposed structure, in the event of a local fire on the surface of the water. The rate of discharge for such a system should be at least 10 litres per minute per square metre.

When fire-fighting boats are not available or cannot provide a quick response to a fire, a fixed system of foam/water sprinklers may be installed below deck for cooling and protecting the supporting structure that is constructed of non-fire resistant, unprotected materials. Under these circumstances, such a system would provide rapid below deck fire control and extinguishment. A system of this type should discharge not less than 6.5 litres per minute per square metre. When supporting piles and beams are constructed with fire resistant materials, for example concrete, a fixed system of foam/water sprinklers discharging at reduced application rates may be advisable.

19.6 Water-Borne Fire-Fighting Equipment

Water-borne fire-fighting equipment, normally in the form of fire boats or fire tugs, can be highly effective, particularly when there is the scope to manoeuvre upwind of a fire. Such manoeuvres are generally possible, particularly at sea island berths.

In locations where fire-fighting boats are well equipped, continuously available and able to be in attendance very quickly from time of call, for example within 15-20 minutes, then the scale of fire-fighting equipment provided at a berth may be established after consideration of, and in relation to, the calibre of local water-borne fire-fighting equipment.

The water-borne fire-fighting capability is normally best provided by working tugs or workboats fitted with fire-fighting equipment, including foam facilities, which should be capable of tackling a deck fire on the largest tanker likely to use the port.

Where the fire-fighting capability of tugs is part of a terminal's planned response to fires on tankers or on the terminal itself, they should be made available as soon as they are required if their contribution is to be effective. If these tugs are assisting a ship berthing or unberthing at the terminal or in some other part of the harbour when a fire emergency occurs, arrangements should be made to ensure that they can be released in the shortest possible time to assist in fire-fighting. When these tugs are idle between routine tasks, they should be moored with easily slipped moorings, within easy reach and, where possible, within sight of the terminal, and must keep a continuous radio and visual watch on the terminal. Where the attendance of these fire-fighting tugs at a fire cannot be assured within a reasonable timescale, their contribution should not be included when assessing the fire-fighting requirements for the terminal.

In special circumstances, such as terminals handling a high number of tankers or harbours with multiple terminals, consideration may be given to the provision of a specifically equipped fire-fighting boat.

Fire-fighting boats or craft, especially those at terminals with sea island berths, should each be equipped with an International Shore Fire Connection for providing fire water to a ship's fire water main, or should have a suitable adaptor for this purpose. The craft should also have a similar connection to enable them to supply water to the terminal fire-main. One 63 mm hose connection should be provided for every 57 m³/hr of required pumping capacity.

The decision to use tugs to assist in fighting a fire on a tanker or on the terminal, or to use them to unberth other ships in danger of becoming involved, should be made by the person in overall charge of the fire-fighting and in conjunction with the harbour authority. Fire-fighting tugs should be equipped with UHF/VHF radio with separate channels for towing and fire-fighting and, when fire-fighting, they must be in direct contact with, and under the control of, the person in overall charge of the fire-fighting.

Tugs with fire-fighting equipment should be inspected regularly to ensure that their equipment and foam compound stocks are in good condition. Tests of the fire pump and monitors should be carried out weekly. The foam filling points on the tugs should be kept clear, so as to be immediately ready for use.

A decision should be made as part of the terminal emergency plan as to whether trained fire-fighters should board the tug or whether the crew will be used for fire-fighting duties. The decision should be supported with appropriate training for the designated fire-fighters.

19.7 Protective Clothing

All fire protective clothing gives some protection against radiant heat and consequently from burns. Conventional, heavy fire-fighting jackets are very good in this respect.

However, modern practice is to provide fire protective clothing that is manufactured from a lightweight, fire resistant fabric incorporating an aluminium covering, sometimes referred to as a fire proximity suit. This type of suit is not suitable for direct fire exposure. Heavier suits, termed fire entry suits, will allow personnel wearing breathing apparatus with suitable rescue and backup provisions to withstand direct flame exposure for a limited period.

Depending on local fire-fighting arrangements, provision at the terminal of a minimum of one or two complete sets of fire proximity and fire entry suits, including helmets, gloves and boots, may be advisable.

All protective clothing should be kept serviceable and dry. It should be properly fastened while being worn.

19.8 Access for Fire-Fighting Services

Parking areas should be provided for fire-fighting vehicles close to marine terminal approaches. The provision of a lay-by or 'passing' area on jetty approach structures should also be considered. Consideration must also be given to any limitations regarding the maximum axle weights for vehicles accessing berth structures.

EMERGENCY PREPAREDNESS

A comprehensive and well practised plan is essential if a terminal is to respond to emergencies in an orderly and effective manner. This Chapter deals with the preparation of terminal emergency response plans and with the provision of resources and training necessary to support them.

Actions to be taken by the terminal and the tanker in the event of an emergency at the ship/shore interface are given in Section 26.5.

Additional information on fire protection in terminals is contained in Chapter 19.

20.1 Overview

All terminals should have procedures ready for immediate implementation in the event of an emergency. The procedures should cover all types of emergency that can be envisaged in the context of particular activities at the terminal, for example major oil spillage, gas leak resulting in an unconfined vapour cloud, fire, explosion and ill or injured persons. While the deployment of fire-fighting equipment is likely to be prominent in any emergency procedure, equipment such as breathing apparatus, resuscitation equipment, stretchers and means of escape or exit should also be covered.

Personnel involved must be familiar with the emergency procedures, should be adequately trained and should clearly understand the action they would be required to take in responding to an emergency. This should include the sounding of alarms, the setting up of a control centre and the organisation of personnel to deal with the emergency.

Information on the hazards associated with products handled at the terminal should be immediately available in case of emergency. It is recommended that Material Safety Data Sheets (MSDS) are available to provide both workers and emergency personnel with procedures for handling or working with each particular product. The MSDS should include details of physical data (melting point, boiling point, flashpoint etc), toxicity, health effects, first aid, reactivity, storage, disposal and the personal protective equipment to be used.

Sufficient manpower is necessary to initiate successfully and to then sustain any response plan. Therefore, a thorough study should be made to determine the total manpower requirements over the whole period of any emergency. Where appropriate, assistance may be obtained from local emergency organisations, nearby airports, industrial plants or military installations. However, it should be ensured that terminal manpower is sufficient to mount an initial response to any emergency.

In addition to addressing incidents which may occur during normal operational times, terminal emergency plans should also cover those which may occur outside normal working hours, when operations are continuing with reduced manpower on site.

The most important and critical elements of every emergency plan are the organisation and resources necessary to support it. The plan will only be effective if careful consideration has been given to these elements in its preparation so that it will fully meet the requirements of the individual terminal.

When drawing up the plan, all parties who are likely to be involved should be consulted.

It will be necessary to:

- Analyse probable emergency scenarios and identify potential problems.
- Agree on the best practical approach to respond to the scenarios and to resolve identified problems.
- Agree on an organisation with the necessary resources to execute the plan efficiently.

The plan should be reviewed and updated on a regular basis to ensure that it reflects any changes within the terminal, current best practice and any key lessons from emergency exercises/previous emergencies.

20.2 Terminal Emergency Planning – Plan Components and Procedures

20.2.1 Preparation

All terminals should develop an emergency plan, which should cover all aspects of the action to be taken in the event of an emergency. The plan should be drawn up in consultation with the port authority, fire brigade, police etc, and should integrate with any other relevant plans, such as the port emergency plan. The plan should include:

- The specific action to be taken by those at the location of the emergency to raise the alarm.
- Initial action to contain and overcome the incident.
- Procedures to be followed in mobilising the resources of the terminal, as required by the incident.
- Evacuation procedures.
- Assembly points.
- Emergency organisation, including specific roles and responsibilities.
- Communications systems.
- Emergency control centres.
- Inventory and location of emergency equipment.

Each terminal should have an emergency team whose duties include planning, implementing and revising emergency procedures, as well as executing them. An emergency plan, when formulated, should be properly documented in an 'Emergency Procedures Manual', which should be available to all personnel whose work is connected with the terminal.

The main elements forming the initial response to an emergency, such as reporting and action to contain and control, together with the location of emergency equipment, should be displayed conspicuously on notices at all strategic locations within the terminal.

Ships alongside the terminal should be advised of the terminal's emergency plan, as it relates to the ship, particularly the alarm signals, emergency escape routes and the procedure for a ship to summon assistance in the event of an emergency on board.

The terminal emergency plan should harmonise and, as appropriate, be integrated with:

- Other parts of the company organisation and facilities; and
- Relevant outside organisations (other companies, public bodies etc).

Those outside bodies which may be involved in an emergency should be familiar with all appropriate parts of the terminal emergency plan and should participate in joint exercises and drills.

The essential elements of a terminal emergency plan are summarised in Section 20.4.

20.2.2 Control

The terminal emergency plan should make absolutely clear the person or persons who have overall responsibility for dealing with the emergency, listed in order of priority. Responsibilities for actions to be taken by others within the terminal organisation to contain and control the emergency should also be clearly established.

Failure to define lines of responsibility can easily lead to confusion and to the loss of valuable time.

If there is no dedicated control centre, an office should be pre-designated for this purpose, and kept ready for use in the event of emergencies. The location of the control centre, and a list of those personnel assigned to it, should be clearly described in the plan. The control centre should be located at a convenient central point, not adjacent to likely hazardous areas, and possibly in the main terminal office.

During an emergency, the control centre should be manned by leading representatives from the terminal and, as relevant, by those from the port authority, fire brigade, tug company, police or other appropriate civil authority. If the emergency involves, or is likely to involve, a ship, it may also be desirable that a Responsible Officer from the casualty ship is in attendance at the control centre to give advice. An 'Information Officer' should be designated to relay information to the public, other port users and all involved parties.

During an emergency, it is important that key personnel are easily recognisable in the field, for example by wearing different coloured safety helmets. The emergency plan should include such details.

The plan should also identify those authorised to declare that an emergency is over.

20.2.3 Communications and Alarms

20.2.3.1 Alarms

All installations should have an emergency alarm system.

Alarm protocols will vary, depending on the terminal. For example, a single common alarm may be quite appropriate for a small terminal while a complex terminal/refinery may have to install a differentiated alarm system to reflect a hierarchy of possible emergencies.

It may be beneficial to include the option of a silent alarm, whereby no audible general alarms are raised, but a small number of key personnel are informed by telephone or portable radio and are put on alert. Typical applications would be in response to bomb threats and other forms of sabotage.

20.2.3.2 Contact Lists

The terminal emergency plan should include full contact details, both during and outside office hours, for those inside and outside the organisation who must be called in case of emergency.

The names of alternates, who will be available in the event that the appointed person is absent or unavailable, should be included. Alternates should be fully aware of their responsibilities and trained in the proper execution of their duties.

The contact list should be sufficiently comprehensive to eliminate the need to refer to other documentation, such as telephone directories.

20.2.3.3 Communication System Requirements

Reliable communications are essential for dealing successfully with an emergency situation. Alternative power supplies should be provided in case the primary system fails.

There are three basic elements that the system should be able to handle:

- Terminal emergency alarm.
- Summoning of assistance.
- Co-ordination and control of all emergency activities, including movement of ships.

The communications system should have the flexibility to cover operations on the jetty, on a ship, on adjacent waters or from elsewhere within the terminal.

Small terminals should, as a minimum, be able to sound an evacuation signal that is clearly identifiable as such. However, radio and telephone communications will be high on the list of priorities in most emergency plans.

Larger terminals should be equipped with a complete range of communication systems, which may include VHF/UHF radio and public address equipment. Key personnel should always be supplied with portable radio equipment. A communication centre should be established in the emergency control centre.

If special dedicated telephone lines are not used, the emergency communications system should be capable of suppressing other calls using the same line.

The emergency control centre should facilitate the direction, co-ordination and control of all emergency activities, including the provision of advice and information to other port users. For these purposes, it should have a suitable communications system linking it with all necessary contacts, both inside and outside the terminal.

20.2.3.4 Communications Discipline

All personnel should understand and appreciate the necessity for strict observance of established rules for the use of communications in an emergency, and should receive frequent instruction on the effective use of communications equipment and procedures.

The emergency plan should include a basic set of communication disciplines, including passwords for the various types or degrees of emergency.

Once mobilised, the key staff involved in actually combating and controlling the emergency should be kept free of communication requirements with other parties, other than those immediately required to handle central communications and press and public relations. The inclusion of an 'Information Officer' in the emergency plan is recommended (see Section 20.2.2).

A log should be kept at the control centre. Radio and telephone calls should be recorded.

20.2.4 Site Plans and Maps

Plans showing fire-fighting equipment, major facilities and road access should be kept up to date and be readily available for use in an emergency, with copies kept in the control centre.

The locations and details of fire-fighting and other emergency equipment on or near a berth should also be displayed on the berth.

20.2.5 Access to Equipment

All emergency equipment should be readily accessible and kept free of obstructions at all times.

20.2.6 Road Traffic Movement and Control

Roadways in the terminal approaches and areas in way of jetty heads should be kept free of obstructions at all times. Vehicles should only be parked in designated areas and ignition keys should be left in place.

During an emergency, traffic into a terminal or onto berths should be strictly restricted to those vehicles and people required to deal with the emergency or to render assistance. In allowing emergency vehicles access to jetty areas, due account must be taken of any limitations on vehicle weights related to deck loadings.

20.2.7 Outside Services

The terminal emergency plan should make the best possible use of external services. The success in responding to an emergency may depend on the degree of co-operation received from third parties and this will often be dependent on their familiarity with the terminal and its response procedures. It is important that external service providers are involved in joint training activities. Combined drills involving tugs, ships and shore emergency services, as appropriate, should be conducted at least annually.

If the terminal is located in an area with other industry activities, it may be practical to sponsor the establishment of a mutual assistance plan.

20.2.7.1 Harbour Authorities, Vessel Traffic Control Centres, Police and Fire Services

The terminal emergency plan should make provision for the local harbour authority and vessel traffic control centre, if applicable, to be fully informed of any emergency involving the terminal, or ships berthed or moored at the terminal, including:

- The nature and extent of the emergency.
- The nature of the ship or ships involved, with locations and cargo details.
- The nature of assistance required.

This information will enable the harbour authority and vessel traffic control centre to decide whether to restrict navigation within the port area or to close the port.

The emergency plan should also ensure that any emergency that requires, or might require, assistance beyond the resources of the terminal is immediately reported to the local fire services or the local police.

20.2.7.2 Pilots

If, in an emergency, it is decided to partially or totally evacuate jetties, the local pilot organisation may be called upon at short notice to provide several pilots to advise on the handling of ships not directly involved in the incident. The emergency plan should make provision for this eventuality.

20.2.7.3 Rescue Launches

A launch or launches, if available, should be included in the plan to assist with:

- The recovery of personnel who may be in the water.
- The evacuation of personnel trapped on a tanker or on a berth.

Launches detailed for these duties should have the following equipment and supplies:

- A communication link capable of being integrated into the control centre's communication system.

- Fixed or portable searchlights for operations during darkness or periods of reduced visibility.
- Blankets, as personnel recovered from the water are likely to be suffering from cold and shock.
- Portable boarding ladders to facilitate entry into the launch, as personnel in the water may have little or no reserve energy and may be unable to help themselves.
- Self-contained breathing apparatus.
- Resuscitation equipment.

The crews of the launches should receive instruction in rescuing survivors from the water, bearing in mind that casualties may be seriously injured or suffering from extensive burns. Crews should also receive instruction in artificial respiration. Launch crews should be made aware that survival time in water could be very short and the prompt rescue of personnel is therefore important.

20.2.7.4 Medical Facilities

Depending on the nature of the emergency, it may be necessary to alert medical facilities within and outside the terminal. The emergency plan should make provision for this.

Medical facilities likely to be used will need to be told:

- The nature and location of the emergency.
- The likelihood or number of casualties.
- Whether medical staff are required at the location of the emergency.
- Actual details of the casualties, including their names, as soon as these are known.

20.2.8 Training for Emergencies

Training should be provided in the following emergency activities, as appropriate:

- Fire-fighting using equipment that will be available in an emergency.
- Transfer of hazardous materials away from the site of the fire.
- Fire isolation.
- Use of personal protective equipment.
- Co-ordinated operation with outside bodies.
- Rescue, including training for selected personnel in life saving from water.
- Spill containment and clean-up.

Unannounced drills should be held in different parts of the terminal, followed by discussions aimed at highlighting any deficiencies encountered. Evacuation drills are an essential part of training and help to minimise panic in an actual emergency.

Local operating procedures for use in an emergency should be available to all concerned, and thorough training given in their use. The terminal emergency plan should be exercised regularly.

Records should be kept and deficiencies or lessons learnt should be recorded and formally followed up.

20.3 Definition and Hierarchy of Emergencies

20.3.1 General

Whether a certain event would represent an 'emergency' or an 'operational incident' that requires swift action will depend on local circumstances. For instance, it may be possible for a large terminal, with adequate equipment and manpower, to deal with a local fire or similar event without calling the full terminal emergency plan into operation. The same incident at a small terminal might be classified as an emergency requiring activation of the emergency plan.

The following guidelines are not intended to be prescriptive, but are intended to provide a framework or starting point that can be customised to suit a particular terminal. For terminals that already have emergency plans in place, the guidance provides a check-list against which the existing plans can be assessed. It should be noted that the guidelines only provide a minimum basis for developing and sustaining an effective terminal emergency plan.

20.3.2 Hierarchy of Emergencies

Before establishing a terminal emergency plan, a study should be made of the terminal, available resources (both during and outside normal working hours) and the potential emergencies that are considered possible at the location. Based on this study, a hierarchy of emergencies should be established, for example:

- Local emergency.
- Terminal emergency.
- Major emergency.

20.3.2.1 Local Emergency

A local emergency is one of minor consequence for life and property that can be dealt with locally, for example at the jetty or on board a ship, by available staff, with or without assistance. Such an emergency does not normally influence operations in other parts of the terminal or in the port.

20.3.2.2 Terminal Emergency

A terminal emergency is one that is more complex or of a larger size or scope that requires an emergency plan to be initiated. It influences operations in the whole terminal, or has the potential to do so, may affect more than one ship and may influence the port environment.

20.3.2.3 Major Emergency

A major emergency is one that is similar to a terminal emergency but is of such size and scope, and of such serious consequence for life and property, that the whole terminal and the neighbouring port environment is involved, and/or greatly endangered.

20.3.2.4 Escalation

Not every operational incident should be handled as an emergency. However, an incident may develop into an emergency and the plan should clearly describe the procedures for escalating the response to a higher level.

20.3.3 Assessing Risks

In assessing the range of emergencies that a terminal may have to deal with, consideration should be given to incidents at the terminal itself and those in the port environment that may threaten the terminal, or would require major assistance from the terminal.

The suggested approach is to begin with a very broad view of risks and then to prioritise them by evaluating the potential effect on the terminal operation if the risk were to materialise, together with the likelihood of its occurrence. A review of incidents in the recent past can provide a guide.

20.3.3.1 Incident Check-List

Incidents that should normally be covered within the scope of the terminal risk assessment include:

- Fire or explosion at the terminal and on or around a berthed ship.
- Major escape of flammable and/or toxic vapours, gases, oil or chemicals.
- Collisions, both ship-shore or ship-ship.
- A ship drifting and breaking away from a jetty, dragging anchor or grounding.
- Major port accidents involving ships, tugs, mooring boats, ferries etc.
- Meteorological hazards, such as floods, hurricanes, heavy electrical storms.
- Attack, sabotage and threat against ships or the terminal.

20.3.3.2 Special Situations

The terminal emergency plan should apply to an otherwise normal operational environment. Special situations, such as acts of war, will require different responses.

20.4 Emergency Response Plan

20.4.1 Format

The format of the terminal emergency plan will depend on local circumstances, the scope of the plan and its relationship to other documentation. The following have proven useful in practice:

- Loose-leaf format to facilitate amendments.
- Bound in a distinctively coloured binder.
- Good quality paper of a strong texture.
- Each page dated and sequentially numbered.
- Written in more than one language, if necessary. All those involved should be able to read and understand the plan. If more than one language version of the plan is used, one version, usually the local language version, should be designated to be the original, in case of legal argument.
- Use of flow charts and decision diagrams with multicolour print symbols to minimise written text.
- Minimal use of cross-references to other parts of the plan.

20.4.2 Preparation

In developing a terminal emergency plan, it is important that the functions concerned, such as operations, engineering, marine and safety, are involved. This can best be achieved by way of a part time task force under appropriate leadership. However, one member of the task force should be retained full time, if possible, until completion of the plan. This person should also take care of the necessary liaison with outside parties who are included in the plan.

One of the greatest drawbacks of a terminal emergency plan is its potential for rapid obsolescence. As staff members and organisations change, the plan should be updated to accommodate such changes. It is recommended that one appointed staff member should be responsible for keeping the plan up to date, using a single master copy. Only the appointed staff member should be entitled to make changes to the emergency plan.

Every staff member with a specific role in the emergency plan should have their own copy of the plan. Furthermore, one or more copies should be available and always accessible in the relevant control rooms. Records should be kept of copies in circulation and of each revision issued (names, locations, contact details etc), receipt of which is to be acknowledged in writing.

Where plans are made available to all relevant personnel in electronic form, such as via a local server, the electronic copy is normally considered to be the controlled or extant copy and any printed versions are uncontrolled.

Unless other satisfactory arrangements exist, it is recommended that the plan administrator is also nominated as room manager for the emergency control centre. The role will include ensuring that the centre is kept stocked with emergency materials, up to date documents and other materials, and that it is kept clean and ready for immediate occupation.

20.4.3 Resource Availability

It may be necessary to plan for mobilisation of resources, such as materials, equipment and manpower, that are additional to those immediately available at a location. Should this be necessary, the plan should contain instructions regarding the accessibility and availability of such resources, both those owned by the terminal organisation and those available from outside.

The plan should include details regarding who is entitled to call on additional resources and information, such as who holds keys to the resources out of hours. The resources can include, but need not be limited to, the following:

- Craft for assistance, rescue and evacuation.
- Road transport, including buses and trucks.
- Earthmoving equipment.
- Aircraft for oil spill tracking and surveillance.
- Floodlights for night operation.
- Spill containment, pollution control and clean-up equipment.
- Sand, dispersants, fire hose and foam making equipment, fire extinguishers and additional stocks of fire-fighting foam concentrate.
- Breathing air equipment.
- Fire suits, helmets and other fire protective clothing.
- Rescue devices such as hydraulic spreaders and jacks, life lines, life buoys, ladders and stretchers.
- Medical resources and portable life support systems.
- Food and beverages.
- Human resources – drivers, electricians, mechanics and general manpower to enable deployment of the necessary material resources, for example.

For each resource group, the plan should list:

- Availability, amounts and numbers.
- Main characteristics and performance data.
- Accessibility on a 24 hour basis.
- Addresses of people and location of stores, telephones, radios etc as applicable.
- Lead time for supply/mobilisation.

20.4.4 Miscellaneous Organisational Items

The following additional items are intended to assist terminals further with development of their emergency planning. In general, an emergency plan should:

- Be specific to the terminal and cover only those emergencies that are considered feasible.
- Not include references to unlikely occurrences, to products not handled and to resources that are not available.

- Be as complete as possible, but also as short as possible. Instructions should be to the point and not so elaborate that they detract from quick response.
- Not normally include instructions about how to combat the emergency physically, for example fire-fighting, pollution abatement etc. It should be limited to people, equipment, organisation and communications. An exception to this can be more 'predictable' emergencies, such as hurricanes and/or flood warnings. In these cases, the plan can specify emergency precautions to be organised. This also applies to 'pre-planned' evacuation of personnel and similar activities.
- Allow operations and other activities not directly affected by the emergency to continue in an orderly and safe manner. Sufficient staff/supervision and resources should therefore be kept non-assigned for that purpose. If this is not possible, the plan should include safe shutdown procedures.
- Be integrated with, or at least be compatible with, other industry or port emergency plans. However, for the primary activities covered by the plan, reliance should always be placed upon in-house staff and resources and not on those from outside.
- Avoid overreaction in any part of the organisation.
- Contain an organisation diagram illustrating the key personnel involved and their immediate actions and communications. The extent and amount of detail in such a diagram should be limited to standard actions.
- Itemise actions in a proper sequence. For example, the priority action to protect life and thereafter property, and to terminate the emergency, must not be frustrated by communications with secondary parties such as the police, harbour authorities etc.
- List the reporting line and authority of each key person mentioned both within and outside working hours. For each person, a short check-list of important actions and communications should be included.
- Ensure that key personnel have a manageable task and that they can be released to deal with an emergency on a full time basis, if necessary. Where required, replacement staff should be brought in to take over those operations of the terminal that are not directly involved or influenced by the emergency. All functions in the plan that require special abilities or skills, for example fire tender operation, boatmen and special radio operations, should be provided with backup.
- Specify that all staff and contractors not assigned duties in the plan must return to and remain available at their normal work location. Alternatively, certain staff should assemble at pre-nominated central locations.

Recommended pre-arrangements to be dealt with in the plan include:

- Tug/fireboats either on standby or ready to proceed at short notice.
- Craft for water-borne assistance or the evacuation of personnel, including designated landings, to be manned.
- Harbour pilots on standby to assist in removing ship(s) from berths.
- Cars, buses etc directed to evacuation collection points, including craft landing areas.
- Unmooring crew and transport on standby.

- Emergency traffic regulations.
- Properly manned reception points to be assigned to receive evacuated ship's crew and/or family members of terminal staff, press representatives etc.

It should be possible to test the effectiveness of the plan without causing undue disruption to day-to-day operations.

No emergency plan can embrace all factors and users should be made aware that the particular circumstances of an emergency might dictate that they or others have to deviate from the plan.

20.5 Emergency Removal of Tanker from Berth

When the emergency is on a tanker, it is recognised that, in the interest of the tanker, the safety of the shore installation, and often that of the whole port, the ship should be kept alongside whenever possible. This would improve the possibility of shore based personnel and equipment being used to tackle an emergency on board.

However, if a fire on a tanker or on a berth cannot be controlled, it may be necessary to consider whether or not the tanker should be removed from the berth. Planning for such an event may require consultation between a port authority representative or harbour master, the Terminal Representative, the Master of the tanker and the senior local authority fire officer.

In the event that an incident escalates, the plan may invite consideration of removing other, presently unaffected, ships from adjacent or downwind berths.

The plan should stress the need to avoid precipitate action that might increase, rather than decrease, the danger to the tanker, the terminal, other ships berthed nearby and other adjacent installations.

Chapter 21

EMERGENCY EVACUATION

The primary consideration in the event of a fire, explosion or other emergency at a terminal will be the safety of personnel. Therefore, the means and method by which personnel can be safely evacuated are of great importance.

This Chapter describes the elements that should be included within a terminal's evacuation plan and provides guidance on options to ensure that a safe and effective means of emergency escape is available.

21.1 General

To ensure the efficient evacuation of personnel in the event of a serious emergency, all terminals should provide adequate evacuation facilities and have an evacuation plan in place.

The evacuation plan will vary from terminal to terminal and will be dependent on the design, location and the availability of equipment. However, in general, the design of the facility should provide at least two escape paths not likely to be involved simultaneously in a fire.

'T' Head Jetties and Finger Piers

Terminal facilities with a shore connection, such as 'T' head jetties and finger piers, have the advantage of providing a means of evacuation by road transport. Some facilities are designed with oil and gas pipelines supported on the underside of the pier. For this type of facility, means of evacuation via water transport may be required unless a second escape path via the shore is provided.

Sea Islands

From sea islands, the only means of evacuation is by water transport, although at very large facilities at distant locations, helicopter transport may also be an option.

The possible evacuation of ship's personnel should also be considered. The very nature of oil and gas operations does not require a large number of operating personnel to be involved at marine terminals and it is probable that a ship's crew will outnumber the shore personnel. It may also be possible that maintenance personnel will, on occasions, outnumber operational personnel, and the evacuation plan should recognise and cater for such a contingency.

21.1.1 Ship Evacuation

There should always be a reciprocal arrangement between ship and shore in any evacuation plan, and it is important that Masters of all ships using the facility are appraised of the emergency evacuation arrangements. These arrangements should be discussed at the pre-cargo safety conference and identified during the completion of the Ship/Shore Safety Check-List. There may be occasions whereby the safest and most efficient means of evacuation, especially if the ship is not involved in the

emergency, is provided by removing the ship from the terminal (see Section 20.5).

21.1.2 Non-Essential Personnel

On every occasion, when it is evident that an emergency situation will or may develop into an incident of significant proportions, all personnel not directly involved in remedial or fire-fighting operations should be evacuated at an early stage.

The decision to evacuate all non-essential personnel, including ship's personnel, or to unberth the ship, should on every occasion be made, after liaison between ship and shore, at an early stage of any emergency situation. Early evacuation of such personnel will always serve to reduce the overall responsibility for personnel safety, thereby permitting the person in charge to concentrate on the emergency and attend to the needs of those personnel in immediate danger.

The most important and critical elements of every emergency evacuation plan are organisational control and communications, and the resources necessary to support them. Guidance on these essential elements is included in Chapter 20.

21.2 Evacuation and Personnel Escape Routes

21.2.1 Primary and Secondary Escape Routes

Terminal facilities and sea island structures should have at least two separate evacuation routes from all occupied or work areas and from berthed ships. Escape routes should be located such that, in the event of fire, at least one route provides a safe evacuation path, sufficiently far from the source of probable fire to afford personnel protection during evacuation. Evacuation routes and secondary evacuation routes should be clearly marked, and preferably numbered, in order that precise instructions can be given to personnel to proceed via a designated route and/or disembarkation position.

21.2.2 Protection of Personnel

If escape routes cannot be led clear of sources of probable fire, the route should be protected, where practicable, by fire walls/barriers or heat shields and should afford personnel protection from exposure to burning hydrocarbons on water, on the topside of loading/unloading facilities, or on shore.

Evacuation routes should be designed, and maintained, obstacle free in order to eliminate the need for personnel to jump into water in order to reach an area of refuge.

Berths and jetties can be difficult to escape from in the event of fire or other emergency. Consequently, careful thought should be given to designing escape routes. Access ways to and from offshore berths and dolphins require special attention as personnel must not be left unattended on isolated dolphins. Moreover, steps or steel ladders are usually required between berths and the water level. On sea islands, access routes and assembly points for rescue craft or dedicated life boats

may require fire walls, enclosures or barriers to provide extended personnel protection.

21.2.3 Boat Access

All terminals should be designed or modified to provide adequately for the emergency evacuation of personnel. Particular emphasis should be given to safe disembarkation positions at suitably protected locations. Sea islands and other offshore installations provide such facilities for operational purposes. 'T' head jetties and finger piers should provide fixed means for embarking personnel into tugs, boats and other rescue craft, in the event of the shore route being inaccessible.

21.2.4 Availability of Rescue Craft

When evacuation is required to be undertaken by rescue craft, such transport should be alerted at a very early stage of the emergency and be kept as close as possible to the evacuation point, such that they can be on scene rapidly, certainly no later than 15 minutes from initial advice. The mobilisation of all available harbour or terminal rescue craft would also form part of any emergency plan.

Harbour craft and tugs, not under the control of the terminal but available for use in rescue operations, should be identified for use in an emergency. Early warning should be given for the assembly of all craft used for evacuation, which will then be under the control of the person in charge of managing response to the incident.

21.2.5 Life Saving Appliances

Every terminal and sea island installation should be equipped with life saving appliances for use in evacuation and rescue, such as life buoys, personal flotation devices for every person located at the site and, where appropriate, life rafts or life boats. Personal flotation devices should be located in prominent and accessible positions.

Life buoys and life rafts are not suitable for use in evacuation in the case of fire on water. These devices are typically utilised for emergency rescue from water in the case of someone going over board. However, such life saving equipment may be required under local regulations.

21.3 Survival Craft

Remote sea islands may be provided with dedicated emergency evacuation craft, commonly referred to as 'survival craft'. Survival craft are motor propelled, enclosed boats. They are self-righting with fire retardant rigid hulls, which are protected by external cooling water sprays. There is a great deal of merit in providing such craft since they have the capability of being launched by remote control within the craft after personnel have embarked and afford protection to personnel when the craft passes through fire on water.

Such survival craft would be placed at selected locations to provide a means of safe escape for personnel who may be unable to evacuate in conventional rescue craft, such as boats and tugs. It is also appropriate that a craft with protection for passing

through fire on water should receive due consideration for inclusion in the rescue fleet of boats at some installations.

There are many pros and cons associated with providing survival craft at marine terminals and the eventual decision must be a local one based on a risk assessment of site specific criteria. Objections are commonly voiced on the grounds of maintenance and the training of personnel in their operation. There is certainly merit in recognising that, particularly at distant sea island berths, survival craft, together with permanently installed launching systems, will provide the means for finally evacuating those personnel responsible for dealing with the emergency situation, taking into account the very real probability of a rapidly deteriorating situation.

21.4 Training and Drills

The effectiveness of evacuation plans will depend upon the training and familiarity of personnel in the use of such plans.

Evacuation drills should be held frequently, typically at least once every three months, and all key and supervisory personnel at the facility should have a thorough knowledge of the evacuation plans. The evacuation plan should be reviewed from time to time, particularly in the light of findings arising from routine drills and exercises.

PART 4

**MANAGEMENT OF
THE TANKER
AND TERMINAL
INTERFACE**

Chapter 22

COMMUNICATIONS

This Chapter deals with communications required between the tanker and the shore, including pre-arrival communications between the tanker and local authorities and between the tanker and the terminal. It addresses communication exchanges between the ship and the terminal before berthing and before and during cargo, ballast or bunkering operations, including emergency communication procedures.

22.1 Procedures and Precautions

22.1.1 Communications Equipment

Telephone and portable VHF/UHF and radiotelephone systems should comply with the appropriate safety requirements.

The provision of adequate means of communication, including a backup system between ship and shore, is the responsibility of the terminal.

Communication between the Responsible Officer and the Terminal Representative should be maintained in the most efficient way.

When telephones are used, they should be continuously manned by persons, on board and ashore, who can immediately contact their superior. Additionally, it should be possible for that superior to override all calls.

When VHF/UHF systems are used, units should preferably be portable and carried by the Responsible Officer on duty and the Terminal Representative, or by persons who can contact their respective superior immediately. Where fixed systems are used, they should be continuously manned.

The selected system of communication, together with the necessary information on telephone numbers and/or channels to be used, should be recorded on an appropriate form. This form should be signed by both ship and shore representatives.

22.1.2 Communications Procedures

To ensure the safe control of operations at all times, it should be the responsibility of both parties to establish, agree in writing and maintain a reliable communications system.

Before loading or discharging commences, the system should be tested. A secondary standby system should also be established and agreed. Allowance should be made for the time required for action in response to signals.

Signals should be agreed for:

- Identification of ship, berth and cargo.
- Stand by.

- Start loading or start discharging.
- Slow down.
- Stop loading or stop discharging.
- Emergency stop.

Any other necessary signals should be agreed and understood.

When different products or grades are to be handled, their names and descriptions should be clearly understood by the ship and shore personnel on duty during cargo handling operations.

The use of one VHF/UHF channel by more than one ship/shore combination should be avoided.

Where there are difficulties in verbal communication, these can be overcome by appointing a person with adequate technical and operational knowledge and a sufficient command of a language understood by both ship and shore personnel.

22.1.3 Compliance with Terminal and Local Regulations

Terminals should have security, safety and pollution regulations, which must be complied with by both tanker and terminal personnel. All tankers at the terminal should be made aware of such regulations, together with any other regulations relating to the safety of shipping, which the appropriate port authority may issue.

22.2 Pre-Arrival Exchange of Information

Before the tanker arrives at the terminal, there should be an exchange of information on matters such as the following:

22.2.1 Exchange of Security Information

Security protocols need to be agreed between the ship and the port or terminal security officer. Pre-arrival communications should establish who performs these functions and how they will be carried out.

22.2.2 Tanker to Appropriate Competent Authority

The tanker should provide information as required by international, regional, and national regulations and recommendations.

22.2.3 Tanker to Terminal

Wherever possible, the following information should be sent at least 24 hours prior to arrival:

- Name and call sign of ship.
- Country of registration.
- Overall length and beam of ship and draught on arrival.

- Estimated time of arrival at designated arrival point, for example pilot station or fairway buoy.
- Ship's displacement on arrival. If loaded, type of cargo and disposition.
- Maximum draught expected during and upon completion of cargo handling.
- Any defects of hull, machinery or equipment that could adversely affect safe operations or delay commencement of cargo handling.
- If fitted with an inert gas system, confirmation that the ship's tanks are in an inert condition and that the system is fully operational.
- Any requirement for tank cleaning and/or gas freeing.
- Whether crude oil washing is to be employed and, if so, confirmation that the pre-arrival check-list has been satisfactorily completed.
- Ship's manifold details, including type, size, number, distance between centres of connections to be presented. Also products to be handled at each manifold, numbered from forward.
- Advance information on proposed cargo handling operations, including grades, sequence, quantities and any rate restrictions.
- Information, as required, on quantity and nature of slops and dirty ballast and of any contamination by chemical additives. Such information should include identification of any toxic components, such as hydrogen sulphide and benzene.
- Quantities and specifications of bunkers required, if applicable.

22.2.4 Terminal to Tanker

The terminal should ensure that the ship has been provided with relevant port information as soon as practicable. For example:

- Depth of water at chart datum and range of salinity that can be expected at the berth.
- Maximum permissible draught and maximum permissible air draught.
- Availability of tugs and mooring craft together with any terminal requirements on their usage.
- Details of any shore moorings that will be provided.
- Which side to be moored alongside.
- Number and size of hose connections and manifolds.
- Whether a Vapour Emission Control (VEC) system is in use.
- Inert gas requirements for cargo measurement.
- Closed loading requirements.
- For jetty berths, arrangement of gangway landing space or availability of terminal access equipment.
- Advance information on proposed cargo specification, handling operations or changes in existing plans for cargo operations. Such information should include identification of any toxic components, such as hydrogen sulphide and benzene.
- Any restrictions on crude oil washing procedures, tank cleaning and gas freeing, that are applicable.

- Advice on environmental and load restrictions applicable to the berth.
- Facilities for the reception of slops, oily ballast residues and garbage.
- Security levels in effect within the port.

22.3 Pre-Berthing Exchange of Information

22.3.1 Tanker to Terminal and/or Pilot

On arrival at the port, the Master will establish direct communications with the terminal and/or the pilot station. The following information should be exchanged:

- Details of any deficiencies or incompatibilities in the ship's equipment that might affect the safety of the mooring.
- Identity of the chocks, bollards and strong points that can be used for towing.
- The Safe Working Load (SWL), if known, of any equipment to be used for towing.
- The number and location of areas on the ship's hull that are strengthened or suitable for pushing, and description of relevant identification marks employed.

22.3.2 Terminal and/or Pilot to Tanker

Before berthing, the terminal should provide the Master, through the pilot or Berthing Master, with details of the mooring plan. The procedure for mooring the ship should be specified and this should be reviewed by the Master with the pilot or Berthing Master and agreed between them.

Information should include:

For all Types of Berth

- The plan for approaching the berth, including turning locations, environmental limits and maximum speeds.
- The number of tugs to be used.
- The type of tugs to be used and their bollard pull(s).
- For escort tugs, the maximum towline force that the tug is able to generate or should not exceed at escort speeds.

For Jetty Berths

- Minimum number of ship's moorings.
- Number and position of bollards or quick release hooks.
- Number and location of jetty manifold connections or hard arms.
- Limitations of the fendering system and of the maximum displacement, approach velocity and angle of approach, for which the berth and the fendering system have been designed.
- Details of any berthing aids, such as doppler radar or laser equipment.
- Any particular feature of the berth which it is considered essential to bring to the prior notice of the Master.

For Conventional Multi-Buoy Moorings

- Minimum number of shackles of cable required on each anchor that may be used during the course of mooring.
- Number and position of mooring lines, shackles and other mooring equipment likely to be needed.

For all Sea Berths and Single Point Moorings (SPMs)

- Required Safe Working Load (SWL) of the ship's hose handling equipment.
- Number and flange size of the hoses to be connected and details of any equipment that the ship must provide to assist in hose handling.

For Single Point Moorings (SPMs)

- Diameter of the chafe chain links used in the mooring.
- Weight of each of the moorings that has to be lifted on board.
- Length and size of any messenger lines that have to be used to pick up the moorings.
- Minimum requisite dimension of bow chock or lead required.
- Method used to make the SPM fast to the ship and details of any equipment that must be provided by the ship.

Any deviation from the agreed mooring plan made necessary by changing weather conditions should be communicated to the Master as soon as possible.

22.4 Pre-Transfer Exchange of Information

Completion of safe and efficient cargo, ballast and bunkering operations is dependent upon effective co-operation and co-ordination between all parties involved. This Section covers information that should be exchanged before those operations begin.

22.4.1 Tanker to Terminal

Before transfer operations commence, the Responsible Officer should inform the terminal of the general arrangement of the cargo, ballast and bunker tanks, and should have available the information listed below:

22.4.1.1 Information in Preparation for Loading Cargo and Bunkers:

- Details of last cargo carried, method of tank cleaning (if any) and state of the cargo tanks and lines.
- Where the ship has part cargo on board on arrival, grade, volume and tank distribution.
- Maximum acceptable loading rates and topping-off rates.
- Maximum acceptable pressure at the ship/shore cargo connection during loading.
- Cargo quantities acceptable from terminal nominations.
- Proposed distribution of nominated cargo and preferred order of loading.

- Maximum acceptable cargo temperature (where applicable).
- Maximum acceptable True Vapour Pressure (where applicable).
- Proposed method of venting.
- Quantities and specifications of bunkers required.
- Distribution, composition and quantities of ballast together, if relevant, with time required for discharge and maximum light freeboard.
- Quantity, quality and distribution of slops.
- Quality of inert gas (if applicable).
- Communication system for loading control, including the signal for emergency stop.

22.4.1.2 Information in Preparation for Cargo Discharge:

- Cargo specifications.
- Whether or not the cargo includes toxic components, for example H₂S, benzene, lead additives or mercaptans.
- Any other characteristics of the cargo requiring special attention, for example high True Vapour Pressure (TVP).
- Flashpoint (where applicable) of products and their temperatures upon arrival, particularly when the cargo is non-volatile.
- Distribution of cargo on board by grade and quantity.
- Quantity and distribution of slops.
- Any unaccountable change of ullage in ship's tanks since loading.
- Water dips in cargo tanks (where applicable).
- Preferred order of discharge.
- Maximum attainable discharge rates and pressures.
- Whether tank cleaning, including crude oil washing, is required.
- Approximate time of commencement and duration of ballasting into permanent ballast tanks and cargo tanks.

22.4.2 Terminal to Tanker

The following information should be made available to the Responsible Officer:

22.4.2.1 Information in Preparation for Loading Cargo and Bunkers:

- Cargo specifications and preferred order of loading.
- Whether or not the cargo includes toxic components, for example H₂S, benzene, lead additives or mercaptans.
- Tank venting requirements.
- Any other characteristics of the cargo requiring attention, for example high True Vapour Pressure.

- Flashpoints (where applicable) of products and their estimated loading temperatures, particularly when the cargo is non-volatile.
- Bunker specifications including H₂S content.
- Proposed bunker loading rate.
- Nominated quantities of cargo to be loaded.
- Maximum shore loading rates.
- Standby time for normal pump stopping.
- Maximum pressure available at the ship/shore cargo connection.
- Number and sizes of hoses or arms available and manifold connections required for each product or grade of the cargo and Vapour Emission Control (VEC) systems, if appropriate.
- Limitations on the movement of hoses or arms.
- Communication system for loading control, including the signal for emergency stop.
- Material Safety Data Sheets for each product to be handled.

22.4.2.2 Information in Preparation for Cargo Discharge:

- Order of discharge of cargo acceptable to terminal.
- Nominated quantities of cargo to be discharged.
- Maximum acceptable discharge rates.
- Maximum pressure acceptable at ship/shore cargo connection.
- Any booster pumps that may be on stream.
- Number and sizes of hoses or arms available and manifold connections required for each product or grade of the cargo, and whether or not these arms are common with each other.
- Limitations on the movement of hoses or arms.
- Any other limitations at the terminal.
- Communication system for discharge control including the signal for emergency stop.

22.5 Agreed Loading Plan

On the basis of the information exchanged, an operational agreement should be made in writing between the Responsible Officer and the Terminal Representative covering the following, as appropriate:

- Ship's name, berth, date and time.
- Names of ship and shore representatives.
- Cargo distribution on arrival and departure.
- The following information on each product:
 - Quantity.
 - Ship's tank(s) to be loaded.
 - Shore tank(s) to be discharged.
 - Lines to be used ship/shore.

Cargo transfer rate.
 Operating pressure.
 Maximum allowable pressure.
 Temperature limits.
 Venting system.
 Sampling procedures.

- Restrictions necessary because of:
 - Electrostatic properties.
 - Use of automatic shutdown valves.

This agreement should include a loading plan indicating the expected timing and covering the following:

- The sequence in which ship's tanks are to be loaded, taking into account:
 - Deballasting operations.
 - Ship and shore tank change over.
 - Avoidance of contamination of cargo.
 - Pipeline clearing for loading.
 - Other movements or operations that may affect flow rates.
 - Trim and draught of the tanker.
 - The need to ensure that permitted stresses will not be exceeded.
- The initial and maximum loading rates, topping-off rates and normal stopping times, having regard to:
 - The nature of the cargo to be loaded.
 - The arrangement and capacity of the ship's cargo lines and gas venting system.
 - The maximum allowable pressure and flow rate in the ship/shore hoses or arms.
 - Precautions to avoid accumulation of static electricity.
 - Any other flow control limitations.
- The method of tank venting to avoid or reduce gas emissions at deck level, taking into account:
 - The True Vapour Pressure of the cargo to be loaded.
 - The loading rates.
 - Atmospheric conditions.
- Any bunkering or storing operations.
- Emergency stop procedure.

A bar diagram may be a helpful means of depicting this plan.

Once the loading plan has been agreed, it should be signed by the Responsible Officer and Terminal Representative.

22.6 Agreed Discharge Plan

On the basis of the information exchanged, an operational agreement should be made in writing between the Responsible Officer and the Terminal Representative covering the following:

- Ship's name, berth, date and time.
- Names of ship and shore representatives.
- Cargo distribution on arrival and departure.
- The following information on each product:
 - Quantity.

Shore tank(s) to be filled.
 Ship's tank(s) to be discharged.
 Lines to be used ship/shore.
 Cargo transfer rate.
 Operating pressure.
 Maximum allowable pressure.
 Temperature limits.
 Venting systems.
 Sampling procedures.

- Restrictions necessary because of:
 - Electrostatic properties.
 - Use of automatic shutdown valves.

The discharge plan should include details and expected timing of the following:

- The sequence in which the ship's tanks are to be discharged, taking account of:
 - Ship and shore tank change over.
 - Avoidance of contamination of cargo.
 - Pipeline clearing for discharge.
 - Crude oil washing, if employed, or other tank cleaning.
 - Other movements or operations which may affect flow rates.
 - Trim and freeboard of the tanker.
 - The need to ensure that permitted stresses will not be exceeded.
 - Ballasting operations.
- The initial and maximum discharge rates, having regard to:
 - The specification of the cargo to be discharged.
 - The arrangements and capacity of the ship's cargo lines, shore pipelines and tanks.
 - The maximum allowable pressure and flow rate in the ship/shore hoses or arms.
 - Precautions to avoid accumulation of static electricity.
 - Any other limitations.
- Bunkering or storing operations.
- Emergency stop procedure.

A bar diagram may be a helpful means of depicting this plan.

Once the discharge plan has been agreed, it should be signed by the Responsible Officer and the Terminal Representative.

22.7 Agreement to Carry Out Repairs

22.7.1 Repairs on the Tanker

When any repair or maintenance is to be done on board a tanker moored at a berth, the Responsible Officer must inform the Terminal Representative. Agreement should be reached on the safety precautions to be taken, with due regard to the nature of the work.

22.7.1.1 Immobilisation of the Tanker

While a tanker is berthed at a terminal, its boilers, main engines, steering machinery and other equipment essential for manoeuvring should normally be kept in a condition that will permit the tanker to be moved away from the berth in the event of an emergency.

Repairs and other work that may immobilise the tanker should not be undertaken at a berth without prior written agreement with the terminal.

Before carrying out any repairs that may immobilise the tanker, it may also be necessary to obtain permission from the local port authority. Certain conditions may have to be met before permission can be granted.

Any unplanned condition that results in the loss of operational capability, particularly to any safety system, should be immediately communicated to the terminal.

22.7.1.2 Hot Work on the Tanker

Hot Work on board the tanker must be prohibited until all applicable regulations and safety requirements have been met and a Permit to Work has been issued (see Section 9.3). This may involve the Master, Company, chemist, shore contractor, Terminal Representative and port authority, as appropriate.

When alongside a terminal, no Hot Work should be allowed until the Terminal Representative and, where appropriate, the port authority has been consulted and approval obtained.

A Hot Work permit should only be issued after obtaining a gas free certificate from an authorised chemist.

22.7.2 Repairs on the Terminal

No construction, repair, maintenance, dismantling or modification of facilities should be carried out on a tanker berth without the permission of the Terminal Representative. If a tanker is moored at the berth, the Terminal Representative should also obtain the agreement of the Master.

22.7.3 Use of Tools whilst a Tanker is Alongside a Terminal

No hammering, chipping or grit blasting should take place, nor should any power tool be used, outside the engine room or accommodation spaces on a tanker, or on a terminal at which a tanker is berthed, without agreement between the Terminal Representative and the Responsible Officer, and unless a Permit to Work has been issued.

In all cases, the Terminal Representative and the Responsible Officer should satisfy themselves that the area is gas free and remains so while the tools are in use. The precautions in Section 4.5 should be observed.

Chapter 23

MOORING

This Chapter deals with the preparations and procedures necessary to provide and maintain an efficient mooring arrangement whilst the ship is berthed at a jetty or buoy mooring. Exchange of information between the tanker and the terminal on matters relating to mooring arrangements is dealt with in Chapter 22.

The use of mooring equipment is described in detail in the OCIMF publication '*Mooring Equipment Guidelines*'. Descriptions of good operational practice for mooring operations are given in the OCIMF publication '*Effective Mooring*'. Ship, terminal and berth operators are strongly recommended to bring this information to the attention of their respective workforces to ensure that the mooring operation can be undertaken safely.

23.1 Personnel Safety

Mooring and unmooring operations, including tug line handling, are dangerous operations. It is important that everybody concerned is fully aware of the hazards and takes appropriate precautions to prevent accidents.

23.2 Security of Moorings

Any excessive movement or the breaking adrift of a tanker from the berth owing to inadequate moorings could cause injury to personnel and damage to the jetty installations and to the tanker.

Mooring restraint requirements for tankers above 16,000 tonnes deadweight intended for general worldwide trade are given in the OCIMF publication '*Mooring Equipment Guidelines*'. Those requirements are based on standard environmental criteria and cannot possibly cater for the most extreme combination of environmental conditions at every terminal. At exposed terminals, or those where for some reason the criteria are likely to be exceeded, the ship's moorings should be supplemented with appropriate shore based equipment.

For ships below 16,000 tonnes deadweight and ships operating exclusively on a dedicated route using terminals whose specific environmental data is available, the recommended criteria may be revised to suit local conditions or trading patterns.

Although responsibility for the adequate mooring of a tanker rests with the Master, the terminal has an interest in ensuring that ships are securely and safely moored. Cargo hoses or arms should not be connected until both the Terminal Representative and the Master are satisfied that the ship is safely moored.

23.3 Preparations for Arrival

23.3.1 Tanker's Mooring Equipment

Before arrival at a port or berth, all necessary mooring equipment should be ready for use. Anchors should be ready for use if required, unless anchoring is prohibited. Provision for emergency towing-off pennants should be made in accordance with Section 26.5.5. There should always be an adequate number of personnel available to handle the moorings.

23.3.2 Use of Tugs

Before tugs come alongside to assist a tanker, all cargo and ballast tank lids and ullage ports should be closed, no matter what grade of oil is being or has been carried, unless all the cargo tanks are tested and proven free of hydrocarbon vapour. Tugs and other craft must not be permitted to come alongside before the Master has satisfied himself that it is safe for them to do so.

Tugs should be adequately fendered to avoid causing damage to the tanker's hull and should push the tanker at designated 'strong points', which should be indicated by markings.

Tugs should switch off their radar systems when approaching a tanker.

Except in an emergency, tugs should not be allowed to come alongside or remain alongside a tanker while it is loading or discharging volatile petroleum or ballasting tanks containing hydrocarbon vapour. Any intent by the Master or request from the shore for tugs to remain alongside during any such cargo or ballast activities should be treated as non-routine and must not be undertaken without the full agreement of all parties concerned, and only after a risk assessment has been carried out.

23.3.3 Emergency Use of Tugs

Occasionally, severe weather may place excessive strain on the moorings with consequent risk of mooring line failure and movement of the tanker in or off the berth. In such circumstances, tugs can perform a very useful function in holding the ship against the berth in order to reduce the strain on the moorings. In such circumstances, cargo operations should be immediately suspended, hoses or loading arms should be disconnected and engines placed on standby.

23.4 Mooring at Jetty Berths

Effective ship mooring management requires a sound knowledge of mooring principles, information about the mooring equipment installed on the ship, proper maintenance of this equipment and regular tending of mooring lines.

The safety of the ship, and hence its proper mooring, is the prime responsibility of the Master. However, the terminal has local knowledge of the operating environment at the site and knows the capabilities of shore equipment, and should therefore be in a position to advise the Master regarding mooring line layout and operating limits.

23.4.1 Type and Quality of Mooring Lines

Mooring lines should preferably all be of the same material and construction. Ropes with low elastic elongation properties are recommended for larger tankers, as they limit the tanker's movement at the berth. High modulus synthetic fibre ropes are a viable replacement for winch-stowed steel wire ropes for the mooring of large tankers at terminals, other than single point moorings. Recommendations on their use are contained in the OCIMF publication '*Guidelines on the Use of High Modulus Synthetic Fibre Ropes as Mooring Lines on Large Tankers*'.

Moorings composed entirely of high elasticity ropes are not recommended as they can allow excessive movement from strong wind or current forces or through interaction from passing ships. Within a given mooring pattern, ropes of different elasticity should never be used together in the same direction.

Mooring conditions and regulations may differ from port to port.

Where dynamic (shock) loading on moorings can be caused by swell conditions or the close passing of ships, fibre tails on the ends of mooring wires and high modulus synthetic fibre mooring ropes can provide sufficient elasticity to prevent failure of the mooring and other components in the mooring system. The tanker or the terminal may provide the tails, whose length should not exceed one third of the distance between the ship's fairlead and the shore mooring bollard.

Because fibre tails will deteriorate more rapidly than the wires or high modulus synthetic fibre ropes to which they are attached, they should be at least 25% stronger than the line to which they are attached. They should be inspected frequently, particularly where they are connected to the wire, and replaced if there are signs of damage.

23.4.2 Management of Moorings at Alongside Berths

23.4.2.1 Tending of Moorings

Ship's personnel are responsible for the frequent monitoring and careful tending of the moorings, but suitably qualified shore personnel should check the moorings periodically to satisfy themselves that they are being properly tended.

When tending moorings which have become slack or too taut, an overall view of the mooring system should be taken so that the tightening or slackening of individual lines does not allow the tanker to move or place undue loads on other lines. The tanker should maintain contact with the fenders, and moorings should not be slackened if the tanker is lying off the fenders.

During cold weather, steam operated winches and windlasses should be rotated slowly when not in use to avoid damage due to freezing.

23.4.2.2 Tension Winches

Self-tensioning winches fitted with automatic rendering and hauling capability should not be used in the automatic mode while the vessel is moored. In automatic mode, such winches, by

definition, will render under load and will allow the vessel to move out of position, with consequent risk to cargo arms or hoses.

23.4.2.3 Self-Stowing Mooring Winches

Because their weight and size make manual handling difficult, mooring wires used by large tankers are normally stored on self-stowing mooring winches, which may be either single drum or split drum. Some features of these winches need to be clearly understood by ship's personnel in order to avoid tankers breaking adrift from berths as the result of slipping winch brakes.

The design holding power of the brake may either have been specified by the shipowner or be the standard design of the winch manufacturer. Every ship's officer should be aware of the designed brake holding capacity of the self-stowing mooring winches installed on the ship.

The physical condition of the winch gearing and brake shoe linings or blocks has a significant effect on brake holding capacity in service. Mooring winch brakes should therefore be tested at regular intervals, not exceeding twelve months. A record, both of regular maintenance and inspections and of tests, should be kept on the ship. If the deterioration is significant, the linings or blocks must be renewed.

Some of the newer self-stowing mooring winches are fitted with disc brakes, which are less affected by wear.

Kits are available for testing winch brake holding capacity and can be placed on board for use by the crew.

In addition, there are a number of operational procedures that can seriously reduce the holding capacity of winch brakes if they are not correctly carried out. These include:

The Number of Layers of Wire on the Drum

The holding capacity of a winch brake is in inverse proportion to the number of layers of the mooring wire or rope on the drum. The designed holding capacity is usually calculated with reference to the first layer and there is a reduction in the holding capacity for each additional layer. This can be substantial – as much as an 11% reduction for the second layer.

If the rated brake holding capacity of a split drum winch is not to be reduced, only one layer should be permitted on the working drum.

The Direction of Reeling on the Winch Drum

On both single and split drum winches, the holding power of the brake is decreased substantially if the mooring line is reeled on the winch drum in the wrong direction. Before arrival at the berth, it is important to confirm that the mooring line is reeled so that its pull will be against the fixed end of the brake strap, rather than the pinned end. Reeling in the contrary direction can seriously reduce the brake holding capacity, in some cases by as much as 50%. The correct reeling direction to assist the brake should be permanently marked on the drum to avoid misunderstanding.

Winches fitted with disc brakes are not subject to this limitation.

The Condition of Brake Linings and Drum

Oil, moisture or heavy rust on the brake linings or drum can seriously reduce the brake holding capacity. Moisture may be removed by running the winch with the brake applied lightly, but care must be taken not to cause excessive wear. Oil impregnation cannot be removed so contaminated brake linings will need to be renewed.

The Application of the Brake

Brakes must be adequately tightened to achieve the required holding capacity. (This is usually 60% of the line's Minimum Breaking Load (MBL) – see OCIMF '*Mooring Equipment Guidelines*'.) The use of hydraulic brake applicators or a torque wrench showing the degree of torque applied is recommended. If brakes are applied manually, they should be checked for tightness.

23.4.2.4 Shore Moorings

At some terminals, shore moorings are used to supplement the tanker's moorings. Where shore personnel handle shore moorings, they must be fully aware of the hazards of the operation and should adopt safe working practices.

If the adjustable ends of the shore mooring are on board the tanker, the moorings should be tended by the tanker's personnel in conjunction with its own moorings. If shore based wires with winches are provided, agreement should be reached over the responsibility for tending. If shore based pulleys are provided, the tanker should tend the mooring since both ends of the line are on board. For the avoidance of doubt, there should be clear agreement between the Responsible Officer and the Terminal Representative with regard to who will take responsibility for tending any moorings provided by the terminal.

23.4.2.5 Anchors

Whilst moored alongside, anchors not in use should be properly secured by brake and guillotine, but otherwise be available for immediate use.

23.5 Berthing at Buoy Moorings

All the normal precautions taken during berthing alongside a jetty should be taken when berthing at a buoy mooring.

At terminals with buoy moorings for ocean going tankers, it is desirable to have professional advice on those aspects of safety related to the local marine operations. This may be by the assignment of a Berthing Master (Mooring Master) to the terminal or by consultation with a port or pilotage authority.

23.5.1 Mooring at Conventional Multi-Buoy Moorings

At conventional buoy moorings, good communication between bridge and poop is essential to avoid moorings or mooring boats being caught up in the ship's propeller.

Severe loads can sometimes develop in mooring lines during the mooring operation. It is essential that good quality moorings of adequate length are used and that personnel are closely supervised so as to ensure their safety.

At many conventional buoy mooring berths, the ship's moorings are supplemented by shore moorings run from the buoys or by ground moorings. These wires are often heavy and the handling of them around the warping drum of a winch should therefore only be undertaken by experienced personnel.

23.5.2 Mooring at Single Point Moorings (SPMs)

Complicated and non-standard mooring arrangements at SPMs frequently lead to dangerous and protracted operations. Therefore, the fitting, both on ships and on SPMs, of well designed and, in the case of the ship, accurately positioned, items of standard equipment will considerably reduce the risk of injury to personnel. The proper fitting of such equipment will also provide a more efficient method of securing ships to SPMs at offshore terminals.

OCIMF has produced guidelines for SPM mooring equipment entitled '*Recommendations for Equipment Employed in the Mooring of Ships at Single Point Moorings*' and it is recommended that they are followed by all SPM terminals and the ships using them.

A storage drum should be used to heave in the SPM pick-up rope prior to connection of the chafing chain to the stopper. A warping end should never be used for this purpose.

Ship and terminal operators should refer to the OCIMF publication '*Single Point Mooring Maintenance and Operations Guide*' for detailed information regarding SPM operations.

23.5.3 Management of Moorings at Buoy Berths

While the tanker is at a conventional multi-buoy mooring, frequent and regular inspection is essential to ensure that mooring lines are kept taut and that movement of the tanker is kept to a minimum. Excessive movement may cause rupture of the cargo connections.

At single point moorings, a watchman (equipped with appropriate means to communicate with the Officer of the Watch) should be stationed on the forecastle head to report any failure or imminent failure of moorings or leakage of oil. The watchman should also report immediately if the tanker 'rides-up' to the buoy and should be equipped with appropriate means to communicate with the Officer of the Watch.

PRECAUTIONS ON SHIP AND TERMINAL DURING CARGO HANDLING

This Chapter provides guidance on precautions to be observed by both ship and shore when cargo handling, ballasting, bunkering, tank cleaning, gas freeing and purging operations are to be carried out in port. Eliminating the risk of fire and explosion is paramount. The hazards associated with smoking, galleys, electrical equipment and other potential sources of ignition are discussed in Chapter 4, to which reference should be made.

Detailed information on equipment and operations that are principally related to either the tanker or the terminal is contained in Parts 2 and 3 of this Guide respectively.

24.1 External Openings in Superstructures

A tanker's accommodation and machinery spaces contain equipment that is not suitable for use in flammable atmospheres. It is therefore important that petroleum gas is kept out of these spaces.

All external doors, ports and similar openings should be closed when the tanker, or a ship at an adjacent berth, is conducting any of the following operations:

- Handling volatile petroleum or non-volatile petroleum near to or above its flashpoint.
- Loading non-volatile petroleum into tanks containing hydrocarbon vapour.
- Crude oil washing.
- Ballasting, purging, gas freeing or tank washing after discharge of volatile petroleum.

A screen door cannot be considered a safe substitute for an external door. Additional doors and ports may have to be closed in special circumstances or due to structural peculiarities of the tanker.

If external doors have to be opened for access, they should be closed immediately after use. Where practical, a single door should be used for working access in port. Doors that must be kept closed should be clearly marked.

Doors should not normally be locked in port. However, where there are security concerns, measures may need to be employed to prevent unauthorised access while at the same time ensuring that there is a means of escape for the personnel inside. Although discomfort may be caused to personnel in accommodation that is

completely closed during conditions of high temperatures and humidity, this discomfort should be accepted in the interests of safety.

24.2 Central Air Conditioning and Ventilation Systems

On ships with central air conditioning units, it is essential that the accommodation is kept under positive pressure to prevent the entry of hydrocarbon vapours. Intakes for air conditioning units are usually positioned in a safe area and vapours will not be drawn into the accommodation under normal conditions. A positive pressure will be maintained only if the air conditioning system is operating with its air intakes open and if all access doors are kept closed, except for momentary entry or exit. The system should not be operated with the intakes fully closed, that is in 100% recirculation mode, because the operation of extraction fans in galley and sanitary spaces will reduce the atmospheric pressure in the accommodation to less than that of the ambient pressure outside.

There is a benefit from having a gas detection and/or alarm system fitted to air conditioning intakes. In the event that hydrocarbon vapours are present at the inlets, the ventilation system should be shut down and transfer of cargo suspended until such time as the surrounding atmosphere is free of hydrocarbon vapours.

The same principles of positive pressure and gas detection apply to ships that have alternative air conditioning systems or where additional units have been fitted. The overriding consideration in all cases is that hydrocarbon vapours must not be permitted to enter the accommodation.

Externally located air conditioning units, such as window or split air conditioning types, should not be operated during any of the operations listed in Section 24.1 unless they are either located in safe areas or are certified as safe for use in the presence of flammable vapours.

On ships that depend on natural ventilation, ventilators should be kept trimmed to prevent the entry of petroleum gas. If ventilators are located so that petroleum gas can enter regardless of the direction in which they are trimmed, they should be covered, plugged or closed.

24.3 Openings in Cargo Tanks

24.3.1 Cargo Tank Lids

During the handling of volatile petroleum and the loading of non-volatile petroleum into tanks containing hydrocarbon vapour, and while ballasting after the discharge of volatile cargo, all cargo tank lids should be closed and secured.

Cargo tank lids or coamings should be clearly marked with the number and location (port, centre or starboard) of the tank they serve.

Tank openings of cargo tanks that are not gas free should be kept closed, unless gas freeing operations are being conducted alongside by prior agreement.

24.3.2 Sighting and Ullage Ports

During any of the cargo and ballast handling operations referred to in Section 24.1, sighting and ullage ports should be kept closed, unless required to be open for measuring and sampling and when agreed between the ship and the terminal.

If, as a result of the system design, sighting or ullage ports are required to be open for venting purposes, the openings should be protected by a flame screen which may be removed for a short period during ullaging, sighting, sounding and sampling. These screens should be a good fit and should be kept clean and in good condition.

24.3.3 Cargo Tank Vent Outlets

The cargo tank venting system should be set for the operation concerned. High velocity vents should be set in the operational position to ensure the high exit velocity of vented gas.

When volatile cargo is being loaded into tanks connected to a venting system which also serves tanks into which non-volatile cargo is to be loaded, particular attention should be paid to the setting of pressure/vacuum valves and the associated venting system, including any inert gas system, in order to prevent flammable gas entering the tanks to be loaded with non-volatile cargo.

Whenever tanks are isolated to prevent cross-contamination, the likelihood of oxygen entering the tank due to pressure variations on passage should be taken into consideration and measures may need to be planned to restore the inert condition prior to discharge.

24.3.4 Tank Washing Openings

During tank cleaning or gas freeing operations, tank washing cover plates should only be removed from the tanks in which these operations are taking place and should be replaced immediately upon completion. Any openings in the deck should be covered by gratings. Other tank washing covers may be loosened in preparation, but they should be left in their fully closed position.

24.4 Inspection of Ship's Cargo Tanks Before Loading

Where possible, inspection of ship's tanks before loading cargo should be made without entering the tanks.

Tank atmospheres which are, or which have been, inerted frequently have a blue haze which, together with the size of the tanks, makes it difficult to see the bottom even with the aid of a powerful torch or strong sunlight reflected by a mirror. Other methods such as dipping and measuring the heel, or having the stripping line or eductors opened in the tank and listening for suction, may then have to be used. It may sometimes be necessary to remove tank cleaning opening covers to sight parts of the tank not visible from the ullage or sighting ports, but this should only be done when the tank is gas free. The covers must be replaced and secured immediately after the inspection. The person carrying out the inspection should take care not to inhale vapours or inert gas when inspecting tanks that have not been gas freed.

Before entering a tank that has been inerted, it must be gas freed for entry and, unless all tanks are gas freed and the inert gas system is completely isolated, each individual tank to be entered for inspection must be isolated from the inert gas system (see Sections 7.1.6.12).

If, because the cargo to be loaded has a critical specification, it is necessary for the inspector to enter a tank, all the precautions contained in Section 10.5 must be followed.

24.5 Segregated Ballast Tank Lids

Segregated ballast tank lids may be opened before discharge of ballast is commenced, to allow the surface of the ballast to be inspected for contamination. Segregated ballast tank lids should, however, normally be kept closed when cargo or ballast is being handled because petroleum gas could be drawn into them.

Segregated ballast tank lids must be clearly marked to indicate the tank they serve.

24.6 Ship and Shore Cargo Connections

24.6.1 Flange Connections

Flanges for ship-to-shore cargo connections at the end of the terminal pipelines and on the ship's manifold should be in accordance with the OCIMF publication *'Recommendations for Oil Tanker Manifolds and Associated Equipment'*.

Flange faces, gaskets and seals should be clean and in good condition. When in their storage location, flange faces should be suitably protected from corrosion/pitting.

Where bolted connections are made, all bolt holes should be used. Care should be taken when tightening bolts as uneven or over tightened bolts could result in leakage or fracture. Improvised arrangements using 'G' clamps or similar devices must not be used for flange connections.

24.6.2 Removal of Blank Flanges

Each tanker and terminal manifold flange should have a removable blank flange made of steel or other approved material, such as phenol resin, and preferably fitted with handles.

Precautions should be taken to ensure that, prior to the removal of blanks from tanker and terminal pipelines, the section between the last valve and blank does not contain oil under pressure. Precautions must also be taken to prevent any spillage.

Blank flanges shall be capable of withstanding the working pressure of the line or system to which they are connected. Blank flanges should normally be of a thickness equal to that of the end flange to which they are fitted.

24.6.3 Reducers and Spools

Reducers and spools should be made of steel and be fitted with flanges that conform to ANSI B16.5, Class 150 or equivalent. Ordinary cast iron should not be used (see OCIMF *'Recommendations for Oil Tanker Manifolds and Associated Equipment'*).

There should be an exchange of information between the ship and terminal when manifold reducers or spools are made of any material other than steel, since particular attention is necessary in their manufacture to achieve the equivalent strength of steel and to avoid the possibility of fracture.

Manifold pressure gauges should be fitted to the spool pieces/reducers on the outboard side of the manifold valves.

24.6.4 Lighting

During darkness, adequate lighting should be arranged to cover the area of the ship-to-shore cargo connection and any hose handling equipment, so that the need for any adjustment can be seen in good time and any leakage or spillage of oil can be quickly detected.

24.6.5 Emergency Release

A special release device may be used for the emergency disconnection of cargo hoses or arms.

If possible, the hoses or arms should be drained, purged or isolated as appropriate before emergency disconnection so that spillage is minimised (see Section 11.1.15.1).

Periodic checks should be made to ensure that all safety features are operational.

(See also Section 18.1.10 – Powered Emergency Release Couplings (PERCs).)

24.7 Accidental Oil Spillage and Leakage

24.7.1 General

Ship and shore personnel should maintain a close watch for the escape of oil at the commencement of and during cargo transfer operations. In particular, care should be taken to ensure that pipeline valves, including drop valves, are closed when not in use.

The ullages of cargo or bunker tanks that have been topped-up should be checked from time to time during the remaining loading operations to ensure that overflows do not occur as a result of leaking valves or incorrect operations.

On double hull ships, care should be taken not to reduce the transverse metacentric height (GM) such that it can induce an angle of list or loll when deballasting double bottom tanks after some cargo tanks have been topped-off, as this could cause an overflow of cargo. (See Section 11.2.)

If leakage occurs from a pipeline, valve, hose or metal arm, operations through that item should be stopped until the cause has been ascertained and the defect has been rectified. If a pipeline, hose or arm bursts or if there is an overflow or other spill, all cargo and bunker operations should be stopped immediately and should not be restarted until the fault has been rectified and all hazards from the released oil have been eliminated. If there is any possibility of the released oil or of petroleum gas entering an engine room or accommodation space intake, appropriate preventive measures must be taken quickly.

Means should be provided for the prompt removal of any spillage on deck. Any oil spill should be reported to the terminal and port authorities and the relevant shore and shipboard oil pollution emergency plans should be activated.

Harbour authorities and any adjacent ship or shore installations should be warned of any potential hazard caused by the spill.

24.7.2 Sea and Overboard Discharge Valves

At the start of loading and at regular intervals throughout loading, discharging, ballasting and tank washing, a watch should be kept to ensure that oil is not escaping through sea valves.

Sea and overboard discharge valves connected to the cargo and ballast systems must be securely closed and lashed and may be sealed when not in use. In-line blanks should be inserted where provided. When lashing is not practical, as with hydraulic valves, some suitable means of marking should be used to indicate clearly that the valves are to remain closed.

For further information on this subject, reference should be made to the ICS/OCIMF publication '*Prevention of Oil Spillages Through Cargo Pumphoom Sea Valves*'.

24.7.3 Scupper Plugs

Before cargo handling commences, all deck scuppers and, where applicable, open drains on the jetty must be effectively plugged to prevent spilled oil escaping into the water around the tanker or terminal. Accumulations of water should be drained periodically and scupper plugs replaced immediately after the water has been run off.

Oily water should be transferred to a slop tank or other suitable receptacle. The tank pressure should be reduced to facilitate draining, if necessary.

24.7.4 Spill Containment

A permanently fitted spill tank, provided with suitable means of draining, should be fitted under all ship and shore manifold connections. If no permanent means are fitted, portable drip trays should be placed under each connection to retain any leakage. The use of plastic should be avoided unless provision for bonding is made.

24.7.5 Ship and Shore Cargo and Bunker Pipelines not in Use

The tightness of valves should not be relied upon to prevent the escape or seepage of oil. All shore pipelines, loading arms and hoses not in use at a berth must be securely blanked.

All ship's cargo and bunker pipelines not in use must be securely blanked at the manifold. The stern cargo pipelines should be isolated from the tanker's main pipeline system forward of the aft accommodation by blanking or by the removal of a spool piece.

24.8 Fire-Fighting Equipment

When a tanker is alongside a berth, fire-fighting equipment is to be ready for immediate use.

On board the ship, this is normally achieved by having fire hoses with spray/jet nozzles connected run out forward and aft of, and adjacent to, the manifold in use. Having a portable dry chemical powder extinguisher available near the manifold provides additional protection against small flash fires.

On the jetty, fire-fighting equipment should be ready for immediate use. While this may not involve the rigging of fire hoses, the preparations for emergency operation of the fire-fighting equipment should be apparent and communicated to the tanker. Consideration should be given to having portable extinguishers available for use adjacent to the jetty manifold area.

24.9 Proximity to Other Vessels

24.9.1 Tankers at Adjacent Berths

Flammable concentrations of petroleum gas may be encountered if another tanker at an adjacent berth is conducting cargo or ballast handling, purging, tank cleaning or gas freeing operations. In such circumstances, appropriate precautions should be taken as described in Section 24.1.

24.9.2 General Cargo Ships at Adjacent Berths

It is unlikely that general cargo ships will be able to comply as fully as tankers with the safety requirements relating to possible sources of ignition, such as smoking, naked lights, cooking and electrical equipment.

Accordingly, when a general cargo ship is at a berth in the vicinity of a tanker that is loading or discharging volatile petroleum, loading non-volatile petroleum into tanks containing hydrocarbon vapour, ballasting tanks containing hydrocarbon vapour, or purging or gas freeing after the discharge of volatile petroleum, it will be necessary for the terminal to evaluate any consequential safety hazards and to take precautions additional to those set out in this Chapter. Such precautions should include inspecting the general cargo ship involved and clearly defining the precautions to be taken on board that ship.

24.9.3 Tanker Operations at General Cargo Berths

Where tanker operations are conducted at general cargo berths, it is unlikely that personnel on such berths will be familiar with safety requirements relating to possible sources of ignition, or that cranes or other equipment will comply with the requirements for the design and installation of electrical equipment in hazardous areas.

Accordingly, it will be necessary for the terminal to take precautions additional to those set out in this Chapter. Such precautions should include restricted vehicular access, removable barriers to control access to the berth, additional fire-fighting equipment and control of sources of ignition, together with restrictions on the movement of goods and equipment and the lifting of loads.

24.9.4 Tugs and Other Craft Alongside

The number of craft that come alongside, and the duration of their stay, should be kept to a minimum. Subject to any port authority regulations, only authorised craft having the permission of the Responsible Officer and, where applicable, the Terminal Representative, should be permitted to come alongside or remain alongside a tanker while it is handling volatile petroleum or is ballasting tanks containing hydrocarbon vapour. The Responsible Officer should instruct personnel manning the craft that smoking, naked light and cooking appliance regulations must be observed on the craft. In the event of a breach of the regulations, it will be necessary to cease operations. (See also Sections 23.3.2 for additional guidance on tugs lying alongside.)

Terminals should issue appropriate instructions to the operators of authorised craft on the use of engines and other apparatus and equipment, so as to avoid sources of ignition when going alongside a tanker or a jetty. These will include provision of spark arresters for engine exhausts, where applicable, and instructions on proper fendering. Terminals should also ask for suitable notices to be posted prominently on the craft, informing personnel and passengers of the safety precautions to be observed.

If any unauthorised craft come alongside or secure in a position that may endanger the operations, they should be reported to the port authority and, if necessary, operations should cease.

24.10 Notices

24.10.1 Notices on the Tanker

On arrival at a terminal, a tanker should display notices at the gangway in appropriate languages stating:

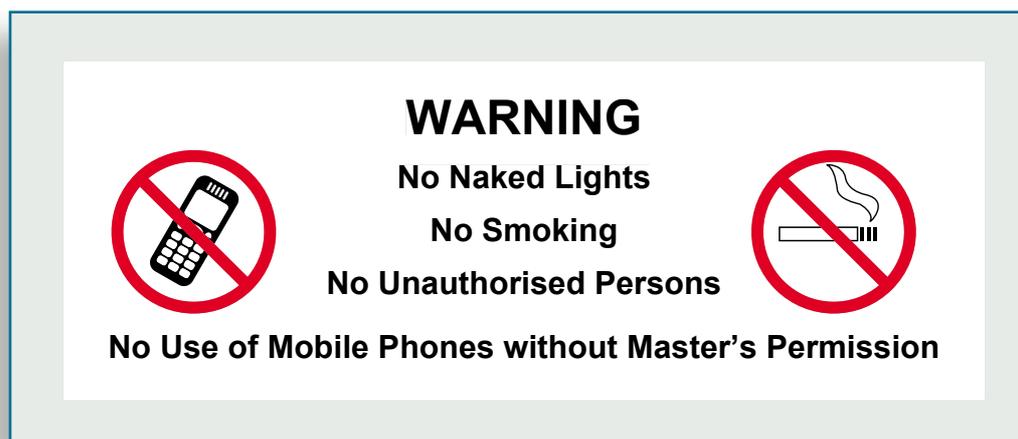


Figure 24.1 – Notices on the tanker

Alternative wording containing the same warnings may also be used.

Shore personnel should observe these requirements when on board the tanker.

Photo luminescent notices stating 'EMERGENCY ESCAPE ROUTE', together with directional signs, should be displayed at appropriate locations.

24.10.2 Notices on the Terminal

Permanent notices and signs indicating that smoking and naked lights are prohibited should be displayed conspicuously on the jetty in appropriate languages. Similar permanent notices and signs should be displayed at the entrance to the terminal area or the shore approaches to the jetty.

In buildings and other shore locations where smoking is allowed, notices to this effect should be displayed conspicuously.

Emergency escape routes from the tanker berth to safe areas ashore should be indicated clearly.

24.11 Manning Requirements

A sufficient number of personnel to deal with an emergency should be present on board the ship and in the shore installation at all times during the ship's stay at a terminal.

Those personnel involved with the operations should be familiar with the risks associated with handling petroleum.

24.12 Control of Naked Flames and Other Potential Ignition Sources

The hazards associated with smoking, galleys, electrical equipment and other potential sources of ignition are discussed in Chapter 4.

24.13 Control of Vehicles and Other Equipment

The use of vehicles and equipment should be controlled, particularly in hazardous zones. Routes to and from work places and parking areas should be clearly indicated. Barriers or fencing should be provided, where necessary, to prevent unauthorised access.

24.14 Helicopter Operations

Helicopter operations must not be permitted over the tank deck unless all other operations have been suspended and all cargo tank openings have been closed.

Helicopter operations should only be conducted in accordance with the ICS '*Guide to Helicopter/Ship Operations*'.

BUNKERING OPERATIONS

Spillages and leakages during bunkering operations are a primary source of oil pollution from ships. Experience has shown that many of the bunker overflows and spillages that do occur can be attributed to human error.

This Chapter provides guidance on the planning and execution of bunkering operations and includes an example of a pre-transfer safety check-list.

25.1 General

Although residual fuel oil normally has a flashpoint above 60°C, it is often stored and managed at temperatures close to, or even above, its flashpoint. Further, high flashpoint fuels sometimes contain residual quantities of light components that slowly migrate to the surface and vaporise after loading, so raising the flammability of the vapour space. It should never be assumed that the vapour spaces in, and emissions from, bunker tanks will always be safe simply on account of a high specified flashpoint. For this reason, ullaging, dipping and sampling procedures must follow the recommendations given in Section 11.8. See Section 2.7 with regard to the flammability hazards associated with residual fuel oils.

All bunkering operations should be carefully planned and executed in accordance with MARPOL regulations. Pollution caused when heavy fuel oil is spilt is particularly damaging and difficult to clean-up.

Personnel involved in the bunkering operation on board should have no other tasks and should remain at their workstations during topping-off. This is particularly important when bunkers are being loaded concurrent with cargo operations, in order to avoid conflicts of interest for operational personnel. Spillages often occur when staff are distracted by another task.

When bunkers are being delivered by barge, reference should be made to Sections 11.9.2 and 12.5.9 with regard to the precautions to be taken during barge-to-tanker transfers of petroleum.

25.2 Bunkering Procedures

Companies should require that all bunkering operations are controlled under procedures that are incorporated in the ship's Safety Management System.

The procedures should ensure that the risks associated with the operation have been assessed and that controls are in place to mitigate these risks. The procedures should also address contingency arrangements in the event of a spill. The Company should consider the following items when producing the procedures:

- Determining that there is adequate space for the volume of bunkers to be loaded.
- Establishing maximum loading volume for all tanks.
- Controls for the setting of bunker system valves.
- Determining loading rates for the start of loading, bulk loading and topping-off.
- Special precautions when loading into double bottom tanks.
- Arrangements of bunker tank ventilation.
- Internal tank overflow arrangements.
- Verification of gauging system operation and accuracy.
- Alarm settings on overfill alarm units.
- Communication with the terminal to establish when bunkering can be undertaken.
- Communications with the bunker supplier prior to commencement, to establish and record the loading procedure to be followed and to determine how quantity and quality checks may be carried out, particularly if safe access is needed between the ship and a barge.
- Methods of managing the handling of bunkers which have or may have a hydrogen sulphide (H₂S) content.
- Testing procedures for determining the presence of hydrocarbon or H₂S vapours.
- Method of determining the temperature of the bunkers during loading.
- Communications procedure for the operation, including emergency stop.
- Manning requirements to execute the operation safely.
- Monitoring of the bunkering operation and checking it conforms to the agreed procedure.
- Changing over tanks during loading.
- Containment arrangements and clean-up equipment to be available.

Once the procedure is produced, it should be implemented by use of a check-list, an example of which is included in Section 25.4.3.

25.3 The Bunkering Operation

Prior to commencing the operation, all pre-loading checks should be carried out and communication systems verified as working.

The loading rate should be checked regularly.

When changing over from one tank to another, care should be taken to ensure that an excessive back pressure is not put on the hose or loading lines.

When topping-off tanks, the loading rate should be decreased to reduce the possibility of air locks in the tank causing mist carry over through the vents, and to minimise the risk of the supplier not stopping quickly enough.

On completion of loading, all hoses and lines should be drained to the tank or, if applicable, back to the barge, prior to disconnection. The practice of blowing lines with air into bunker tanks is a common one, but has a high risk of causing a spillage unless the tank is only part full and has sufficient ullage on completion of loading.

25.4 The Bunkering Safety Check-List

25.4.1 General

Responsibility and accountability for the safe conduct of operations while a ship is receiving bunkers by barge is shared jointly between the Masters of the tanker and of the barge. The responsibility for the bunkering operation is usually delegated to designated Responsible Officers on the ship and on the barge. Before the bunkering operation commences, the Responsible Officers should:

- Agree in writing the handling procedures, including the maximum transfer rates.
- Agree in writing the action to be taken in the event of an emergency during transfer operations.
- Complete and sign the Bunkering Safety Check-List.

The Bunkering Safety Check-List is based upon the Ship/Shore Safety Check-List (see Section 26.3) and the Pre-Transfer Bunkering Check-List contained in the IMO publication '*Recommendations on the Safe Transport of Dangerous Cargoes and Related Activities in Port Areas*'.

The Check-List is primarily structured for loading bunkers from a barge, but it is also suitable for use when taking bunkers from a jetty or when loading bulk lubricating oil or gas oil from a road tanker.

25.4.2 Guidelines for Use

The following guidelines have been produced to assist ship, barge and terminal operators in their joint use of the Bunkering Safety Check-List.

The Bunkering Safety Check-List uses statements assigning responsibility and accountability. Ticking or initialling the appropriate box, and finally signing the declaration, confirms the acceptance of obligations. Once signed, it provides the minimum basis for safe operations as agreed through a mutual exchange of critical information.

Some of the Check-List statements are directed to considerations for which the ship has sole responsibility and accountability, some for which the barge has sole responsibility and accountability and others which assign joint responsibility and accountability. Shaded boxes are used to identify statements that generally may be applicable to only one party, although the ship or barge may tick or initial such sections if they so wish.

The assignment of responsibility and accountability does not mean that the other party is excluded from carrying out checks in order to confirm compliance. The assignment of responsibility and accountability ensures clear identification of the party responsible for initial and continued compliance throughout the transfer activity.

The Responsible Officers completing the Check-List should be the people carrying out the bunkering operation.

The tanker's Responsible Officer should personally check all considerations lying within the responsibility of the tanker. Similarly, the barge's Responsible Officer should personally check all considerations that are within the responsibility of the barge. In fulfilling their responsibilities, Responsible Officers should assure themselves that the

standards of safety on both sides of the operation are fully acceptable. This can be achieved by means such as:

- Confirming that a competent person has satisfactorily completed the Check-List.
- Sighting appropriate records.
- By joint inspection, where deemed appropriate.

For mutual safety, before the start of operations, and from time to time thereafter, a barge representative and a ship's officer should conduct inspections of the barge and the ship to ensure that their obligations, as accepted in the Check-List, are being effectively managed.

The Bunkering Safety Check-List contains the following sections:

1. Bunkers to be Transferred

A joint agreement on the quantity and grades of bunkers to be transferred, together with agreed transfer rates and the maximum line back pressures.

2. Bunker tanks to be Loaded

An identification of the tanks to be loaded with the aim of ensuring that there is sufficient space to safely accommodate the bunkers to be transferred. Space is provided to record each tank's maximum filling capacity and the available volume.

3. Checks by Barge Prior to Berthing

This section provides the checks to be carried out before the barge goes alongside the ship.

4. Checks Prior to Transfer

This section provides the checks to be jointly undertaken before transfer activities commence.

The numbers in brackets after each of the questions in Sections 3 and 4 relate to the guidance notes for completing the Ship/Shore Safety Check-List in Section 26.4, which should be referred to for additional information.

The safety of operations requires that all relevant statements are considered and the associated responsibility and accountability for compliance accepted. Where either party is not prepared to accept an assigned accountability, a comment must be made in the Remarks column and due consideration given to whether operations should proceed.

Where an item is agreed not to be applicable to the ship, to the barge or to the operation envisaged, a note to that effect should be entered in the 'Remarks' column.

The presence of the letters 'A' or 'R' in the Code column indicates the following:

- A** ('Agreement'). This indicates an agreement or procedure that should be identified in the Check-List or communicated in some other mutually acceptable form.
- R** ('Re-check'). This indicates items to be re-checked at appropriate intervals, as agreed between both parties and stated in the declaration.

The joint declaration should not be signed until all parties have checked and accepted their assigned responsibilities and accountabilities.

25.4.3 Bunkering Safety Check-List

Port _____ Date _____
 Ship _____ Barge _____
 Master _____ Master _____

1. Bunkers to be Transferred

Grade	Tonnes	Volume at Loading Temp	Loading Temperature	Maximum Transfer Rate	Maximum Line Pressure
Fuel Oil					
Gas Oil/Diesel					
Lub. Oil in Bulk					

2. Bunker Tanks to be Loaded

Tank No.	Grade	Volume of Tank @ _____%	Vol. of Oil in Tank before Loading	Available Volume	Volume to be Loaded	Total Volumes Grade

3. Checks by Barge Prior to Berthing

Bunkering	Ship	Barge	Code	Remarks
1. The barge has obtained the necessary permissions to go alongside receiving ship.				
2. The fenders have been checked, are in good order and there is no possibility of metal to metal contact.			R	
3. Adequate electrical insulating means are in place in the barge-to-ship connection. (34)				
4. All bunker hoses are in good condition and are appropriate for the service intended. (7)				

4. Checks Prior to Transfer

Bunkering	Ship	Barge	Code	Remarks
5. The barge is securely moored. (2)			R	
6. There is a safe means of access between the ship and barge. (1)			R	
7. Effective communications have been established between Responsible Officers. (3)			A R	(VHF/UHF Ch). Primary System: Backup System: Emergency Stop Signal:
8. There is an effective watch on board the barge and on the ship receiving bunkers. (22)				
9. Fire hoses and fire-fighting equipment on board the barge and ship are ready for immediate use. (5)				
10. All scuppers are effectively plugged. Temporarily removed scupper plugs will be monitored at all times. Drip trays are in position on decks around connections and bunker tank vents. (10) (11)			R	
11. Initial line up has been checked and unused bunker connections are blanked and fully bolted. (13)				
12. The transfer hose is properly rigged and fully bolted and secured to manifolds on ship and barge. (7)				
13. Overboard valves connected to the cargo system, engine room bilges and bunker lines are closed and sealed. (16)				
14. All cargo and bunker tank hatch lids are closed. (15)				
15. Bunker tank contents will be monitored at regular intervals.			A R	at intervals not exceeding minutes
16. There is a supply of oil spill clean-up material readily available for immediate use.				
17. The main radio transmitter aerials are earthed and radars are switched off. (42)				
18. Fixed VHF/UHF transceivers and AIS equipment are on the correct power mode or switched off. (40)				
19. Smoking rooms have been identified and smoking restrictions are being observed. (36)			A R	Nominated Smoking Rooms Tanker: Barge:

BUNKERING OPERATIONS

Bunkering	Ship	Barge	Code	Remarks
20. Naked light regulations are being observed. (37)			R	
21. All external doors and ports in the accommodation are closed. (17)			R	
22. Material Safety Data Sheets (MSDS) for the bunker transfer have been exchanged where requested. (26)			R	
23. The hazards associated with toxic substances in the bunkers being handled have been identified and understood. (27)			R	H ₂ S Content Benzene Content

DECLARATION

We have checked, where appropriate jointly, the items of the Check-List in accordance with the instructions and have satisfied ourselves that the entries we have made are correct to the best of our knowledge.

We have also made arrangements to carry out repetitive checks as necessary and agreed that those items coded 'R' in the Check-List should be re-checked at intervals not exceeding ____ hours.

If, to our knowledge, the status of any item changes, we will immediately inform the other party.

For Ship	For Barge
Name _____	Name _____
Rank _____	Rank _____
Signature _____	Signature _____
Date _____	Date _____
Time _____	Time _____

Record of repetitive checks:

Date:			
Time:			
Initials for Ship:			
Initials for Barge:			

SAFETY MANAGEMENT

This Chapter provides a summary of information for assisting the ship and the terminal jointly to manage personnel and operational safety. Reaction to changing weather conditions during cargo handling is addressed. The correct use of personal protective equipment for both ship and shore personnel is also discussed.

The diligent and conscientious joint completion of the Ship/Shore Safety Check-List provides the foundation for a safe transfer operation. The Check-List is included in this Chapter, together with guidelines to assist its completion.

This Chapter also includes guidance on the interface between ship and terminal emergency procedures.

26.1 Climatic Conditions

26.1.1 Terminal Advice of Adverse Weather Conditions

The terminal should establish limiting parameters for controlling or stopping cargo operations based on the design criteria for the berth and its equipment. The parameters may be determined by environmental conditions, such as wind speed, tidal current and swell, or by the physical limitations of the berth, such as fender loads or mooring point strength. Any limitations should be discussed with the tanker before operations commence and recorded in the Ship/Shore Safety Check-List (see question 48).

The Terminal Representative should alert the tanker to any forecast of adverse weather conditions which may require operations to be stopped, or loading or discharge rates to be reduced. In some instances, necessary information may be provided by third parties in the immediate vicinity or by the ship.

Where environmental conditions are critical to the operation of the berth, the terminal should consider providing appropriate measuring instrumentation to provide information that will assist in managing the risk.

26.1.2 Wind Conditions

If there is little air movement, petroleum gas may persist on deck in heavy concentrations. If there is a wind, eddies can be created on the lee side of a tanker's accommodation or deck structure which can carry vented gas towards the structure. Either of these effects may result in local heavy petroleum gas concentrations and it may be necessary to extend the precautions set out in Section 24.1 or to stop loading, ballasting of non-gas free tanks, purging, tank cleaning or gas freeing while these

conditions persist. All operations should also be stopped if wind conditions cause funnel sparks to fall on deck.

26.1.3 Electrical Storms (Lightning)

When an electrical storm is anticipated in the vicinity of the tanker or terminal, the following operations must be stopped, whether or not the ship's cargo tanks are inerted:

- Handling of volatile petroleum.
- Handling of non-volatile petroleum in tanks not free of hydrocarbon vapour.
- Ballasting of tanks not free of hydrocarbon vapour.
- Purging, tank cleaning or gas freeing after the discharge of volatile petroleum.

All tank openings and vent valves must be closed, including any bypass valves fitted on the tank venting system.

26.2 Personnel Safety

26.2.1 Personal Protective Equipment (PPE)

Protective clothing and equipment should be worn by all personnel engaged in operations on board and ashore. It is recommended that this should comprise a boiler suit (or similar clothing providing full cover), safety shoes, safety glasses and a safety helmet as appropriate. Shore personnel should also wear life vests or other similar buoyancy devices where there is a risk of falling into the water.

Storage places for PPE, including breathing apparatus, should be protected from the weather and should be clearly marked. Personnel should utilise the equipment and clothing whenever the situation requires.

Personnel who are likely to be required to use breathing apparatus should be trained in its safe use.

Ships should establish the PPE requirements for visitors and these should include appropriate clothing, safe footwear and a safety helmet. Likewise, terminals should establish requirements for ship's personnel passing through the terminal. A clearly marked safe route and/or safe transport through the terminal should be provided.

26.2.2 Slip and Fall Hazards

Due to the high incidence of slips and falls on tankers, owners, operators and seafarers should pay particular attention to on board arrangements and the changing conditions that may contribute to these accidents.

Particular attention should be given to providing non-skid coatings or gratings on the deck in working areas and walkways. It is suggested that these areas are clearly marked so that personnel are aware of their existence and extent. Areas for consideration include:

- Mooring areas.
- Manifold areas.
- Dipping and sampling locations.
- Access walkways.
- Pipeline step-overs.

Irrespective of the arrangements provided to prevent slips and falls, it is essential that personnel use the prescribed walkways and keep them clear and free of spillages. Shore personnel and visitors should also use the prescribed areas.

The risk of trips and slips is significantly higher when using access ladders and companionways. Good design and construction will help to prevent accidents of this nature. Trip hazards, such as high plate edges at the top of ladders and unevenly spaced steps, should be avoided. Where the design cannot be modified, trip hazards should be clearly marked or highlighted with contrasting paint.

26.2.3 Personal Hygiene

In view of the danger to health that may arise from prolonged contact with oil, personal hygiene is most important. Wherever possible, direct skin contact with oil or with oily clothing should be avoided.

26.2.4 Clothing Made of Synthetic Materials

Experience has shown that clothing made from synthetic material does not give rise to any significant electrostatic hazard under conditions normally encountered on tankers (see Section 3.3.7).

However, the tendency for synthetic material to melt and fuse together when exposed to high temperatures leads to a concentrated heat source which causes severe damage to body tissue. Clothing made of such material is therefore not considered suitable for persons who may be exposed to flame or hot surfaces in the course of their duties.

26.3 The Ship/Shore Safety Check-List

26.3.1 General

The responsibility and accountability for the safe conduct of operations while a ship is at a terminal are shared jointly between the ship's Master and the Terminal Representative. Before cargo or ballast operations commence, the Master, or his representative, and the Terminal Representative should:

- Agree in writing on the transfer procedures, including the maximum loading or unloading rates.
- Agree in writing on the action to be taken in the event of an emergency during cargo or ballast handling operations.
- Complete and sign the Ship/Shore Safety Check-List.

Terminals may wish to issue an explanatory letter to the Masters of visiting ships advising them of the terminal's expectations regarding the

joint responsibility for the safe conduct of operations, and inviting the co-operation and understanding of the tanker's personnel. An example of the text for such a letter is in Section 26.3.4.

While the Ship/Shore Safety Check-List is based upon cargo handling operations, it is recommended that the same practice is adopted when a tanker presents itself at a berth for tank cleaning.

26.3.2 Guidelines for Use

Guidelines for completing the Check-List and to assist in responding to each individual statement are included in Section 26.4. They have been produced to assist berth operators and ships' Masters in their joint use of the Ship/Shore Safety Check-List.

The Master and all under his command should adhere strictly to these requirements throughout the ship's stay alongside. The Terminal Representative and all shore personnel should do likewise. Each party will be committed to co-operate fully in the mutual interest of achieving safe and efficient operations.

Responsibility and accountability for the statements within the Ship/Shore Safety Check-List are assigned within the document. The acceptance of responsibility is confirmed by ticking or initialling the appropriate box and finally signing the declaration at the end of the Check-List. Once signed, the Check-List details the minimum basis for safe operations as agreed through the mutual exchange of critical information.

Some of the Check-List statements are directed to considerations for which the ship has sole responsibility and accountability, some to considerations for which the terminal has sole responsibility and accountability, and there are others which assign joint responsibility and accountability. Shaded boxes are used to identify statements that generally would be applicable to only one party, although the ship or terminal may tick or initial such sections if they so wish.

The assignment of responsibility and accountability does not mean that the other party is excluded from carrying out checks in order to confirm compliance. It is intended to ensure clear identification of the party responsible for initial and continued compliance throughout the ship's stay at the terminal.

The Responsible Officer should personally check all considerations lying within the responsibility of the tanker. Similarly, the Terminal Representative should personally check all considerations that are the terminal's responsibility. In fulfilling these responsibilities, representatives should assure themselves that the standards of safety on both sides of the operation are fully acceptable. This can be achieved by means such as:

- Confirming that a competent person has satisfactorily completed the Check-List.
- Sighting appropriate records.
- Joint inspection, where deemed appropriate.

For mutual safety, before the start of operations, and from time to time thereafter, a Terminal Representative and, where appropriate, a Responsible Officer, should conduct an inspection of the ship to ensure

that the ship is effectively managing its obligations, as accepted in the Ship/Shore Safety Check-List. Similar checks should be conducted ashore. Where basic safety requirements are found to be insufficient, either party may require that cargo and ballast operations are stopped until corrective action is implemented satisfactorily.

26.3.2.1 Composition of the Check-List

The Ship/Shore Safety Check-List comprises four parts, the first two of which (Parts 'A' and 'B') address the transfer of Bulk Liquids. These are applicable to all operations. Part 'A' identifies the required physical checks and Part 'B' identifies elements that are verified verbally.

Part 'C' contains additional considerations relating to the transfer of Bulk Liquid Chemicals and Part 'D' contains those for Bulk Liquefied Gases.

The safety of operations requires that all relevant statements are considered and the associated responsibility and accountability for compliance are accepted, either jointly or singly. Where either party is not prepared to accept an assigned accountability, a comment must be made in the 'Remarks' column and due consideration should be given to assessing whether operations can proceed.

Where a particular item is considered not to be applicable to the ship, the terminal or to the planned operation, a note to this effect should be entered in the 'Remarks' column.

26.3.2.2 Coding of Items

The presence of the letters 'A', 'P' or 'R' in the column entitled 'Code' indicates the following:

- A ('Agreement'). This indicates an agreement or procedure that should be identified in the 'Remarks' column of the Check-List or communicated in some other mutually acceptable form.
- P ('Permission'). In the case of a negative answer to the statements coded 'P', operations should not be conducted without the written permission from the appropriate authority.
- R ('Re-check'). This indicates items to be re-checked at appropriate intervals, as agreed between both parties, at periods stated in the declaration.

The joint declaration should not be signed until both parties have checked and accepted their assigned responsibilities and accountabilities.

26.3.3 The Ship/Shore Safety Check-List

Ship's Name _____

Berth _____

Port _____

Date of Arrival _____

Time of Arrival _____

Part 'A' – Bulk Liquid General – Physical Checks

Bulk Liquid – General	Ship	Terminal	Code	Remarks
1. There is safe access between the ship and shore.			R	
2. The ship is securely moored.			R	
3. The agreed ship/shore communication system is operative.			A R	System: Backup System:
4. Emergency towing-off pennants are correctly rigged and positioned.			R	
5. The ship's fire hoses and fire-fighting equipment are positioned and ready for immediate use.			R	
6. The terminal's fire-fighting equipment is positioned and ready for immediate use.			R	
7. The ship's cargo and bunker hoses, pipelines and manifolds are in good condition, properly rigged and appropriate for the service intended.				
8. The terminal's cargo and bunker hoses or arms are in good condition, properly rigged and appropriate for the service intended.				
9. The cargo transfer system is sufficiently isolated and drained to allow safe removal of blank flanges prior to connection.				
10. Scuppers and save-alls on board are effectively plugged and drip trays are in position and empty.			R	
11. Temporarily removed scupper plugs will be constantly monitored.			R	
12. Shore spill containment and sumps are correctly managed.			R	
13. The ship's unused cargo and bunker connections are properly secured with blank flanges fully bolted.				
14. The terminal's unused cargo and bunker connections are properly secured with blank flanges fully bolted.				

SAFETY MANAGEMENT

Bulk Liquid – General	Ship	Terminal	Code	Remarks
15. All cargo, ballast and bunker tank lids are closed.				
16. Sea and overboard discharge valves, when not in use, are closed and visibly secured.				
17. All external doors, ports and windows in the accommodation, stores and machinery spaces are closed. Engine room vents may be open.			R	
18. The ship's emergency fire control plans are located externally.				Location:

If the ship is fitted, or is required to be fitted, with an inert gas system (IGS), the following points should be physically checked:

Inert Gas System	Ship	Terminal	Code	Remarks
19. Fixed IGS pressure and oxygen content recorders are working.			R	
20. All cargo tank atmospheres are at positive pressure with oxygen content of 8% or less by volume.			P R	

Part 'B' – Bulk Liquid General – Verbal Verification

Bulk Liquid – General	Ship	Terminal	Code	Remarks
21. The ship is ready to move under its own power.			P R	
22. There is an effective deck watch in attendance on board and adequate supervision of operations on the ship and in the terminal.			R	
23. There are sufficient personnel on board and ashore to deal with an emergency.			R	
24. The procedures for cargo, bunker and ballast handling have been agreed.			A R	
25. The emergency signal and shutdown procedure to be used by the ship and shore have been explained and understood.			A	
26. Material Safety Data Sheets (MSDS) for the cargo transfer have been exchanged where requested.			P R	

Bulk Liquid – General	Ship	Terminal	Code	Remarks
27. The hazards associated with toxic substances in the cargo being handled have been identified and understood.				H ₂ S Content: Benzene Content:
28. An International Shore Fire Connection has been provided.				
29. The agreed tank venting system will be used.			A R	Method:
30. The requirements for closed operations have been agreed.			R	
31. The operation of the P/V system has been verified.				
32. Where a vapour return line is connected, operating parameters have been agreed.			A R	
33. Independent high level alarms, if fitted, are operational and have been tested.			A R	
34. Adequate electrical insulating means are in place in the ship/shore connection.			A R	
35. Shore lines are fitted with a non-return valve, or procedures to avoid back filling have been discussed.			P R	
36. Smoking rooms have been identified and smoking requirements are being observed.			A R	Nominated smoking rooms:
37. Naked light regulations are being observed.			A R	
38. Ship/shore telephones, mobile phones and pager requirements are being observed.			A R	
39. Hand torches (flashlights) are of an approved type.				
40. Fixed VHF/UHF transceivers and AIS equipment are on the correct power mode or switched off.				
41. Portable VHF/UHF transceivers are of an approved type.				
42. The ship's main radio transmitter aerials are earthed and radars are switched off.				
43. Electric cables to portable electrical equipment within the hazardous area are disconnected from power.				
44. Window type air conditioning units are disconnected.				

SAFETY MANAGEMENT

Bulk Liquid – General	Ship	Terminal	Code	Remarks
45. Positive pressure is being maintained inside the accommodation, and air conditioning intakes, which may permit the entry of cargo vapours, are closed.				
46. Measures have been taken to ensure sufficient mechanical ventilation in the pumproom.			R	
47. There is provision for an emergency escape.				
48. The maximum wind and swell criteria for operations have been agreed.			A	Stop cargo at: Disconnect at: Unberth at:
49. Security protocols have been agreed between the Ship Security Officer and the Port Facility Security Officer, if appropriate.			A	
50. Where appropriate, procedures have been agreed for receiving nitrogen supplied from shore, either for inerting or purging ship's tanks, or for line clearing into the ship.			A P	

If the ship is fitted, or is required to be fitted, with an inert gas system (IGS) the following statements should be addressed:

Inert Gas System	Ship	Terminal	Code	Remarks
51. The IGS is fully operational and in good working order.			P	
52. Deck seals, or equivalent, are in good working order.			R	
53. Liquid levels in pressure/vacuum breakers are correct.			R	
54. The fixed and portable oxygen analysers have been calibrated and are working properly.			R	
55. All the individual tank IG valves (if fitted) are correctly set and locked.			R	
56. All personnel in charge of cargo operations are aware that, in the case of failure of the inert gas plant, discharge operations should cease and the terminal be advised.				

If the ship is fitted with a Crude Oil Washing (COW) system, and intends to crude oil wash, the following statements should be addressed:

Crude Oil Washing	Ship	Terminal	Code	Remarks
57. The Pre-Arrival COW check-list, as contained in the approved COW manual, has been satisfactorily completed.				
58. The COW check-lists for use before, during and after COW, as contained in the approved COW manual, are available and being used.			R	

If the ship is planning to tank clean alongside, the following statements should be addressed:

Tank Cleaning	Ship	Terminal	Code	Remarks
59. Tank cleaning operations are planned during the ship's stay alongside the shore installation.	Yes/No*	Yes/No*		
60. If 'yes', the procedures and approvals for tank cleaning have been agreed.				
61. Permission has been granted for gas freeing operations.	Yes/No*	Yes/No*		

* Delete Yes or No as appropriate

Part 'C' – Bulk Liquid Chemicals – Verbal Verification

Bulk Liquid Chemicals	Ship	Terminal	Code	Remarks
1. Material Safety Data Sheets are available giving the necessary data for the safe handling of the cargo.				
2. A manufacturer's inhibition certificate, where applicable, has been provided.			P	
3. Sufficient protective clothing and equipment (including self-contained breathing apparatus) is ready for immediate use and is suitable for the product being handled.				
4. Countermeasures against accidental personal contact with the cargo have been agreed.				
5. The cargo handling rate is compatible with the automatic shutdown system, if in use.			A	
6. Cargo system gauges and alarms are correctly set and in good order.				

Bulk Liquid Chemicals	Ship	Terminal	Code	Remarks
7. Portable vapour detection instruments are readily available for the products being handled.				
8. Information on fire-fighting media and procedures has been exchanged.				
9. Transfer hoses are of suitable material, resistant to the action of the products being handled.				
10. Cargo handling is being performed with the permanent installed pipeline system.			P	
11. Where appropriate, procedures have been agreed for receiving nitrogen supplied from shore, either for inerting or purging ship's tanks, or for line clearing into the ship.			A P	

Part 'D' – Bulk Liquefied Gases – Verbal Verification

Bulk Liquefied Gases	Ship	Terminal	Code	Remarks
1. Material Safety Data Sheets are available giving the necessary data for the safe handling of the cargo.				
2. A manufacturer's inhibition certificate, where applicable, has been provided.			P	
3. The water spray system is ready for immediate use.				
4. There is sufficient suitable protective equipment (including self-contained breathing apparatus) and protective clothing ready for immediate use.				
5. Hold and inter-barrier spaces are properly inerted or filled with dry air, as required.				
6. All remote control valves are in working order.				
7. The required cargo pumps and compressors are in good order, and the maximum working pressures have been agreed between ship and shore.			A	
8. Re-liquefaction or boil-off control equipment is in good order.				

Bulk Liquid Chemicals	Ship	Terminal	Code	Remarks
9. The gas detection equipment has been properly set for the cargo, is calibrated, has been tested and inspected and is in good order.				
10. Cargo system gauges and alarms are correctly set and in good order.				
11. Emergency shutdown systems have been tested and are working properly.				
12. Ship and shore have informed each other of the closing rate of ESD valves, automatic valves or similar devices.			A	Ship: Shore:
13. Information has been exchanged between ship and shore on the maximum/minimum temperatures/pressures of the cargo to be handled.			A	
14. Cargo tanks are protected against inadvertent overfilling at all times while any cargo operations are in progress.				
15. The compressor room is properly ventilated, the electrical motor room is properly pressurised and the alarm system is working.				
16. Cargo tank relief valves are set correctly and actual relief valve settings are clearly and visibly displayed. <i>(Record settings below.)</i>				

Tank No 1 Tank No 5 Tank No 8

Tank No 2 Tank No 6 Tank No 9

Tank No 3 Tank No 7 Tank No 10

Tank No 4

DECLARATION

We, the undersigned, have checked the above items in Parts A and B, and where appropriate Part C or D, in accordance with the instructions, and have satisfied ourselves that the entries we have made are correct to the best of our knowledge.

We have also made arrangements to carry out repetitive checks as necessary and agreed that those items with code 'R' in the Check-List should be re-checked at intervals not exceeding ____ hours.

If to our knowledge the status of any item changes, we will immediately inform the other party.

For Ship	For Shore
Name _____	Name _____
Rank _____	Position or Title _____
Signature _____	Signature _____
Date _____	Date _____
Time _____	Time _____

Record of repetitive checks:

Date:			
Time:			
Initials for Ship:			
Initials for Shore:			

26.3.4 Example Safety Letter

Company _____

Terminal _____

Date _____

The Master SS/MV _____

Port _____

Dear Sir,

Responsibility for the safe conduct of operations while your ship is at this terminal rests jointly with you, as Master of the ship, and with the responsible Terminal Representative. We wish, therefore, before operations start, to seek your full co-operation and understanding on the safety requirements set out in the Ship/Shore Safety Check-List, which are based on safe practices that are widely accepted by the oil and tanker industries.

We expect you, and all under your command, to adhere strictly to these requirements throughout your ship's stay alongside this terminal and we, for our part, will ensure that our personnel do likewise, and co-operate fully with you in the mutual interest of safe and efficient operations.

Before the start of operations, and from time to time thereafter, for our mutual safety, a member of the terminal staff, where appropriate together with a Responsible Officer, will make a routine inspection of your ship to ensure that elements addressed within the scope of the Ship/Shore Safety Check-List are being managed in an acceptable manner. Where corrective action is needed, we will not agree to operations commencing or, should they have been started, we will require them to be stopped.

Similarly, if you consider that safety is being endangered by any action on the part of our staff or by any equipment under our control, you should demand immediate cessation of operations.

There can be no compromise with safety.

Please acknowledge receipt of this letter by countersigning and returning the attached copy.

Signed _____
Terminal Representative

Terminal Representative on duty is: _____

Position or Title: _____

Contact Details: _____

Signed _____
Master

SS/MV _____

Date/Time _____

26.4 Guidelines for Completing the Ship/Shore Safety Check-List

Part 'A' – Bulk Liquid General – Physical Checks

1. There is safe access between the ship and shore.

The access should be positioned as far away from the manifolds as practicable.

The means of access to the ship should be safe and may consist of an appropriate gangway or accommodation ladder with a properly secured safety net fitted to it.

Particular attention to safe access should be given where the difference in level between the point of access on the ship and the jetty or quay is large, or is likely to become large.

When terminal access facilities are not available and a ship's gangway is used, there should be an adequate landing area on the berth so as to provide the gangway with a sufficient clear run of space and so maintain safe and convenient access to the ship at all states of tide and changes in the ship's freeboard.

Near the access ashore, appropriate life-saving equipment should be provided by the terminal. A lifebuoy should be available on board the ship near the gangway or accommodation ladder.

The access should be safely and properly illuminated during darkness.

Persons who have no legitimate business on board, or who do not have the Master's permission, should be refused access to the ship.

The terminal should control access to the jetty or berth in agreement with the ship.

2. The ship is securely moored.

When considering this item, due regard should be given to the need for adequate fendering arrangements.

Ships should remain adequately secured in their moorings. Alongside piers or quays, ranging of the ship should be prevented by keeping all mooring lines taut. Attention should be given to the movement of the ship caused by wind, currents, tides or passing ships and the operation in progress.

Wire ropes and fibre ropes should not be used together in the same direction (i.e. as breast lines, spring lines, head or stern lines) because of the difference in their elastic properties.

Once moored, ships fitted with automatic tension winches should not use such winches in the automatic mode.

Means should be provided to enable quick and safe release of the ship in case of an emergency. In ports where anchors are required to be used, special consideration should be given to this matter.

Irrespective of the mooring method used, the emergency release operation should be agreed, taking into account the possible risks involved.

Anchors not in use should be properly secured.

3. The agreed ship/shore communication system is operative.

Communication should be maintained in the most efficient way between the Responsible Officer on duty on the ship and the Terminal Representative.

When telephones are used, the telephone both on board and ashore should be continuously manned by a person who can immediately contact his respective supervisor. Additionally, the supervisor should have a facility to override all calls. When radio systems are used, the units should preferably be portable and carried by the supervisor or a person who can get in touch with his respective supervisor immediately. Where fixed systems are used, the guidelines for telephones should apply.

The selected primary and back-up systems of communication should be recorded on the check-list and necessary information on telephone numbers and/or channels to be used should be exchanged and recorded.

The telephone and portable radio systems should comply with the appropriate safety requirements.

4. Emergency towing-off pennants are correctly rigged and positioned.

Unless the terminal specifically advises to the contrary, emergency towing-off pennants (fire wires) should be positioned on both the off-shore bow and quarter of the ship. At a buoy mooring, emergency towing-off pennants should be positioned on the side opposite to the hose string.

There are various methods for rigging emergency towing-off pennants currently in use. Some terminals may require a particular method to be used and the ship should be advised accordingly.

5. The ship's fire hoses and fire-fighting equipment are positioned and ready for immediate use.

See Question 6 below.

6. The terminal's fire-fighting equipment is positioned and ready for immediate use.

Fire-fighting equipment on board and on the jetty should be correctly positioned and ready for immediate use.

Adequate units of fixed or portable equipment should be stationed to cover the ship's cargo deck and the jetty area, having due regard to the presence of both the ship and nearby shore tanks. The shore and ship's fire-main systems should be pressurised or be capable of being pressurised at short notice.

Both ship and shore should ensure that their fire-main systems can be inter-connected in a quick and easy way utilising, if necessary, the International Shore Fire Connection (see Question 28).

7. The ship's cargo and bunker hoses, pipelines and manifolds are in good condition, properly rigged and appropriate for the service intended.

See Question 8 below.

8. The terminal's cargo and bunker hoses or arms are in good condition, properly rigged and appropriate for the service intended.

Hoses should be in a good condition and properly fitted and rigged so as to prevent strain and stress beyond design limitations.

All flange connections should be fully bolted and any other types of connections should be properly secured.

Hoses and pipelines and metal arms should be constructed of a material suitable for the substance to be handled, taking into account its temperature and the maximum operating pressure.

Cargo hoses should be indelibly marked so as to allow the identification of the products for which they are suitable, specified maximum working pressure, the

test pressure and last date of testing at this pressure. If to be used at temperatures other than ambient, maximum and minimum service temperatures should be marked.

- 9. The cargo transfer system is sufficiently isolated and drained to allow safe removal of blank flanges prior to connection.**

A positive means of confirming that both ship and shore cargo systems are isolated and drained should be in place and used to confirm that it is safe to remove blank flanges prior to connection. The means should provide protection against pollution due to unexpected and uncontrolled release of product from the cargo system and injury to personnel due to pressure in the system suddenly being released in an uncontrolled manner.

- 10. Scuppers and save-alls on board are effectively plugged and drip trays are in position and empty.**

Where applicable, all scuppers on board should be properly plugged during the operations. Accumulation of water should be drained off periodically.

The ship's manifolds should ideally be provided with fixed drip trays in accordance with OCIMF recommendations, where applicable. In the absence of fixed containment, portable drip trays should be used.

All drip trays should be emptied in an appropriate manner whenever necessary but always after completion of the specific operation.

When only corrosive liquids or refrigerated gases are being handled, the scuppers may be kept open, provided that an ample supply of water is available at all times in the vicinity of the manifolds.

- 11. Temporarily removed scupper plugs will be constantly monitored.**

Scuppers that are temporarily unplugged, in order to drain clean rainwater from the cargo deck for example, must be constantly and closely monitored. The scupper must be re-sealed immediately in the event of a deck oil spill or any other incident that has the potential to cause pollution.

- 12. Shore spill containment and sumps are correctly managed.**

Shore containment facilities, such as bund walls, drip trays and sump tanks, should be properly maintained, having been sized for an appropriate containment volume following a realistic risk assessment.

Jetty manifolds should ideally be provided with fixed drip trays; in their absence, portable drip trays should be used.

Spill or slop transfer facilities should be well maintained and, if not an automatic system, should be readily available to deal with spilled product or rainwater.

- 13. The ship's unused cargo and bunker connections are properly secured with blank flanges fully bolted.**

See Question 14 below.

- 14. The terminal's unused cargo and bunker connections are properly secured with blank flanges fully bolted.**

Unused cargo and bunker connections should be closed and blanked. Blank flanges should be fully bolted and other types of fittings, if used, properly secured.

15. All cargo, ballast and bunker tank lids are closed.

Apart from the openings in use for tank venting (see Question 29), all openings to cargo, ballast and bunker tanks should be closed and gas tight.

Except on gas tankers, ullaging and sampling points may be opened for the short periods necessary for ullaging and sampling, which activities should be conducted taking account of the controls necessary to avoid electrostatic discharge.

Closed ullaging and sampling systems should be used where required by international, national or local regulations and agreements.

16. Sea and overboard discharge valves, when not in use, are closed and visibly secured.

Experience shows the importance of this item in pollution avoidance on ships where cargo lines and ballast systems are interconnected. Remote operating controls for such valves should be identified in order to avoid inadvertent opening.

If appropriate, the security of the valves in question should be checked visually.

17. All external doors, ports and windows in the accommodation, stores and machinery spaces are closed. Engine room vents may be open.

External doors, windows and portholes in the accommodation should be closed during cargo operations. These doors should be clearly marked as being required to be closed during such operations, but at no time should they be locked.

This requirement does not prevent reasonable access to spaces during operations, but doors should not be left open when unattended.

Engine room vents may be left open. However, consideration should be given to closing them where such action would not adversely affect the safe and efficient operation of the engine room spaces served.

18. The ship's emergency fire control plans are located externally.

A set of fire control plans should be permanently stored in a prominently marked weather-tight enclosure outside the accommodation block for the assistance of shoreside fire-fighting personnel. A crew list should also be included in this enclosure.

If the ship is fitted, or is required to be fitted, with an inert gas system (IGS), the following points should be physically checked:**19. Fixed IGS pressure and oxygen content recorders are working.**

All recording equipment should be switched on, tested as per manufacturer's instructions and operating correctly.

20. All cargo tank atmospheres are at positive pressure with oxygen content of 8% or less by volume.

Prior to commencement of cargo operations, each cargo tank atmosphere should be checked to verify an oxygen content of 8% or less by volume. Inerted cargo tanks should be kept at a positive pressure at all times.

Part 'B' – Bulk Liquid General – Verbal Verification

21. The ship is ready to move under its own power.

The ship should be able to move under its own power at short notice, unless permission to immobilise the ship has been granted by the port authority and the Terminal Representative.

Certain conditions may have to be met for permission to be granted.

22. There is an effective deck watch in attendance on board and adequate supervision of operations on the ship and in the terminal.

The operation should be under constant control and supervision on the ship and in the terminal.

Supervision should be aimed at preventing the development of hazardous situations. However, if such a situation arises, the controlling personnel should have adequate knowledge and the means available to take corrective action.

The controlling personnel on the ship and in the terminal should maintain effective communications with their respective supervisors.

All personnel connected with the operations should be familiar with the dangers of the substances handled and should wear appropriate protective clothing and equipment.

23. There are sufficient personnel on board and ashore to deal with an emergency.

At all times during the ship's stay at the terminal, a sufficient number of personnel should be present on board the ship and in the shore installation to deal with an emergency.

24. The procedures for cargo, bunker and ballast handling have been agreed.

The procedures for the intended operation should be pre-planned. They should be discussed and agreed upon by the Responsible Officer and Terminal Representative prior to the start of the operations. Agreed arrangements should be formally recorded and signed by both the Responsible Officer and Terminal Representative. Any change in the agreed procedure that could affect the operation should be discussed by both parties and agreed upon. After both parties have reached agreement, substantial changes should be laid down in writing as soon as possible and in sufficient time before the change in procedure takes place. In any case, the change should be laid down in writing within the working period of those supervisors on board and ashore in whose working period agreement on the change was reached.

The operations should be suspended and all deck and vent openings closed on the approach of an electrical storm.

The properties of the substances handled, the equipment of ship and shore installation, and the ability of the ship's crew and shore personnel to execute the necessary operations and to sufficiently control the operations are factors which should be taken into account when ascertaining the possibility of handling a number of substances concurrently.

The manifold areas, both on board and ashore, should be safely and properly illuminated during darkness.

The initial and maximum loading rates, topping-off rates and normal stopping times should be agreed, having regard to:

- The nature of the cargo to be handled.
- The arrangement and capacity of the ship's cargo lines and gas venting systems.

- The maximum allowable pressure and flow rate in the ship/shore hoses and loading arms.
- Precautions to avoid accumulation of static electricity.
- Any other flow control limitations.

A record to this effect should be formally made as above.

25. The emergency signal and shutdown procedure to be used by the ship and shore have been explained and understood.

The agreed signal to be used in the event of an emergency arising ashore or on board should be clearly understood by shore and ship personnel.

An emergency shutdown procedure should be agreed between ship and shore, formally recorded and signed by both the Responsible Officer and Terminal Representative.

The agreement should state the circumstances in which operations have to be stopped immediately.

Due regard should be given to the possible introduction of dangers associated with the emergency shutdown procedure.

26. Material Safety Data Sheets (MSDS) for the cargo transfer have been exchanged where requested.

An MSDS should be available on request to the receiver from the terminal or ship supplying the product.

As a minimum, such information sheets should provide the constituents of the product by chemical name, name in common usage, UN number and the maximum concentration of any toxic components, expressed as a percentage by volume or as ppm.

27. The hazards associated with toxic substances in the cargo being handled have been identified and understood.

Many tanker cargoes contain components that are known to be hazardous to human health. In order to minimise the impact on personnel, information on cargo constituents should be available during the cargo transfer to enable the adoption of proper precautions. In addition, some port states require such information to be readily available during cargo transfer and in the event of an accidental spill. This is particularly relevant to cargoes that could contain H₂S, benzene or lead additives.

28. An International Shore Fire Connection has been provided.

The connection must meet the standard requirements and, if not actually connected prior to commencement of operations, should be readily available for use in an emergency.

29. The agreed tank venting system will be used.

Agreement should be reached and recorded as to the venting system to be used for the operation, taking into account the nature of the cargo and international, national or local regulations and agreements.

There are three basic systems for venting tanks:

1. Open to atmosphere via open ullage ports, protected by suitable flame screens.
2. Fixed venting systems which includes inert gas systems.
3. To shore through a vapour collection system (see Question 32 below).

30. The requirements for closed operations have been agreed.

It is a requirement of many terminals that, when the ship is ballasting into cargo tanks, loading or discharging, it operates without recourse to opening ullage and sighting ports. In these cases, ships will require the means to enable closed monitoring of tank contents, either by a fixed gauging system or by using portable equipment passed through a vapour lock, and preferably backed up by an independent overfill alarm system.

31. The operation of the P/V system has been verified.

The operation of the P/V valves and/or high velocity vents should be checked using the testing facility provided by the manufacturer. Furthermore, it is imperative that an adequate check is made, visually or otherwise, to ensure that the checklift is actually operating the valve. On occasion, a seized or stiff vent has caused the checklift drive pin to shear and the ship's personnel to assume, with disastrous consequences, that the vent was operational.

32. Where a vapour return line is connected, operating parameters have been agreed.

Where required, a vapour return line will be used to return flammable vapours from the cargo tanks to shore.

The maximum and minimum operating pressures and any other constraints associated with the operation of the vapour return system should be discussed and agreed by ship and shore personnel.

33. Independent high level alarms, if fitted, are operational and have been tested.

Owing to the increasing reliance placed on gauging systems for closed cargo operations, it is important that such systems are fully operational and that backup is provided in the form of an independent overfill alarm arrangement. The alarm should provide audible and visual indication and should be set at a level that will enable operations to be shutdown prior to the tank being overfilled. Under normal operations, the cargo tank should not be filled higher than the level at which the overfill alarm is set.

Individual overfill alarms should be tested at the tank to ensure their proper operation prior to commencing loading unless the system is provided with an electronic self-testing capability which monitors the condition of the alarm circuitry and sensor and confirms the instrument set point.

34. Adequate electrical insulating means are in place in the ship/shore connection.

Unless measures are taken to break the continuous electrical path between ship and shore pipework provided by the ship/shore hoses or metallic arms, stray electric currents, mainly from corrosion prevention systems, can cause electric sparks at the flange faces when hoses are being connected and disconnected.

The passage of these currents is usually prevented by an insulating flange inserted at each jetty manifold outlet or incorporated in the construction of metallic arms. Alternatively, the electrical discontinuity may be provided by the inclusion of one length of electrically discontinuous hose in each hose string.

It should be ascertained that the means of electrical discontinuity is in place, that it is in good condition and is not being by-passed by contact with an electrically conductive material.

- 35. Shore lines are fitted with a non-return valve, or procedures to avoid back filling have been discussed.**

In order to avoid cargo running back when discharge from a ship is stopped, either due to operational needs or excessive back pressure, the terminal should confirm that it has a positive system that will prevent unintended flow from the shore facility onto the ship. Alternatively, a procedure should be agreed that will protect the ship.

- 36. Smoking rooms have been identified and smoking requirements are being observed.**

Smoking on board the ship may only take place in areas specified by the Master in consultation with the Terminal Representative.

No smoking is allowed on the jetty and the adjacent area, except in buildings and places specified by the Terminal Representative in consultation with the Master.

Places that are directly accessible from the outside should not be designated as places where smoking is permitted. Buildings, places and rooms designated as areas where smoking is permitted should be clearly marked as such.

- 37. Naked light regulations are being observed.**

A naked light or open fire comprises the following: flame, spark formation, naked electric light or any surface with a temperature that is equal to or higher than the auto-ignition temperature of the products handled in the operation.

The use of naked lights or open fires on board the ship, and within a distance of 25 metres of the ship, should be prohibited, unless all applicable regulations have been met and agreement reached by the port authority, Terminal Representative and the Master. This distance may have to be extended for ships of a specialised nature such as gas tankers.

- 38. Ship/shore telephones, mobile phones and pager requirements are being observed.**

Ship/shore telephones should comply with the requirements for explosion-proof construction, except when placed and used in a safe space in the accommodation.

Mobile telephones and pagers should not be used in hazardous areas unless approved for such use by a competent authority.

- 39. Hand torches (flashlights) are of an approved type.**

Battery operated hand torches (flashlights) should be of a safe type, approved by a competent authority. Damaged units, even though they may be capable of operation, should not be used.

- 40. Fixed VHF/UHF transceivers and AIS equipment are on the correct power mode or switched off.**

Fixed VHF/UHF and AIS equipment should be switched off or on low power (1 watt or less) unless the Master, in consultation with the Terminal Representative, has established the conditions under which the installation may be used safely.

- 41. Portable VHF/UHF transceivers are of an approved type.**

Portable VHF/UHF sets should be of a safe type, approved by a competent authority.

VHF radio telephone sets may only operate in the internationally agreed wave bands.

Equipment should be well maintained. Damaged units, even though they may be capable of operation, should not be used.

- 42. The ship's main radio transmitter aerials are earthed and radars are switched off.**

The ship's main radio station should not be used during the ship's stay in port, except for receiving purposes. The main transmitting aerials should be disconnected and earthed.

Satellite communications equipment may be used normally, unless advised otherwise.

The ship's radar installation should not be used unless the Master, in consultation with the Terminal Representative, has established the conditions under which the installation may be used safely.

- 43. Electric cables to portable electrical equipment within the hazardous area are disconnected from power.**

The use of portable electrical equipment on wandering leads should be prohibited in hazardous zones during cargo operations, and the equipment preferably removed from the hazardous zone.

Telephone cables in use in the ship/shore communication system should preferably be routed outside the hazardous zone. Wherever this is not feasible, the cable should be so positioned and protected that no danger arises from its use.

- 44. Window type air conditioning units are disconnected.**

Window type air conditioning units should be disconnected from their power supply.

- 45. Positive pressure is being maintained inside the accommodation, and air conditioning intakes, which may permit the entry of cargo vapours, are closed.**

A positive pressure should, when possible, be maintained inside the accommodation, and procedures or systems should be in place to prevent flammable or toxic vapours from entering accommodation spaces. This can be achieved by air conditioning or similar systems, which draw clean air from non-hazardous locations.

Air conditioning systems should not be operated on 100% recirculation.

- 46. Measures have been taken to ensure sufficient mechanical ventilation in the pumproom.**

Pumprooms should be mechanically ventilated and the ventilation system, which should maintain a safe atmosphere throughout the pumproom, should be kept running throughout cargo handling operations. The gas detection system, if fitted, should be functioning correctly.

- 47. There is provision for an emergency escape.**

In addition to the means of access referred to in Question 1, a safe and quick emergency escape route should be available both on board and ashore. On board the ship, it may consist of a lifeboat ready for immediate use, preferably at the after end of the ship, and clear of the moorings.

48. The maximum wind and swell criteria for operations have been agreed.

There are numerous factors which will help determine whether cargo or ballast operations should be discontinued. Discussion between the terminal and the ship should identify limiting factors, which could include:

- Wind speed and direction and the effect on hard arms.
- Wind speed and direction and the effect on mooring integrity.
- Wind speed and direction and the effect on gangways.
- At exposed terminals, swell effects on moorings or gangway safety.

Such limitations should be clearly understood by both parties. The criteria for stopping cargo, disconnecting hoses or arms and vacating the berth should be written in the 'Remarks' column of the check-list.

49. Security protocols have been agreed between the Ship Security Officer and the Port Facility Security Officer, if appropriate.

In states that are signatories to SOLAS, the ISPS Code requires that the Ship Security Officer and the Port Facility Security Officer co-ordinate the implementation of their respective security plans with each other.

50. Where appropriate, procedures have been agreed for receiving nitrogen supplied from shore, either for inerting or purging ship's tanks, or for line clearing into the ship.

Ship and shore should agree in writing on the inert gas supply, specifying the volume required, and the flow rate in cubic metres per minute. The sequence of opening valves before beginning the operation and after completion should be agreed, so that the ship remains in control of the flow. Attention should be given to the adequacy of open vents on a tank in order to avoid the possibility of over-pressurisation.

The tank pressure should be closely monitored throughout the operation.

The ship's agreement should be sought when the terminal wishes to use compressed nitrogen (or air) as a propellant, either for pigging to clear shore lines into the ship or to press cargo out of shore containment. The ship should be informed of the pressure to be used and the possibility of receiving gas into a cargo tank.

If the ship is fitted, or is required to be fitted, with an inert gas system (IGS) the following statements should be addressed:**51. The IGS is fully operational and in good working order.**

The inert gas system should be in safe working condition with particular reference to all interlocking trips and associated alarms, deck seal, non-return valve, pressure regulating control system, main deck IG line pressure indicator, individual tank IG valves (when fitted) and deck P/V breaker.

Individual tank IG valves (if fitted) should have easily identified and fully functioning open/close position indicators.

52. Deck seals, or equivalent, are in good working order.

It is essential that the deck seal arrangements are in a safe condition. In particular, the water supply arrangements to the seal and the proper functioning of associated alarms should be checked.

53. Liquid levels in pressure/vacuum breakers are correct.

Checks should be made to ensure that the liquid level in the P/V breaker complies with manufacturer's recommendations.

54. **The fixed and portable oxygen analysers have been calibrated and are working properly.**

All fixed and portable oxygen analysers should be tested and checked as required by the Company and/or manufacturer's instructions and should be operating correctly.

The in-line oxygen analyser/recorder and sufficient portable oxygen analysers should be working properly.

The calibration certificate should show that its validity is as required by the ship's SMS.

55. **All the individual tank IG valves (if fitted) are correctly set and locked.**

For both loading and discharge operations, it is normal and safe to keep all individual tank IG supply valves (if fitted) open in order to prevent inadvertent under or over-pressurisation. In this mode of operation, each tank pressure will be the same as the deck main IG pressure and thus the P/V breaker will act as a safety valve in case of excessive over or under-pressure. If individual tank IG supply valves are closed for reasons of potential vapour contamination or de-pressurisation for gauging etc, then the status of the valve should be clearly indicated to all those involved in cargo operations. Each individual tank IG valve should be fitted with a locking device under the control of a Responsible Officer.

56. **All personnel in charge of cargo operations are aware that, in the case of failure of the inert gas plant, discharge operations should cease and the terminal be advised.**

In the case of failure of the IG plant, the cargo discharge, de-ballasting and tank cleaning operations should cease and the terminal be advised.

Under no circumstances should the ship's officers allow the atmosphere in any tank to fall below atmospheric pressure.

If the ship is fitted with a crude oil washing (COW) system, and intends to crude oil wash, the following statements should be addressed:

57. **The Pre-Arrival COW Check-List, as contained in the approved COW Manual, has been satisfactorily completed.**

The approved Crude Oil Washing Manual contains a Pre-Arrival Crude Oil Washing Check-List, specific to each ship, which should be completed by the Responsible Officer prior to arrival at every discharge port where it is intended to undertake Crude Oil Washing.

58. **The COW check-lists for use before, during and after COW, as contained in the approved COW Manual, are available and being used.**

The approved Crude Oil Washing Manual contains a Crude Oil Washing Check-List, specific to each ship, for use before, during and after Crude Oil Washing operations. This Check-List should be completed at the appropriate times and the Terminal Representative should be invited to participate.

If the ship is planning to tank clean alongside, the following statements should be addressed:

59. Tank cleaning operations are planned during the ship's stay alongside the store installation.

During the pre-transfer discussion between the Responsible Officer and Terminal Representative, it should be established whether any tank cleaning operations are planned while the ship is alongside and the check-list should be annotated accordingly.

60. If 'yes', the procedures and approvals for tank cleaning have been agreed.

It should be confirmed that all necessary approvals that may be required to enable tank cleaning to be undertaken alongside have been obtained from relevant authorities. The method of tank cleaning to be used should be agreed, together with the scope of the operation.

61. Permission has been granted for gas freeing operations.

It should be confirmed that all necessary approvals that may be required to enable gas freeing to be undertaken alongside have been obtained from the relevant authorities.

Part 'C' – Bulk Liquid Chemicals – Verbal Verification

1. Material Safety Data Sheets are available giving the necessary data for the safe handling of the cargo.

Information on the product to be handled should be available on board the ship and ashore and should include:

- A full description of the physical and chemical properties, including reactivity, necessary for the safe containment and transfer of the cargo.
- Action to be taken in the event of spills or leaks.
- Countermeasures against accidental personal contact.
- Fire-fighting procedures and fire-fighting media.

2. A manufacturer's inhibition certificate, where applicable, has been provided.

Where cargoes are required to be stabilised or inhibited in order to be handled, ships should be provided with a certificate from the manufacturer stating:

- Name and amount of inhibitor added.
- Date inhibitor was added and the normal duration of its effectiveness.
- Any temperature limitations affecting the inhibitor.
- The action to be taken should the length of the voyage exceed the effective lifetime of the inhibitor.

3. Sufficient protective clothing and equipment (including self-contained breathing apparatus) is ready for immediate use and is suitable for the product being handled.

Suitable protective equipment (including self-contained breathing apparatus and protective clothing) appropriate to the specific dangers of the product handled, should be readily available in sufficient quantity for operational personnel both on board and ashore.

4. **Countermeasures against accidental personal contact with the cargo have been agreed.**

Sufficient and suitable means should be available to neutralise the effects and remove small quantities of spilled products. Should unforeseen personal contact occur, in order to limit the consequences it is important that sufficient and suitable countermeasures are undertaken.

The MSDS should contain information on how to handle such contact with reference to the special properties of the cargo, and personnel should be aware of the procedures to follow.

A suitable safety shower and eye rinsing equipment should be fitted and ready for instant use in the immediate vicinity of places on board or ashore where operations regularly take place.

5. **The cargo handling rate is compatible with the automatic shutdown system, if in use.**

Automatic shutdown valves may be fitted on the ship and ashore. The action of these is automatically initiated by, for example, a certain level being reached in the ship or shore tank being filled. Where such systems are used, the cargo handling rate should be established to prevent pressure surges from the automatic closure of valves causing damage to ship or shore line systems. Alternative means, such as a re-circulation system and buffer tanks, may be fitted to relieve the pressure surge created.

A written agreement should be made between the Responsible Officer and Terminal Representative indicating whether the cargo handling rate will be adjusted or alternative systems will be used.

6. **Cargo system gauges and alarms are correctly set and in good order.**

Ship and shore cargo system gauges and alarms should be checked regularly to ensure they are in good working order.

In cases where it is possible to set alarms to different levels, the alarm should be set to the required level.

7. **Portable vapour detection instruments are readily available for the products being handled.**

The equipment provided should be capable of measuring, where appropriate, flammable and/or toxic levels.

Suitable equipment should be available for operational testing of those instruments capable of measuring flammability. Operational testing should be carried out before using the equipment. Calibration should be carried out in accordance with the Safety Management System.

8. **Information on fire-fighting media and procedures has been exchanged.**

Information should be exchanged on the availability of fire-fighting equipment and the procedures to be followed in the event of a fire on board or ashore.

Special attention should be given to any products that are being handled which may be water reactive or which require specialised fire-fighting procedures.

9. **Transfer hoses are of suitable material, resistant to the action of the products being handled.**

Each transfer hose should be indelibly marked so as to allow the identification of the products for which it is suitable, its specified maximum working pressure, the test pressure and last date of testing at this pressure, and, if used at temperatures other than ambient, its maximum and minimum service temperatures.

10. Cargo handling is being performed with the permanent installed pipeline system.

All cargo transfer should be through permanently installed pipeline systems on board and ashore.

Should it be necessary, for specific operational reasons, to use portable cargo lines on board or ashore, care should be taken to ensure that these lines are correctly positioned and assembled in order to minimise any additional risks associated with their use. Where necessary, the electrical continuity of these lines should be checked and their length should be kept as short as possible.

The use of non-permanent transfer equipment inside tanks is not generally permitted unless specific approvals have been obtained.

Whenever cargo hoses are used to make connections within the ship or shore permanent pipeline system, these connections should be properly secured, kept as short as possible and be electrically continuous to the ship and shore pipeline respectively. Any hoses used must be suitable for the service and be properly tested, marked and certified.

11. Where appropriate, procedures have been agreed for receiving nitrogen supplied from shore, either for inerting or purging ship's tanks, or for line clearing into the ship.

Ship and shore should agree in writing on the nitrogen supply, specifying the volume required, and the flow rate in cubic metres per minute. The sequence of opening valves before beginning the operation and after completion should be agreed, so that the ship remains in control of the flow. Attention should be given to the adequacy of open vents on a tank in order to avoid the possibility of over-pressurisation.

The tank pressure should be closely monitored throughout the operation.

The ship's agreement should be sought when the terminal wishes to use compressed nitrogen (or air) as a propellant, either for pigging to clear shore lines into the ship or to press cargo out of shore containment. The ship should be informed of the pressure to be used and the possibility of receiving gas into a cargo tank.

Part 'D' – Bulk Liquefied Gases – Verbal Verification

1. Material Safety Data Sheets are available giving the necessary data for the safe handling of the cargo.

Information on each product to be handled should be available on board the ship and ashore before and during the operation.

Cargo information, in a written format, should include:

- A full description of the physical and chemical properties necessary for the safe containment of the cargo.
- Action to be taken in the event of spills or leaks.
- Countermeasures against accidental personal contact.
- Fire-fighting procedures and fire-fighting media.
- Any special equipment needed for the safe handling of the particular cargo(es).
- Minimum allowable inner hull steel temperatures.
- Emergency procedures.

2. A manufacturer's inhibition certificate, where applicable, has been provided.

Where cargoes are required to be stabilised or inhibited in order to be handled, ships should be provided with a certificate from the manufacturer stating:

- Name and amount of inhibitor added.
- Date inhibitor was added and the normal duration of its effectiveness.
- Any temperature limitations affecting the inhibitor.
- The action to be taken should the length of the voyage exceed the effective lifetime of the inhibitor.

3. The water spray system is ready for immediate use.

In cases where flammable or toxic products are handled, water spray systems should be tested regularly. Details of the last tests should be exchanged.

During operations, the systems should be kept ready for immediate use.

4. There is sufficient suitable protective equipment (including self-contained breathing apparatus) and protective clothing ready for immediate use.

Suitable protective equipment, including self-contained breathing apparatus, eye protection and protective clothing appropriate to the specific dangers of the product handled should be available in sufficient quantity for operational personnel, both on board and ashore.

Storage places for this equipment should be protected from the weather and be clearly marked.

All personnel directly involved in the operation should utilise this equipment and clothing whenever the situation requires.

Personnel required to use breathing apparatus during operations should be trained in its safe use. Untrained personnel and personnel with facial hair should not be selected for operations involving the use of breathing apparatus.

5. Hold and inter-barrier spaces are properly inerted or filled with dry air, as required.

The spaces that are required to be inerted by the IMO Gas Carrier Codes should be checked by ship's personnel prior to arrival.

6. All remote control valves are in working order.

All ship and shore cargo system remote control valves and their position-indicating systems should be tested regularly. Details of the last tests should be exchanged.

7. The required cargo pumps and compressors are in good order, and the maximum working pressures have been agreed between ship and shore.

Agreement in writing should be reached on the maximum allowable working pressure in the cargo line system during operations.

8. Re-liquefaction or boil-off control equipment is in good order.

It should be verified that re-liquefaction and boil-off control systems, if required, are functioning correctly prior to commencement of operations.

9. The gas detection equipment has been properly set for the cargo, is calibrated, has been tested and inspected and is in good order.

Suitable gas should be available to enable operational testing of gas detection equipment. Fixed gas detection equipment should be tested for the product to be handled prior to commencement of operations. The alarm function should have been tested and the details of the last test should be exchanged.

Portable gas detection instruments, suitable for the products handled, capable of measuring flammable and/or toxic levels, should be available.

Portable instruments capable of measuring in the flammable range should be operationally tested for the product to be handled before operations commence.

Calibration of instruments should be carried out in accordance with the Safety Management System.

10. Cargo system gauges and alarms are correctly set and in good order.

Ship and shore cargo system gauges should be checked regularly to ensure that they are in good working order.

In cases where it is possible to set alarms to different levels, the alarm should be set to the required level.

11. Emergency shutdown systems have been tested and are working properly.

Where possible, ship and shore emergency shutdown systems should be tested before commencement of cargo transfer.

12. Ship and shore have informed each other of the closing rate of ESD valves, automatic valves or similar devices.

Automatic shutdown valves may be fitted in the ship and the shore systems. Among other parameters, the action of these valves can be automatically initiated by a certain level being reached in the tank being loaded, either on board or ashore.

The closing rate of any automatic valves should be known and this information should be exchanged.

Where automatic valves are fitted and used, the cargo handling rate should be so adjusted that a pressure surge evolving from the automatic closure of any such valve does not exceed the safe working pressure of either the ship or shore pipeline systems.

Alternatively, means may be fitted to relieve the pressure surge created, such as re-circulation systems and buffer tanks.

A written agreement should be made between the Responsible Officer and Terminal Representative indicating whether the cargo handling rate will be adjusted or alternative systems will be used. The safe cargo handling rate should be noted in the agreement.

13. Information has been exchanged between ship and shore on the maximum/minimum temperatures/pressures of the cargo to be handled.

Before operations commence, information should be exchanged between the Responsible Office and Terminal Representatives on cargo temperature/pressure requirements.

This information should be in writing.

14. Cargo tanks are protected against inadvertent overfilling at all times while any cargo operations are in progress.

Automatic shutdown systems are normally designed to close the liquid valves, and if discharging, to trip the cargo pumps, should the liquid level in any tank rise above the maximum permitted level. This level must be accurately set and the operation of the device should be tested at regular intervals.

If ship and shore shutdown systems are to be inter-connected, then their operation must be checked before cargo transfer begins.

15. The compressor room is properly ventilated, the electrical motor room is properly pressurised and the alarm system is working.

Fans should be run for at least 10 minutes before cargo operations commence and then continuously during cargo operations.

Audible and visual alarms, provided at airlocks associated with compressor/motor rooms, should be tested regularly.

16. Cargo tank relief valves are set correctly and actual relief valve settings are clearly and visibly displayed.

In cases where cargo tanks are permitted to have more than one relief valve setting, it should be verified that the relief valve is set as required by the cargo to be handled and that the actual setting of the relief valve is clearly and visibly displayed on board the ship. Relief valve settings should be recorded in the check-list.

26.5 Emergency Actions

The actions to be taken in the event of an emergency at a terminal should be contained in the terminal's Emergency Response Plan (see Chapter 20). Particular attention should be given to factors to be taken into consideration when deciding whether or not to remove a ship from the berth in the event of an emergency (see also Section 20.5).

26.5.1 Fire or Explosion on a Berth

Action by Ships:

Should a fire or explosion occur on a berth, the ship or ships at the berth must immediately report the incident to the terminal control room by the quickest possible method (VHF/UHF, telephone contact, sounding ship's siren etc). All cargo, bunkering, deballasting and tank cleaning operations should be shut down and all cargo arms or hoses should be drained ready for disconnection.

The ship's fire-mains should be pressurised and water fog applied in strategic places. The ship's engines, steering gear and unmooring equipment must be brought to a state of immediate readiness. A pilot ladder should be deployed on the offshore side.

Action by Ships at Other Berths:

On hearing the terminal alarm being sounded or on being otherwise advised of a fire at the terminal, a ship at a berth not directly involved in the fire should shut down all cargo, bunkering and ballasting operations. Fire-fighting systems should be brought to a state of readiness and engines, steering gear and mooring equipment should be made ready for immediate use.

26.5.2 Fire on a Tanker at a Terminal

Action by Ship's Personnel:

If a fire breaks out on a tanker while at a terminal, the tanker must raise the alarm by sounding the recognised alarm signal consisting of a series of long blasts on the ship's whistle, each blast being not less than 10 seconds in duration unless the terminal has notified the ship of some other locally recognised alarm signal. All cargo, bunkering or ballasting

Fire Action - Ship	
<p>Fire on your Ship</p> <ul style="list-style-type: none"> • Raise alarm • Fight fire with aim of preventing spread • Inform terminal • Cease all cargo/ballast operations and close all valves • Stand by to disconnect hoses or arms • Bring engines to standby 	<p>Fire on another Ship or Ashore</p> <ul style="list-style-type: none"> • Raise alarm <p>Stand by, and when instructed:</p> <ul style="list-style-type: none"> • Cease all cargo/ballast operations and close all valves • Disconnect hoses or arms • Bring engines and crew to standby, ready to unberth
Fire Action - Ashore	
<p>Fire on a Ship</p> <ul style="list-style-type: none"> • Raise alarm • Contact ship • Cease all cargo/ballast operations and close all valves • Stand by to disconnect hoses or arms • Stand by to assist fire-fighting • Inform all ships • Implement terminal emergency plan 	<p>Fire Ashore</p> <ul style="list-style-type: none"> • Raise alarm • Cease all cargo/ballast operations and close all valves • Fight fire with aim of preventing spread • If required, stand by to disconnect hoses or arms • Inform all ships • Implement terminal emergency plan
In case of fire, do not hesitate to raise the alarm	
<p>Terminal Fire Alarm</p> <p>At this terminal, the fire alarm signal is <input style="width: 150px; height: 15px;" type="text"/></p>	
<p>In Case of Fire:</p> <ol style="list-style-type: none"> 1. Sound one or more blasts on the ship's whistle, each blast of not less than ten seconds duration supplemented by a continuous sounding of the general alarm system. 2. Contact the terminal. 	
<input style="width: 95%; height: 15px;" type="text"/>	<input style="width: 95%; height: 15px;" type="text"/>
<p>In the case of fire, personnel will direct the movement of vehicular traffic ashore</p>	

Figure 26.1 – Example of fire instructions notice

operations must be stopped and the main engines and steering gear brought to a standby condition.

Once the alarm has been raised, responsibility for fighting the fire on board the ship will rest with the Master or other Responsible Officer assisted by the ship's crew. The same emergency organisation should be used as when the ship is at sea (see Section 9.9.2.2) with an additional group under the command of an Officer or Senior Rating to make preparations, where possible, for disconnecting metal arms or hoses from the manifold.

On mobilisation of the terminal and, where applicable, the civil fire-fighting forces and equipment, the Master or other Responsible Officer, in conjunction with the professional fire-fighters, must make a united effort to bring the fire under control.

Action by Terminal Personnel:

On hearing a tanker sounding its fire alarm, the person in charge of a berth should immediately advise the control room. The terminal control room personnel should sound the terminal fire alarm, inform the port authority and commence shutting down any loading, discharging, bunkering or deballasting operations that may be taking place.

The terminal's fire emergency plan should be activated and this may involve shutting down cargo, bunkering and ballast handling operations on ships on adjacent or neighbouring berths. All other ships at the terminal should be informed of the emergency and, where considered necessary, make preparations to disconnect metal arms or hoses and bring their engines and steering gear to a state of readiness.

Where there are fire-fighting tugs, the terminal control room will summon them to assist in fighting the fire until a decision is made by the person in overall control whether or not to use them to assist in the evacuation of unaffected ships (see Section 20.5).

The terminal control room should be responsible for summoning any outside assistance, such as the civil fire brigade, rescue launches, medical aid and ambulances, police, harbour authority and pilots.

The above emergency procedures may be summarised for the information of visiting ships in a fire instructions notice, an example of which is included in Figure 26.1.

26.5.3 International Shore Fire Connection

As described in Sections 8.1.2 and 19.5.3.5, all ships and terminals should be provided with means to enable the fire-mains on board and ashore to be inter-connected. The International Shore Fire Connection provides a standardised means of connecting two systems where each might otherwise have couplings or connections that do not match.

The flanges on the connection should have the dimensions shown on Figure 26.2. It should have a flat face on one side and on the other should be a coupling that will fit the hydrant or hose on the ship or shore, as appropriate.

If fixed on a ship, the connection should be accessible from both sides of the ship and its location should be clearly marked.

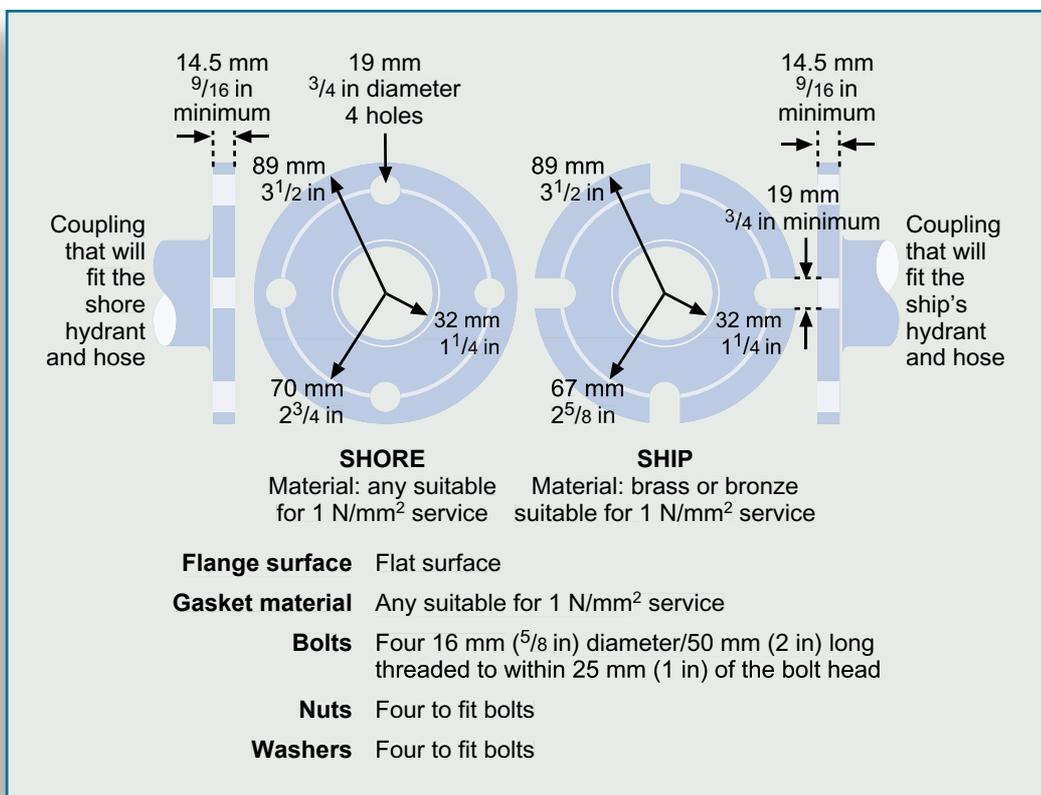


Figure 26.2 – Details of International Shore Fire Connection

To inter-connect the two fire-mains, a fire hose having a shore connection on the end is led to its counterpart and the flange joints are bolted together.

The shore connection should be ready for use whenever a ship is in port.

26.5.4 Emergency Release Procedures

Means should be provided to permit the quick and safe release of the ship in an emergency. The method used for the emergency release operation should be discussed and agreed, taking into account the possible risks involved.

26.5.5 Emergency Towing-Off Pennants

26.5.5.1 Rigging

Except at terminals where no tugs are available, it has become standard practice to have fire wires, or more correctly emergency towing-off pennants, provided by the tanker so that in an emergency tugs can pull the ship away from the berth without the intervention of any crew member.

There are various methods for rigging emergency towing-off pennants and the arrangement may vary from port to port. The preferred method is to secure the inboard end to bollards, with a minimum of five turns, and to lead the outboard end direct to a shipside chock with a bight hanging over the side and no slack on

Dwt	MBL	Length
Less than 20,000	30 tonnes	25 m
20-100,000	55 tonnes	45 m
100-300,000	100 tonnes	60 m
300,000+	120 tonnes	70 m

Table 26.3 – Guidance on minimum breaking load (mbl) and length for emergency towing-off pennants

deck. The outboard end of the line is provided with an eye to which a messenger line is attached and led back to the deck. During loading or discharging, the messenger is periodically adjusted to maintain the eye of the emergency towing-off pennant one or two metres above the waterline. (See OCIMF 'Mooring Equipment Guidelines' for further details and illustration.)

Where terminals require that an alternative method be used, the ship should be advised accordingly.

On tankers alongside a jetty, emergency towing-off pennants should be rigged on the offshore side. For tankers at buoy berths, they should be hung on the side opposite to the hose strings.

Table 26.3 gives guidance on Minimum Breaking Loads (MBL) and lengths for emergency towing-off pennants for various ship sizes. The lengths of pennant may vary, dependent on positioning of mooring bitts and the ship's freeboard. The pennants should be in good condition. It should be noted that this information is provided for guidance only and is not intended to indicate a uniform standard.

Emergency towing-off pennants should not be attached to a set of bitts with a Safe Working Load (SWL) that is less than the Minimum Breaking Load (MBL) of the pennant. (Note: For double bollards, the SWL marked on the bollard should be the maximum allowed when using a wire or rope belayed in a figure of eight near the base of the bollard. This will be half the maximum permissible SWL when a single eye is placed over the bollard.)

26.5.5.2 Handling

Attention is drawn to the hazards associated with the ship's crew handling heavy wires that are hung over the ship's side, in particular the risk of strain injuries. Handling of towing-off pennants is increasingly being cited as a cause of personal injury, particularly for spinal and muscular back complaints.

It is recommended that terminals review their requirement for emergency towing-off pennants by considering the following:

- Are they really necessary? What is the real risk of them having to be used?
- Do the emergency procedures require the ship to be removed from the berth if it is immobilised by fire?

- Is it possible to release the ship's moorings to allow it to be removed from the berth?
- How long will it take for tugs to be mobilised?
- Could the deployment of emergency towing-off pennants compromise security arrangements at the terminal?

To avoid any unnecessary handling of large wires on ships, it is suggested that a risk assessment is carried out at the terminal to determine whether or not there should be a routine requirement for ships to rig emergency towing-off pennants.

26.5.5.3 Possible Future Developments

Previous editions of ISGOTT have specifically referred to 'Fire Wires' and 'Emergency Towing-Off Wires' because there were no viable alternatives to wires for this purpose. *Mooring Equipment Guidelines* (OCIMF) specifically prohibits the use of synthetic or natural fibre ropes for this purpose on the grounds that they would burn in the event of a fire.

Since the 4th Edition of ISGOTT was published in 1996, synthetic fibre ropes having the potential to combine high strength, low stretch and light weight (typically about one seventh the weight of a wire of equivalent strength) have become available. It is likely that, during the life of this 5th Edition, synthetic fibre ropes with fire resistance characteristics comparable to wires will become available.

This edition of ISGOTT therefore leaves open the question of whether emergency towing-off pennants should be of wire or of some other material. If terminals wish to accept the use of synthetic fibre lines that can provide similar functionality to wires, whilst being safer for personnel to handle on the ship and on the tugs, they are encouraged to do so.

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