ISGOTT

International Safety Guide for Oil Tankers and Terminals

Sixth Edition

International Chamber of Shipping
Shaping the Future of Shipping

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The International Chamber of Shipping (ICS) is the principal international trade association for the shipping industry, representing shipowners and operators in all sectors and trades.

ICS membership comprises national shipowners' associations in Asia, Europe and the Americas whose member shipping companies operate over 80% of the world's merchant tonnage.

Established in 1921, ICS is concerned with all technical, legal, employment affairs and policy issues that may affect international shipping. It represents shipowners with the various intergovernmental regulatory bodies that impact on shipping, including the International Maritime Organization (IMO).

ICS also develops best practices and guidance, including a wide range of publications and free resources that are used by ship operators globally.

Founded in 1970, the Oil Companies International Marine Forum (OCIMF) is a voluntary association of oil companies having an interest in the shipment and terminalling of crude oil, oil products, petrochemicals and gas, and includes companies engaged in offshore marine operations supporting oil and gas exploration, development and production.

Our vision is a global marine industry that causes no harm to people or the environment.

Our mission is to lead the global marine industry in the promotion of safe and environmentally responsible transportation of crude oil, oil products, petrochemicals and gas, and to drive the same values in the management of related offshore marine operations. We do this by developing best practices in the design, construction and safe operation of tankers, barges and offshore vessels and their interfaces with terminals and considering human factors in everything we do.

Founded in 1955, the International Association of Ports and Harbors (IAPH) is a non-profit-making global alliance of 170 ports and 140 port-related organisations covering 90 countries. Its member ports handle more than 60 percent of global maritime trade and around 80 percent of world container traffic. IAPH has consultative NGO status with several United Nations agencies. In 2018, IAPH established the World Ports Sustainability Program (WPSP). Guided by the 17 UN Sustainable Development Goals, it aims to unite sustainability efforts of ports worldwide, encouraging international cooperation between all partners involved in the maritime supply chain. WPSP (sustainableworldports.org) covers five main areas of collaboration: energy transition, resilient infrastructure, safety and security, community outreach and governance.

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Foreword

I am very pleased to introduce the revised Sixth Edition of the *International Safety Guide for Oil Tankers and Terminals*, or *ISGOTT* as it is generally known throughout the global tanker industry and amongst the Member States of the UN International Maritime Organization (IMO).

ISGOTT, first published in 1978, is now widely recognised as the definitive best practice guidance on tanker safety and pollution prevention, and is a perfect example of the good cooperation that exists between the IMO and the shipping industry the Organization regulates. The authors of this major publication – the International Chamber of Shipping (ICS), the Oil Companies International Marine Forum (OCIMF) and the International Association of Ports and Harbors (IAPH) – all enjoy consultative status with the IMO and contribute significantly to its work through their active participation at IMO meetings.

I believe that a reason why *ISGOTT* has endured, and is so highly regarded, is the vital complementary role it plays in working alongside the comprehensive framework of global shipping regulation that has been adopted by the IMO to help ensure safe and pollution-free ship operations.

Global maritime regulations, enforced by Flag States, are vital for ensuring that all ships, regardless of flag, can operate safely and efficiently wherever in the world they are trading. However, further detailed guidance on best operational practice is leveraged from the vast experience of industry professionals. Industry publications such as *ISGOTT* are therefore crucial for ensuring that the aims and objectives of IMO instruments, such as the MARPOL and SOLAS Conventions, are achieved in real life.

The safety record and the environmental performance of the tanker industry has improved substantially since the adoption by the IMO of its many Conventions and Codes. This impressive improvement in performance has not been delivered by regulation alone. It is a testimony to the good practices deployed, and constantly refined, by the industry itself and the dedication and huge professionalism of the seafarers and other personnel it employs.

This firm commitment by the industry to continuous improvement is a concept fully embraced by the IMO's ISM Code, and I believe this is clearly demonstrated by the industry's ongoing efforts to keep *ISGOTT* updated.

I fully support the industry-wide collaboration that has made this new edition of *ISGOTT* possible. This is crucial to ensuring that the maritime industry will not only contribute to maintaining and further improving its excellent safety record and reducing its environmental impact, but will also bring us ever closer to the ultimate goal of zero accidents.

Kitack Lim
Secretary-General
International Maritime Organization

Introduction to the Sixth Edition

Effective management of health, safety and environmental protection is critical to the tanker and terminal industry and the *International Safety Guide for Oil Tankers and Terminals (ISGOTT)* has become the standard reference on the safe operation of oil tankers and the terminals they serve.

ISGOTT 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). This revision of *ISGOTT* updates and replaces the prior Fifth Edition that was published in 2006 and has been reviewed by OCIMF and ICS together with the International Association of Ports and Harbors (IAPH). In addition, support has also been provided by other industry associations including the International Association of Independent Tanker Owners (INTERTANKO), the Society of International Gas Tanker and Terminal Operators (SIGTTO) and the Society for Gas as a Marine Fuel (SGMF), as well as specialists in topics such as human factors.

Through the combined effort of multidisciplinary subject matter experts from these industry leading organisations, this publication has been enhanced to ensure that it continues to reflect current best practice and legislation and, as a result, will maintain its position as a definitive reference for the safe operation of oil tankers and the marine terminals they visit.

This Sixth Edition encompasses the latest thinking on a range of topical issues including gas detection, the toxicity and the toxic effects of petroleum products (including benzene and hydrogen sulphide), the generation of static electricity and stray currents, fire protection and the growing use of mobile electronic technology.

In addition, the opportunity was taken to include new topics or to significantly reappraise topics previously covered that have undergone a shift in emphasis since the Fifth Edition. These include:

- Enclosed space entry.
- Human factors.
- Safety Management Systems (SMSs), including complementary tools and processes such as permits to work, risk assessment, Lock-out/Tag-out (LO/TO), Stop Work Authority (SWA) and their linkage to the underlying principles of the *International Safety Management (ISM) Code*.
- Marine terminal administration and the critical importance of the tanker/terminal interface.
- Alternative and emerging technologies.
- Bunkering operations, including the use of alternative fuels such as Liquefied Natural Gas (LNG).
- Cargo inspectors.
- Alignment with OCIMF's recently revised *Mooring Equipment Guidelines*.
- Maritime security and linkage to both the *International Ship and Port Facility Security (ISPS) Code* and industry's maritime security *Best Management Practices (BMP)*.

The Ship/Shore Safety and Bunkering Operations Checklists have also been completely revised to reflect changes in the understanding of the impact of human factors in their effective use. The importance of ensuring that individual and joint responsibilities for the tanker and the terminal are clearly communicated before arrival, as well as when alongside, is central to this objective.

The Sixth Edition of *ISGOTT* retains the four section format of:

Part 1 General Information
Part 2 Tanker Information
Part 3 Marine Terminal Information
Part 4 Ship/Shore (Tanker/Terminal) Interface

Care has been taken to ensure that where the guidance given in previous editions is still relevant and accurate, any amendments, changes or deletions have only enhanced the content and not diminished the ethos of ensuring the health, safety and environmental protection of those who use the guide.

The authors believe that *ISGOTT Sixth Edition* continues to provide the best technical guidance on oil tanker and terminal operations. All operators are urged to ensure that the recommendations in this guide are not only read and fully understood, but are also followed through their SMSs and procedures.

Purpose and Scope

The primary purpose of the *International Safety Guide for Oil Tankers and Terminals (ISGOTT)* is to provide operational advice to assist personnel directly involved in tanker and terminal operations. It 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 does not, however, provide a definitive description of how tanker and terminal operations are conducted.

To achieve its purpose *ISGOTT* provides guidance on, and examples of, certain aspects of tanker and terminal operations and how they may be managed. Effective management of risk demands SMSs, processes and controls and procedures that can quickly adapt to change. Therefore, the guidance given is, in many cases, intentionally non-prescriptive and alternative procedures may be adopted by operators in the management of their operations. These alternative procedures may exceed the recommendations contained in this guide and are strongly encouraged where they will further enhance the safety objective.

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 safely managed. Guidance in the Sixth Edition is aimed at further assisting operators of tankers and marine terminals in these principles of safe management. For shipboard operations, this course of action must satisfy the requirements of the ISM Code.

In all cases, the advice given in *ISGOTT* is subject to any international, national or local regulations that may be applicable and is intended only to complement or strengthen those requirements. Companies responsible for the operation of tankers and terminals should ensure that they are aware of any such requirements and ensure full compliance.

It is recommended that a copy of *ISGOTT* is kept and used on board every tanker and in every marine 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 the 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 scope of *ISGOTT* relates only to cargoes of 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 other than in the context of where they may be used on board oil tankers, e.g. LNG as a marine fuel. The carriage of chemicals and gases as cargo are the subject of other industry guides.

Industry guidance such as *ISGOTT* is based on the best knowledge and information available to the authors. Irrespective of this and the subject matter, or how strong and important the information provided, the industry is not in a position to mandate its own advice. For this reason, industry guidance in *ISGOTT* is characterised by the word 'should'. IMO regulations implemented by national administrations are legally enforceable and, therefore, when *ISGOTT* references such regulations or their implications the term used is 'must'.

Finally, the guide is not intended to encompass offshore facilities such as 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:

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Glossary

Adjacent spaces	Spaces bordering another space.
Administration	As used in international conventions, the government of the State whose flag the ship is flying.
Anti-static 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.
Ballast	Water ballast carried in ships' tanks designated for this purpose.
Barge	Barges can be self-propelled, towed or pushed, and may be used to carry or store liquid hydrocarbons, chemicals or liquefied gases in bulk. They may be employed in inland waterways or at sea outside port limits.
Berthing	Bringing a ship to her berth until the ship is made fast. A berth could be any facility where a ship moors alongside or anchors, including a quay, jetty, offshore buoy or facility.
Best practice	A method of working, or procedure, to aspire to as part of continuous improvement.
Bonding	The connecting together of metal parts to ensure electrical continuity.
Burst pressure	The actual pressure at which a prototype hose fails.
Cargo transfer	Operation when crude oil, Liquefied Petroleum Gas (LPG) or other hydrocarbon products are moved from either a ship to another ship, a ship to a terminal or a terminal to a ship, by means of pumping.
Cathodic protection	The prevention of corrosion by electrochemical, impressed current or cathodic protection 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.
Charterers	An organisation/a company entered into a contract with owners for the use of a ship. May take the form of a demise or bareboat charter under which the charterer has the use of the ship and engages their own crew, or where the ship is let out to the charterer for either a defined period of time (time charter) or a specific voyage (voyage charter).
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.

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 easily ignited and of burning. For the purposes of this guide, the terms 'combustible' and 'flammable' are synonymous.

Combustible gas detector (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 the ship or any other organisation or person such as the manager, or the bareboat charterer, who has assumed the responsibility for operation of the ship from the shipowner and who, on assuming such responsibility, has agreed to take over all the duties and responsibility imposed by the *International Safety Management (ISM) Code*.

Competent Person — A person who has adequate training and experience 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.

Conventional tanker — An oil tanker equipped for regular trading and not specially designed or adapted for loading at offshore terminals requiring specialised mooring or bow loading equipment.

Crude oil — A liquid, occurring naturally in the earth and composed mainly of mixtures of chemical compounds of carbon and hydrogen.

Crude Oil Washing (COW) — A system whereby the tanks of a crude oil tanker are cleaned with processed crude oil.

Cryogenic — Cryogenic liquids are liquefied gases that are kept in their liquid state at very low temperatures.

Dangerous area — An area on a tanker which, for the purposes of the installation and use of electrical equipment, is regarded as dangerous due to the likelihood for an explosive atmosphere to be present. (For terminal, see 'Hazardous area'.)

Deadweight — Deadweight is the difference between the displacement and the mass of the empty ship (lightweight). It may be defined for any load waterline from the ship's tables, but is normally referenced for ship comparative purposes to the summer deadweight.

Designated area — An area or space that has been identified and dedicated for a specific purpose.

Displacement — The mass of water in tonnes displaced by a ship at a given draught.

Dry chemical powder — A flame inhibiting powder used in firefighting.

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.
Elasticity	The elastic (non-permanent) elongation of a unit length of an element caused by a unit load. May refer to a material or a composite structure such as a mooring line.
Emergency Release System (ERS)	A system for quickly and safely disconnecting the cargo transfer connection (e.g. loading arm or hose) from a ship with minimal product spillage. It consists of an emergency release coupler between two interlocked block valves.
Enclosed space	A space that has limited openings for entry and exit, unfavourable natural ventilation, and where it is foreseeable that a risk of death or serious injury may exist making it unsuitable for continuous worker occupancy. It is not possible to include a comprehensive list but includes cargo spaces, double bottoms, fuel tanks, ballast tanks, pumprooms, cofferdams, void spaces, duct keels, inter-barrier spaces, engine crankcases and sewage tanks.
Entry permit	A document issued by a Responsible Person on completion of all required preparation and testing allowing entry into a space or compartment during a specific time interval.
Explosimeter	See 'Combustible gas detector'.
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.
Fatigue	A state of physical and/or mental impairment resulting from factors such as inadequate sleep, extended wakefulness, work/rest requirements out of sync with circadian rhythms and physical, mental or emotional exertion that can impair alertness and the ability to safely operate a ship or perform safety related duties.
Fibre	A long, fine, very flexible structure that may be woven, braided, stranded or twisted into a variety of fabrics, twine, cordage or rope.
Flame arrester (also referred to as a 'flame trap')	A permeable matrix of metal, ceramic or other heat-resisting materials that allow gas to pass through but stop the propagation of flame through cooling of the combustion products to 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 atmosphere	An atmosphere that contains 10% or more of the Lower Flammable Limit (LFL) of a substance that is capable of ignition and burning.
Flammable 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 vapour 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/sec). 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 firefighting.
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	An unrestricted fall.
Freeboard	The vertical distance between the ship's deck and the waterline at the amidships location. On ships with manifolds not amidships, it may also be provided separately for the manifold location.
From the top (or overall)	See 'Loading over the top'.
Gas free	A tank, compartment or container is gas free when it has been adequately cleaned and 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'.

Guidance Provision of advice or information by OCIMF/ICS/IAPH.

Halon A halogenated hydrocarbon used in firefighting that inhibits flame propagation.

Hazard Any event/object that could cause harm.

Hazardous area Any place in which a sufficiently explosive atmosphere may occur to require special precautions to protect the safety of workers (for ships, see 'Dangerous area').

Hazardous situation A situation that may directly cause an accident that causes harm to people or the environment.

Hazardous task A task other than hot work that 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 A hazardous zone is a classification designation found within a hazardous area and is determined by an assessment based upon the frequency of the occurrence and duration that an explosive gas atmosphere may be present.

High Modulus Synthetic Fibre (HMSF) Manmade, continuous filament synthetic fibre with modulus in the range of 50–150Pa.

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 that 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 on completion of all required preparation and testing that permits specific hot work to be done during a particular time interval in a defined area.

Hydrocarbon gas An organic chemical gas compound composed entirely of hydrogen and carbon atoms.

Incident Any unplanned event, including accidents or near-misses, that may result in injury or ill health of people, damage or loss to property, plant, materials or the environment.

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

Inert Gas (IG) A gas or a mixture of gases, such as exhaust flue gas or nitrogen, 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	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 process of introducing 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 pipelines, hose strings and Marine Loading Arms (MLAs).
Interface detector	An electrical instrument for detecting the boundary between oil and water.
International Safety Management (ISM) Code	The International Management Code for the Safe Operation of Ships and for Pollution Prevention.
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 (or 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 hatch or 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 (m^3/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).
Manifold	The flanged pipe assembly mounted on board ship to which the presentation flange of the Marine Loading Arm (MLA) or spool piece connects.
Marine terminal (or terminal)	For the purposes of this publication, a marine terminal is defined as a place where ships are berthed or moored for loading or discharging cargoes that include crude oil and products, chemicals and liquefied gases.
Marine terminal manager	The person, or management team, having overall responsibility for the safe and efficient operation of a marine terminal.
Master	The Master is responsible for the safe and efficient operation of the ship (including its seaworthiness, safety and security, cargo operations, navigation, crew management, and legal compliance) and for the persons and cargo on board.
Material Safety Data Sheet (MSDS)	A document identifying a substance, and all its constituents, and occupational health and safety information. It provides the recipient with all necessary information to manage the substance safely. The format and content of an MSDS for *International Convention for the Prevention of Pollution from Ships (MARPOL)* Annex I Cargoes and Marine Fuel Oils are prescribed by the IMO and follow the Globally Harmonized System (GHS).

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.
Metacentric height	The vertical distance between the centre of gravity (the point through which the force of gravity is considered to act vertically downwards) and the metacentre (the point at which the force of buoyancy will cut the centreline at a given angle of heel).
Mooring buoy	A floating cylinder or drum, anchored to the seabed, to which mooring lines are attached. The mooring buoy may serve only as a float with the anchor chain passing through the buoy directly to the mooring hook, in which case none of the tension loads are transferred to the buoy. Alternatively, the buoy may be used as a tension member whereby loads are transferred from the mooring lines via the buoy to the anchor system. In this case, the mooring buoy is a structural member of the mooring system.
Mooring hook	A device for connecting a ship's mooring line to a quay, jetty, offshore buoy or facility, which is often fitted with a quick release system.
Mooring Master	A suitably qualified marine representative placed on board ships to advise the Master during navigation of the ship to/from the facility. The Mooring Master may also assist with, or undertake, ship handling, hose handling, cargo operations and documentation duties.
Multi Buoy Mooring (MBM)	A facility where a tanker is usually moored by an array of mooring buoys, typically between three and seven, positioned at some distance from the tanker, or a combination of mooring buoys and one or more ship's anchors, to moor the ship on a fixed heading.
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. This also includes 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 the human sense of smell.
Oil/Bulk/Ore (OBO)	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. Depending on the nature of the goods the relevant provisions of the *International Maritime Dangerous Goods (IMDG) Code* and MARPOL may apply.

Permit to work	A document issued by a Responsible Person on completion of all required preparation and testing, which allows work to be performed in compliance with the ship's Safety Management System (SMS).
Permit to work system	A documented system for controlling activities that expose the ship, the terminal, personnel or the environment to hazard. The system will use 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.
Pigging	A form of line clearance where a cylindrical object (known as a 'pig') is propelled along a line by liquid or compressed gas. Pigging may also be undertaken during line maintenance functions, such as line integrity checks, using a so called 'intelligent pig' to measure the thickness of the pipeline wall.
Port authority	The organisation that is responsible for the safe and efficient operation and management of a specific port.
Portable tank	A tank used for the storage and transportation of liquids, including liquefied gases, that can be moved. Also known as UN portable tanks, ISO tank containers, bulk or intermodal tanks.
Pour point	The lowest temperature at which a petroleum oil will flow under standard conditions.
Presentation flange	Loading arm flange for connection to either the ship's manifold or spool piece.
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 enables a tank to 'breathe', keeping a tank over pressure or under pressure within approved limits by providing for the flow of the small volumes of vapour, air or inert gas mixtures caused by thermal variations in a cargo tank.
Product	Any substance that flows through a Marine Loading Arm (MLA). This includes, but is not limited to, crude oil, refined and chemical products, liquefied gases, vapour and ballast water.
Public Relations Officer	Person who relays information to the public, other port users and all involved groups.

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.
Quick Connect/Disconnect Coupling (QC/DC)	The manual or hydraulic mechanical device used to clamp the presentation flange to the ship's manifold without the use of bolts.
Recommendations	OCIMF/ICS/IAPH support and endorse a particular method of working or procedure.
Reid Vapour Pressure (RVP)	A common measure of volatility and defined as the absolute vapour pressure exerted by the vapour of a hydrocarbon liquid and any dissolved gases at 37.8°C under specified conditions. 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	A device using positive pressure to assist or restore the breathing of a person overcome by gas or lack of oxygen.
Risk	The exposure to a hazard.
Risk assessment	The process that collects information and assigns values to risks for informing priorities, developing or comparing courses of action, and informing decision making.
Safety Management System (SMS)	A formal, documented system or framework designed to manage safety in the workplace on shore or on a ship. An SMS will include policies, objectives, plans and procedures, as well as organisational responsibilities for those involved in ensuring the system is effectively implemented. For ship activities, an SMS is a requirement of the ISM Code.
Safety of Life at Sea (SOLAS)	The International Convention for the Safety of Life at Sea 1974, as amended.
Sea chest	Underwater opening within the shell plating through which sea water is drawn in or discharged, for example, for cooling of machinery systems.
Self-stowing mooring winch	A mooring winch fitted with a drum on which a mooring wire or rope is made fast and automatically stowed. They may be split drum (where the wire or rope is stored separately to the working/tension drum) or a single undivided drum.

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.

Ship — Any vessel, including barges, that is designed to carry oil, liquefied gases or chemicals in bulk.

Single Point Mooring (SPM) — An integrated mooring arrangement for bow mooring a conventional tanker. An SPM includes Catenary Anchor Leg Mooring (CALM) buoy, Single Anchor Leg Mooring (SALM), Single Buoy Mooring (SBM), Floating Production Storage and Offloading Unit (FPSO) and a turret type mooring to a spar or similar structure.

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 crude oil or product containing appreciable amounts of hydrogen sulphide and/or mercaptans. They will often be associated with a strong pungent odour.

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 reduce the flow rate of oil or product into a tank to reduce static electricity generation when loading static accumulator cargoes.

Stakeholders — Individuals, groups or organisations that have an interest in or are affected by the activity of a business.

Static accumulator oil — An oil with an electrical conductivity of less than 50 picoSiemens/metre (pS/m), 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), incapable of retaining a significant electrostatic charge.

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

Surge pressure — A sudden increase in the pressure of the liquid in a pipeline, brought about by an abrupt change in flow velocity e.g. through the starting or stopping of a pump, a rapid closure or opening of a valve or a reduction of pipeline diameter. The pressure surge may cause a rupture of the piping and an extensive oil spill.

Tank breathing (see also 'P/V valve')
The ability of a tank to maintain over pressure or under pressure within approved limits by providing for the flow of the small volumes of vapour, air or inert gas mixtures caused by thermal variations in a cargo tank.

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.

Telemetry
A system of two-way radio communication that interlinks data between ship and installation. This data is often related to Emergency Shutdown (ESD) and emergency release activities, but can also include information on valve positions.

Tension winch (automated or self-tensioning mooring system)
A mooring winch designed and fitted with a device that can maintain the tension on a mooring line automatically to a certain pre-set value.

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.

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 ensure the minimum tank pressure is maintained and 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.

Under Keel Clearance (UKC)
The vertical distance between the ship's bottom, at its deepest point of immersion, and the seabed or any objects resting on the seabed (for example, submarine pipelines, manifolds or concrete clumps).

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).
Vacuum breaker	A valve in the apex which, when opened to atmosphere, breaks the internal vacuum and expedites gravity draining of the outboard arm.
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. They are frequently fitted to sounding pipes, particularly on ships not fitted with inert gas systems.
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 firefighting.
Water spray	A spray of water divided into coarse drops by delivery through a special nozzle for use in firefighting.

Abbreviations

ABM	All Buoy Mooring
AC	Alternating Current
AFFF	Aqueous Film Forming Foam
AIS	Automatic Identification System
ALARP	As Low As Reasonably Practicable
ANSI	American National Standards Institute
API	American Petroleum Institute
AR-AFFF	Alcohol Resistant Aqueous Film Forming Foam
ASME	American Society of Mechanical Engineers
AUV	Autonomous Underwater Vehicles
BCM	Bow to Centre of Manifold
BMP	Best Management Practices
BOG	Boil-Off Gas
BWM	Ballast Water Management
CBM	Conventional Buoy Mooring
CH_3OH	Methanol
CH_4	Methane
CO_2	Carbon Dioxide
COSWP	Code of Safe Working Practices for Merchant Seafarers
COW	Crude Oil Washing
DFDE	Dual Fuel Diesel Engine
EEBD	Emergency Escape Breathing Device
EPSS	Emergency Power Supply System
ERS	Emergency Release System
ESD	Emergency Shutdown
FAME	Fatty Acid Methyl Esters
FP	Fluoroprotein Foam
FPAR	Alcohol Resistant Fluoroprotein Foam
FPSO	Floating Production Storage and Offloading Unit
GCU	Gas Combustion Unit
GHS	Globally Harmonized System
GM	Transverse Metacentric Height
H_2S	Hydrogen Sulphide
HAZID	Hazard Identification Studies
HAZOP	Hazard and Operability Studies
HFO	Heavy Fuel Oil

HMSF	High Modulus Synthetic Fibre
HP	High Pressure
IACS	International Association of Classification Societies
IAPH	International Association of Ports and Harbors
IBC Code	International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk
ICS	International Chamber of Shipping
IEC	International Electrotechnical Commission
IECEx	International Electrotechnical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres
IG	Inert Gas
IGC Code	International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk Code
IGF Code	International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels Code
IMDG Code	International Maritime Dangerous Goods Code
IMO	International Maritime Organization
IOGP	International Association of Oil & Gas Producers
IPIECA	International Petroleum Industry Environmental Conservation Association
IR	Infrared
ISM Code	International Safety Management Code
ISO	International Organization for Standardization
ISPS Code	International Ship and Port Facility Security Code
IT	Information Technology
LFL	Lower Flammable Limit
LNG	Liquefied Natural Gas
LO/TO	Lock-out/Tag-out
LOA	Length Overall
LPG	Liquefied Petroleum Gas
LRIT	Long Range Identification and Tracking
MARPOL	International Convention for the Prevention of Pollution from Ships
MASS	Marine Autonomous Surface Ships
MAWP	Maximum Allowable Working Pressure
MBL	Minimum Breaking Load
MBM	Multi Buoy Mooring
MBR	Minimum Bend Radius
MCA	Maritime and Coastguard Agency
MDO	Marine Diesel Oil
MLA	Marine Loading Arm
MOC	Management of Change

MSC	Marine Safety Committee
MSDS	Material Safety Data Sheet
MSMP	Mooring System Management Plan
MTIS	Marine Terminal Information System
MTMSA	Marine Terminal Management and Self Assessment
MTOCT	Marine Terminal Operator Competence and Training
MTPQ	Marine Terminal Particulars Questionnaire
MWP	Maximum Working Pressure
NEC	National Electric Code
NFPA	National Fire Protection Association
NH_4	Ammonia
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NORM	Naturally Occurring Radioactive Material
NRV	Non-Return Valve
OBO	Oil/Bulk/Ore
OCIMF	Oil Companies International Marine Forum
OEL	Occupational Exposure Limit
OEL-STEL	Occupational Exposure Limit - Short-term Exposure Limit
OEL-TWA	Occupational Exposure Limit - Time Weighted Average
OSHA	Occupational Safety and Health Administration
OSRO	Oil Spill Response Organisation
OT	Operational Technology
P	Protein Foam
P/V	Pressure/Vacuum
PBL	Parallel Body Length
PEP	Portable Electronic Product
PERC	Powered Emergency Release Coupling
PFD	Personal Flotation Device
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonate
PFSO	Port Facility Security Officer
PIANC	World Association for Waterborne Transport Infrastructure
PIC	Person In Charge
PID	Photoionisation Detector
PLEM	Pipeline End Manifold
PMS	Planned Maintenance System
PP	Polypropylene

PPE	Personal Protective Equipment
ppm	parts per million
PSC	Port State Control
PTFE	Polytetrafluoroethylene
QC/DC	Quick Connect/Disconnect Coupling
QRA	Quantitative Risk Assessment
RF	Radio Frequency
RPE	Respiratory Protective Equipment
RVP	Reid Vapour Pressure
RWP	Rated Working Pressure
SCBA	Self-Contained Breathing Apparatus
SCM	Stern to Centre of Manifold
SCT	Safety Critical Tasks
SCTA	Safety Critical Task Analysis
SDS	Safety Data Sheet
SGMF	Society for Gas as a Marine Fuel
SIGTTO	Society of International Gas Tanker and Terminal Operators
SIMOPS	Simultaneous Operations
SIRE	Ship Inspection Report Programme
SMPEP	Shipboard Marine Pollution Prevention Emergency Plan
SMS	Safety Management System
SOLAS	International Convention for the Safety of Life at Sea
SOPEP	Ship Oil Pollution Emergency Plan
SPM	Single Point Mooring
SSO	Ship Security Officer
SSSCL	Ship/Shore Safety Checklist
STCW	Standards of Training, Certification and Watchkeeping for Seafarers
STS	Ship to Ship
SVG	Site Verification Guideline
SWA	Stop Work Authority
SWL	Safe Working Load
TEL	Tetraethyl Lead
TIB	Terminal Information Booklet
TIC	Testing, Inspection and Certification
TLV	Threshold Limit Value
TML	Tetramethyl Lead
TMSA	Tanker Management and Self Assessment
TOL	Terminal Operating Limit

TVP	True Vapour Pressure
UFL	Upper Flammable Limit
UHP	Ultra High Pressure
UKC	Under Keel Clearance
UN GHS	United Nations Globally Harmonized System of Classification and Labelling of Chemicals
USCG	United States Coast Guard
VECS	Vapour Emission Control System
VHF/UHF	Very High Frequency/Ultra High Frequency
VOC	Volatile Organic Compound
VOCON	Volatile Organic Compound Control Valve
VOL	Volume
VPQ	Vessel Particulars Questionnaire
VRL	Vapour Return Line
WG	Water Gauge

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CHAPTER 1

Basic Properties and Hazards of Petroleum

1.1 Vapour pressure

1.2 Flammability

1.3 Density of hydrocarbon gases

1.4 Toxicity

1.5 Pyrophoric iron sulphide

1.6 The hazards associated with handling, storing and carrying residual fuel oils

This chapter looks at the physical and chemical characteristics of petroleum liquids that pose a risk during handling operations. These are the flammability of petroleum, the effects of the density and vapour pressure of petroleum gases, and vapours and their toxic properties.

Other issues covered include pyrophoric iron sulphides forming in cargo tanks and the hazards associated with handling, storing and carrying residual fuel oils.

Practical guidance for gas testing operations is in chapter 2, which also addresses gas evolution and dispersion.

1.1 Vapour pressure

1.1.1 True Vapour Pressure

Crude oils and petroleum products are mixtures of a wide range of hydrocarbons, i.e. chemical compounds of hydrogen and carbon. The boiling points of these compounds range widely. Their volatility depends, primarily, on the relative quantities of the more volatile constituents, i.e. those with a lower boiling point.

Volatility is the tendency of a crude oil or petroleum product to produce gas and is characterised by the vapour pressure. When a petroleum mixture is transferred to an empty tank or container it starts to vaporise, so gas forms in the space above it.

This gas tends to re-dissolve in the liquid until it reaches an equilibrium, with a certain amount of gas evenly distributed throughout the space. The pressure this gas exerts is the equilibrium vapour pressure of the liquid, usually known simply as the vapour pressure.

The vapour pressure of a pure compound depends on its temperature alone. The vapour pressure of a mixture depends on its temperature, constituents and volume of the gas in the vaporisation space. In other words, it depends on the ratio of gas to liquid by volume.

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

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

The TVP of a petroleum mixture indicates its ability to produce gas. The TVP 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 be estimated from the stabilisation conditions, allowing 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 (RVP) and temperature.

1.1.2 Reid Vapour Pressure

The RVP test is a simple, widely used method for measuring the volatility of petroleum liquids. It is conducted with standard equipment 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 produce equilibrium conditions, the pressure, now increased due to vaporisation, can be seen on an attached pressure gauge. This reading is a close approximation to the absolute 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. However, because it measures at the standard temperature of 37.8°C and at a fixed gas/liquid ratio, it is of little value in estimating the likely gas evolution in specific situations. For this purpose, TVP is much more useful.

1.2 Flammability

1.2.1 General

Flammability is the primary and always present risk when handling petroleum.

When hydrocarbon gases burn, they react with the oxygen in the air to produce carbon dioxide (CO_2) and water. The reaction produces enough heat to form a flame that travels through the mixture of hydrocarbon gas and air. When the gas above a liquid hydrocarbon is ignited, the heat is usually enough to evaporate enough fresh gas to maintain the flame. While it looks as though the liquid is on fire, it is in fact the gas that is burning, being continuously replenished from the liquid.

1.2.2 Flammable limits

A mixture of hydrocarbon gas and air cannot ignite and burn unless its gas-in-air concentration lies within the flammable range. The lower limit of this range, known as the Lower Flammable Limit (LFL), is the hydrocarbon concentration below which there is not enough gas to support combustion (too lean). The upper limit, known as the Upper Flammable Limit (UFL), is the concentration above which there is not enough air to support combustion (too rich).

The flammable limits vary for different pure hydrocarbon gases and for the gas mixtures derived from different petroleum liquids. For practical purposes, the gas mixtures from crude oils, motor or aviation gasolines and natural gasoline products can be represented by the pure hydrocarbon gases propane, butane and pentane. Table 1.1 gives the flammable limits for these three gases and the dilution needed for each to bring a mixture of 50% by volume in air down to the LFL. This shows that vapours will disperse with ease to a non-flammable concentration in the atmosphere.

In practice, and for general purposes, the LFL and UFL of crude oil and petroleum products can 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 The effect of Inert Gas on flammability

When Inert Gas (IG) is added to a hydrocarbon gas/air mixture, the result is to increase the LFL hydrocarbon concentration and to decrease the UFL concentration. These effects are shown in figure 1.1.

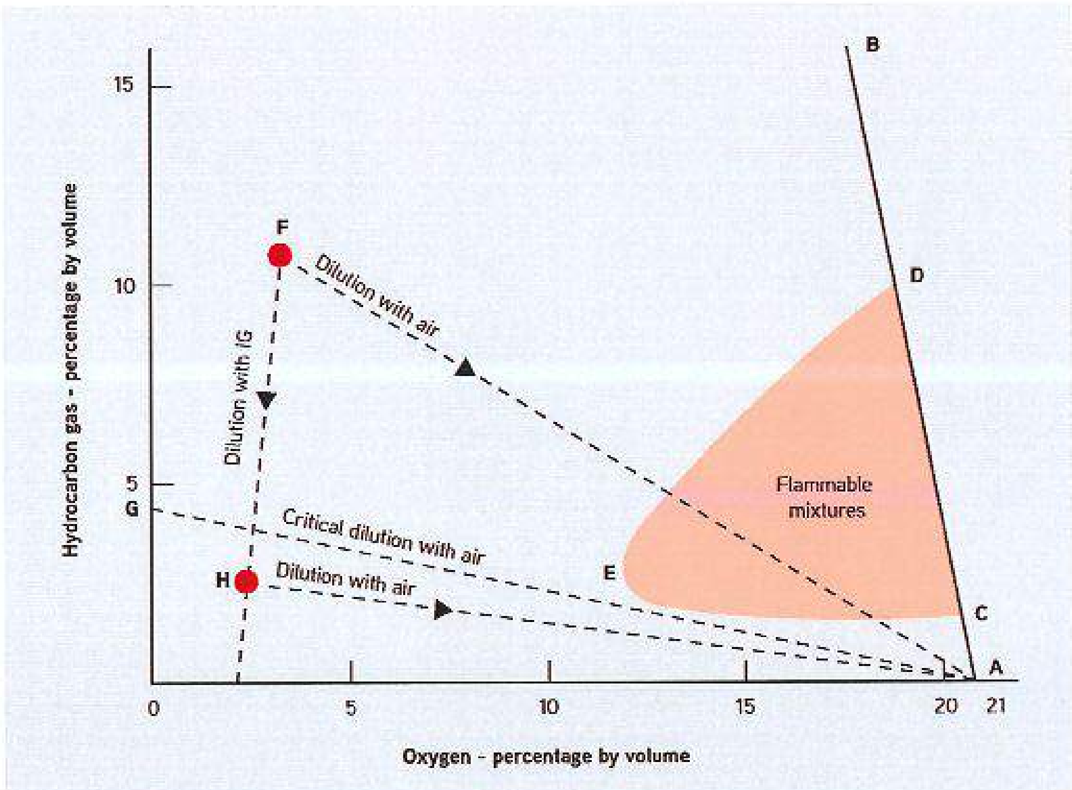


Figure 1.1: Flammability composition diagram for a hydrocarbon gas/air/IG mixture

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

Every point on the diagram represents a hydrocarbon gas/air/IG mixture in terms of its hydrocarbon and oxygen content. Hydrocarbon gas/air mixtures without IG lie on the line AB, its slope reflecting 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 IG.

The points C and D represent the lower and upper flammability limit mixtures for hydrocarbon gas in air. As the IG content increases, the flammable limit mixtures change as indicated by the lines CE and DE, which converge at the point E. Only those mixtures in the shaded area within the loop CED can burn.

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

Figure 1.1 demonstrates that as IG is added to hydrocarbon gas/air mixtures, the flammable range decreases until the oxygen content reaches a level, generally about 11% by volume, when no mixture can burn. This guide specifies a margin beyond this value, of a safely inerted gas mixture of 8% by volume of oxygen.

When an inerted mixture like that at point F is diluted by air, its composition moves along the line FA and 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, e.g. during a gas freeing operation.

Those mixtures below the line GA, like that at point H, do not become flammable on dilution. Note that it is possible to move from a mixture like F to one like H by dilution with additional IG, i.e. by 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 depends on vapour pressure, in principle it should be possible to test for flammability by measuring vapour pressure. In practice, the wide range of petroleum products, and the range of temperatures they are handled at, has prevented the development of one simple test.

Instead, the oil industry uses two standard methods. One is the RVP test (see section 1.1.2) and the other is the flashpoint test, which measures flammability directly. However, with some residual fuel oils, the flashpoint test will not always provide a direct indication of flammability (see section 1.6.2).

1.2.5 Flashpoint

In this test, a sample of the liquid is gradually heated and a small flame repeatedly and briefly 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, 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 LFL mixture.

Flashpoint equipment falls into two classes. In one, as the liquid is heated, the surface is permanently open to the atmosphere. The result of this test is an open cup flashpoint. In the other class, the liquid is kept enclosed except when the initiating flame is briefly introduced through a small port. The result of this test is a closed cup flashpoint.

The greater loss of gas to atmosphere in the open cup test means 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 equipment also produces a much more consistent result. For this reason, the closed cup method is generally favoured and used in this guide when considering the classification of petroleum. However, open cup test figures may still be found in some national legislation, in Classification Society rules and other similar documents.

1.2.6 Flammability classification of petroleum

Many schemes exist for dividing the complete range of petroleum liquids into different flammability classes based on flashpoint and vapour pressure and these schemes vary considerably between countries. Usually, the basic principle is to consider whether a flammable equilibrium gas/air mixture can be formed in the space above the liquid when the liquid is at ambient temperature.

This guide generally groups petroleum liquids into two categories, non-volatile and volatile, defined in terms of flashpoint as:

Non-volatile

A flashpoint of 60°C or above, based on closed cup testing. At any normal ambient temperature these liquids produce equilibrium gas concentrations below the LFL. They include distillate fuel oils, heavy gas oils and diesel oils. Their RVPs are below 0.007 bar and are not usually measured.

Volatile

A flashpoint below 60°C, based on closed cup testing. In some part of the normal ambient temperature range, some petroleum liquids in this category can produce an equilibrium gas/air mixture within the flammable range. At all normal ambient temperatures, the majority give equilibrium gas/air mixtures above the UFL. Examples of the former are jet fuels and kerosenes. Examples of the latter are gasolines and most crude oils. In practice, gasolines and crude oils are frequently handled before reaching equilibrium conditions, so gas/air mixtures in the flammable range may be present.

The choice of 60°C as the flashpoint division between non-volatile and volatile liquids is, to an extent, arbitrary. Less stringent precautions are applied to non-volatile liquids, so it is vital that no liquid capable of producing a flammable gas/air mixture is ever included in the non-volatile category. The dividing line should allow for factors such as misjudging the temperature, inaccurate flashpoint measurement and minor contamination by more volatile materials. The closed cup flashpoint figure of 60°C allows for these and is compatible with international definitions.

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. This means that layering effects are possible during cargo handling, which can create hazards.

Table 1.2 shows the gas densities relative to air for the three pure hydrocarbon gases, propane, butane and pentane, which roughly represent the gas mixtures produced by crude oils, motor or aviation gasolines and natural gasolines. These figures do not change greatly when IG is substituted for air.

Gas	Density relative to air		
	Pure hydrocarbon	50% by volume hydrocarbon/50% by volume air mixture	LFL 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

The density of the undiluted gas from a product (e.g. motor gasoline) is likely to be about twice that of air and from a typical crude oil it is about 1.5 times. These high densities and their resulting layering effects are only significant while the gas remains concentrated. As it is diluted, the density of the gas/air mixture from all three types of cargo approaches that of air. At the LFL it is indistinguishable from air.

1.4 Toxicity

1.4.1 Introduction

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

Toxic substances can enter the human body in three main ways:

- Swallowed (ingestion).
- Skin contact (absorption).
- Via the lungs (inhalation).

Toxic substances may have local effects, e.g. skin or eye irritation, and may also affect other, more widespread parts of the body, known as systemic effects.

This section describes the effects of the toxic substances that tanker and terminal personnel are most likely to encounter. It looks at what happens with both a single and a repeated exposure, and how to reduce the risks. It also covers the effects of oxygen deficiency, although this is not strictly a case of toxicity.

1.4.2 Liquid petroleum

1.4.2.1 Ingestion

Petroleum has low oral toxicity, but when swallowed causes acute discomfort and nausea. When vomiting, liquid petroleum may be drawn into the lungs, which can have serious consequences, especially with more volatile products such as gasoline and kerosene.

1.4.2.2 Absorption

Many petroleum products, especially the more volatile ones, cause irritation when they come in contact with the skin. They remove essential oils and can cause dermatitis. They can also cause irritation to the eyes. Repeated and prolonged contact with certain heavier oils can cause serious skin disorders.

Avoid direct contact with petroleum at all times by wearing the appropriate Personal Protective Equipment (PPE), especially impermeable gloves and goggles.

1.4.3 Petroleum gases

1.4.3.1 Inhalation

When inhaled, even small quantities of petroleum gas can cause symptoms of diminished responsibility and dizziness similar to intoxication, along with headaches and irritation to the eyes. It can be fatal if inhaled in sufficient quantities.

These symptoms can occur at concentrations well below the LFL. However, petroleum gases vary in their effects and people vary in their tolerance of those effects. Even if the conditions can be tolerated, do not assume the gas concentration is within safe limits.

The smell of petroleum gas mixtures is variable and in some cases may dull the sense of smell. This is especially likely, and serious, if the mixture contains hydrogen sulphide (H_2S) (see section 1.4.6).

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

1.4.3.2 Exposure limits

The toxic hazards personnel are exposed to in tanker and terminal operations arise almost entirely from liquids, gases or vapours of various kinds. Many of these substances have Occupational Exposure Limits (OELs). These limits protect personnel against harmful exposures in the working environment.

Exposure limits are set by international organisations, national administrations or by local regulatory bodies and should never be exceeded. The limits set by different organisations may differ and operators should adopt those set by their flag or appropriate administration. The limits should be detailed in the Safety Management System (SMS). Where they are not available, adopt those from a country with an internationally recognised occupational hygiene institute or society.

OELs are expressed in parts per million (ppm) by volume of gas in air or milligrams per cubic metre (mg/m³). There are three main types of OEL:

- Time Weighted Average (TWA): TWA values are calculated by taking the sum of exposure during a working day to a toxic contaminant in terms of ppm-hours and dividing by an eight hour period. As averages, TWAs assume short-term exposures above the OEL-TWA that are not high enough to damage health and are compensated by equivalent exposures below the OEL-TWA during the conventional eight hour working day.
- Short-Term Exposure Limits (STEL): these are assigned to substances that cause acute effects. They are higher than the eight hour TWA. The STEL is the maximum average concentration an unprotected worker may be exposed to in any 15 minute interval during the day. Where no specific STEL is available, use a figure three times the long-term (OEL-TWA) exposure limit.
- Ceiling value: this is the concentration of an airborne toxic substance that should not be exceeded at any time during the working day.

OELs protect the health of workers. They are not safe working limits, so exposure should be kept below the limit wherever possible. Best practice is to reduce exposure of all contaminants to As Low As Reasonably Practicable (ALARP).

1.4.3.3 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, it can lead to paralysis, unconsciousness and death.

The toxicity of petroleum gases and vapours varies widely depending on their different hydrocarbon constituents. Toxicity can be greatly increased by the presence of some minor components such as aromatic hydrocarbons, e.g. H_2S and benzene. Compliance with the OEL of a 'total' hydrocarbon, such as gasoline, does not ensure compliance with the individual OELs of potentially hazardous constituents, such as H_2S or benzene.

1.4.4 Safety Data Sheets

The Safety Data Sheets (SDSs) should indicate the type and probable concentrations of hazardous or toxic components in the cargo or bunkers to be loaded, particularly H_2S and benzene. The SDS should be United Nations Globally Harmonized System of Classification and Labelling of Chemicals (UN GHS) compliant.

The supplier is responsible for providing the relevant SDS to a tanker before it starts loading an oil cargo or bunker fuel. The tanker is responsible for providing the receiver with an SDS for the cargo to be discharged. The tanker should also advise the terminal, and any tank inspectors or surveyors, whether the previous cargo contained any toxic substances (see section 25.4).

An SDS does not guarantee that all the hazardous or toxic components of the cargo or bunkers being loaded have been identified or documented. An SDS can be generic and may not directly reflect the specific composition of the cargo or fuel described. Tanker and terminal operators should have procedures and equipment to verify the actual levels of toxic components present in cargoes and/or bunkers loaded or discharged.

For *International Convention for the Prevention of Pollution from Ships (MARPOL)* Annex I cargoes, the term Material Safety Data Sheets (MSDSs) may still be used and referenced in industry documents.

1.4.5 Benzene and other aromatic hydrocarbons

1.4.5.1 Aromatic hydrocarbons

The aromatic hydrocarbons include benzene, toluene and xylene. They are components, in varying amounts, in many petroleum cargoes, e.g. gasoline, gasoline-blending components, reformate, naphtha and crude oil.

Personnel engaged in cargo operations involving products containing aromatic hydrocarbons should follow the precautions and procedures in sections 12.1.6.6 (closed loading) and 12.8.4 (measuring and sampling) in order to minimise their exposure during cargo handling operations. The OEL of an aromatic hydrocarbon vapour is generally lower than other hydrocarbons.

1.4.5.2 Benzene

Exposure to concentrations of benzene vapours of only a few ppm in air can affect bone marrow and cause anaemia and leukaemia.

The International Maritime Organization (IMO) has established minimum standards for ships carrying liquids in bulk with a benzene content of 0.5% or more: see MSC/Circ.1095 *Revised Minimum Safety Standards for Ships Carrying Liquids in Bulk Containing Benzene*. These standards cover requirements for transferring information on the cargo by SDS, OELs, air quality monitoring, PPE 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 *International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code)* and the *Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (BCH Code)*. The following guidance provides general advice on precautions to be adopted by oil tankers carrying cargoes containing benzene at concentrations of less than 0.5%.

Benzene primarily presents an inhalation hazard. It provides little warning as its odour threshold is above the OEL levels. Benzene is heavier than air, with a relative vapour density of 2.8 that means it may accumulate in low level areas.

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

For practical guidance on measures to minimise the risks associated with loading cargoes containing benzene, see section 12.1.10.1.

Operators should refer to their Flag State or national authority to confirm applicable OELs for benzene.

Benzene is a carcinogen, so exposure should always be reduced to below the OEL or respiratory protection provided, following the hierarchy of control principle (see section 4.2.3).

Personal Protective Equipment

Personnel should wear Self-Contained Breathing Apparatus (SCBA) when:

- They are at risk of being exposed to unknown concentrations of benzene vapours or levels that exceed the OEL-TWA.
- National or internationally specified OEL-TWAs are likely to be exceeded.
- Monitoring cannot be carried out.
- Closed operations cannot be carried out for any reason.

The tanker operator should decide what other Respiratory Protective Equipment (RPE) should be worn, but this should not fall below the regulations or guidance required by the IMO. Local regulations or company procedures may extend the need to use RPE to personnel not directly involved in cargo operations (see section 10.13).

Operators should be aware of the stated lower limit of detection and accuracy range of gas detection equipment used, and that portable gas measuring equipment can only provide spot readings. Personnel may also find concentrations of vapour that exceed the readings, so carefully consider the type of RPE used for specific tasks.

Operators should keep records of all employees engaged in handling cargoes that contain benzene. Personnel carrying out tasks, e.g. cargo gauging and sampling, or disconnecting cargo hoses after transfer, should be made aware of the hazards of benzene.

Tank entry

Before anybody enters a tank that has recently contained petroleum, the tank should be tested for benzene concentrations. This is in addition to the requirements for entering enclosed spaces given in chapter 10.

1.4.6 Hydrogen sulphide

Hydrogen sulphide (H_2S) is a toxic, corrosive and flammable gas. It has a very low odour threshold and distinctive rotten egg smell. H_2S is colourless, heavier than air with a relative vapour density of 1.189 and is soluble in water.

1.4.6.1 Sources of hydrogen sulphide

Many crude oils come out of the well with high levels of H_2S, but a stabilisation process usually reduces this level before the crude oil is delivered to the tanker. However, the level of stabilisation may be reduced at times and a tanker may receive a cargo with an H_2S content higher than usual or expected. Some crude oils are never stabilised and always contain high levels of H_2S.

H_2S can also be found in refined products, e.g. naphtha, gas oil, bitumen and fuel oil, carried on board either as cargo or marine bunker fuel.

As a by-product of the refining process, fuel oil is a mixture of different types of residues, both from the crude distillation units (straight run residues) and from the conversion units (cracked/converted residues). The mixture of less stable residues can mean H_2S is slowly released even though testing at the time of production indicated no H_2S present.

For residual marine fuels typically used as bunker fuel, the applicable International Organization for Standardization (ISO) Standard (currently ISO 8217-2017) defines an H_2S limit of 2mg/kg (2ppm by weight). This limit can still lead to high accumulations of H_2S in the vapour space of bunker tanks. Applying heat to the fuel oil will also promote the release of H_2S from the liquid into the vapour phase.

H_2S scavengers based on nitrogen-based compounds (triazines) or oxygen-based compounds (aldehydes) can be used as additives to depress H_2S in final products, but overdosage can create issues with sediments and odour.

Cargo and bunker fuels should not be treated as free of H_2S until after they have been loaded and the absence of H_2S has been confirmed by the results of initial and ongoing monitoring and by the information in the relevant SDS.

1.4.6.2 Expected vapour concentrations

It is important to distinguish between concentrations of H_2S in the atmosphere, expressed in ppm by volume, and concentrations in liquid, expressed in ppm by weight.

Predicting the likely vapour concentration from any given liquid concentration is not possible but, as an example, a crude oil containing H_2S at 70ppm (by weight) has been shown to produce a concentration of 7,000ppm (by volume) in the gas stream leaving the tank vent.

Precautions against high H_2S concentrations are normally necessary if the H_2S content in the vapour phase is 5ppm by volume or above.

The effects of H_2S at various increasing concentrations in air are shown in table 1.3.

H_2S concentration (ppm by vol in air)	Symptoms/effects
0.00011–0.00033	Typical background concentrations
0.01–1.5	Odour threshold (when the rotten egg smell is first noticeable to some). Odour becomes more offensive at 3–5ppm. Above 30ppm, odour described as sweet or sickeningly sweet
2–5	Prolonged exposure may cause nausea, tearing of the eyes, headaches or loss of sleep. Airway problems (bronchial constriction) in some asthma patients
20	Possible fatigue, loss of appetite, headache, irritability, poor memory, dizziness
50–100	Slight conjunctivitis (gas eye) and respiratory tract irritation after one hour. May cause digestive upset and loss of appetite
100	Coughing, eye irritation, loss of sense of smell after 2–15 minutes (olfactory fatigue). Altered breathing, drowsiness after 15–30 minutes. Throat irritation after one hour. Gradual increase in severity of symptoms over several hours. Death may occur after 48 hours
100–150	Loss of sense of smell (olfactory fatigue or paralysis)
200–300	Marked conjunctivitis and respiratory tract irritation after one hour. Pulmonary oedema may occur from prolonged exposure
500–700	Staggering then collapse in five minutes. Serious damage to the eyes in 30 minutes. Death after 30–60 minutes
700–1,000	Rapid unconsciousness, 'knockdown' or immediate collapse within one to two breaths, breathing stops, death within minutes
1,000–2,000	Nearly instant death

Table 1.3: Typical effects of exposure to H_2S (Source – Occupational Safety and Health Administration (OSHA))

The H_2S concentration in the vapour space will vary greatly and depends on factors such as:

- Liquid H_2S content.
- Amount of air circulation.
- Temperature of air and liquid.
- Liquid level in the tank.
- Amount of agitation.

1.4.6.3 Guidance for handling cargo and bunkers containing hydrogen sulphide

Take the following precautions when handling all cargoes and bunker fuels likely to contain hazardous concentrations of H_2S. Also take them when ballasting, cleaning or gas freeing tanks that previously contained a cargo with H_2S content. Practical guidance on operational measures to minimise the risks associated with loading cargoes containing H_2S is in section 12.1.9.

1.4.6.3.1 Vapour monitoring

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

High concentrations and the corrosive nature of the gas can damage electronic gas detection instruments. Low concentrations of H_2S can have a similar effect over time. Some portable gas monitoring equipment may have a dedicated channel for high H_2S so that other sensors are not damaged. Gas detection tubes, or similar equipment, should be used if it is necessary to monitor high concentrations. Operators should be aware of the stated lower limit of detection and accuracy range of the gas detection equipment used.

The Energy Institute's *HM 69. Procedures for determining H_2S concentration in cargo tank head spaces* summarises good practice used within the industry. It recommends suitable vapour space sampling equipment that allow a closed sampling arrangement, minimising the operator's potential exposure to the vapour tested.

Bunker fuel tanks should be monitored before, during and after bunkering. If H_2S has been detected, the bunker tank should be regularly tested. Gas testing bunker tank vapour spaces should be risk assessed, considering the design of the bunker tanks, and appropriate measures taken to ensure the safety of personnel.

If H_2S might be present, bridge, control room, accommodation and engine spaces should be monitored. Ventilation systems should be operated to prevent H_2S vapours entering the accommodation and engine spaces. Low concentrations of H_2S over time can cause discomfort to personnel.

Personal measuring equipment

Personal H_2S 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 H_2S reading and an alarm. The alarms should be set at a value of 5ppm.

Personnel should always carry personal monitors whenever H_2S concentrations could exceed the OEL-TWA. Examples of these occasions include but are not limited to:

- Gauging.
- Sampling.
- Entering a pumproom.
- Connecting and disconnecting lines/hoses.
- Cleaning filters.
- Draining to open containment.
- Mopping up spills.

Personal gas monitors normally have an instantaneous alarm that activates when concentrations of H_2S exceed a set threshold, but may also have time-weighted alarms that trigger when the average concentration over the measurement period (typically 15 minutes or eight hours) exceeds other thresholds, e.g. OEL-STEL or OEL-TWA.

Unless the personal gas monitor has the functionality of raising alarms simultaneously for OEL-TWA and pre-set instantaneous readings, then instantaneous alarms should be selected rather than OEL-TWA alarms.

As an instrument may have several programable alarm limits, the safest approach to any alarm activation is to vacate the area and confirm the content from a safe location.

Users should understand each alarm setting. The operator's procedures should also assign clear actions to each setting.

Passive sampling badges are simple exposure monitoring devices and should never be used as an item of PPE.

1.4.6.3.2 Personal Protective Equipment

Consider providing Emergency Escape Breathing Devices (EEBDs) to personnel working in hazardous areas. These can be put on quickly if gas is detected.

Personnel should wear RPE under the following circumstances:

- Whenever there is a risk of exposure to H_2S vapours that either exceed the OEL-TWA, or when there is a potential that OEL-TWA levels set 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 and H_2S concentrations could exceed the OEL-TWA.

See section 4.8.1 on PPE.

1.4.6.3.3 Tanker and terminal systems for managing safety

Systems for managing safety should include procedures to ensure safe operations when handling cargo and bunker fuels that may contain H_2S. The procedures should include, but not be limited to:

- Training all tanker and terminal personnel in the hazards associated with H_2S and the precautions to reduce the risks to acceptable levels.
- Gas testing/atmosphere monitoring procedures.
- Additional safety measures for routine cargo operations when H_2S is present.
- Maintenance procedures for cargo related systems.
- PPE requirements.
- Contingency planning.
- Emergency response measures.
- Measures to protect visitors from exposure.

1.4.6.4 Additional procedures when handling cargoes with very high concentrations of hydrogen sulphide

Companies and terminals should develop additional procedures for handling cargoes with very high levels of H_2S, e.g. when 100ppm or more is detected in the vapour space.

EEBDs should be readily available to all personnel working in hazardous areas. They should already have a personal H_2S gas monitoring instrument.

Personnel should be instructed that if their alarm activates, they should put on the EEBD and immediately leave the area to an upwind location. They should advise the central control location of high gas concentrations so that appropriate procedures can be initiated.

When very high concentrations of H_2S are likely, SCBA should always be worn if it is necessary to breach the integrity of the cargo system and a vapour free atmosphere cannot be guaranteed. This would include the following activities:

- 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, e.g. drip trays or savealls.
- Mopping up spills.

Procedures should require personnel to use SCBA. Chemical cartridge respirators should not be used for protection against H_2S vapour as the concentrations in the atmosphere may exceed the protection factor of the respirator used.

1.4.6.5 Corrosion

H_2S is very corrosive, so enhanced inspection and maintenance regimes for cargo handling systems should in place if high concentrations of H_2S are likely.

Pressure/Vacuum (P/V) valve seats made of brass are more likely to fail than stainless steel seats.

Mechanical tank gauges are more likely to fail since H_2S can damage stainless steel tension springs and metals, e.g. brass and bronze. It may be necessary to increase the spare parts inventory.

Even low H_2S concentrations will affect computer and instrument components made of silver and gold.

1.4.6.6 Public nuisance

H_2S odour is also considered a public nuisance. Most local environmental regulations limit or ban the release of H_2S concentrations to the atmosphere. In any case this is good practice, so it is necessary to maintain cargo tank pressures within acceptably low limits. Tank vapour pressure will rapidly increase if the vapour space is exposed to heat or the product is agitated. Crude Oil Washing (COW) may also rapidly increase the vapour pressure and should begin at relatively low tank pressures, preferably while maintaining a relatively high discharge rate.

1.4.7 Mercaptans

Mercaptans are naturally occurring colourless gases. They have a very low odour threshold and their smell is similar to rotting cabbage. This is why they are used as odorising agents in natural gas and Liquefied Petroleum Gas (LPG).

Mercaptans may be found on tankers where sea water has remained beneath an oil cargo or where oil residues are left in slop tanks that contain sea water. Mercaptans are also present in the vapours of pentane plus cargoes and in some crude oils.

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

The initial effects of mercaptans are similar to those caused by H_2S, i.e. irritation to the lungs, eyes, nose and throat. If the concentration is very high, they can cause unconsciousness and oxygen may have to administered.

1.4.8 Cargo and bunker residues

Ship and terminal operators should be aware that residues left in tanks, pipelines and equipment may contain contaminants that are hazardous and/or toxic. Where the potential for these substances to be present has been identified, the facility operator or supplier has a duty of care to identify and inform the potential receivers of the oil or product that may be contaminated of the presence of the hazardous substance, and to provide information to enable the receivers to undertake an appropriate risk assessment that covers the health, safety and environmental risks.

Examples include, but are not limited to, mercury and Naturally Occurring Radioactive Materials (NORMs) both of which may be present in sludge and residues of crude oil, the latter being more likely found in upstream or refining operations.

Further information on mercury can be found in OCIMF's *Safety, Health, Environmental Issues and Recommendations for Shipboard Handling of Elevated Mercury Crude Cargoes.*

More information on NORMs can be sourced direct from the International Association of Oil & Gas Producers (IOGP) who have produced a number of technical reports providing factual information and guidance on the management of NORMs in the oil and gas industry.

1.4.9 Gasolines containing tetraethyl lead or tetramethyl lead

The amounts of tetraethyl lead (TEL) or tetramethyl lead (TML) normally added to gasolines are insufficient to make the gases significantly more toxic than those from unleaded gasolines. The effects of the gases from leaded gasolines are like those described for petroleum gases in section 1.4.3.3. The use of these compounds is now limited to some aviation gasolines and automotive gasoline in a small number of countries.

1.4.10 Biofuels

Biofuels are produced from renewable organic materials and include ethyl alcohol, Fatty Acid Methyl Esters (FAME), vegetable oils (triglycerides) and alkanes (C10-C26). They may have a flashpoint either above or below 60°C.

1.4.11 Inert Gas

1.4.11.1 General

IG is principally used to control cargo tank atmospheres to prevent the formation of flammable mixtures. The key requirement for IG is low oxygen content. Other than that, its composition can vary.

1.4.11.2 Toxic constituents

The main health hazard associated with IG is its low oxygen content. However, IG produced by combustion ('flue gas') either in a steam boiler or in a separate IG generator, will contain trace amounts of various toxic gases that may raise the level of hazard to personnel. These include nitrogen oxides, sulphur dioxide (SO_2) and carbon monoxide (CO). The OELs set by different organisations for these gases may differ. Operators should adopt the OELs set by their flag or appropriate administration and detail them in the SMS.

The precautions to protect personnel against the toxic components of IG during tank entry are in section 11.1.6.12. However, they do not include requirements for directly measuring 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 reached, is enough to dilute these toxic constituents to below their OEL-TWA.

For entering enclosed spaces, follow the recommendations in chapter 10.

1.4.11.3 Nitrogen oxides

Exhaust gases typically contain about 200ppm by volume of mixed nitrogen oxides. The majority is nitric oxide (NO), which is not removed by water scrubbing. NO reacts slowly with oxygen, forming nitrogen dioxide (NO_2). As the gas stands in tanks, the total concentration of nitrogen oxides falls, over a period of one to two days, to a level of 10–20ppm as the more soluble NO_2 goes into solution in free water, or by condensation, to give nitrous and nitric acids. Any further decrease below this level is very slow.

1.4.11.4 Sulphur dioxide

Exhaust gas produced by the combustion of fuel oil contains SO_2. IG system water scrubbers remove this gas, although their efficiency depends on the design and operation. However, IG will always contain a level of residual SO_2 of, typically, between 2 and 50ppm.

SO_2 irritates the eyes, nose and throat and may also cause breathing difficulties in sensitive people.

1.4.11.5 Carbon monoxide

Carbon monoxide (CO) is normally present in exhaust gas at a level of only a few ppm. Abnormal combustion conditions can create levels in excess of 200ppm.

1.4.12 Oxygen deficiency

The oxygen content of the atmosphere in enclosed spaces may be low for several reasons, the most obvious of which being that the space is inerted and the oxygen displaced by the IG. Oxygen may also be removed from an atmosphere by chemical reactions, e.g. rusting or hardening paints or coatings.

As the amount of oxygen falls below the normal 21% by volume, breathing tends to become faster and deeper. The symptoms that indicate an atmosphere is deficient in oxygen may not give enough warning. Most people would fail to recognise the danger until they were too weak to escape without help, especially if it 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 depth of unconsciousness increases as the 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, the brain is irreversibly damaged, even if the person's life is saved.

1.5 Pyrophoric iron sulphide

1.5.1 Pyrophoric oxidation

In an oxygen-free atmosphere where H_2S gas is present or where the concentration of H_2S exceeds 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, forming either free sulphur or SO_2 gas. This oxidation can be accompanied by considerable heat, so individual particles may become incandescent. Rapid exothermic oxidation with incandescence is called pyrophoric oxidation.

1.5.2 Formation of pyrophors

1.5.2.1 General

The formation of pyrophors depends on three factors:

- Presence of iron oxide (rust).
- Presence of H_2S.
- Lack of oxygen.

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 H_2S 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 support the view that there is no safe level of H_2S below which a pyrophor cannot be generated.

1.5.2.2 In marine operations

While pyrophoric iron sulphide is a widely recognised ignition source in shore based operations, it has rarely been the cause of a marine ignition and, in those few cases, the H_2S levels were very high. It is believed that marine operations have been free of this hazard because tank breathing means the cargo tanks of non-inerted tankers normally contain some oxygen in the vapour space.

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

1.5.3 Preventing pyrophoric ignition in inerted cargo tanks

If the cargo tanks remain inerted, there is no danger of ignition from a pyrophoric exothermic reaction. This means it is imperative that the atmosphere in the tank is not allowed to become flammable. Flammable atmospheres are inevitable if the tanks are discharged while the IG plant is inoperable.

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

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

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

- Diligent maintenance of IG plants.
- Keep spares nearby for critical parts that cannot be easily obtained or that can fail abruptly, e.g. the fans.
- If an IG plant fails before or during discharge of cargo or ballast from cargo tanks, do not start discharging, or do not resume, until the IG plant operation is restored or an alternative source of IG is provided.

1.6 The hazards associated with handling, storing and carrying residual fuel oils

1.6.1 The nature of the hazard

Residual fuel oils can produce light hydrocarbons in the tank headspace with a vapour composition that may be near or within the flammable range. This can happen 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 associated risk is small unless the atmosphere is within the flammable range and an ignition source is present. However, residual fuel oil headspaces should still be regarded as potentially flammable.

1.6.2 Flashpoint and headspace flammability measurement

1.6.2.1 Flashpoint

The safe storage, handling and transportation of fuel oils is classified according to their closed cup flashpoint (see section 1.2.5). However, the relationship between the flammability of a headspace atmosphere and the flashpoint of the residual fuel oil carried has no fixed correlation. A flammable atmosphere can be produced in a tank headspace even when a residual fuel oil is stored at a temperature below its flashpoint.

1.6.2.2 Headspace flammability

When using a combustible gas detector to assess the degree of hazard in non-inerted residual fuel oil tank headspaces, the instrument should be calibrated with a pentane/air or hexane/air mixture. While this will give a more conservative estimate of the flammability, the readings should not be regarded as a precise measurement of the vapour space condition.

When taking measurements, closely follow the manufacturer's operating instructions for the instrument and frequently check the instrument's calibration as catalytic sensors are susceptible to poisoning when exposed to residual fuel oil vapours.

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. Therefore, care should be exercised when interpreting the figures obtained by such gas detectors.

1.6.3 Precautionary measures

1.6.3.1 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.

1.6.3.2 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 vent outlets.

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.

1.6.3.3 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.

1.6.3.4 Hazard reduction

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

If a measured value in excess of 50% LFL is detected, 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 IG, it is recommended that the IG is used and that the headspace is maintained in an inert condition.

1.6.3.5 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 12.8.2).

1.6.4 Hydrogen sulphide hazard in residual fuel oils

Bunker fuels containing high H_2S concentrations may be supplied without advice being passed to the ship beforehand. Ship's personnel should always be alert to the possible presence of H_2S 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 H_2S 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 H_2S above the OEL-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 H_2S should be continued until the bunker tank is refilled with a fuel oil not containing H_2S.

CHAPTER 2

Gas Evolution and Measurement

2.1 Hydrocarbon gas evolution and dispersion
2.2 Loading very high vapour pressure cargoes
2.3 Volatile Organic Compounds
2.4 Gas measurement
2.5 Sampling
2.6 Fixed hydrocarbon gas detection systems

The chapter covers issues relating to gas evolution and dispersion. It also describes the principles, uses and limitations of portable and fixed gas detection equipment and provides practical guidance for gas testing operations.

2.1 Hydrocarbon gas evolution and dispersion

2.1.1 Introduction

During cargo handling and associated operations, enough petroleum gas is often expelled from cargo tank vents to create flammable gas mixtures in the atmosphere outside the tanks. It is essential that these flammable gas mixtures are not exposed to a source of ignition. In most cases, this means eliminating the source of ignition or ensuring there are barriers, e.g. closed doors and ports, between the gas and potential sources of ignition.

A further safeguard should be introduced if operations can be arranged so that petroleum gas issuing from vents is dispersed well enough to prevent flammable gas mixtures reaching any areas where sources of ignition may exist.

Volatile cargoes with a high vapour pressure are most likely to result in flammable atmospheres outside the tanks. Examples are:

- Crude oil.
- Motor and aviation gasolines.
- Natural gasolines.
- Light distillate feedstocks and naphtha.

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

Gas will be evolved by loading, cargo standing in full tanks or part-filled tanks (including slop tanks), evaporation of tank residues after discharge and COW. Vented gas is evolved within the tanks and the way it evolves affects the concentration when vented and the time it takes for a high concentration to vent.

Whether air or IG, the initial tank atmosphere has no bearing on gas evolution or venting.

2.1.2 Gas evolution and venting

2.1.2.1 Evolution during loading

As a high vapour pressure petroleum cargo enters an empty gas free tank, the gas rapidly evolves. 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 time it normally takes to fill a tank, although ultimately an equilibrium gas mixture is established throughout the vapour space.

The volume and concentration of gas forming this layer at the beginning of loading depends on many factors, including the:

- 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 gas concentration in the layer varies with distance above the liquid surface. Close to the surface, its value closely relates to the TVP of the adjoining liquid. For example, if the TVP is 0.75 bar, the gas concentration just above the surface is about 75% by volume. If the tank was originally gas free, then the gas concentration well above the surface will be small. To consider further the influence of gas layer depth, it is necessary to define this layer.

When considering the dispersion of gases outside cargo tanks, only high hydrocarbon concentrations in the vented gas are relevant. For this purpose, 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. Remember that hydrocarbon gas will still 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 one metre. The precise depth depends on the factors above and most of the advice on vented gas in this guide is intended for such cargoes. Gas layers greater than one metre in depth may be encountered if the cargo TVP is high enough. Cargoes that create these deeper gas layers may require special precautions (see sections 2.2.2 and 12.1.8).

2.1.2.2 Venting during the loading of cargo

As the liquid rises in the tank, the hydrocarbon gas layer rises with it. Above this layer, the atmosphere originally present in the tank remains almost unchanged. 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 mainly air (or IG) with a hydrocarbon concentration below the LFL. As loading proceeds, the hydrocarbon content of the vented gas increases.

Concentrations of 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.

Evaporation then continues until an equilibrium hydrocarbon gas concentration is established throughout the ullage space. This may be very high, depending on the cargo composition and temperature. Values as high as 90–95% by volume have been seen with crude oils. However, this gas is only vented by breathing of the tank, and so 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 on 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, a layer of highly concentrated gas sits 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, a homogeneous hydrocarbon gas concentration of up to 10% by volume exists throughout the tank. When the tank is next loaded, this gas is expelled until the concentrated gas layer immediately above the liquid surface begins to exert its influence. This concentrated layer then dominates the composition of the vented gas.
- In a crude oil tank that has been crude oil washed but not then purged with IG 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 next loading until the, possibly even richer, gas next 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 the tank is 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 not been 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.

2.1.2.3 Ballasting into a cargo tank

Where ballasting into cargo tanks is required (e.g. heavy weather ballast), the atmosphere will be similar to the atmosphere before loading an oil cargo, given a similar tank history. The gas concentration expected to enter the venting system during ballasting will compare to that in the examples in section 2.1.2.2. If it is necessary for tankers using COW to load ballast into a cargo tank before departure, some ports require controls on vapour emissions to the atmosphere. This is done by containing the vapour in empty cargo tanks, by simultaneous ballasting and cargo discharge, or by other approved means.

2.1.2.4 Inert Gas purging

If IG purging is carried out by the displacement method (see section 11.1.4), any dense concentrated hydrocarbon layer at the bottom of the tank is expelled in the early stages. The remainder of the tank atmosphere follows as it is pressed downwards by the IG. If there is a uniformly high concentration throughout the tank, e.g. after COW, the hydrocarbon concentration of the vented gas remains high throughout the purging process until the IG reaches the bottom of the tank.

If IG purging is being carried out by the dilution method (see section 11.1.4), the gas concentration at the outlet is highest at the beginning of the operation and falls continuously as it proceeds.

2.1.2.5 Gas freeing

In a gas freeing operation, air is delivered into the tank where it mixes with the existing tank atmosphere. It will also tend to mix together any layers. The resulting 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 then decreases. For example, on a non-inerted tanker, gas freeing a motor gasoline tank can give initial concentrations as high as 40% by volume, although in most circumstances the concentration in the vented gas is much lower even at the start.

On inerted tankers, after purging to remove hydrocarbon vapour before gas freeing, the initial concentration will be less than 2% by volume (Marine Environment Protection Committee (MEPC) 250(66), Paragraph 6; *International Convention for the Safety of Life at Sea (SOLAS)* Chapter VIII-5).

2.1.3 Gas dispersion

Whether the hydrocarbon gas at the outlet is mixed with air or IG 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 emerges 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 is no longer a flammability hazard because it cannot be ignited. However, a flammable zone exists in the vicinity of any vent, where the gas concentration is above the LFL (see section 1.2).

Fire and explosion are potential dangers if this flammable zone reaches any area where sources of ignition may exist, e.g.:

- Superstructures and accommodation blocks where the gas can enter through doors, ports or ventilation intakes.
- The cargo deck and adjacent jetty, which are work areas even though they are usually regarded as free of sources of ignition.
- Adjacent vessels such as lightering tankers, bunker and stores craft, pilot and crew-transfer boats.

2.1.3.1 The dispersion process

A mixture of hydrocarbon gas and air (or IG), emerging vertically from an outlet, rises under its own momentum as a plume above the outlet. If there is no wind, the plume remains vertical, 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 also reduces the hydrocarbon gas concentration and, therefore, the gas density in the plume. The progressive plume decreases in velocity, hydrocarbon concentration and density, together with the wind speed and other meteorological factors, determine the final shape of the plume and the flammable zone.

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

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

These high velocity vents and risers may not be placed closer than ten metres to any accommodation block air intakes so that any vapours are safely dispersed before they reach them.

2.1.3.2 Wind speed

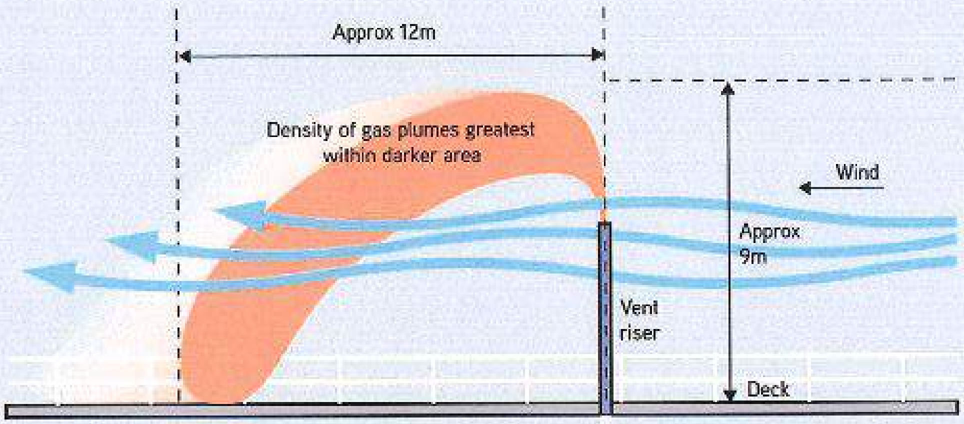
Low wind speeds inhibit the dispersion of hydrocarbon gas/air mixtures. This observation is based on experience on tankers, although little experimental work has been done to obtain quantitative information on the effect of wind speed. Much depends upon the quantity of gas being vented and how it is vented, but experience at terminals has shown that at wind speeds above 5m/sec (ten knots), dispersion is enough to minimise flammability risk. However, this wind speed is an indication only and each operation should be assessed on a case by case basis.

2.1.3.3 Rate of flow of gas

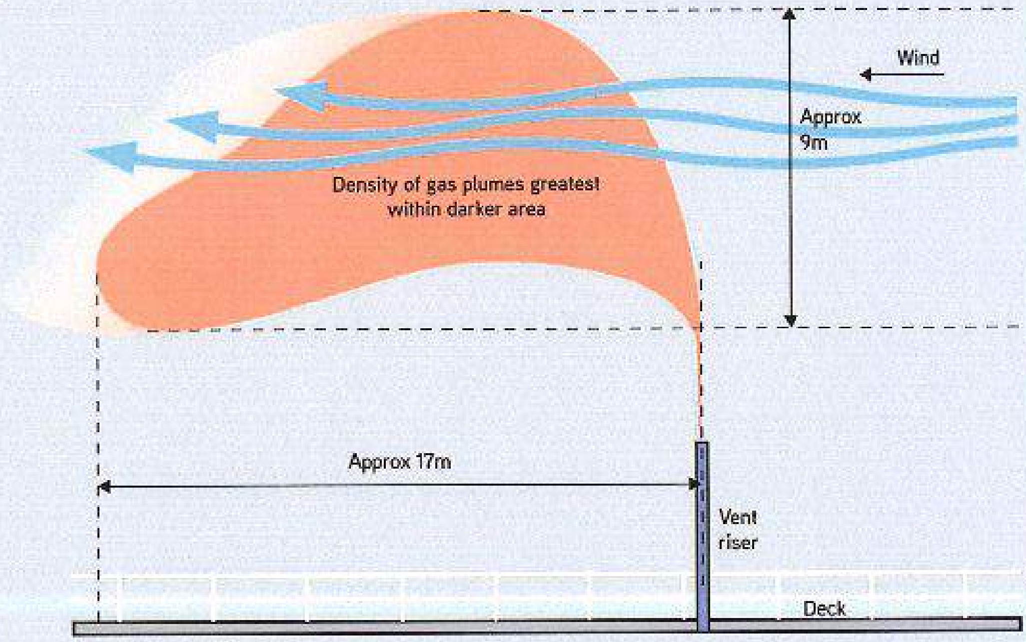
As the flow rate of a hydrocarbon gas/air mixture of fixed composition increases through a given opening, several effects come into play. First, the rate of emission of the hydrocarbon constituent increases in proportion to the total gas/airflow rate, so the distance the plume travels before it is diluted to the LFL should be greater. However, the higher the velocity, the more efficient the mixing of the initially hydrocarbon-rich gas with the air, which tends to counterbalance the first effect.

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

The results of the interaction of these different processes at low wind speeds are shown in figure 2.1. The gas mixture that these diagrams use is 50% by volume propane and 50% by volume air, which is typical of that expected when topping-off a crude oil cargo. At the lowest flow rate, figure 2.1 (a), the density effect predominates and the gas sinks back towards the deck. At the highest flow rate, figure 2.1 (c), mixing is far more efficient and there is no tendency for the plume to sink.



a) Total gas flow 9m³/minute. Approximate loading rate 465 tonnes/hr.



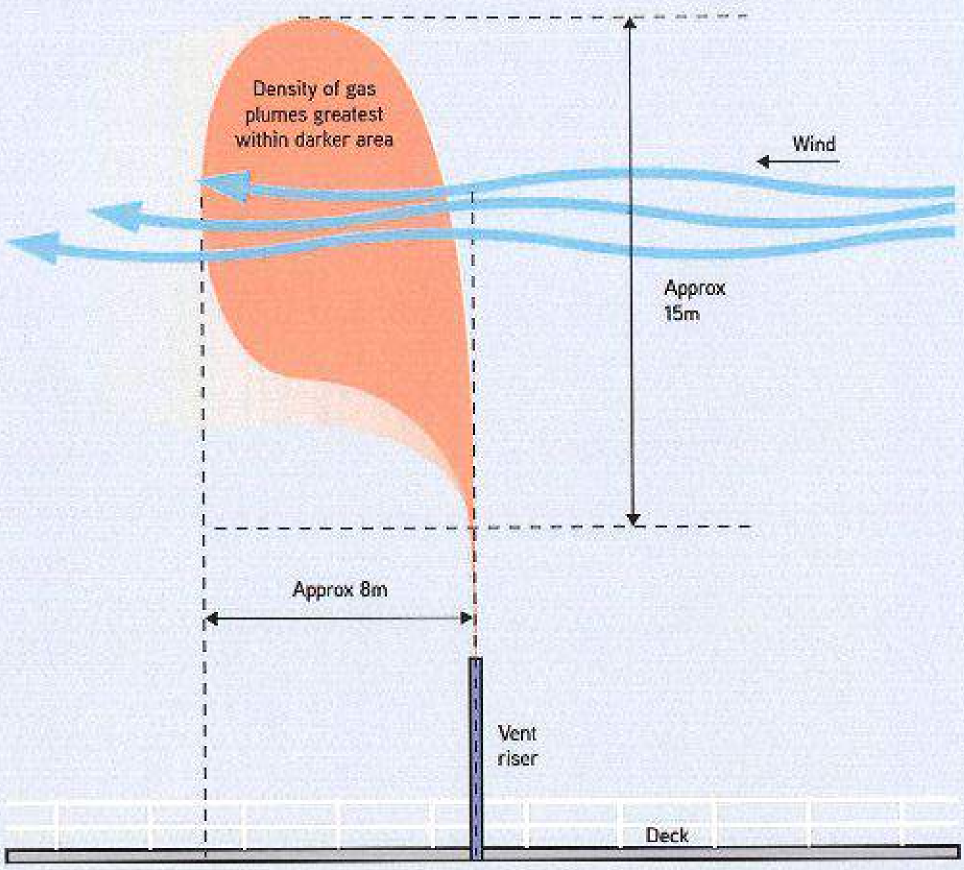
b) Total gas flow 28m³/minute. Approximate loading rate 1,400 tonnes/hr.

Both illustrations above show a vent riser 6m above the deck.

The plumes are based upon wind tunnel data of:

Gas mixture	50% by volume propane in the air
Diameter of opening	254mm
Wind speed	1.1m/sec

Figures 2.1 (a) and (b): Indicative effect of gas flow rate on flammable zone



c) Total gas flow 46m³/minute. Approximate loading rate 2,300 tonnes/hr.

The above illustration shows a vent riser 6m above the deck.

The plumes are based upon wind tunnel data of:

Gas mixture	50% by volume propane in the air
Diameter of opening	254mm
Wind speed	1.1m/sec

Figure 2.1 (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, which would be even more pronounced with a natural gasoline type cargo. The greater dilution required to reach the LFL with motor or aviation gasolines (see section 1.2.2) tends to make the flammable zones larger than for crude oils and the flammable zone for natural gasolines is even larger. Therefore, the dispersion problem gets progressively worse from crude oils to motor or aviation gasolines to natural gasoline type cargoes.

2.1.3.4 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 emerges from the opening becomes greater, so there is a greater tendency for the plume to sink.

At low concentrations a flammable zone similar in outline to that shown in figure 2.1 (c) is 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 the shapes in figures 2.1 (b) and 2.1 (a) as the increasing density exerts its influence. The overall size of the zone becomes greater due to the greater rate of emission of hydrocarbon gas.

2.1.3.5 Cross-sectional area of the opening

The area of the opening that the hydrocarbon gas/air mixture emerges from determines, for a given volumetric rate of flow, the linear flow velocity and so the efficiency of the mixing of the plume with the atmosphere. Effects of this kind occur during gas freeing, for example. 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 encourage dispersion in the atmosphere. When using small portable blowers, which normally should 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, which encourages the gas to remain close to the deck.

2.1.3.6 The design of the vent outlet

The design and position of a vent outlet must comply with current SOLAS requirements. For certain operations, such as gas freeing, vapour may be vented from the tank through apertures other than the designated tank vents.

2.1.3.7 Position of the vent outlet

If vent outlets are 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. Figure 2.2 illustrates the kind of eddies formed. 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, turbulent air tends 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 2.3 (a) shows the flammable zone from a tank opening only about 1.5m upwind of an accommodation block. The plume is almost vertical and only just touches the accommodation block. However, a lower rate of venting would result in the zone coming into much wider contact with the accommodation block.

Figure 2.3 (b) shows the effect of an extra opening, which results in double the amount of gas being released. Partly as the result of eddies and partly due to the denser combined plume, the flammable zone is in close contact with the top of the accommodation block.

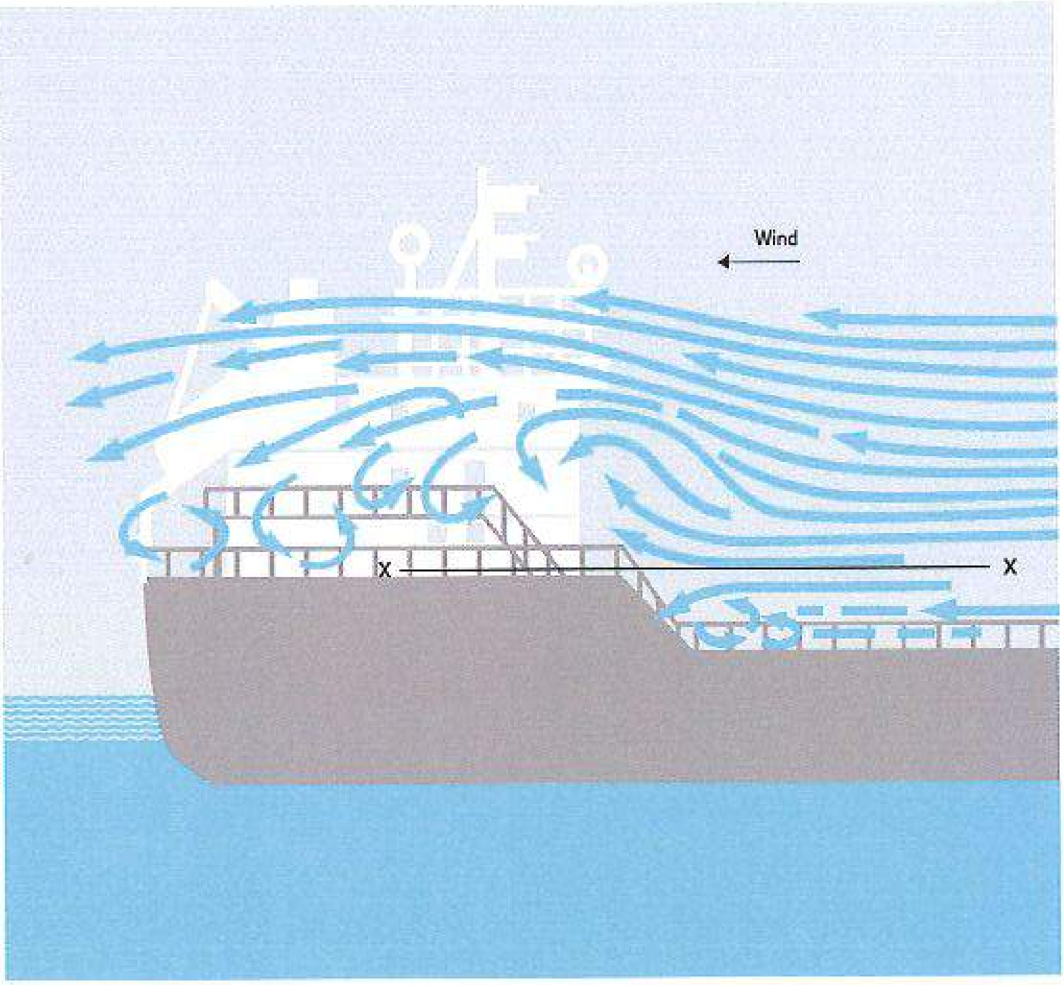


Figure 2.2: Typical pattern of airflow around an accommodation block

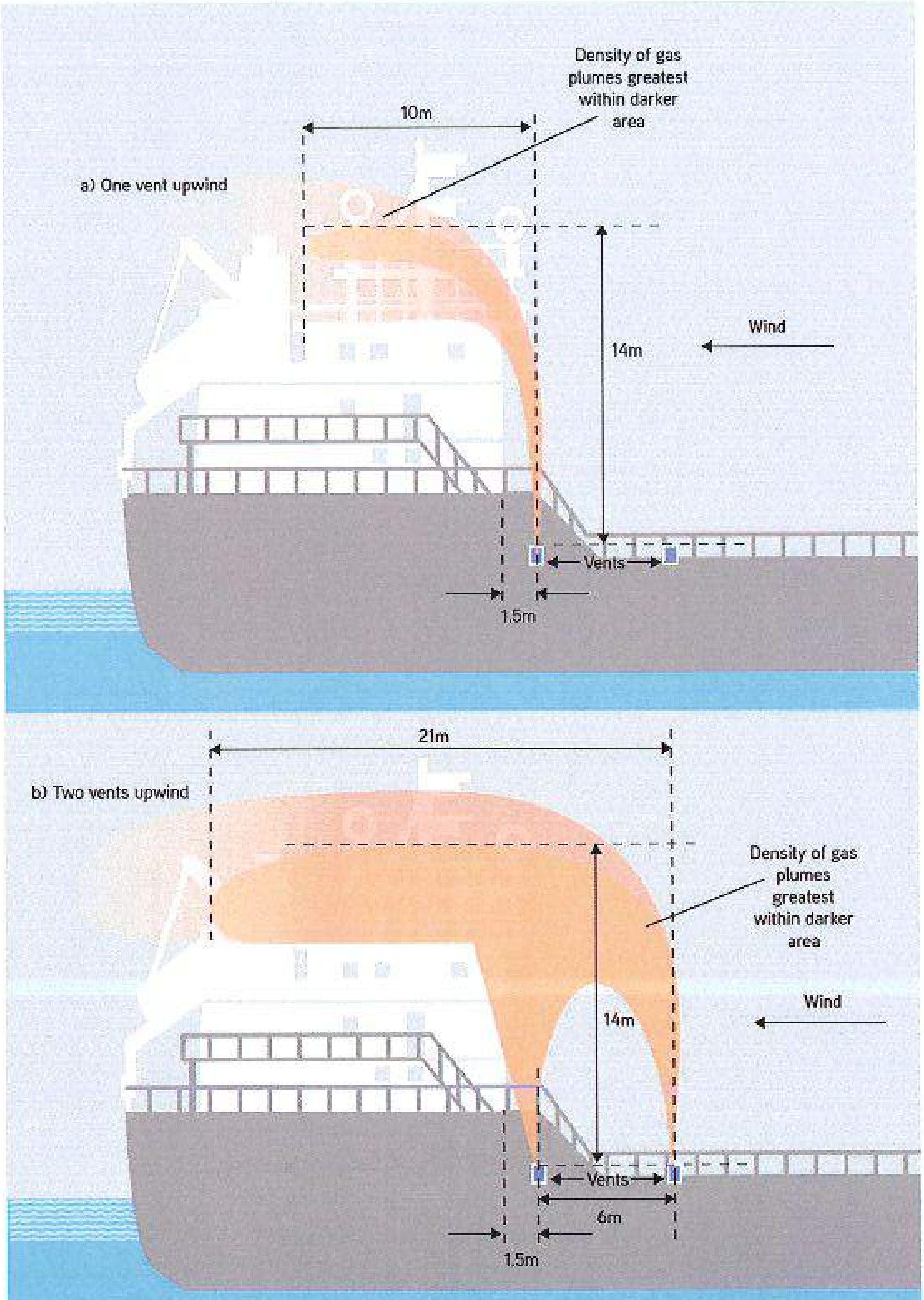
2.1.4 Minimising hazards from vented gas

The objective of venting arrangements and their operational control is to minimise the possibility of flammable gas concentrations entering enclosed spaces where there are sources of ignition, or reaching deck areas where, despite all other precautions, there might also be a source of ignition. Previous sections have described ways of promoting rapid dispersion of gas and minimising its tendency to sink to the deck. While this section is concerned with flammability, the same principles apply to the dispersion of gas down to hydrocarbon concentrations that are safe for personnel.

SOLAS requires the following conditions for any operation where flammable mixtures are displaced to the atmosphere or where displaced mixtures could become flammable on dilution with air, such as on inerted tankers:

- An unimpeded vertical discharge at a high efflux velocity.
- The outlet positioned sufficiently high above the deck.
- The outlet placed 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 depends on whether venting is through a mast riser or a high velocity vent valve.



Both illustrations above are based upon wind tunnel data of:

Gas mixture	50% by volume propane in the air
Diameter of openings	152mm
Wind speed	1.1m/sec
Total gas flow per opening	1,220m³/hr

Figures 2.3 (a) and (b): Flammable zone from apertures near an accommodation block

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

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

When gas freeing by portable blowers, it may be necessary to open a tank hatch lid to act as a gas outlet, resulting in a 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 an open hatch, localised areas may have an atmosphere 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, exercise great vigilance, especially under bad conditions, e.g. if there is little or no wind. In such cases, it may be prudent to stop operations until conditions improve.

2.2 Loading very high vapour pressure cargoes

2.2.1 Gas evolution

Cargoes yielding deeper layers are sometimes encountered. The main examples are crude oils, which may have their vapour pressures increased by an additional gas, such as butane, and some natural gasolines (by-products of Liquefied Natural Gas (LNG)/LPG production) that are sometimes known as pentanes plus (or C5+).

Examples of the variation of gas layer depth (greater than or equal to 50% by volume concentration level) related to TVP are shown in figure 2.4 for typical natural gasolines and crude oils. Some cargoes have intermediate properties, e.g. 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 content.

The natural gasoline curve in figure 2.4 is for a series of blends with different TVP. The crude oil curve is for a series produced by adding increasing amounts of butane to a crude oil. At lower TVP, the dependence of depth on TVP is not marked for either type of cargo. At greater TVP, the curve becomes progressively steeper, indicating that in this range a small increase in TVP can cause a large increase in gas evolution.

Boiling starts when the TVP exceeds one 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 one bar is reached. Crude oils may be stabilised so that their TVPs are near, or somewhat above, one bar as they enter the tanker. In practice, 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. In addition, 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, even though the TVP of the bulk of the liquid is above one bar. This is why crude oils can be handled with their TVPs somewhat above one 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 far greater with the 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 than with crude oils.

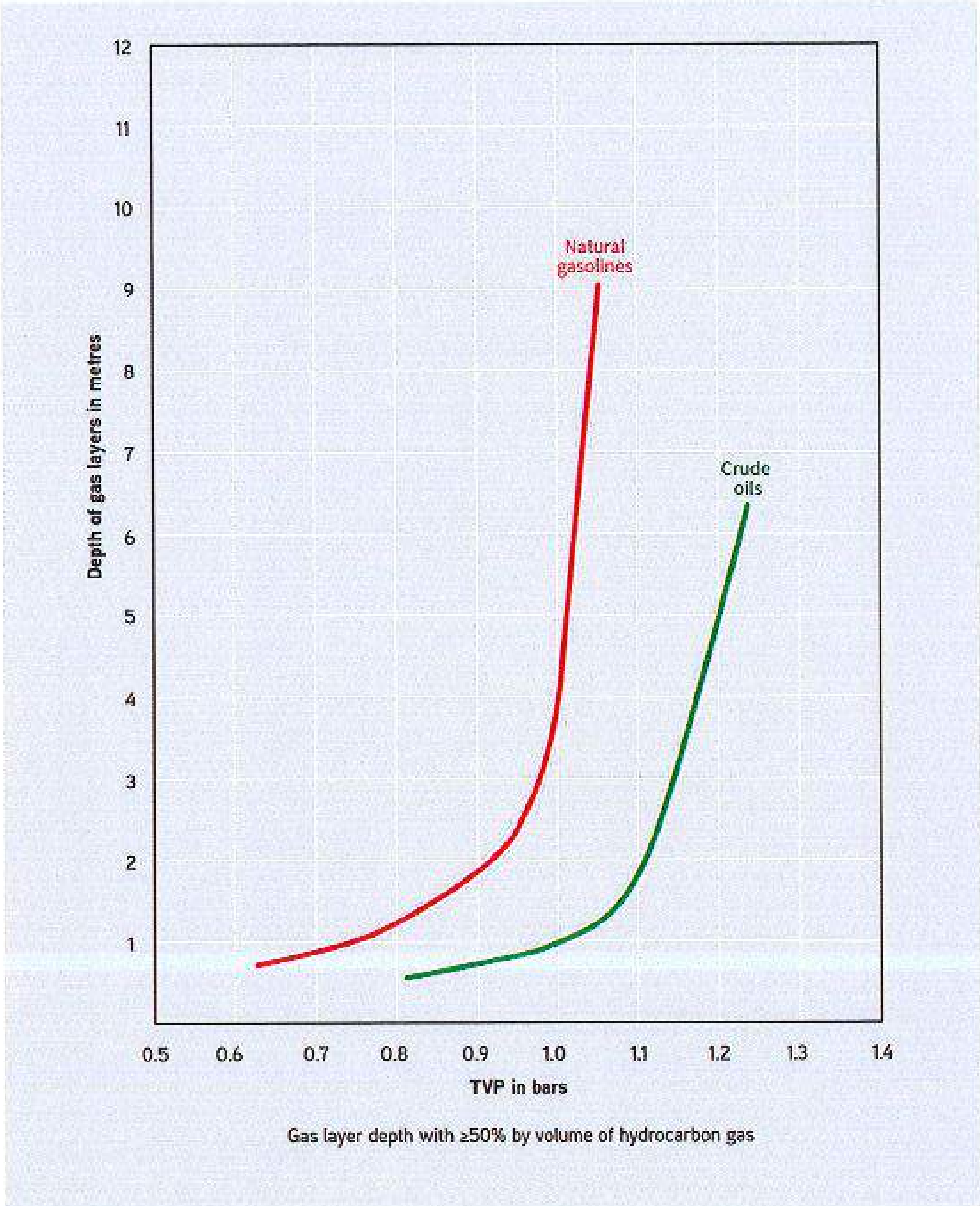


Figure 2.4: Relationship between depth of gas layer and TVP

2.2.2 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.

Curves of the kind in figure 2.4 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 RVP of a cargo gives 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 tankers. As a general guide, the available information suggests that special precautions may be needed when the TVP is expected to exceed the following values:

- For natural gasoline type cargoes, e.g. pentanes plus (C5+), 0.75 bar.
- For crude oils, with or without added gas, 1.0 bar.
- For some intermediate cargoes, e.g. 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 RVPs are known, TVPs can be calculated by checking with the above criteria.

Precautions that might be applied are given in section 12.1.8.

2.3 Volatile Organic Compounds

Volatile Organic Compounds (VOCs) are organic compounds that have a high vapour pressure at ambient temperature. These include, but are not limited to, hydrocarbons that are emitted during cargo operations. Some of these compounds are harmful to health and/or the environment, e.g. benzene. For further information on the control of VOC emissions refer to OCIMF's *Volatile Organic Compound Emissions from Cargo Systems on Oil Tankers*.

2.4 Gas measurement

This section describes the operating principles, applications and limitations of equipment and instruments used for measuring concentrations of hydrocarbon gases, other toxic gases and oxygen.

It is essential that any instrument used is:

- Suitable for the gases and atmosphere to be tested.
- Sufficiently accurate for the test required.
- Used within the instrument's design ambient range.
- An approved type.
- Correctly maintained, tested and calibrated.

Manufacturer's instructions or recommendations for any of the instruments mentioned should take precedence over the guidelines in this publication.

2.4.1 Provision of gas measurement instruments

Tankers should be equipped with at least two instruments capable of measuring, as a minimum, concentrations of oxygen, flammable gases or vapours (% LFL), H_2S and CO in order to carry out the tests required for enclosed space entry.

Note that enclosed spaces might have additional atmospheric hazards that may not be detected by these instruments. If this is known to be the case, additional means to measure the toxic gases in the cargoes being carried should be provided. An up-to-date inventory of the instruments should be maintained on board.

Tankers equipped with IG or nitrogen padding should ensure that the instruments are also capable of measuring oxygen and hydrocarbon content (% Vol) in an inert atmosphere.

Gas detection instruments should be capable of remote sampling through the entire height of the compartment for any gas they are designed to detect, unaffected by the atmosphere or any other characteristic of intervening spaces.

Every instrument should have a manual that describes its features, settings and alarms and explains calibration, testing, operation and maintenance. The information in the manuals should be available in the working language of the tanker.

2.4.1.1 Arrangements for gas measurement in double hull spaces and double bottom spaces

Suitable portable instruments for measuring oxygen and flammable vapour concentrations in double hull spaces and double bottom spaces should be provided. In selecting these instruments, pay attention to their use in combination with the fixed gas sampling lines referred to below.

Where the atmosphere in double hull spaces cannot be reliably measured using flexible gas sampling hoses, such spaces should be fitted with permanent gas sampling lines. The configuration of gas sampling lines should be adapted to the design of the spaces.

The construction material and dimensions of gas sampling lines should prevent restriction. Where plastic materials are used, they should be electrically conductive.

2.4.1.2 Protection of cargo pumprooms on tankers

A system for continuous monitoring of the concentration of hydrocarbon gases should be fitted. When this concentration reaches a pre-set level (not be higher than 10% LFL), it should automatically activate a continuous audible and visual alarm in the pumproom, engine control room, cargo control room and navigation bridge to alert personnel to the potential hazard.

2.4.1.3 Arrangements for fixed hydrocarbon gas detection systems in double hull and double bottom spaces of oil tankers

Oil tankers of 20,000 tonnes DWT and above, constructed on or after 1 January 2012, must have a fixed hydrocarbon gas detection system that complies with the fire safety systems code for measuring hydrocarbon gas concentrations in all ballast tanks and void spaces of double hull and double bottom spaces next to the cargo tanks, including the forepeak tank and any other tanks and spaces under the bulkhead deck next to cargo tanks.

Oil tankers with constantly operating inerting systems for such spaces do not need to have fixed hydrocarbon gas detection equipment.

2.4.2 Gas measurement instruments

Some gas measurement instruments can analyse only one type of gas. Others can analyse several pre-set types of gases at the same time (multi-gas detectors) and have a range of capabilities based on different technologies. They can be divided into personal, portable and fixed gas measurement instruments and can be further classified by their function.

Personal gas measurement instruments: these are used to continuously monitor a worker's immediate environment. They should be worn and switched on at all times. They are not to be used in inerted atmospheres or pressures above atmospheric. When a gas measured by the equipment is detected at concentrations above the permissible limit, the instrument will produce an audible and visual alarm and will vibrate to alert the user to an imminent danger.

Portable gas measurement instruments: these measure different atmospheres, usually remotely and using an extension hose, mainly in confined spaces. They are not for personal use but to determine the condition of a particular space, e.g. a cargo tank, ballast tank, cofferdam or drain tank. Many of these instruments can be used in inerted atmospheres at atmospheric pressure and other pressures as defined by the manufacturer.

Fixed gas detection installations: these measure gas concentrations remotely and can be used to measure more than one type of gas at the same time.

2.4.3 Instruments for measuring hydrocarbon concentration

Combustible gas detectors: these measure hydrocarbon gas in air at concentrations below the LFL at atmospheric pressure to detect the presence of potential flammable atmospheres. The readings are usually shown and recorded as % LFL. They are used before entry in spaces such as pumprooms or washed and ventilated cargo tanks.

Hydrocarbon gas meters: these measure hydrocarbon gas as a percentage by volume of the total atmosphere being measured. This is usually done to measure the percentage of hydrocarbon vapour in oxygen deficient atmospheres (inerted cargo tanks). The readings are expressed as the percentage of hydrocarbon vapour by volume and are recorded as % Vol.

2.4.4 Instruments for measuring oxygen concentrations

These instruments measure oxygen concentrations in inerted or non-inerted atmospheres.

Correctly interpreting oxygen concentrations is crucially important. Normal concentration of oxygen in fresh air is 20.9% and modern oxygen analysers are capable of measuring to a high level of accuracy. However, it is always important to check for oxygen, hydrocarbons and other toxic gases before a decision is made to enter an enclosed space.

There could be toxic levels of harmful gases that may not be apparent purely from readings obtained by an oxygen analyser. A small reduction of oxygen concentration, for example, from 20.9% to 20.5% may be due not only to factors such as temperature fluctuations, humidity or equipment accuracy, but also to the presence of toxic gases that should be tested for.

2.4.5 Instruments for measuring toxic gases

Throughout this guide the percentage of oxygen in air is referred to as 21%. However, due to atmosphere characteristics and variation, the percentage of oxygen in air falls several hundredths of a percent below this figure, variously quoted as being between 20.80% and 20.95%.

Modern instrumentation with digital indicators can measure so accurately that the full 21% may be impossible to obtain. If an instrument capable of such accuracy is in use, the manufacturer's instructions should be carefully read and understood so that the readings can be properly interpreted.

Electrochemical sensors: these are suitable for measuring toxic gases down to low ppm levels. However, one should be aware that these sensors are susceptible to cross-sensitivity and, therefore, may measure gases other than the target gas.

Chemical indicator tubes: these can measure a wide range of gases and tubes exist for each specific gas in varying measurement ranges. They can be used to analyse both inerted and non-inerted atmosphere at atmospheric pressure, in accordance with manufacturer's instructions, and are used to find a specific type of gas within enclosed spaces, including hydrocarbon gas, toxic gases and VOCs. For example, there are tubes for H_2S, acetone, ammonia, benzene and ethanol. They are single use only.

Optoelectronic instruments: these combine the chemical indicator tubes with optoelectronic technologies. They can measure a wide range of gases because there is a chip for each specific gas and concentration. They can analyse non-inerted atmospheres and are unaffected by fluctuations in air pressure. They can also measure gases such as methyl tert-butyl ether, acetone, benzene and CO.

Direct-reading Photoionisation Detectors (PIDs): these measure VOCs within enclosed spaces prior to entry, but are not limited to this function. They can also analyse non-inert atmospheres, although samples should be at atmospheric pressure. They provide an accurate, alternative way of measuring 10% of LFL for enclosed space entry. An exception to this is that there is no response to methane (CH_4), so these instruments should not be used if methane approaching LFL levels may be present.

2.4.6 Technologies used to measure flammable atmospheres, toxic vapours and oxygen

2.4.6.1 Catalytic sensor

Operating principle

This type of sensor consists of two filaments heated to a temperature between 400 and 600°C. When hydrocarbon gas reaches them, oxidation occurs. This chemical reaction causes a variation in the electrical resistance of the filaments. This variation, which is proportional to the gas concentration, is measured by an electronic circuit and projected on an analogue or digital display as % LFL (see figure 2.5).

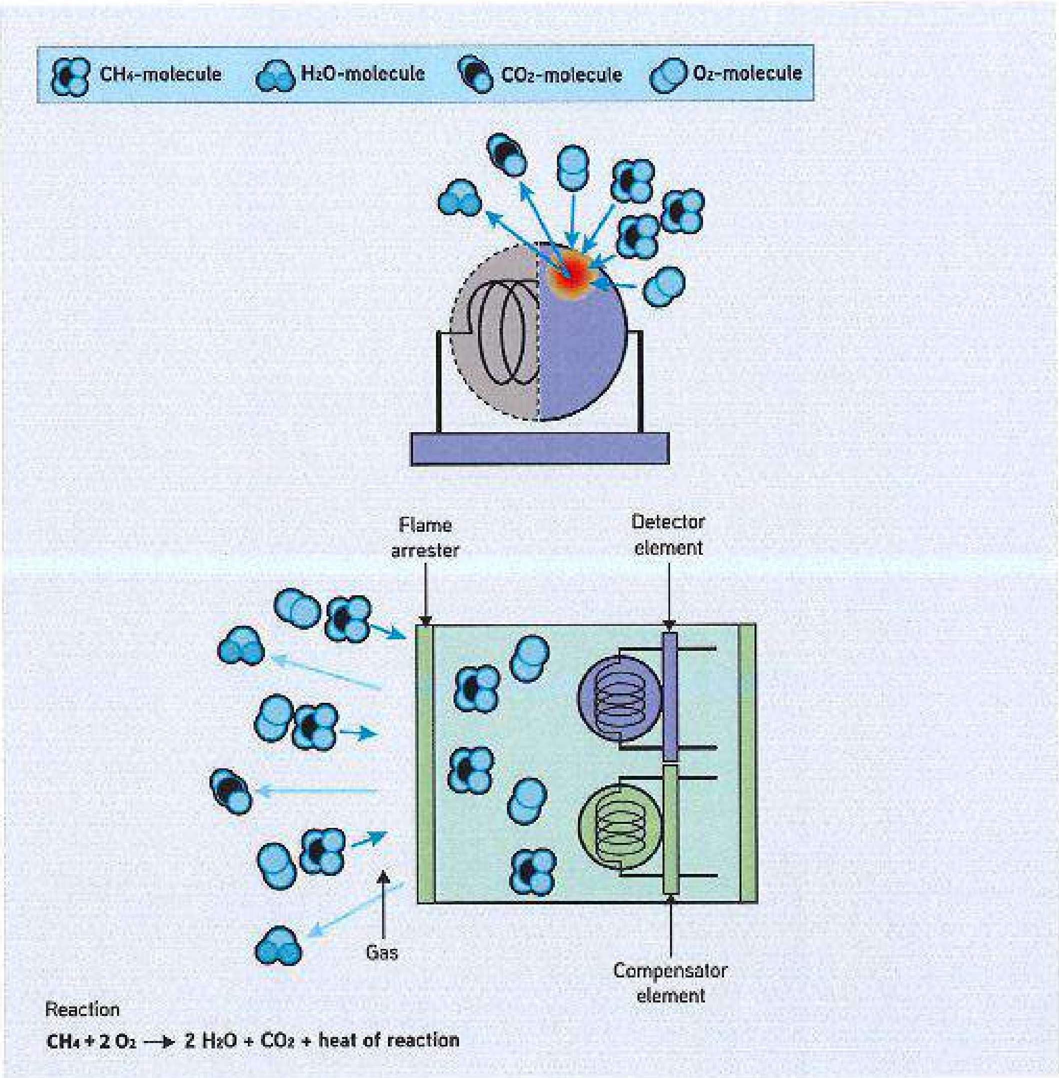


Figure 2.5: Catalytic heated filament sensor

Application

This type of sensor is used to measure the % LFL of flammable gases in air, at atmospheric pressure.

Some examples where these sensors may be used include, but are not limited to:

- Pumprooms.
- Ballast tanks and cofferdams.
- Decks.
- Gas free cargo tanks.
- Near hot work.

Cautions

These sensors should not be used in oxygen depleted atmospheres (less than 11% oxygen by volume).

The samples should always be taken within the manufacturer's design pressure limits, as pressure above these limits could potentially damage the sensor. Liquids, e.g. water, oil, should never enter the sensors. To prevent this, use a water trap and a floating probe. The manufacturer's recommended filters should be used to remove solid particles and humidity from the sample.

Some compounds may reduce the sensitivity of the filaments, either temporarily or permanently, e.g. silicon gases, organic lead compounds, freons, chlorinated hydrocarbons and H_2S. If the presence of H_2S is suspected, this should be tested before any measurements of hydrocarbon concentrations.

The sensors may also be temporarily affected by condensation. This may occur when the instrument is taken from an air-conditioned environment into a humid atmosphere. Allow time for the sensors to acclimatise to the ambient temperature before use.

Gas measurement instruments that use this technology

Combustible gas detector.

2.4.6.2 Thermal conductivity sensor

Operating principle

The sensing element is a non-catalytic heated filament. The composition of the sample gas surrounding the filament determines the rate of heat loss from the filament and, therefore, its electrical resistance.

This variation, which is proportionate to the gas concentration, is measured via an electronic circuit and displayed as % Vol. The heat loss is non-linear but the scale in the instrument reflects this, so a direct reading is given to the user.

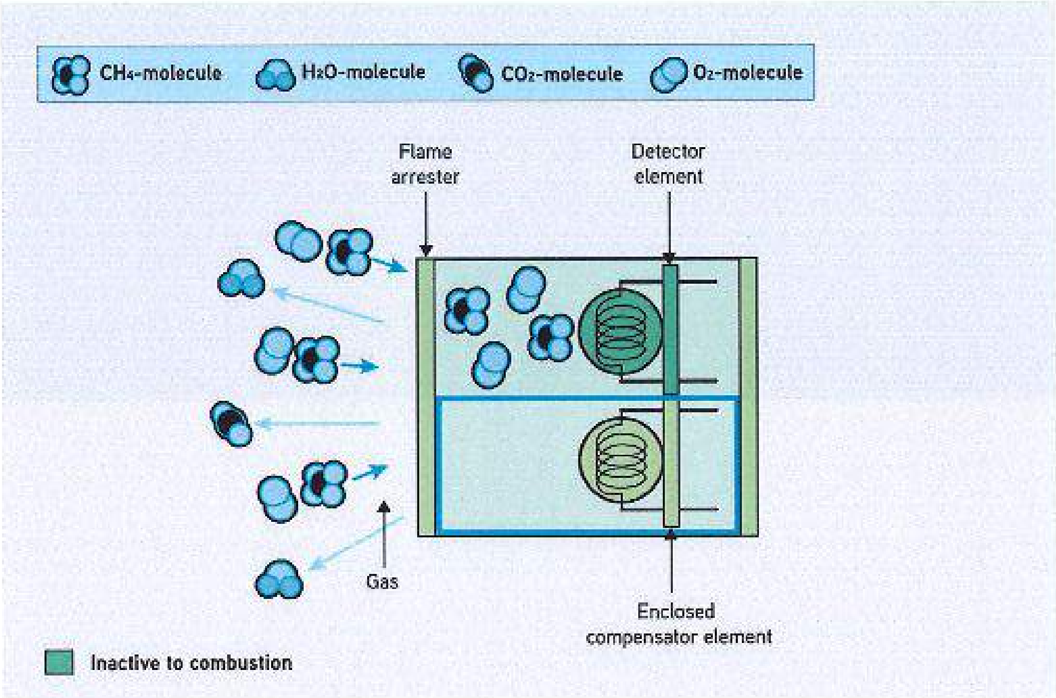


Figure 2.6: Thermal conductivity sensor

Application

This type of sensor does not require oxygen for operation and is capable of measuring concentrations of up to 100% by volume. When used directly on tanks, the pressure should be within the range defined by the manufacturer.

Some examples of areas where it might be used are:

- Inerted cargo tanks.
- Purging of cargo tanks.
- Areas where gas concentrations are expected to exceed the LFL.

Cautions

If a flow sensitive type of thermal conductivity sensor is used, additional care should be given to ensure a stable flow through the instrument, as per maker's recommendations, or it may result in erroneous reading.

Liquids, e.g. water, oil, should never enter this instrument. To prevent this, use a water trap and a floating probe. Only the manufacturer's recommended filters should be used to remove solid particles and humidity from the sample.

Gas measurement instruments that use this technology

Hydrocarbon gas meter.

2.4.6.3 Infrared sensor

Operating principle

This type of sensor is based on the principle that hydrocarbon gases absorb Infrared (IR) light, but air does not.

IR radiation is produced from the transmitter and shines through a window in the measuring chamber. It is focused and reflected by a mirror to a filter to be finally converted into an electric signal.

If the chamber contains a hydrocarbon gas, part of the radiation will be absorbed by the gas. The differences between the radiation from the transmitter and the one received at the filter is proportional to the concentration of the gas analysed (see figure 2.7).

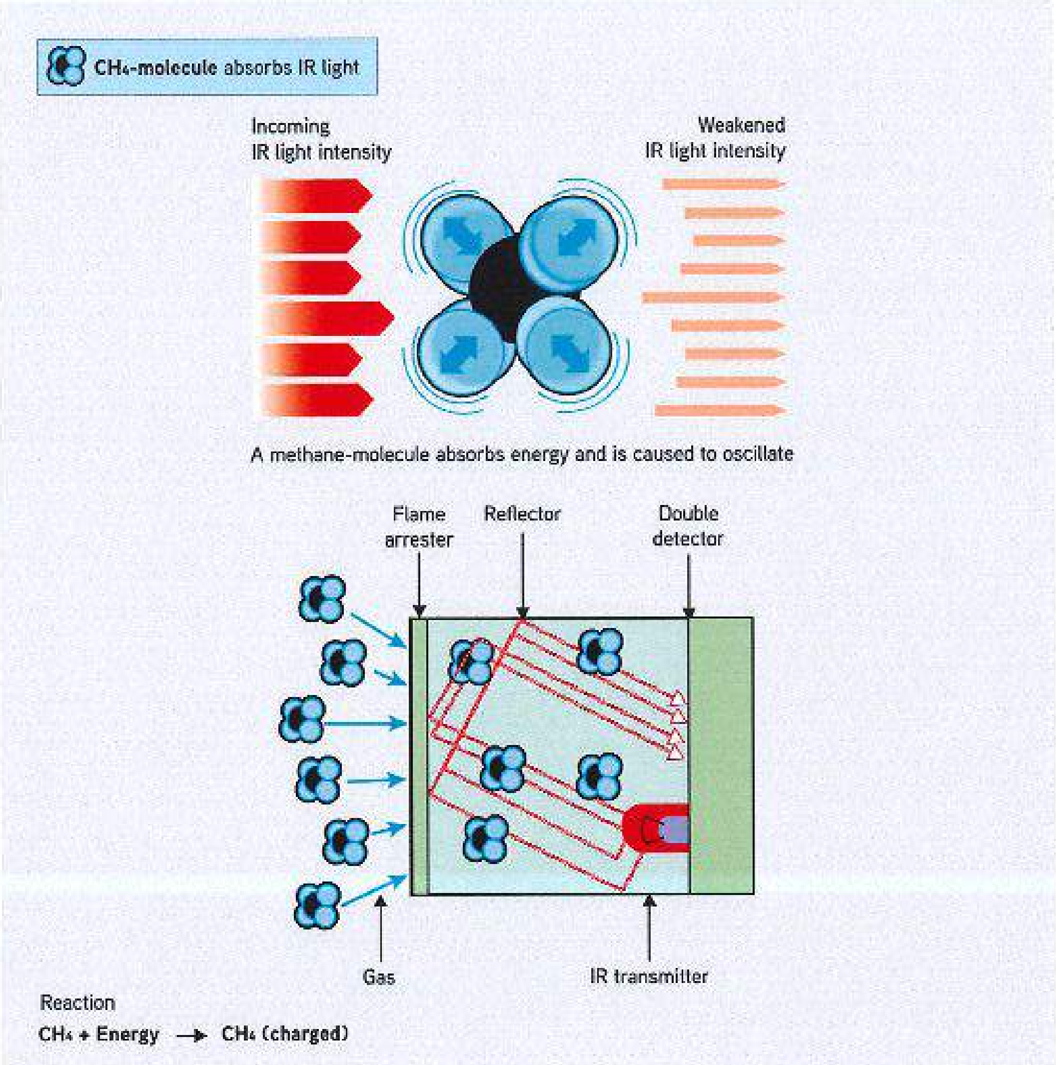


Figure 2.7: IR sensor

Application

Depending on the model, this technology can be used to measure both % LFL and % Vol in inerted and non-inerted atmospheres.

Cautions

Sample pressure limitations depend on the model of the equipment.

Liquids, e.g. water, oil, should never enter this instrument. To prevent this, use a water trap and a floating probe. Only the manufacturer's recommended filters should be used to remove solid particles and humidity from the sample.

This sensor is not affected by concentrations above the scale. The display will go off scale without affecting the instrument. It will read correctly once the concentration reduces sufficiently.

Gas measurement instruments that use this technology

Hydrocarbon gas meter and combustible gas detector.

2.4.6.3.1 Tunable diode laser gas sensor

Operating principle

The gas sample enters the cell of the analyser. A tunable diode laser emits a wavelength of near-IR light, specific to the gas to be measured, into the cell where it passes through the gas and is reflected by a mirror to a detector. Gas molecules in the sample absorb and reduce the intensity of the laser light energy in-direct proportion to their concentration. The detector measures the difference in light intensity and processes this signal to calculate the gas concentration in the sample.

Application

This technology measures a range of gases, including H_2S. This can be point or open-path measurement. Remote sensing is also possible.

Gas measurement instruments that use this technology

Fixed gas detection systems in terminals.

2.4.6.4 Refractive index meter/interferometers

Operating principle

This sensor measures the difference between the refractive indices of the sampled gas and air.

A beam of light is divided into two and then recombined at the eyepiece. One light path is via chambers filled with air, the other path is via chambers where the gas sample is pumped through. The recombined beams show an interference pattern depending on the refractive index of the gas supplied to the measuring chamber.

The interference pattern is interpreted to measure the concentration of gas sampled.

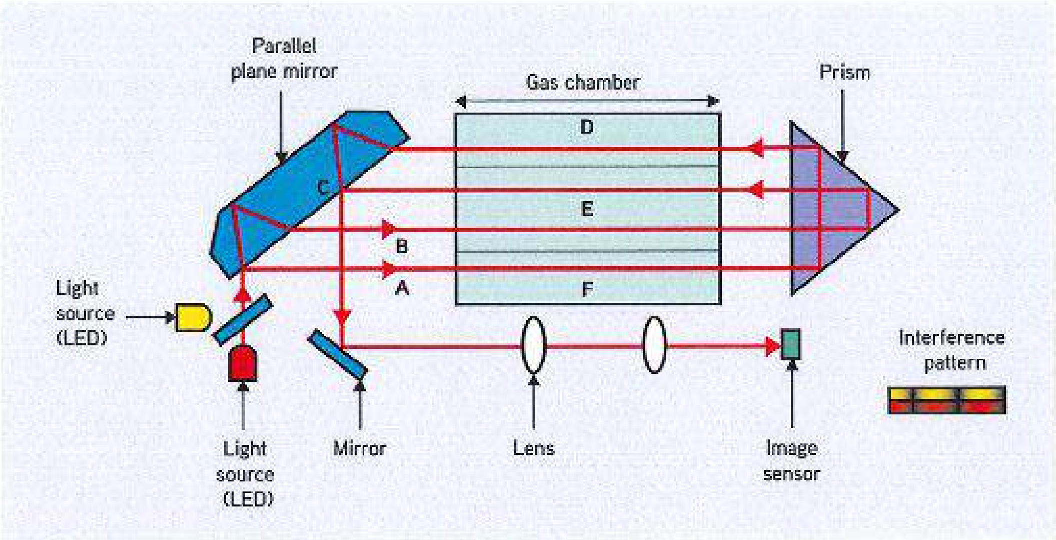


Figure 2.8: Refractive index meter/interferometers

Application

This technology is used to measure not only hydrocarbons, but also other gases such as toxic gases and other compounds.

Cautions

Sample pressure limitations depend on the model of the equipment.

Measuring the concentration of hydrocarbon gas in an inerted atmosphere is affected by the CO_2 present when flue gas is issued for inerting. In this case, soda lime is recommended as an absorbent for CO_2, provided the reading is corrected appropriately.

Liquids (e.g. water, oil) should never enter this instrument. To prevent this, use a water trap and a floating probe. Only the manufacturer's recommended filters should be used to remove solid particles and humidity from the sample.

This sensor is not affected by concentrations above the scale. The display will go off scale without affecting the instrument. It will read correctly once the concentration reduces sufficiently.

Gas measurement instruments that use this technology

Portable refractometer or interferometer.

2.4.6.5 Electrochemical sensor

Operating principle

Measuring cells can be built from compounds, or a mix of them, to react specifically with a gas and so generate an electric current that will be proportional to the concentration of the gas measured. This current is measured via an electronic circuit and visualised in an analogue or digital display (see figure 2.7).

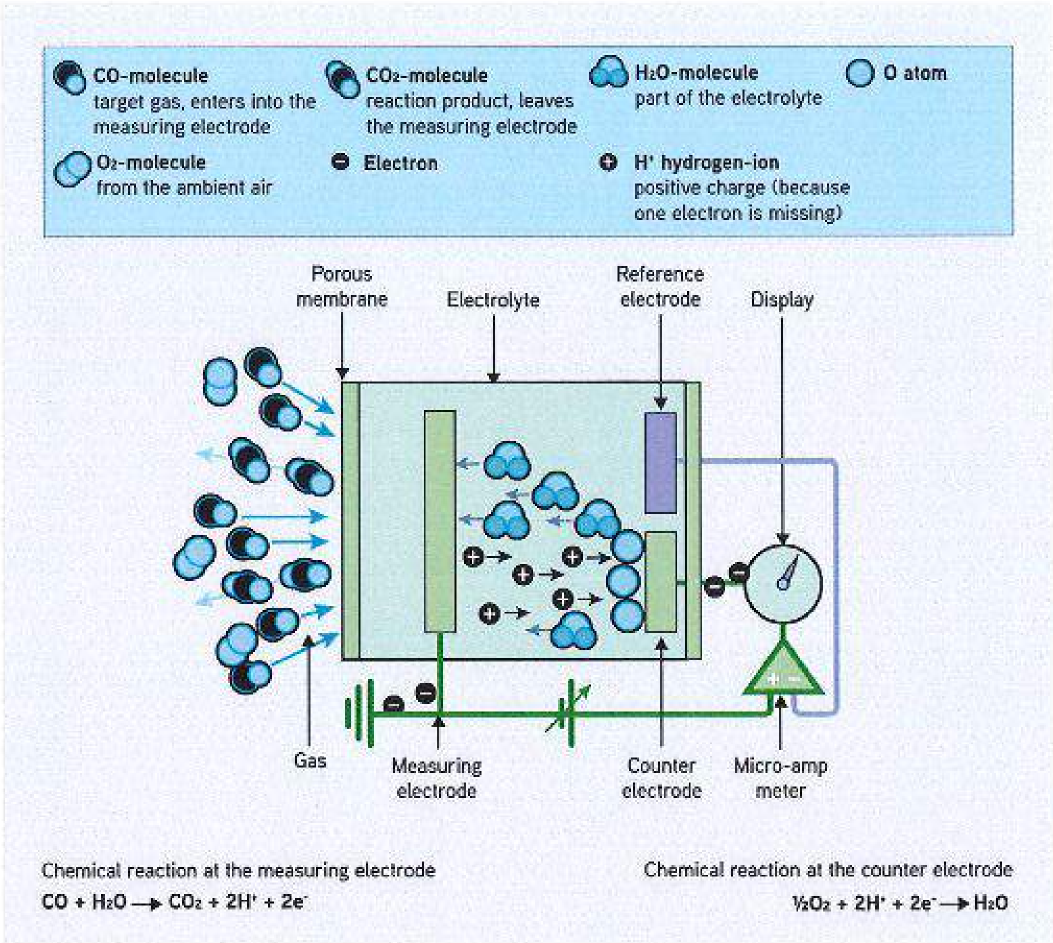


Figure 2.9: Electrochemical sensor

Application

This technology is used to measure not only hydrocarbon gases, but also gases such as ammonia, H_2S, CO, CO_2, SO_2 and oxygen.

Cautions

Sample pressure limitations depend on the model of the equipment.

Liquids (e.g. water, oil) should never enter this instrument. To prevent this, use a water trap and a floating probe. Only the manufacturer's recommended filters should be used to remove solid particles and humidity from the sample.

This sensor can be affected by concentrations over scale. They may cause temporary or permanent loss of sensitivity.

These sensors have an expiry date and should be replaced according to the manufacturer's recommendations.

Gas measurement instruments that use this technology

Hydrocarbon gas meter, oxygen meter and toxic gas measurement in single-gas or multi-gas instruments.

2.4.6.6 Chemical indicator tubes (colorimetric tubes)

Operating principle

Sealed glass tube containing a proprietary filling that reacts with a specific gas to give a visible indication of the concentration of that gas. The colour changes along the tube and the length of discoloration, which is a measure of the gas concentration, is read off an integral scale (see figure 2.10).

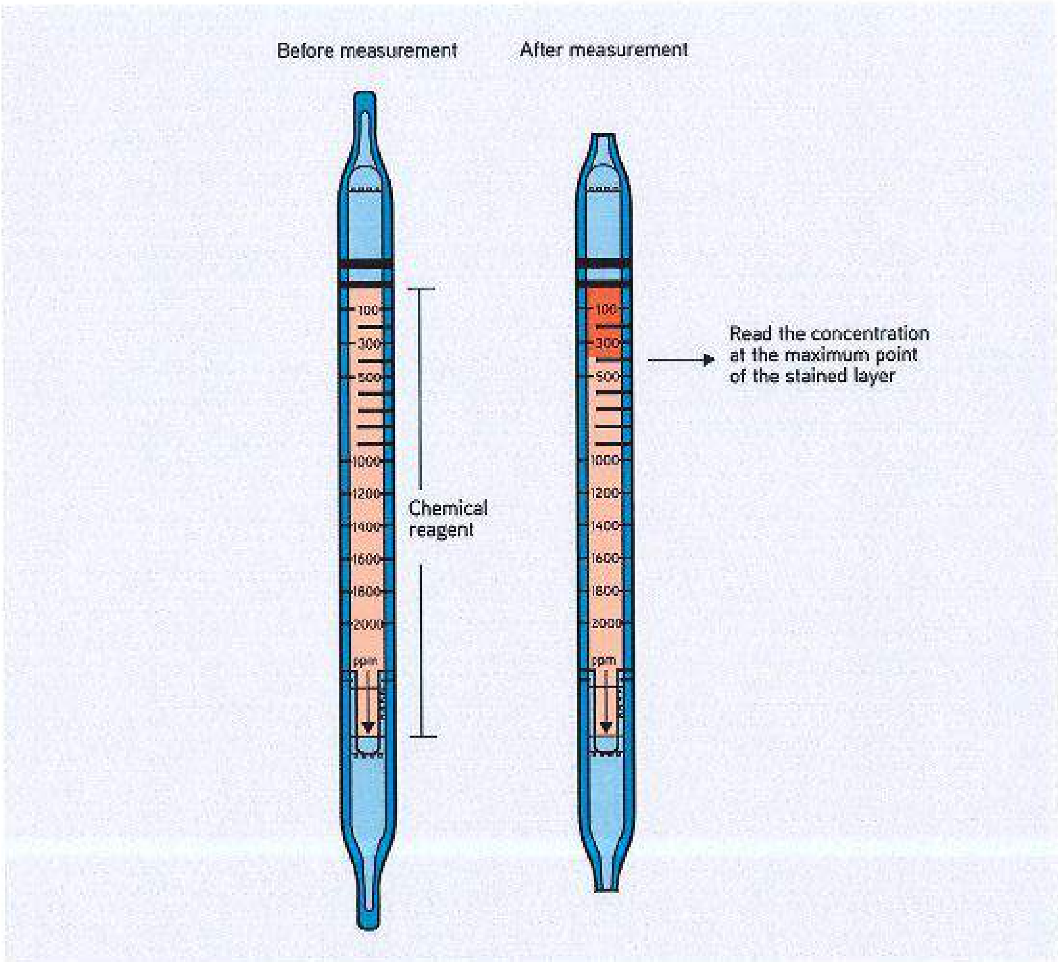


Figure 2.10: Chemical indicator tubes

Application

Chemical indicator tubes are used to measure concentrations of a variety of gases, including H_2S and benzene. An example is measuring benzene in a ventilated cargo tank in preparation for tank entry.

Cautions

Depending on the manufacturer, some tubes are designed to measure gas concentrations in air, while others can be used in inerted atmospheres. Their use is intended to be at atmospheric pressure and in accordance with the manufacturer's instructions.

For accurate results, all the components used should be from the same manufacturer, e.g. tubes, hand pump, hoses, etc. Do not use a tube from one manufacturer with a hand pump from another.

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

All chemical indicator tubes have an expiry date and should be replaced according to the manufacturer's recommendations.

Gas measurement instruments that use this technology

Colorimetric tubes.

2.4.6.7 Chemical reaction via optoelectronic sensor

Operating principle

As with chemical indicator tubes, a given gas reacts with a reagent. In this case the effect is measured by an optoelectronic detector and displayed digitally.

A capillary filled with a specific reagent is inserted into the instrument according to the gas to be measured. The sample is drawn through the capillary and interacts with the reagent. The optoelectronic unit detects the result of this chemical reaction and processes it via electronic circuits to display the concentration of the sample (see figure 2.11).

The time it takes to measure within this technology depends on the concentration of the sample. The higher the concentration, the shorter the analysis. When concentrations are low, the analysis time may be longer.

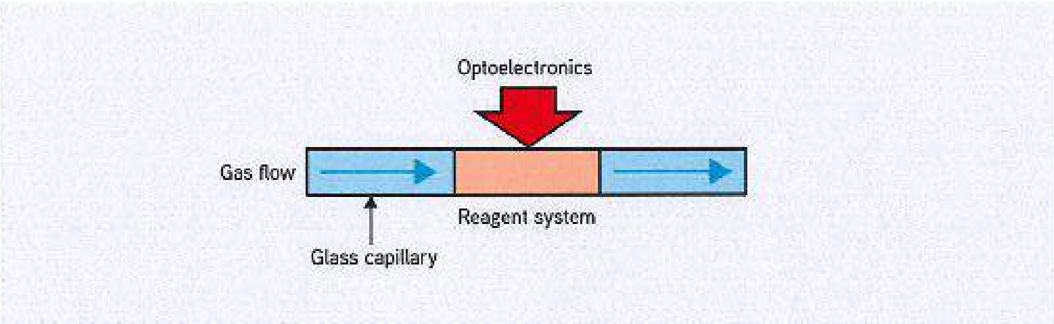


Figure 2.11: Optoelectronic detector sensor

Application

This technology is used for workplace monitoring of a wide variety of gases, including benzene and H_2S at different ranges of concentration.

Cautions

This system is designed to measure gas concentrations in air. Refer to the manufacturer to confirm if it can be used in IG. It should be used at atmospheric pressure.

Liquids, e.g. water, oil, should never enter this instrument. To prevent this, use a water trap.

All the components used should be from the same manufacturer, e.g. chips, measurement instrument, hoses, etc. Do not use a chip from one manufacturer with a measurement instrument from another.

As the measurement depends on a fixed volume of the gas, any extension hoses should be in strict accordance with the manufacturer's instructions.

Gas measurement instruments that use this technology

Proprietary systems.

2.4.6.8 Photoionisation (PID) sensor

Operating principle

A gas sample is introduced to the instrument through the gas inlet and an ultraviolet lamp then ionises hydrocarbon molecules within the sample. The molecules are exposed to an electrical field between electrodes. The magnitude of the resulting current is directly proportional to the concentration of ionised molecules inside the chamber. The current is translated into a direct reading of the gas concentration. This result is produced instantaneously (see figure 2.12).

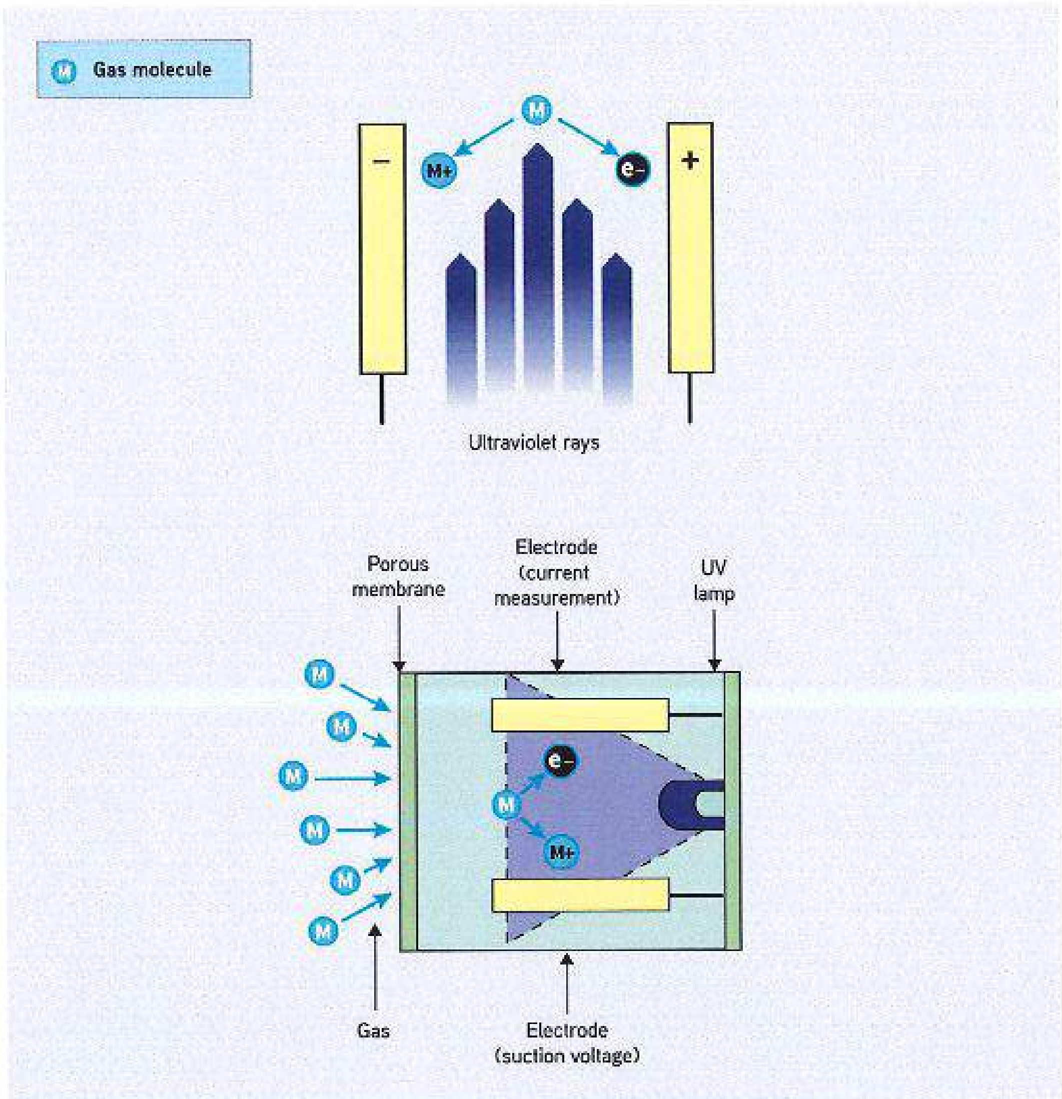


Figure 2.12: PID sensor

Application

This technology is primarily used to measure VOCs such as benzene and other hydrocarbons such as gasoline.

Cautions

Sample pressure limitations depend on the model of the equipment.

These sensors should not be used in an inerted atmosphere.

Liquids, e.g. water, oil, should never enter this instrument. To prevent this, use a water trap and a floating probe. Only the manufacturer's recommended filters should be used to remove solid particles and humidity from the sample.

This sensor is not affected by concentrations that exceed the scale reading and when concentrations reduce the readings will fall back into the range of the scale.

Gas measurement instruments that use this technology

Direct-reading PIDs.

2.4.6.9 Paramagnetic sensors

Operating principle

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

A sample cell has a lightweight body suspended in a magnetic field. When sample gas is drawn through the cell, the torque that the suspended body experiences is 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 so a measure of the magnetic susceptibility of the sample, i.e. related to its oxygen content.

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.

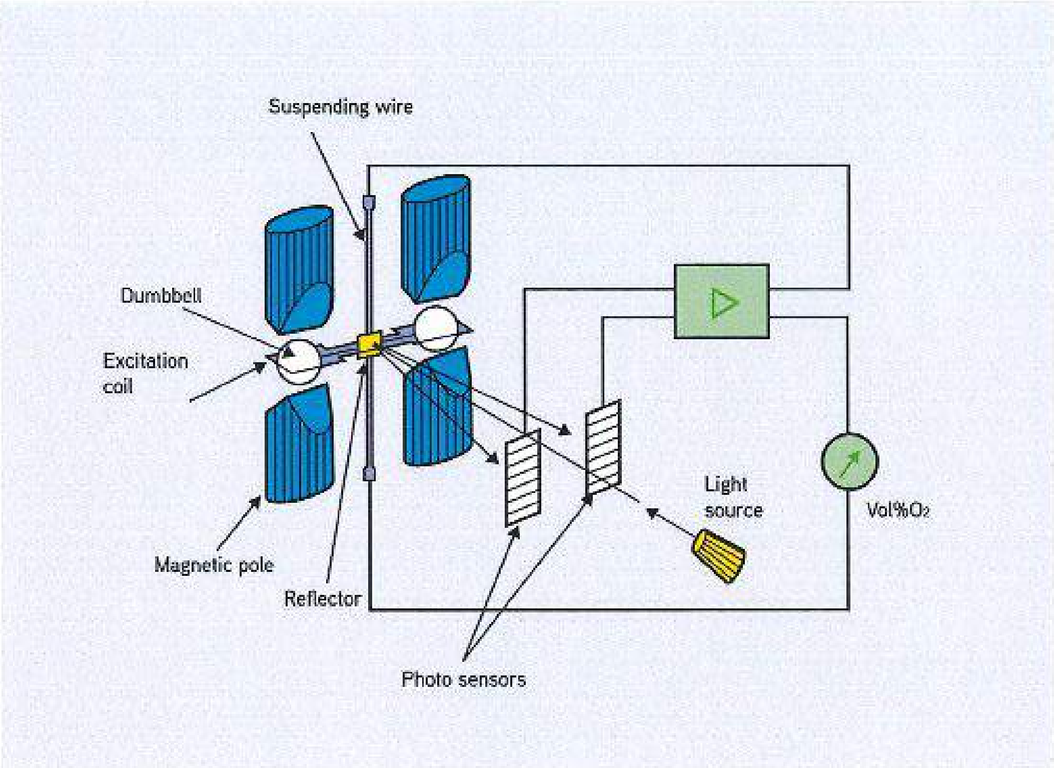


Figure 2.13: Paramagnetic sensor (dumbbell type)

Application

This technology is used to measure oxygen content in both inerted and non-inerted atmospheres.

Cautions

Before use, the analyser should be tested with air for a reference point of 21% oxygen, and with nitrogen or CO_2 for a 0% oxygen reference point.

Releasing nitrogen or CO_2 in a confined or unventilated area can lower the concentration of oxygen to a level that is an immediate danger to life or health. Therefore, calibration should only be carried out in well ventilated areas.

Clear or replace the filter when an increase in sample pressure is needed to maintain a reasonable gas flow through the analyser. The same reduction in flow effect is produced if the filter becomes wet due to insufficient gas drying. Check regularly the need to clean or replace filters.

Gas measurement instruments that use this technology

Fixed oxygen analysers.

2.4.7 Testing and calibrating gas measurement instruments

2.4.7.1 Operational testing (self-testing) gas measurement instruments

Operational testing should not be confused with a span gas check.

Gas measuring instruments should be tested in line with the manufacturer's instructions before daily use. Such tests are meant to ensure the instrument is in good working condition.

Physical checks should include (if applicable):

- Hand pump.
- Extension tubes and houses.
- Tightness of connections.
- Batteries.
- Housing and case.
- Filters and flame arresters.

Instruments not fulfilling the operational and physical tests should be clearly labelled to prevent their use. They should be calibrated and/or repaired before being brought back into use.

During operations it is important to check the instrument and sample lines occasionally. Operators should determine the frequency for these operational checks and record the results.

Operational testing should be included in the tanker and terminal systems for managing safety.

2.4.7.2 Testing gas measurement instruments

Portable and fixed gas measurement instruments should be tested at minimum recommended frequency using test gases as per the manufacturer's instructions and the company's SMS.

In any case, portable and fixed gas measurement instruments should be tested at least every month or after any fault.

When used for enclosed space entry, portable instruments should be tested daily prior to the start of atmosphere checks. This should include a visual inspection and a functional check. The purpose of carrying out a functional check is to verify that the equipment detects gas and gives an audiovisual alarm at required concentrations (International Electrotechnical Commission (IEC) 60079-29-2).

The requirement for pre-use checks should not include fixed equipment as their risk profile is not the same as that of portable instruments.

Testing of gas measurement instruments should only be undertaken by trained personnel, as per the manufacturer's instructions, and the test should be documented appropriately. Testing should not be confused with calibration checks.

2.4.7.3 Calibrating gas measurement instruments

Calibration, adjustment and additional maintenance should be carried out in line with the manufacturer's recommendations.

Calibration should be included in the tanker and terminal systems for managing safety.

2.4.7.4 Disposable personal gas monitors

To confirm they are working properly, disposable personal gas monitors should be tested regularly and in line with the manufacturer's recommendations.

Disposable gas detection monitors cannot be re-calibrated and should be safely discarded when they reach the calibration expiry date. It is important to record the date when disposable instruments are first commissioned in order to establish their expiry date.

2.4.8 Gas measurement instrument alarms

If a gas measurement instrument is fitted with an alarm, it should activate at the appropriate level as determined by the Flag State administration.

If a gas measurement instrument is fitted with an alarm or shutdown function that activates if the manufacturer's calibration interval is exceeded, the alarm should not be bypassed and the instrument should not be used until it is re-calibrated.

2.5 Sampling

2.5.1 Gas sample lines

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

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

The gases from crude oils and many petroleum products are composed of paraffinic hydrocarbons and several suitable materials are available for flexible sample tubing. The problem of material selection is more difficult for gases with a high proportion of aromatic hydrocarbons, particularly xylene. In such cases, suppliers of sample tubing should be asked to provide test data showing the suitability of their product for the intended purpose.

Sample tubing should be resistant to hot wash water.

Sample tubing that is cracked, blocked or contaminated with cargo residues greatly affects instrument readings. Check the condition of the tubing regularly and replace any that is found to be defective.

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

2.5.2 Filters in sample lines

Filters remove water vapour in some catalytic or non-catalytic filament type hydrocarbon gas meters and extra filters are not normally needed. In wet conditions, such as during tank washing, excessive water can be removed from the gas sample using materials that retain water but do not affect the hydrocarbons. Modern gas measurement instruments often use water traps, consisting of a polytetrafluoroethylene (PTFE) membrane that prevents liquid and moisture passing onto the sensors. Water retaining filters are essential with oxygen meters, particularly the paramagnetic type, because any water vapour in the sample can damage the measuring cell. Only the manufacturer's recommended filters should be used.

2.5.3 Gas sample procedures

Every tank has dead spots where the rate of change of gas concentration during ventilation or purging is less than the average. The location of these dead spots depends on the positions of the inlet and outlet for ventilating air or IG and on the disposition of the structural members in the tank. The dead spots are generally within the tank bottom structure. The sample line should be long enough to allow 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. For example, the powerful water jets produced by fixed washing machines are excellent mixing devices and tend to eliminate major differences in gas concentration between one location and another. Similarly, directing powerful jets of ventilating air or IG downwards from the deckhead produces good mixing and minimises variations in concentration.

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

2.6 Fixed hydrocarbon gas detection systems

2.6.1 Fixed hydrocarbon gas detection systems on tankers

The system comprises a central unit for gas measuring and gas sampling pipes in all ballast tanks, void spaces next to the cargo tanks, pumprooms and any other tanks and spaces next to cargo tanks.

The system should be able to continuously measure hydrocarbon gas concentrations and may be arranged to operate on a sequential scanning principle, provided that each sampling line of each protected space is analysed at least every 30 minutes.

If the fixed system is not working or being calibrated, make sure it is possible to measure using portable instruments instead.

If the system is out of order, have procedures to continue monitoring the atmosphere with portable instruments and recording the results.

2.6.1.1 Control panels and indicating units

- Control panels should be in the cargo control room, on the navigation bridge or in a gas safe continuously manned central control station.
- Clear information should be displayed on or next to the control panel to allow the crew to readily determine the source of the alarm or fault condition.
- Control panels should have a button or switch to manually reset to normal operating conditions after alarm and fault conditions are cleared.
- Indicating units should be located on the navigation bridge if the control panel is located elsewhere.
- Control panel and indicating unit alarm signals should be distinct from fault condition signals.
- Indicating units may have common alarms servicing multiple sampling points, provided that all sampling points within an alarm group are in the same space.
- Control panels should be able to manually test audible and visual alarms.

2.6.1.2 Alarm conditions

Audible and visual alarms, in accordance with the IMO's *Code on Alerts and Indicators*, should be initiated in the cargo control room, the navigation bridge, at the control panel and at all indicating units under the following conditions:

- On detection of gas concentrations in any monitored space on a pre-set value not higher than the equivalent of 30% of LFL.
- In a fault condition, such as power failure or short circuit.
- Low or no flow in any sampling pipe.
- Tampering with the alarm set point.
- Failure of any self-test functions.

A visual alarm should remain in effect during an alarm condition. The audible alarm may be silenced manually.

If gas concentrations above the alarm set point are detected within the enclosure, the alarm should sound and the analysis unit should be automatically isolated from all sampling pipes and shut down. Take appropriate steps to vent flammable gas inside the enclosure to an open space away from ignition sources.

2.6.1.3 Operation and maintenance

The following onboard maintenance should be carried out monthly and after any fault condition:

- Visual inspection.
- Testing audible and visual alarms.
- Span gas checking.

Additional maintenance should be carried out as specified by the manufacturer's instructions.

The maintenance and testing described above should be included in the tanker's maintenance plan.

Operating and maintenance instructions for the system should be provided on board and include the following information:

- Operating instructions.
- Gases the system is suitable for.
- System diagrams showing sampling points and the relationship of all components.
- Transfer functions relating the output relative to the calibration gas to other gases.
- Calibration, span gas checking and maintenance procedures.
- Troubleshooting procedures.
- Minimum and maximum flow rates.
- The nature and significance of fault signals (MSC.1/Circ.1370 *Guidelines for the Design, Construction and Testing of Fixed Hydrocarbon Gas Detection Systems*).

If the fixed gas detection system should fail, manual checks should be made. Records should be reviewed to ensure that these have been conducted. The manufacturer's instructions for maintaining the system should be followed.

2.6.2 Fixed hydrocarbon gas detection systems in terminals

2.6.2.1 General

Where not already required by local regulations or requirements, 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. A risk assessment should be undertaken where this risk to personnel exists and should consider:

- The overall safety and health risk to personnel from hydrocarbon and toxic vapours.
- The appropriate placing of sensors in locations where personnel may work and where leaks or spills could occur, e.g. loading arms, valve manifolds and transfer pumps, to ensure that early and adequate warning of an increased risk of exposure is provided.
- Whether the area is properly ventilated to minimise or eliminate the potential for gas to accumulate.

If, as a result of the risk assessment, there remains doubt that exposure to personnel could occur, the fitting of fixed gas detection is recommended.

Toxic gas detectors may also be installed in the supply air intakes of pressurised control rooms and inside non-pressurised control rooms.

These gas detection systems are, typically, permanent, electrically operated devices that sense the presence of combustible or toxic gases and provide early warning before the gas concentration reaches UFL, acute or chronic toxic levels. They continuously monitor potentially hazardous areas to safeguard against fire or explosion and to protect personnel from toxic gas leaks.

2.6.2.2 Sensors

The systems employ a range of the sensors described above, including catalytic, PID, electrochemical and IR, including tunable diode laser sensors.

Depending on the application, each detector location has its pros and cons. IR detectors are available in open-path and point-types and use the hydrocarbon absorption principle to detect combustible gases. However, they cannot be used on non-hydrocarbon gases, such as hydrogen and CO. IR gas detectors are not susceptible to poisoning since they do not require a reaction to take place. Catalytic sensors may require more maintenance than IR detectors and are susceptible to poisoning.

The analysers may be the remote detection type, where electrical cable connects individual sensors to the analysers. In this case, the central equipment can be installed either in non-hazardous locations, such as pressurised control rooms, or in explosion-proof enclosures in hazardous areas. The remote detection type, which uses remote diffusion detectors, is preferred because it provides rapid response and good reliability.

Alternatively, systems may use a central detection unit that uses a suction pump to draw samples from hazardous areas through tubing to the central location. Central detection units that use sample lines have a relatively slow response time. Where central detection units that use sample lines are installed, users should consider the following:

- Relatively slow response time.
- Particulate contamination in the lines.
- Moisture in the lines that will require them to be heated.

2.6.2.3 Design of system

As well as continuously recording data, gas analysers may have the following functions:

- Individual detection sensors should be connected to an interface so that each sampling circuit can continuously analyse for the presence of gases. When an alarm is triggered the registering sensor will be indicated and the alarm will remain active until manually reset.
- Terminals should be fitted with fixed gas detection of an approved type. The system should measure the range of LFL of hydrocarbons. The system should have two alarm points to alert for high and high-high, based on a risk assessment, international standards and national requirements.
- Alarm levels should be adjustable. Multi-level alarm conditions can be provided with ways to activate ventilation equipment or fire-extinguishing systems, or to shut down the facility.
- An inhibiting or bypass switch (hard wire or soft link) should isolate the detector during routine calibration and maintenance work. This disconnection is necessary for routine calibration and maintenance activities. A key operated switch with supervisory alarm is recommended.
- On complicated or extensive systems, the indication of alarms on a graphic display, such as an outline plan of a facility, is recommended.
- 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, e.g. when H_2S concentration reaches 5ppm. Alarms should generally be audible and visual.
- The gas detector head assembly should be suitable for the electrical classification of the hazardous area. If installed outdoors it should be weatherproof and corrosion resistant.
- The detecting unit should provide the necessary sensitivity and stability under all conditions to repeat any reading within ± 2% of the full-scale range.

2.6.2.4 Positioning fixed combustible and toxic gas detectors in terminals

Positioning combustible and toxic gas detectors should be based on a risk assessment and consider:

- Elevations, depending on the relative density of air and any potential gas leaks.
- Possible flow direction of leaking gas.
- Proximity to potential hazards.
- Accessibility of detectors for calibration and maintenance.
- Sources of damage, e.g. water and vibration.
- Industry data on the probability of small-bore leaks and frequency of failures.
- Industry data on the probability and frequency of ignitions.
- Computational fluid dynamics modelling.
- 3D gas detection mapping.
- The manufacturer's recommendations for sensors connected to analysers.

CHAPTER 3

Static Electricity

3.1 Principles of electrostatics

3.2 General precautions against electrostatic hazards

3.3 Other possible sources of electrostatic hazards

This chapter looks at hazards associated with the generation of static electricity during the handling of cargo and bunkers 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 proximity.

The risks presented by static electricity discharges are at their greatest where a flammable atmosphere may be present and there are multiple factors that may create the right environment for an electrostatic discharge, making them difficult to predict.

Although most likely during cargo loading, electrostatic discharges can happen during cargo and bunker transfer operations.

The only way to safely manage the risks from electrostatic discharge is to control the operation in line with established procedures and to follow the precautions in this chapter.

The main precaution for ships against electrostatic risks is to conduct operations with the tanks protected by IG. For tanks that are not protected by IG, section 3.2 describes, in general terms, precautions against electrostatic discharges (see chapter 12 for more detail). Section 3.3 considers other possible sources of electrostatic hazards during operations.

Some bunker fuels (e.g. low sulphur diesels) may be classified as static accumulators, and some bunker tank and piping configurations may introduce factors that could influence the generation of electrostatic risks outlined in this chapter. While the conditions may not present the same level of risk as in a cargo loading scenario, under certain circumstances the risk of electrostatic discharge (see section 3.1.4) should still be considered possible.

If some or all of the risk factors in this chapter exist, it is recommended that ship operators follow the precautions outlined. Where a possible exposure exists, a full risk assessment should be undertaken to ensure the factors influencing that electrostatic risk and the precautions necessary are considered in full.

3.1 Principles of electrostatics

3.1.1 Summary

Static electricity presents fire and explosion hazards during the handling of petroleum products and during other operations such as tank cleaning, dipping, ullaging and sampling. Certain operations can give rise to accumulations of electric charge that may be released in electrostatic discharges with enough energy to ignite flammable hydrocarbon gas/air mixtures. There is no risk of ignition unless a flammable mixture is present. Where there is a flammable mixture, three additional physical processes are involved in creating a potential electrostatic hazard:

- Charge separation.
- Charge accumulation.
- Breakdown/electrostatic discharge.

The potential for an electrostatic ignition can be minimised by managing any or all these physical processes or by eliminating the 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) loaded into a tank, a non-conductive plastic pipe or a synthetic 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 below. See also the guidelines published by the IEC, including the current editions of IEC TS 60079-32-1 *Explosive atmospheres – Part 32-1: Electrostatic hazards – Guidance* and the National Fire Protection Association's (NFPA) *77: Recommended Practice on Static Electricity* for more information.

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, a solid and a liquid or two 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, which include but are not limited to:

- The flow of liquid petroleum through pipes.
- The flow of liquid through fine filters (less than 150 microns).
- Contaminants, such as water droplets or rust moving relative to a liquid as a result of turbulence in the liquid as it flows through pipes.
- Particles inside a pipeline (rust, sand, sediments, water and ice) travelling at high speed when cargo lines are blown with compressed air.
- 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 product transfer into a tank.
- Gas bubbles rising through a liquid (e.g. air or IG introduced into a tank by the blowing of pipelines, or vapour from the liquid itself, released when pressure is dropped). This may also continue for up to 30 minutes after completion of product transfer into a tank.

- Turbulence and splashing in the early stages of transfer of a liquid into an empty tank. This can charge the liquid and can generate mist that could be charged and can increase the flammability of the vapour space above the liquid.
- The ejection of particles or droplets from a nozzle (e.g. during steaming operations or injection of IG).
- The splashing or agitation of a liquid against a solid surface (e.g. water washing operations or the sloshing of product in a part-filled tank).
- The vigorous rubbing together and subsequent separation of certain synthetic polymers (e.g. the sliding of a polypropylene (PP) rope through gloved hands).

3.1.3 Charge accumulation

3.1.3.1 General

When separated charges collect, e.g. in a tank, it is called charge accumulation. When accumulation occurs, large voltage differences and high electric fields can develop both within the material containing charge and in the neighbouring space (electric fields are just the rate of change of voltage).

High electric fields can cause electrical breakdown and discharge and high voltages can induce charge on conductors (see section 3.1.4.2). Examples of accumulation are:

- The charge on a petroleum liquid in a tank during and after filling. This generates voltages and electrostatic fields throughout the tank, both in the liquid and in the ullage space.
- The charge on a water mist formed by tank washing. This also generates voltages and electrostatic fields throughout the tank.

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 materials carrying the separated charges is a poor electrical conductor, recombination is impeded and the material can retain charge for a significant period of time. Accumulation occurs if the separation mechanism (charging process) remains active and adds more charge during this retention period. The retention period is characterised by the relaxation time of the material, which is related to its conductivity; the lower the conductivity, the longer the relaxation time. This is not to be confused with the settling time (see section 12.8.2.3).

When a material is classed as having high conductivity, its electrical conductivity is high enough that, if the material is earthed, the amount of charge required to maintain it at earth potential will flow almost instantaneously between the material and earth. If bonding rather than earthing is used, charges flow to keep the material at the same potential as the rest of the system rather than at earth potential. An earthed conductive material will remain at earth potential irrespective of any charge separation processes that act on it (see section 3.1.4.2). A charge capable of changing its potential from earth can only be passed to such a material if it is insulated from earth by a poorer conductor. The transfer of charge to or from the high conductivity material is then hindered by the resistance of the poorer conductor and charges capable of producing high voltages may accumulate. This illustrates the importance of earthing/bonding.

The important factors governing relaxation are, therefore, the electrical conductivities of:

- The separated materials (liquid or solid).
- Other materials nearby, such as the ship's internal structure.
- Additional materials that may be interposed between the materials after their separation.

Refined clean products tend to have very low conductivity and the relaxation time can be longer than a minute for these products.

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 ship operations is the prevention of discharges in air or vapour 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 a surface 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 spark, a brush discharge or a propagating brush discharge, as described below.

<table>
<tr><td>Corona</td><td>A diffuse discharge from a single sharp conductor that slowly releases some of the available energy.</td><td>Incapable of igniting a gas, such as propane, or a vapour such as gasoline.</td></tr>
<tr><td>Spark</td><td>An almost instantaneous discharge between two conductors at different voltages (e.g. when one is affected by the mechanisms described in section 3.1.4.2). Virtually all the stored energy arising from the voltage difference between the conductors is converted into heat that is available to ignite a flammable atmosphere.
Examples of a spark are discharges between:
• An unearthed conductive object floating on the surface of a charged liquid and the adjacent tank structure.
• Unearthed conductive equipment suspended in a tank and the adjacent tank structure.
• An earthed surface and conductive tools or materials left behind after maintenance when insulated by a rag or piece of lagging.</td><td>Sparks may be energetic enough to ignite all types of flammable mixture, including mists and dust clouds, if various requirements are met. These include:
• At least one of the conductors must be unbonded.
• 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.
• There must be enough stored electrical energy to initiate combustion.</td></tr>
<tr><td>Brush discharge</td><td>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.
Examples include discharges between:
• Sampling apparatus lowered into a tank and the surface of a charged petroleum liquid.
• An earthed conductive protrusion (e.g. fixed tank washing machine) and a charged petroleum liquid being loaded at a high rate.</td><td>Able to ignite gases and vapours but not mists or dust clouds (but beware of hybrid mixtures (dust or droplets plus vapours)).</td></tr>
<tr><td>Propagating brush discharge</td><td>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 (caused e.g. by breakdown through the sheet).
The bipolar sheet can be in free space or, as is more normal, have one surface in 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.
Increasing the charge until the weakest point of the sheet breaks down. Industry guidelines indicate that propagating brush discharges will not occur with linings that are more than 10mm thick or those that have a breakdown potential of 4kV. On most tankers, the thickness of epoxy coatings is not generally greater than 2mm. (Typically, the dry film thickness of epoxy tank coatings is 0.15mm per coat.) It is expected that the breakdown potential of coatings will be less than 4kV. In case of doubt expert advice should be sought.</td><td>Can be highly energetic (1 joule or more) and so will readily ignite a flammable mixture.</td></tr>
</table>

3.1.4.2 Voltages on unbonded conductors

There are two main mechanisms by which unbonded conductors can reach a high voltage by contact with a high voltage region:

1. An unbonded conductor that carries no charge is at a similar potential to its surroundings. Therefore, it is raised to a high voltage simply by being in the high voltage region (e.g. near the centre of the surface of a charged liquid or near the centre of a tank containing a charged mist).
2. A conductor that is not securely bonded may become charged by a process called induction if it loses contact with earth while in a high voltage region (e.g. this happens to a segment of a water jet from a cleaning gun as it breaks up). Charge is induced on the conductor while it is earthed and then trapped on the conductor when earth contact is lost. The trapped charge raises the conductor to a high voltage if it moves away from the high voltage region, e.g. towards a tank wall.

A conductor that is raised to a high voltage by one of the above mechanisms may give a spark that can ignite hydrocarbon/air mixtures when it approaches a bonded conductor such as a cleaning gun, the tank base or the tank wall (see section 3.1.4.1).

3.1.4.3 Conductivity

Materials and liquid products that are handled by ships and terminals are classified as being:

- Non-conductive.
- Semi-conductive (or dissipative).
- Conductive.

Non-conductive materials (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 can generate incendive brush discharges to nearby earthed conductors and can transfer a charge to, or induce a charge on, neighbouring insulated conductors, causing sparks.

Liquid non-conductors have conductivities of less than 50pS/m (picoSiemens/metre). Such liquids are often referred to as static accumulators.

Petroleum products, e.g. clean oils (distillates) including some low sulphur bunker fuels, frequently fall into this category with typical conductivities being below 10pS/m (relaxation times >2s). Chemical solvents and highly refined fuels can have conductivities less than 1pS/m (relaxation times >20s).

Solid non-conductors include plastics, e.g. PP, PVC, nylon and many types of rubber. Their surfaces can become more conductive if they are contaminated with dirt or moisture. Precautions to be taken when handling static accumulator oils are addressed in section 12.1.7.

Semi-conductive materials (dissipative materials or intermediate conductors)

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 (e.g. from electric power system faults).

For materials with intermediate conductivities, the risk of electrostatic discharge is small, particularly if the practices in this guide are adhered to, and the chance of the discharge becoming incendive 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 may not be known.

The liquids in this intermediate category have conductivities exceeding 50pS/m and, along with conductive liquids, they are often known as static non-accumulators. Examples of semi-conductive liquids are black oils (containing residual materials) and other liquids with a conductivity below 10,000pS/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.

Conductive materials

Conductors are incapable of holding a charge unless insulated but, if they are insulated, charged, and an opportunity for an electrostatic discharge occurs, all the charge available is almost instantaneously released in the potentially incendive discharge.

For liquids the normal boundary from semi-conductive to conductive is set at 10,000pS/m. Crude oils have a very wide range of conductivities, only some of which are below 10,000pS/m, so they are generally classified as conductive. Most common alcohols are conductive (e.g. methanol and ethanol both have conductivities of more than 106pS/m) as are the whole range of aqueous solutions, including sea water. The human body, consisting of about 60% water, is effectively a liquid conductor.

In the case of solids, metals are conductors.

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

Product	Typical conductivity (pS/m)	Classification
Non-conductive	Between 0-50	Accumulator
Benzene	0.005	
Xylene	0.1	
Gasoline (straight run)	0.1 to 1	
Diesel (ultra-low sulphur)	0.1 to 2	
Lube oil (base)	0.1 to 1,000*	
Commercial jet fuel	0.2 to 50	
Toluene	1	
Kerosene	1 to 50	
Diesel	1 to 100*	
Cyclohexane	Less than 2	
Motor gasoline	10 to 300*	
Semi-conductive	Between 50-10,000	Non-accumulator
Fuel with anti-static additive	50 to 300	
Heavy black fuel oils	50 to 1,000	
Semi-conductive crude oil	Less than 10,000	
Bitumen	More than 1,000	
Conductive	More than 10,000	Non-accumulator
Conductive crude oil	More than 10,000	
Alcohols	More than 100,000	
Ketones	100,000	
Distilled water	1,000,000,000	
Water	100,000,000,000	

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

Table 3.1: Typical conductivity of products

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. Examples include:

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

Although the liquid 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 CO_2, 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 enough energy to ignite hydrocarbon gas/air mixtures can occur (see also section 3.3.1).

3.2 General precautions against electrostatic hazards

3.2.1 Overview

The safest way to protect from electrostatic risks is to conduct operations with tanks protected by IG.

However, if a flammable atmosphere might be present, the following measures should be taken to prevent electrostatic hazards:

- Bond metal objects to the metal structure of the tanker to eliminate the risk of spark discharges between metal objects that might be electrically insulated. This includes the metallic components of any equipment used for dipping, ullaging and sampling.
- Remove any loose conductive objects that cannot be bonded.
- Restrict the product flow to a maximum of 1m/sec at the individual tank inlets, irrespective of design, during the initial stages of product transfer into a tank, until:
  - The filling pipe and any other structure on the base of the tank has been submerged to twice the filling pipe diameter and all splashing and surface turbulence has ceased, and
  - 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 delivery tank to ship's tank) have been loaded into the receiving tank, whichever is the lesser.
- Continue to restrict the product flow to a maximum of 1m/sec at the tank inlet for the whole operation unless the product is clean. A clean product, in this context, contains less than 0.5% by volume of free water or other immiscible liquid and less than 10mg/l of suspended solids.
- Avoid splash filling by employing bottom entry using a fill pipe terminating close to the bottom of the tank.
- Not blowing lines using compressed air.

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

- Prohibit the use of conductive (metal) ullaging, dipping, gauging or sampling equipment during product transfer into a tank and for 30 minutes after completion of operations to allow the settling of gas bubbles, water or particulate matter in the liquid and the relaxation of any electrical charge. After the 30 minute settling time, metal ullaging, dipping, gauging or sampling equipment may be used 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.
- Prohibit the use of all non-conductive (non-metal) containers of more than one litre capacity for dipping, ullaging and sampling during loading and for 30 minutes after completion of product transfer into a tank.

Non-conductive (non-metal) containers of less than one litre capacity may be used for sampling in tanks at any time if they have no conducting components and if they are not rubbed prior to sampling. Cleaning, with a high conductivity proprietary cleaner or soapy water, is recommended to reduce charge generation. To prevent charging, the container should not be rubbed dry after washing.

Operations can be carried out at any time through a correctly designed and installed full depth sounding pipe. A significant charge cannot accumulate on the surface of the liquid within the sounding pipe and so waiting time is not required. Precautions to prevent the introduction of charged objects into a tank still apply and if metal 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 12.8.2. These precautions should be closely followed to avoid the hazards associated with the accumulation of an electrical charge on the cargo.

3.2.2 Bonding

The most important countermeasure to prevent an electrostatic hazard is to bond all metallic objects together to eliminate the risk of discharges between objects that might be charged to different voltages if they were electrically insulated. To avoid discharges from conductors to earth, it is normal practice to require 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. Note that the bonding of a ship and terminal structure is not recommended, see section 17.4.4.

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

- Ship/shore hose couplings and flanges, except:
  - The insulating flange or block.
  - The single length of discontinuous hose.
  - Where the hoses are Grade Ω hoses specially designed to provide electrical discontinuity (see section 18.2).
- Portable tank washing machines, portable oil spill equipment (e.g. Wilden pumps), closed cargo additive doping systems.
- 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 should 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

Every effort should be made to ensure that loose conductive objects that cannot be bonded are removed from the tank. This requires careful inspection of tanks, particularly after shipyard repairs.

Objects that may be insulated during ship operations include:

- 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 insulating material, left behind after maintenance.

3.2.4 Filters

Three classifications of filter may be used in tanker operations, coarse, fine and microfine.

Coarse (greater than or equal to 150 microns)

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

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

These can generate a significant amount of charge and require enough time for the charge to relax before the liquid reaches the tank. To allow enough time for the charge to relax, the residence time after passing through fine filters should be a minimum of 30 seconds before the product enters the tank. Flow velocity should be adjusted accordingly.

Microfine (less than or equal to 30 microns)

To allow enough 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.

3.2.5 Fixed equipment in tanks

Away from the (earthed) tank walls, the surface of a charged, non-conductive liquid can be at high voltage. This voltage will produce a strong electric field at the tip of any metal protrusion that is near the surface but not close to the wall even if the protrusion is earthed. 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 transfer of static accumulator oils into a tank, this strong electrostatic field may cause electrostatic brush discharges between the protrusion and the approaching liquid surface.

Discharges from metal protrusions 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 that runs from the lower end of the protrusion downward to the tank structure underneath, so that the rising liquid is held at earth potential as it approaches the protrusion. Another possible solution, in some cases, is to construct the probe-like device entirely of a non-conductive material.

3.2.6 Free fall in tanks

Ballasting or transferring product into a tank over the top (overall) delivers charged liquid to a tank that may 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.

Any piping in a tank that does not lead to the bottom of the tank should be directed at the bulkhead and should not be allowed to free fall.

3.2.7 Water mists

The spraying of water into tanks, for example 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 polarity.

When washing begins in a dirty tank, the charge in the mist is negative, reaches a maximum negative value, then goes back through zero and finally rises towards a positive equilibrium value. Among the many variables affecting the level and polarity of charging, the characteristics of the wash water and how clean the tank is are the most significant influences. The electrostatic charging characteristics of the water are altered by recirculation or by the addition of tank cleaning chemicals, either of which may cause very high electrostatic potentials in the mist and which are higher in large tanks than 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, particularly where there are protrusions into the tank. Around relatively sharp protrusions, if the field strength is high enough, electric breakdown occurs into the space, giving rise to a corona. Because sharp 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, spark discharges with enough energy to ignite hydrocarbon gas/air mixtures can occur from unearthed conducting objects within, or introduced into, a tank filled with charged mist (or containing a charged liquid). For example, 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 complex and several conditions need to be met simultaneously for ignition to 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 act as a spark promoter and cause an ignition. 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.

The tanker industry has drawn up the tank cleaning guidelines in section 12.3. 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 Oil/Bulk/Ore (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, even in 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.

3.2.8 Inert Gas

Small particulate matter carried in IG produced by a boiler or IG generator 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 IG is usually small, but levels of charge have been observed well above those encountered from the water mists formed during washing. Because the tanks are normally in an inert condition, the possibility of electrostatic ignition should be considered only if it is necessary to inert a tank that 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 12.8.3).

3.3 Other possible sources of electrostatic hazards

3.3.1 Discharge of carbon dioxide

During the discharge of pressurised liquid CO_2, the rapid cooling that takes place may form particles of solid CO_2 that become electrostatically charged on impact with the release nozzle. The charge can be significant and has potential for incendive sparks. Liquefied CO_2 should not be used for inerting purposes. It should not be injected into pumprooms that may contain flammable gas mixtures, except for the purpose of fire-extinguishing. SOLAS requires that a sign detailing this is displayed at the pumproom CO_2 release controls.

3.3.2 Clothing and footwear

Personnel who are insulated from earth by their footwear or the surface on which they are standing can become electrostatically charged, which may result in a spark. Clothing can generate more static charge through friction and increase the chance of spark generation. Personnel should avoid putting on or removing clothing when in hazardous areas.

3.3.3 Synthetic materials

Several items manufactured from synthetic materials are available for use on board tankers and in terminals, such as coveralls, gloves, rope, bottles, portable drip trays, ventilation hoses and oil spill response equipment.

To avoid introducing electrostatic hazards in areas where flammable atmospheres may be present, the suitability of such equipment for the intended use should be confirmed prior to use.

Consideration to suitability should also be given when ordering, purchasing and receiving such equipment on board.

CHAPTER 4

Managing Hazards and Risks for Ship and Terminal

4.1 Management system

4.2 Risk management

4.3 Stop Work Authority

4.4 Lock-out/Tag-out

4.5 Control of hazardous energy

4.6 Simultaneous Operations

4.7 Permit to work systems

4.8 Personal safety

4.9 Preventing fire and explosion

4.10 Control of potential ignition sources

4.11 Electrical equipment and installations in hazardous areas

4.12 Portable electrical and electronic equipment

4.13 Communications equipment

4.14 Tools

This chapter sets out a general risk management process and then identifies general hazards and their mitigating measures for both tankers and terminals. Risk management processes for specific operations, e.g. cargo handling, are covered in the other chapters.

4.1 Management system

A management system is a defined method to ensure that stated objectives are achieved. The system is documented and includes the following key elements:

- Scope and objectives.
- Procedures.
- Resources responsible and accountable for implementation and execution.

- A verification and measurement process to determine whether the desired results are being achieved.
- A feedback mechanism to provide a basis for further improvement.

4.2 Risk management

4.2.1 General

Tankers and terminals should have a risk management process. It should include procedures to identify hazards, assess associated risks and ensure risks are either eliminated or reduced to ALARP through preventative and mitigating measures or controls.

All activities, including those of contractors, should be included in the risk management process.

4.2.2 Risk assessment

A key tool used by the industry, and a function of all SMSs for managing risks, is the process of a risk assessment. A risk assessment can identify potential hazards, i.e. anything that may cause harm, and analyse the likelihood and severity of a hazard arising and the consequence of it happening. A risk assessment is, typically, a five step process, the results of which may be expressed in a quantitative or qualitative fashion:

1. Identify the hazards.
2. Decide who might be harmed and how.
3. Evaluate the risks and decide on preventative and mitigating measures or controls.
4. Record significant findings.
5. Review the assessment and update following the *International Safety Management (ISM) Code* or the operator's SMS.

Risk assessments should provide the basis for developing policies and procedures that cover all tanker and terminal operations.

All new or non-routine activities not covered by existing procedures should be risk assessed before starting, e.g. emergency repairs.

Risk assessments should consider the possibility of human error introducing a hazard or a control failure. In this situation, Safety Critical Task Analysis (SCTA) (see chapter 7) may be used to help prevent, detect or respond to human error.

To ensure all hazards are identified, risk assessments should be completed by a team of suitably trained and experienced personnel. They should, preferably, not be completed by a single person.

4.2.3 Hierarchy of controls

Table 4.1 provides a recommended order of priority for selecting preventative measures or controls. This is known as the hierarchy of controls.

1. Elimination	Remove the cause of the hazard completely, e.g. by not performing a proposed operation.
2. Substitution	Replace the proposed procedure with a less hazardous one.
3. Engineering controls	Separate personnel from the hazard by physical means, e.g. fitting guards at dangerous items of equipment, rigging barriers around open hatchways or using Lock-out/Tag-out (LO/TO) equipment.
4. Administration controls	Use procedures to perform tasks safely, e.g. hot work permits, enclosed space entry permits, hazard identification tools, risk assessments and duty rosters to minimise exposure to hazards.
5. PPE	Use PPE to protect the person carrying out the operation, e.g. safety glasses. PPE should only be considered when all the above measures have been found to be ineffective at controlling the risks to a reasonable practical level. Select PPE to mitigate against the identified hazard. Train personnel how to use it correctly, including how to check it is still fit for the intended purpose.

Table 4.1: Risk assessment hierarchy of controls

4.2.4 Marine interface risks

Activities at the marine interface that should be risk assessed include:

- Mooring and berthing operations.
- Cargo transfer operations.
- Double banking operations (including multiple banking).
- Discharging or loading over the tide.
- Tug and towing operations.
- Non-cargo related operations, including tank cleaning, bunkering, storing, hot work and repairs while alongside the berth.
- Tank measurement and sampling.

Risk assessments can also be used to develop the following:

- Security plans.
- Emergency response plans.
- Oil spill response plans.
- Terminal safety exclusion zones.
- Non-standard terminal firefighting and protection arrangements.
- Critical equipment and systems identification.

Regularly review existing risk assessments and associated controls to make sure they are still valid. A periodic inspection procedure should be in place for both tanker and terminal facilities and operations. This should be used to identify new hazards and to decide whether a revised risk assessment is needed.

4.2.5 Management of Change

The risk management process should include a Management of Change (MOC) procedure.

MOC is the process of bringing controlled and planned change, either temporary or permanent, to operations, procedures, equipment or personnel to meet a defined goal.

The MOC procedure should ensure that safety and/or environmental standards are not compromised after the change.

MOC should be documented and supported by risk assessment, following on from any initial risk assessments where available.

Changes that might need an MOC procedure include:

- Changes to standard operating procedures in the SMS, e.g. because of changes in regulations and standards.
- Modifications to existing equipment.
- Installation of new equipment.
- Changes to tanker or terminal manning arrangements.
- New cargo products being handled.
- A different type or size of tanker calling at a terminal.

4.3 Stop Work Authority

It is recommended that tanker and terminal SMSs include a Stop Work Authority (SWA) policy and procedure. The SWA gives employees and contractors the responsibility and obligation to intervene and stop work if they see something unsafe that may cause an accident (see section 7.7).

A typical SWA procedure includes five steps:

1. Stop the unsafe activity.
2. Tell the Person In Charge (PIC) so the issue can be addressed.
3. Discuss the concerns with those involved and correct the issue as necessary.
4. Start the activity again.
5. Share what has been learned with other employees and contractors who might be affected.

4.4 Lock-out/Tag-out

Specially designed LO/TO equipment is widely available that provides a system for preventing a valve or device being operated until the lock or tag has been removed, usually under a documented system of safe management control. Uses vary but could include the isolation of overboard sea valves and tanks during tank entry.

Hazardous energy control procedures (see section 4.5) may also include a LO/TO system that places a lock and/or tag on an energy isolating device, e.g. a valve or breaker. This stops the energy isolating device being operated until the lock or tag has been removed.

Training should be provided to all personnel involved in using the LO/TO system and this training should include all associated equipment and the procedures to which the system is being deployed. Training should be extended to contractors who are also required to work with a system that may be specific to the ship or terminal.

4.5 Control of hazardous energy

4.5.1 Hazardous energy

Hazardous energy is any electrical, mechanical, hydraulic, pneumatic, chemical, nuclear, thermal, gravitational, sound, motion, biological or other energy that can harm personnel. Examples of hazardous energy include:

- Pressure in a cargo pipeline due to stored pressure.
- Pressure in a cargo pipeline section due to temperature variations.
- Gas pressure in an IG line.
- Air pressure in reservoirs.
- Stored electrical energy in electrical switchboards.
- Hydrostatic pressure on ship side valves.

4.5.2 Hazardous energy controls

A hazardous energy control procedure should be developed to identify and control hazardous energy. An example five step procedure is given below:

1. Gather information.
2. Perform SCTA.
3. Perform a risk assessment.
4. Implement controls.
5. Communicate and train.

When implemented these should prevent:

- Injuries by an initial uncontrolled release of hazardous energy.
- Injuries by residual energy remaining in a system after shutdown.
- Release of a pollutant to air, the sea, the ground or on deck.
- Uncontrolled sea water entering machinery or other spaces.

Procedures should aim to establish that a zero energy state has been achieved and independently verified before work starts. If this zero energy state cannot be established, work should not start until more risk assessment and control measures are established. Procedures should identify the steps to be followed when a zero energy state cannot be established. Figure 4.1 provides a flowchart setting out the recommended steps to control hazardous energy.

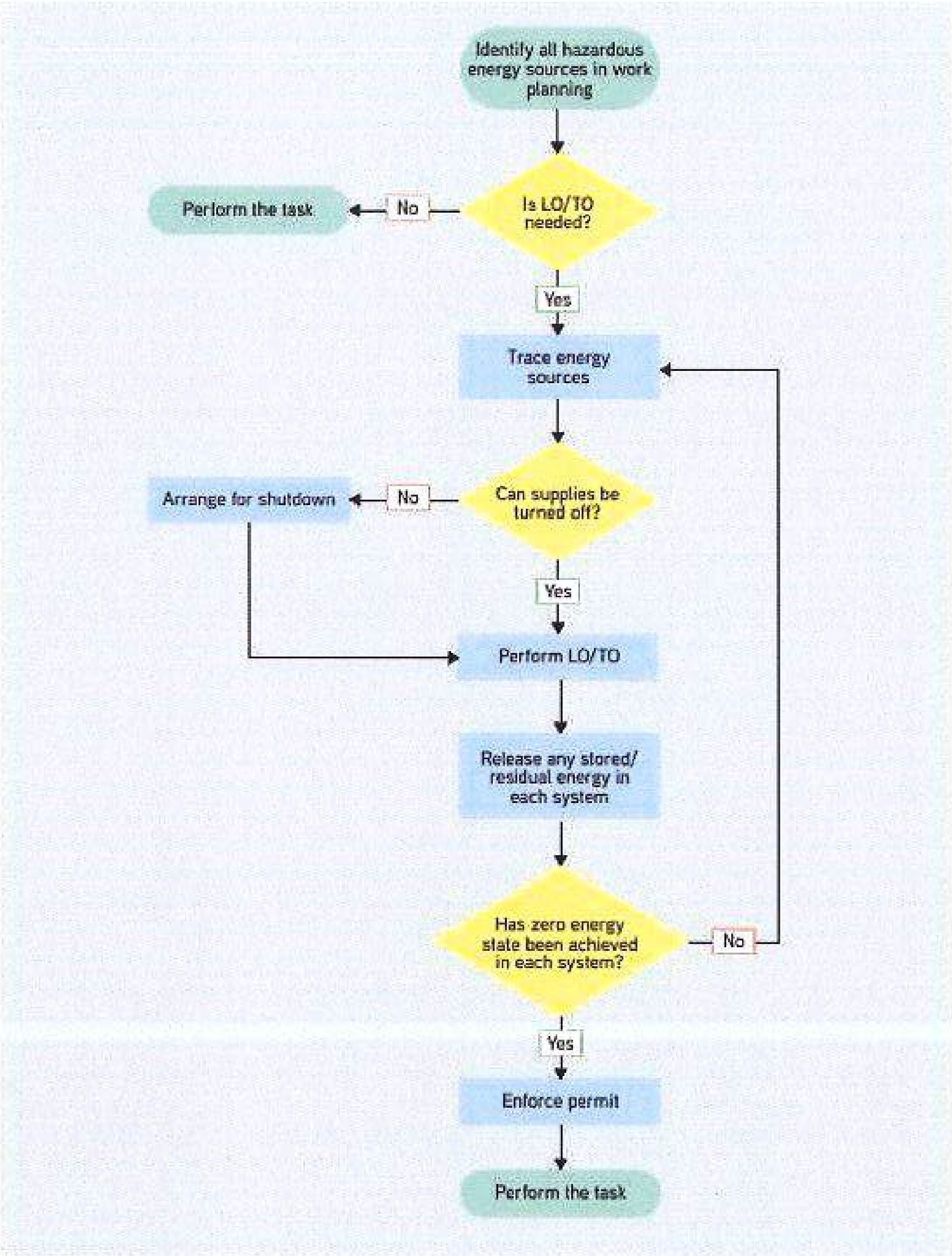


Figure 4.1: Control of hazardous energy flowchart

4.6 Simultaneous Operations

4.6.1 General

Simultaneous Operations (SIMOPS) are activities that take place at the same time in the same area or that could directly or indirectly affect the safety of any other activity on the ship or at the terminal (see figure 4.2).

SIMOPS should be identified at an early stage so that the risk assessment can include the individual risks of each operation and the risks from their interaction. If the operations are only risk assessed individually, additional risks might not be identified.

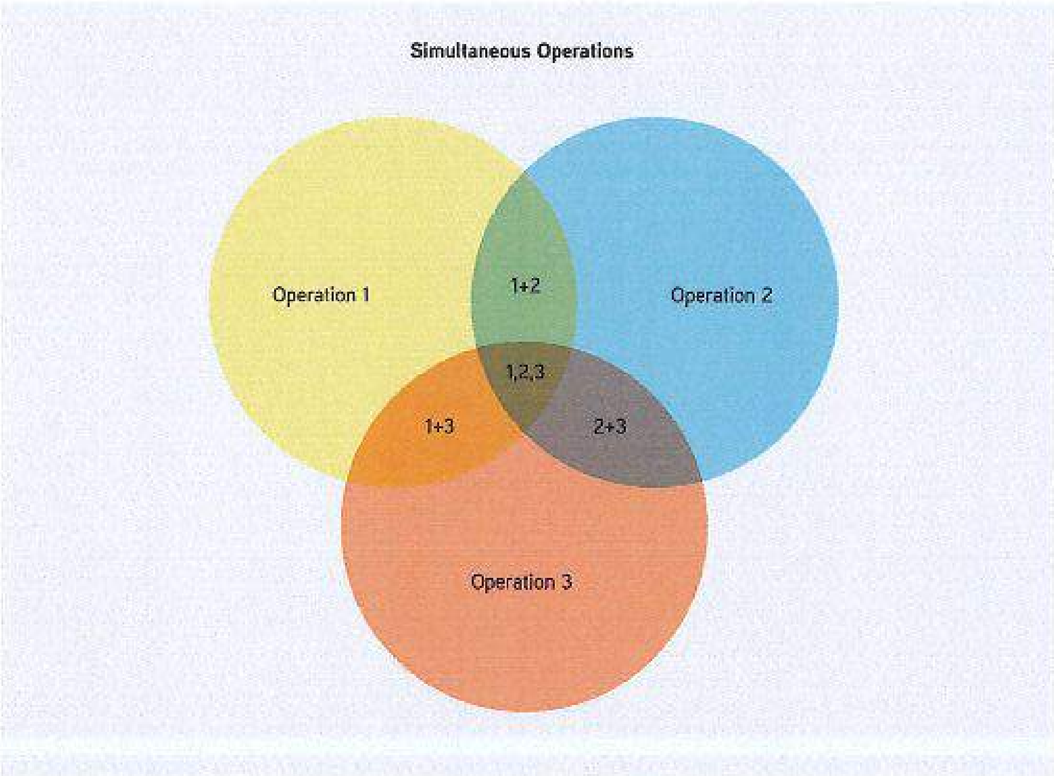


Figure 4.2: Interaction of SIMOPS

4.6.2 Managing Simultaneous Operations

4.6.2.1 Simultaneous Operations risk assessment

Avoid SIMOPS whenever practicable. If this cannot be avoided, then SIMOPS should be carefully managed through risk assessment, toolbox talks and work practices.

A SIMOPS risk assessment should study the intended operations and identify any additional hazards introduced by undertaking the activities simultaneously. The risk assessment should consider factors such as:

- Approval level: in accordance with company procedures and SMS requirements.
- Schedule and workload clashes.
- Resources: there should be enough personnel to safely complete each operation within the anticipated timeframe and enough to assign personnel to individual tasks.
- Supervision: each operation should be adequately supervised.

- Distraction: operations should be controlled from a common location, e.g. single control room for engine or cargo operations.
- Communications: there should be enough communications equipment with separate channels for each operation and contingency arrangements agreed.
- Knowledge and skills: personnel undertaking the tasks should be sufficiently trained and experienced to safely complete the assigned tasks.
- Fatigue: work and rest hour requirements should not be compromised by the demands of the SIMOPS.
- Critical tasks.
- Maintenance activities.
- Contingency plans.

Using the factors identified the level of risk should be assessed and risk reduction measures evaluated. Hierarchy of controls principles should be used to prioritise those measures and to further identify any additional safety barriers required. Additional hazards introduced by the SIMOPS should also be highlighted and further reviewed during the assessment.

4.6.2.2 Simultaneous Operations plan

This will enable a SIMOPS plan/interface document to be prepared, which will outline planned controls to be confirmed as in place to ensure the operation is managed effectively and risks reduced to an acceptable level.

The plan may vary in scope from a simple pre-job meeting to a detailed interface document that considers some or all the following, depending on the complexity and scale of the operation, the number of different activities and the personnel involved:

- Purpose of the operation and identified SIMOPS.
- Risks and their mitigations, along with control measures and safe operating procedures.
- Reporting lines and overall control authority.
- Communications and contingency plans.
- MOC requirements.

4.6.2.3 Simultaneous Operations preparation

Toolbox talks should then be used to review the SIMOPS plan and these should include discussion on the implementation of the control measures and any potential conflicts or challenges.

Examples of SIMOPS include:

- Bunkering or storing operations at the same time as cargo operations.
- Maintenance operations at the same time as bunkering or cargo operations.
- Testing equipment at the same time as bunkering or cargo operations.
- Enclosed space entries at the same time as cargo operations.
- Emergency exercises at the same time as cargo operations.
- Diving operations at the same time as cargo operations.
- Inspections, e.g. Port State Control (PSC), Flag State or the Ship Inspection Report Programme (SIRE), at the same time as cargo operations.
- Ship to Ship (STS) transfer operations. Bridge watchkeeping at the same time as cargo watchkeeping.

4.6.3 Decision matrix

It is recommended that SIMOPS procedures include a decision matrix to help identify the level at which approval is required within the organisation.

4.6.4 Matrix of permitted operations

Procedures may include a matrix of permitted operations. This provides a visual guide to the level of risk identified in SIMOPS. The matrix will identify activities that are:

- Permitted to occur simultaneously without restriction.
- Permitted with restrictions.
- Not permitted at all.

Figure 4.3 provides recommended steps for a SIMOPS procedure.

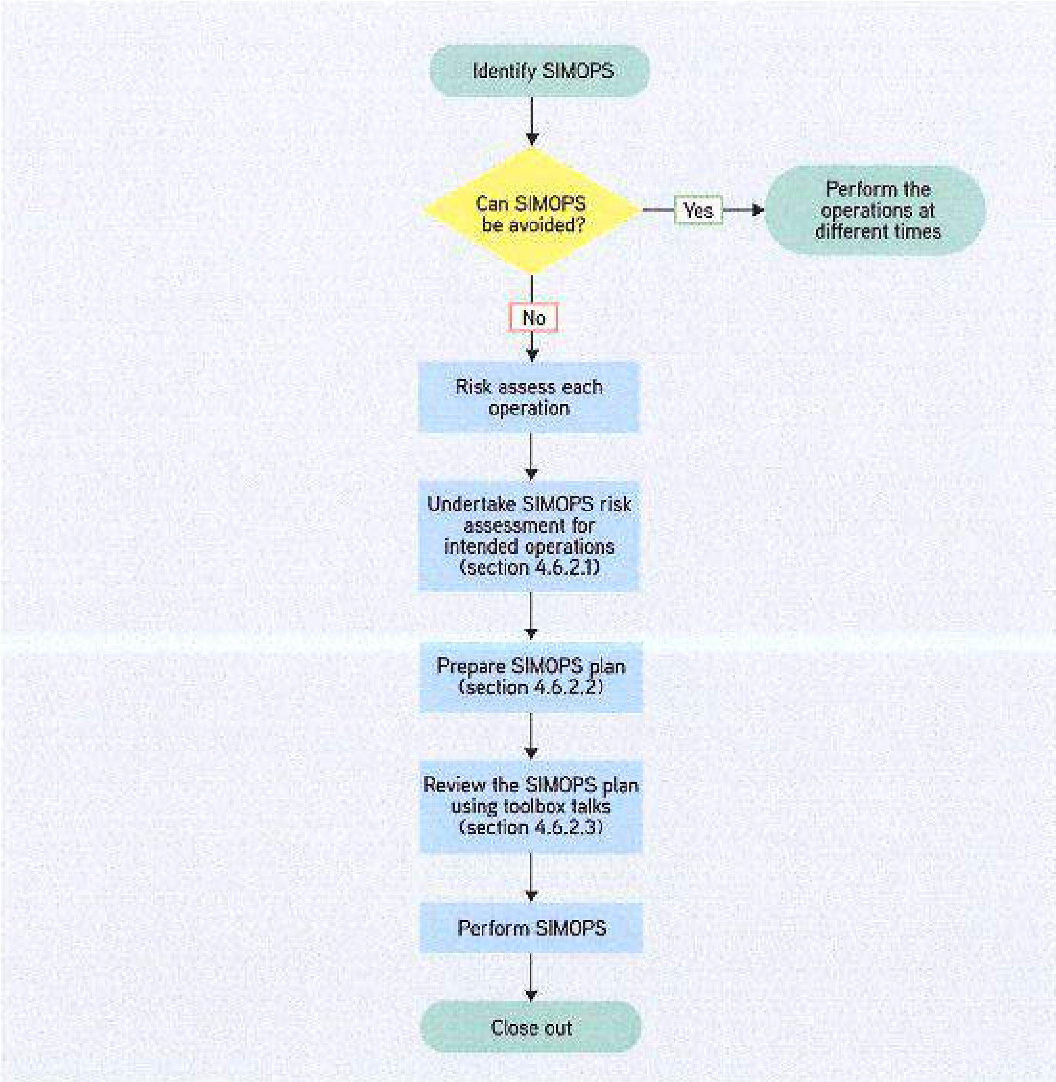


Figure 4.3: SIMOPS control procedures flowchart

4.7 Permit to work systems

4.7.1 General

While tanker and terminal operators will develop their own procedures for managing all aspects of operations and tasks, many 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 controls 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.

A number of publications issued by industry organisations and national safety bodies contain guidance for establishing a permit to work system.

The permit to work system may include one or more of the following management tools to control hazardous activities:

- Work instruction.
- Maintenance procedure.
- Local procedure.
- Operational procedure.
- Checklist.
- Permit.

The measures used when carrying out a particular task are determined by a risk assessment and recorded in the permit to work.

4.7.2 Permit to work systems – structure

The structure of the system and its processes are very important in ensuring that the system delivers the necessary level of safety and operational integrity.

The permit to work system should define:

- Operator 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.
- Associated permits to be reviewed.
- Emergency actions.
- Record-keeping.
- Auditing.
- System updating.

The system will determine the proper controls to manage the risk associated with each task and the right management tool to manage the task, as listed in section 4.7.1.

The system need not require all tasks to be done 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 at identifying and managing the risks.

4.7.3 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 PPE needed.
- Set out 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 the work site to a safe condition.
- Complete the process, keeping records for audit purposes.

4.7.4 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 doing 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 an operator's SMS, but are typically as follows:

- Type of permit.
- Permit number.
- 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 and endorsement by the Master or department head.
- Acceptance by those performing the work.
- Management of changes to workforce or conditions.
- Declaration of completion.
- Cancellation.

A permit does not, by itself, make a job safe.

Complying with the requirements of the permit, and identifying any deviations from the specified controls or expected conditions, are essential parts of completing the task safely. The system should also identify any conflicts with other tasks being carried out on board at the same time.

4.7.5 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, toolbox talks and correct procedures.

The format and frequency of work planning meetings should be in line with the requirements of the operator's SMS and will be determined by the tanker or terminal's activities.

It may be appropriate to have two levels of meeting – one for management and another for the practical issues related to specific tasks.

4.7.6 Toolbox talks

A toolbox talk is a discussion between all workers, including contractors, about the hazards of the planned task.

A toolbox talk is required for all tasks. The PIC of the task should hold a toolbox talk at the worksite with everyone involved before the task begins. Toolbox talks should include:

- Critical job steps, including roles and responsibilities.
- Job hazards and additional safeguards, including PPE.
- Specialised work permits, where applicable.
- Communication plan.
- SWA triggers.

If only one person is needed to perform the task, that person should review the above list before starting.

If the worksite is noisy, identify the hazards at the worksite, then move somewhere quieter to finish the toolbox talk.

4.8 Personal safety

4.8.1 Personal Protective Equipment

Identify what protective clothing and equipment is needed in a risk assessment. PPE should be of an approved standard and should be worn by all personnel engaged in operations. This should include protection for:

- Body.
- Hands and feet.
- Face and eyes.
- Ears.
- Head.

Avoid using synthetic material for tasks involving flames or heat, because it can melt and severely damage skin. Personnel at risk of falling into the water should wear life jackets or approved Personal Flotation Devices (PFDs). Personnel working at a height of 1.8m or more should wear approved fall protection. See the *Code of Safe Working Practices for Merchant Seafarers (COSWP)* and OCIMF/CDI's *Recommendations for Oil and Chemical Tanker Manifolds and Associated Equipment*.

Storage places for PPE, including RPE, should be protected from the weather and clearly marked.

Training on how to use PPE and RPE correctly should be provided.

PPE requirements for visitors should be established.

Inspection and maintenance procedures should be available for PPE and RPE.

4.8.2 Slip, trip and fall hazards

Slips, trips and falls are a common cause of accidents on tankers and in terminals. Management and personnel should pay attention to anything that may cause these accidents, including changing conditions.

Non-skid coatings or gratings should be provided in working areas and on walkways. These areas should be 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.
- External stairways.

Terminals should establish requirements for personnel passing through the terminal. A clearly marked safe route and/or safe transport through the terminal should be provided.

All personnel, including visitors, should use the marked access routes. The routes should be kept well lit, clear and free of spillages.

The risk of slips, trips and falls is significantly higher when using access ladders and companionways. Good design and construction will help prevent these accidents. Trip hazards, e.g. 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.

4.8.3 Asbestos

The disturbance or removal of asbestos should be carried out by specialist contractors. If the crew need to make urgent repairs at sea, measures should be in place to ensure they are adequately protected from asbestos. MSC/Circ.1045 *Guidelines for Maintenance and Monitoring of On-Board Materials Containing Asbestos* provides guidance on how to handle asbestos safely on board tankers. A detailed risk assessment should be conducted before starting any urgent repairs that might involve asbestos.

4.8.4 Personal hygiene

Prolonged contact with oil can be dangerous. Avoid direct skin contact with oil or with oily clothing wherever possible.

4.9 Preventing fire and explosion

To prevent the risk of fire and explosion, a source of ignition and a flammable atmosphere should not be in the same place at the same time. Precautions should be taken to exclude or control either the source or the atmosphere. Flammable gases can be expected in the hazardous zones of tankers and terminals. All possible sources of ignition should be removed.

Oil spillage and leakage present a fire hazard and should be avoided. If they occur, the leak should be stopped immediately and the spill should be cleaned.

Flammable gases and ignition sources can be safely controlled in control rooms, workshops, storerooms, etc. if they are properly designed, operated and maintained.

In a tanker's accommodation block, sources of ignition should be limited or controlled, e.g. by designating a smoking area.

It is essential that flammable gas is not able to enter the accommodation block. Settings on air conditioning systems should ensure the pressure inside the accommodation is greater than the external atmosphere, e.g. do not set to 100% recirculation.

In engine and boiler rooms, ignition sources cannot be avoided (see also section 4.10). Flammable gases should be prevented from entering the engine and boiler rooms. Bunker fuels, including residual fuel oils, may present a flammability hazard (see section 1.6), so bunker spaces should be checked regularly.

4.10 Control of potential ignition sources

4.10.1 Naked lights

Naked lights should be prohibited on the tanker deck, in the terminal and in any other place where flammable gas may be present.

4.10.2 Smoking

Smoking presents significant risks on board all tankers and requires careful management. Controls can be established through SMS requirements and design, e.g. dedicated smoking rooms on tankers. Controls for smoking should also be applied to any other products that are burned, e.g. incense sticks. Any smouldering, smoke-producing product should never be left unattended or allowed near bedding or other combustible materials.

4.10.3 Smoking at sea

While a tanker is at sea, smoking should be permitted only at times and in places specified by the Master. Personnel on board tankers should only smoke in the dedicated smoking room, if one is available. Smoking should be prohibited on the tanker deck or any other place where flammable gas may be present. Criteria that should be considered when determining the location of designated smoking places are listed in section 4.10.5.

4.10.4 Smoking in port and controlled smoking

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

Smoking in port should only be permitted under controlled conditions and in designated smoking areas.

Smoking on board barges and other small craft should be prohibited while they are alongside the tanker or terminal.

4.10.5 Location of designated smoking places

Designated smoking places on a tanker or onshore should be agreed in writing between the Responsible Officer and the Terminal Representative at the pre-transfer conference before operations start (see chapter 24). The Responsible Officer should make sure everyone on the tanker has been told where the designated smoking places are and that suitable notices are posted.

During operations, designated smoking areas should only be allowed:

- In the accommodation area.
- In a room that does not have any doors or ports that open directly on to decks.

Operations include:

- Any handling of petroleum cargoes.
- Stern loading/discharge.
- Ballasting into cargo tanks that are not gas free.
- Purging with IG.
- Gas freeing.
- Tank cleaning.

In the designated smoking area, all portholes should be kept closed and all doors should be kept closed unless in use.

Before or after operations, while the tanker is still at the terminal, designated smoking areas should be selected to take account of any hazardous conditions, e.g. unusually high flammable gas concentrations, particularly when there is no wind, and tanker operations on adjacent berths.

Smoking can only be allowed in other areas if the Master and Terminal Representative have agreed to it in writing. When stern loading/discharge connections are being used, particular care should be taken to ensure that no smoking is allowed in any accommodation or space where the door or portholes open onto the deck where the stern loading/discharge manifold is located.

4.10.6 Matches and cigarette lighters

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

All matches used on board tankers should be safety matches. The use of matches and cigarette lighters should be banned outside the accommodation, except in designated smoking areas. Matches should not be carried on the tank deck or in any other place where flammable 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 because their spark producing mechanism is unprotected, which means they can be accidentally activated.

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

4.10.7 Electronic or e-cigarettes

The existing smoking rules also apply to the use of electronic or e-cigarettes.

4.10.8 Notices

Portable and permanent notices prohibiting smoking and the use of naked lights should be displayed clearly at the access points to the tanker and at the exits from the accommodation area. In the accommodation area, instructions about smoking should be clearly displayed.

4.10.9 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.

Galley personnel should be instructed on how to safely operate galley equipment. Unauthorised and inexperienced persons should not be allowed to use galley equipment.

Fires are often caused by unburnt fuel or fatty deposits that have collected in galley ranges, flue pipes and filters. These areas should be regularly inspected to make sure they are clean. Oil and deep fat fryers should be fitted with thermostats to cut off electrical power and prevent accidental fires.

Galley staff should be trained how to handle fires and how to respond appropriately. Training should include how to operate fixed fire-extinguishing systems fitted to galley equipment. Appropriate fire extinguishers and fire blankets should be available.

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

Steam cookers and other equipment heated by steam can be used at any time.

4.10.10 Funnel emissions

To prevent funnel fires and sparks, burners, tubes, uptakes, exhaust manifolds and spark arresters should be kept in good working condition. If a funnel fire happens at sea, or sparks are emitted from the funnel, the tanker should consider altering course as soon as possible to avoid sparks falling on the tank deck. Cargo, ballasting or tank cleaning operations should be stopped and all tank openings closed.

Boiler tubes should not be soot blown when the tanker is in port. At sea, the officer on bridge watch should be consulted before the operation starts and the tanker's course should be altered if necessary.

4.10.11 Spontaneous combustion

Some materials ignite when they are damp or soaked with oil, especially vegetable oil, without the external application of heat. This is called spontaneous combustion and it happens because the material gradually heats by oxidation (see section 13.4).

The risk of spontaneous combustion is smaller with petroleum oils than with vegetable oils, but it can still happen, particularly if the material is kept warm, e.g. because it is close to a hot pipe or surface.

Cotton waste, rags, canvas, bedding, jute sacking, sawdust or any similar absorbent material should not be stowed in the same compartment as oil, paint, etc. They should also not be left lying on the jetty, on decks, on equipment, on or adjacent to pipelines, etc. Damp materials should be dried before they are stowed. Oil soaked materials should be cleaned or destroyed.

Some chemicals used for boiler treatment are also oxidising agents and can spontaneously combust if they have evaporated. These chemicals should be stored in a safe and secure location.

4.10.12 Auto-ignition

Petroleum liquids ignite without the application of a naked flame when heated sufficiently. Auto-ignition is most common when fuel or lubricating oil under pressure sprays onto a hot surface. It also happens when oil spills onto lagging, vaporises and bursts into flame. Both instances have been responsible for serious fires.

Oil feeder lines require attention to avoid oil being sprayed from leaks. Pipelines carrying fuel and lubricating oil under pressure should be assessed and provided with necessary protection. Oil saturated lagging should be removed and personnel protected from any ignition or re-ignition of vapours during the process.

4.10.13 Equipment made of aluminium

Aluminium equipment should not be dragged or rubbed across steel. It can leave a smear that can cause an incendive spark if it is struck by a hammer or falling object. It is recommended that the underside of aluminium gangways and other heavy portable aluminium structures are protected with a hard plastic or wooden strip to stop 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.

4.10.14 Cathodic protection anodes in cargo tanks

Various materials are used for cathodic protection, including magnesium, aluminium and zinc.

Magnesium anodes are very likely to cause an incendive spark if they strike rusty steel, so they should not be fitted in tanks that may contain flammable gases.

Aluminium anodes spark when they are hit hard. They should only be installed at approved locations in cargo tanks and should never be moved to another location without proper supervision. Because aluminium anodes can easily be mistaken for zinc anodes, they can accidentally be installed in hazardous locations. It is recommended that only aluminium anodes are used in permanent ballast tanks.

Zinc anodes do not generate an incendive spark if they strike rusty steel and are not subject to the above restrictions.

The location, securing and type of anode installed in cargo tanks are subject to approval by the appropriate authorities. Their recommendations should be observed and inspections made as often as possible to check the anodes and mountings are secured. Anodes are easily damaged by high capacity tank washing machines.

4.11 Electrical equipment and installations in hazardous areas

4.11.1 General

This section describes the classification of hazardous areas for electrical installations and equipment on board tankers and in terminals. It also gives general guidance on safety precautions during maintenance and repair of electrical equipment.

4.11.2 Hazardous areas

Hazardous areas may contain a flammable atmosphere during normal operations. They are sometimes called dangerous areas.

Hazardous areas are normally subdivided into zones according to the likelihood of a flammable atmosphere being present, as shown in table 4.2.

The extent of hazardous areas can be determined by reference to Class rules and industry standards.

Zone	Likelihood of flammable atmosphere
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
Zone 1	A place where 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 conditions
Zone 2	A place where 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

Table 4.2: Hazardous area zones

4.11.3 Hazardous areas on a tanker

On tankers, hazardous areas are sometimes described as dangerous areas.

The arrangement of equipment is defined as required by Class rules.

Typically, the designation of the zones is aligned with IEC 60092-502 *Electrical installations in ships – Part 502: Tankers – Special features*.

Certain spaces, e.g. battery lockers and paint stores, are not described as hazardous areas but there are prescriptive requirements in Class rules for the types of electrical equipment and ventilation fans fitted in these spaces.

4.11.4 Hazardous areas at a terminal

At a terminal, hazardous areas and zones are based on national standards. These are aligned with industry standards, e.g. those of the IEC or the Energy Institute.

When a tanker is at a terminal, a tanker safe area may be in a terminal hazardous area. Any unapproved equipment on the tanker that is in the terminal hazardous area may need to be isolated when the tanker is at the terminal.

4.11.5 Sources of ignition from electrical equipment

Potential sources of ignition from electrical equipment include:

- Electric sparks.
- Arcs and flashes.
- Electrostatic discharges.
- Electromagnetic waves.
- Hot surfaces.
- Flames and hot gases.
- Mechanically generated sparks.
- Chemical reaction.

4.11.6 Standards of electrical equipment for use in hazardous areas

To avoid the risk of ignition, electrical equipment in hazardous areas needs to be specially designed and constructed. The most rigorous standards are needed in areas where the likelihood of a flammable atmosphere is highest.

Electrical equipment used in hazardous areas is subject to different regulations and standards depending on the geographical location where the certification is recognised and accepted. Different standards apply in different parts of the world, including the International Electrotechnical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres (IECEx), ATEX and the National Electrical Code (NEC).

Electrical equipment must be certified for use by a recognised certification body. Different certification bodies require different markings on equipment, which may cause confusion. Electrical equipment needs to be selected and installed carefully, and inspected and maintained regularly, to make sure it continues to comply with the selected standard.

4.11.7 Inspection, maintenance and testing of electrical equipment

All equipment, systems and installations, including cables, conduits, glands and similar equipment, should be inspected and maintained.

Continuing functional operation does not assure compliance with the required standards of safety, unless correct maintenance procedures have been followed.

4.11.7.1 Inspection and checks

Typical inspections should include checking:

- Cracks in metal casings or covers, cracked or broken glass, or failure of cement around glass 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.

Inspection routines and check sheets for hazardous areas are described in the IEC 60079-17 *Explosive atmospheres – Part 17: Electrical installations inspection and maintenance.*

When a tanker is at a berth, equipment in hazardous areas should not be serviced without prior agreement between the tanker's Responsible Officer and the Terminal Representative.

4.11.7.2 Maintenance

Incorrect maintenance procedures can compromise the safety of electrical equipment. Even simple repairs and maintenance can compromise safety, e.g. paint covering safety features such as relief holes, passages, etc. Changing a lightbulb could damage explosion-proof lights if the cover is closed incorrectly.

All repairs and maintenance should comply with the manufacturer's instructions and only qualified and competent electrical personnel should work on critical safety equipment, e.g. explosion-proof fittings.

Repair methods for electrical equipment in hazardous areas are described in the IEC 60079-19 *Explosive atmospheres – Part 19: Equipment repair, overhaul and reclamation.*

4.11.7.3 Insulation testing

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

4.11.8 Changes to electrical equipment and systems

If the hazardous area classification or the characteristic of the flammable material changes, check to make sure the electrical equipment:

- Is the correct group.
- Is the correct temperature class.
- Complies with the new area classification.

Any change should be performed under an MOC process.

Approved equipment, systems or installations should not be modified, added to or removed without permission from the appropriate authority.

Safety features of equipment that rely on segregation, pressurisation, purging or other methods to ensure safety should not be modified.

If electrical equipment is removed from the hazardous zone, make sure any associated wiring is also removed or terminated in an appropriate enclosure. Electrical equipment should not be recommissioned until it meets the requirements of the SMS. The cable cores of intrinsically safe circuits should be either insulated from each other or bonded together and insulated from earth.

4.11.9 Electrical repairs, maintenance and testing at terminals

4.11.9.1 General

All maintenance work on electrical equipment should be undertaken under the control of a permit or an equivalent SMS procedure, with procedures to effectively manage electrical and mechanical isolations.

The use of mechanical LO/TO is recommended.

4.11.9.2 Cold work

Cold work means any work that cannot create a source of ignition. Electrical power should be cut off from equipment or wiring at source before:

- Carrying out cold work.
- Opening enclosures to non-intrinsically safe equipment.
- Disabling any special safety features.

Electrical power should not be restored until after the cold work has been completed, the enclosures to non-intrinsically safe equipment have been closed again and the special safety features have been re-enabled.

Cold work, including changing lamps, should only be done by an authorised person.

4.11.9.3 Hot work

Hot work means any work that involves sources of ignition or temperatures high enough to ignite a flammable gas mixture. This includes, but is not limited to:

- Welding (electric arc or gas).
- Cutting, burning, gouging (electric or gas).
- Heating (blow torch or heat gun).
- Soldering (electric or blow torch).

Use of the following temporary/portable equipment in a hazardous area should be classed as hot work:

- Power tools (electric or spark generating pneumatic).
- Electronic equipment that is not intrinsically safe.
- Internal combustion engines (driving air compressors, pumps, pressure washers, etc.).

The Terminal Representative and Responsible Officer will need to reach a joint agreement and issue a hot work permit before any hot work is conducted on:

- A berth with a tanker alongside.
- A tanker at a berth.

Also see section 9.4 before starting any hot work.

4.12 Portable electrical and electronic equipment

4.12.1 General

Portable and fixed electrical and electronic equipment present similar ignition hazards. The electrical energy is, typically, lower in portable equipment, but there are more risks from the use of batteries and an increased likelihood of equipment or cable damage.

Portable electrical and electronic devices should not be brought into a potentially flammable atmosphere unless they are certified as suitable. Certification should be checked for:

- Method of protection.
- Gas group.
- Temperature class.
- Zone.
- Special conditions – marked with an X at the end of the certificate number.

Selected general purpose Portable Electronic Product (PEP) can only be used in hazardous areas if:

- It is intended to be worn directly or supported by a person's body, or handheld, i.e. supported by one hand during normal use.
- It is battery powered or photovoltaic powered.
- It has been approved for use by both the owner/operator of the hazardous area and the authority having jurisdiction over site.

Some PEPs can be used in hazardous areas without meeting the above requirements, as long as they are incapable of causing an ignition under normal conditions and are used for their intended purpose. Examples include electronic wrist watches and hearing aids. However, this exception does not extend to more sophisticated electronic devices, e.g. rechargeable fitness wristbands and smart watches, as they are typically powered by higher risk lithium ion cells that have a greater risk of becoming an ignition source (see section 4.12.8).

More guidance on PEP and the requirements for suitability assessment and classification in hazardous locations, as well as the standard criteria for equipment to meet for acceptance, can be found in the American National Standards Institute (ANSI)/ISA 12.12.03 *Standard for Portable Electronic Products Suitable for Use in Class I and II, Division 2, Class I Zone 2 and Class III, Division 1 and 2 Hazardous (Classified) Locations.*

Portable and battery powered equipment frequently undergo in-service product upgrades, resulting in potential changes in operating parameters that could affect any prior testing and approval.

Testing of equipment for classification in hazardous environments is time consuming, resulting in a limited range of equipment that can be certified and labelled for use in hazardous environments and may periodically require re-testing to maintain certification.

ISGOTT does not recommend the use of PEP in hazardous locations except under strictly controlled and normal operating conditions as described in this section. This will often require PEP to be used only under the conditions of a gas free or hot work permit under the control of the owner/operator of the site.

Before use, portable equipment should be inspected for possible defects, e.g. damaged casings and cables, and to make sure cables are securely attached and will stay attached throughout the work. Special care should be taken to prevent any mechanical damage to flexible cables.

Inspection and maintenance of all portable electrical equipment should be included in the Planned Maintenance System (PMS).

4.12.2 Electrical equipment on flexible cables

The use of portable electrical equipment on flexible cables (also known as wandering leads) on tankers and in terminals should be controlled under the SMS.

On board tankers, electrical equipment on flexible cables can only be used in cargo tanks and over the tank deck if the areas are safe for hot work (see section 9.4).

Adjacent spaces should also be at least one of the following:

- Safe for hot work.
- Purged of hydrocarbon gas to less than 2% by volume and inerted.
- Completely filled with ballast water.

If the adjacent spaces to cargo tanks have not met the above criteria, electrical equipment on flexible cables can only be used if at least one of the following applies:

- All tank openings to the adjacent space are closed throughout the operation.
- Electrical equipment, including the flexible cables, is intrinsically safe.
- Electrical equipment is in an approved explosion-proof housing and the flexible cables are:
  - Approved for extra hard usage.
  - Have an earth conductor.
  - Permanently attached to the explosion-proof housing.

Certain types of equipment are approved for use over the tank deck only.

The above does not apply to flexible cables used with signal or navigation lights or to approved types of telephones if they are used correctly.

4.12.3 Air-driven lamps

Approved air-driven lamps can be used in hazardous areas if the:

- Air supply is fitted with a water trap.
- Supply hoses are low electrical resistance.

This will stop static electricity building up.

Permanently installed units should be earthed.

4.12.4 Torches, lamps and portable battery powered equipment

To stop potentially flammable atmospheres igniting, portable battery equipment should be designed and constructed to the same standards as electrical equipment and should be certified as safe for the area it is being used in. For example:

- Only torches (flashlights) that have been approved by a competent authority for use in flammable atmospheres may be used on board tankers.
- Handheld Very High Frequency/Ultra High Frequency (VHF/UHF) portable transceivers should be intrinsically safe.
- Tri-mode gauging tapes are battery operated electronic units and should be certified as being suitable for use in flammable atmospheres.

Small, battery powered, personal medical items, e.g. miniature hearing aids and heart pacemakers, are not considered significant ignition sources and can be used without certification in some hazardous areas subject to national standards and risk assessment.

4.12.5 Mobile telephones and pagers

Most mobile telephones and pagers are not intrinsically safe and are only considered safe for use in non-hazardous areas. They should be restricted to designated areas of the accommodation space where they are unlikely to interfere with the tanker's equipment. Mobile telephones should only be used on board a tanker or in the terminal as permitted by the applicable SMS. Details on restrictions on the use of mobile telephones should be prominently displayed at main access locations.

Mobile telephones and pagers should be switched off when carried onto a tanker or into a terminal and only switched back on again in a non-hazardous area. The batteries can cause an incendive spark if they are damaged and then activated by a call. Intrinsically safe mobile telephones and pagers are available and these may be used in hazardous areas. They should be clearly identified as being intrinsically safe for all aspects of their operation. Terminal staff going on board a tanker, and tanker staff going into the terminal, should be able to prove their mobile telephones and pagers are intrinsically safe. Visitors to the tanker or terminal should not use mobile telephones or pagers unless prior permission has been received from the tanker or terminal, as appropriate.

4.12.6 Cameras

The following general guidelines should be considered when deciding whether it is safe to use a 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 battery or power operated parts may produce an incendive spark, e.g. from a flash or aperture control. This equipment should not be used in a hazardous area unless it is certified as being suitable for use in a hazardous area. Disposable cameras with a built-in flash should not be used in hazardous areas.

Camera equipment without any battery or power operated parts, e.g. non-flash disposable cameras and clockwork mechanism cameras, can be considered safe for use in hazardous areas. An approved intrinsically safe camera can be used in a gas hazardous zone.

4.12.7 Other portable electrical equipment

Any other electrical or electronic equipment of non-approved type, whether mains or battery powered, should not be active, switched on or used in hazardous areas. This includes:

- Radios.
- Calculators.
- Games consoles.

- Laptop and handheld computers.
- Smart watches.
- Fitness wristbands.
- E-cigarettes.
- Remote controlled devices, e.g. drones.
- CD and DVD players, tape recorders and digital music players.
- Any other portable or wearable technology that is electrically powered but not approved for operation in hazardous areas.

The same measures to prevent use of this equipment in hazardous areas can be used as for other types of electrical equipment, e.g. mobile phones. Personnel should be told what non-approved equipment is banned.

Terminals should have a policy for telling visitors about the hazards of using portable electrical equipment. Terminals should reserve the right to make visitors leave any non-approved electrical equipment at an appropriate place, e.g. at the entrance to the terminal.

4.12.8 Lithium batteries

Lithium batteries are used in a wide variety of industrial and personal electrical equipment. There are two main types of lithium battery: primary (non-rechargeable) and secondary (rechargeable). All lithium batteries are high energy power sources. They can cause fire or explode, especially if they are damaged, exposed to fire, short circuited, overcharged or exposed to water. Used lithium batteries should be stored separately in dry conditions until landed for formal disposal.

The following precautions should be taken:

- Only use lithium batteries that are designed for the equipment being charged, incorporate the necessary safety features and are lithium ion.
- Do not crush, break open or damage lithium batteries or the equipment that contains them.
- Avoid short circuiting. For example, take care when moving the lithium batteries from an air-conditioned environment to a warm moist area, which may cause internal condensation leading to a short circuit.

4.13 Communications equipment

4.13.1 General

Communications equipment on a tanker should not be used, connected or disconnected in a terminal's hazardous area unless it has been certified as intrinsically safe or is an approved design.

Communications equipment may include:

- Telephones.
- Talk-back systems.
- Signalling lamps.
- Search lights.
- Loud hailers.
- Closed circuit television.
- Electrical controls for tanker whistles.

4.13.2 Ship's radio equipment

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

4.13.2.1 Medium and high frequency radio transmissions

Significant energy is radiated during medium and high frequency radio transmission (300KHz–30MHz). This energy can travel 500m from the transmitting antenna and can induce an electrical potential in unearthed equipment, e.g. cranes, derricks, rigging, mast stays, etc., that can produce 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.

It is recommended:

- All cranes, derricks, rigging and mast stays should be earthed.
- Transmissions should not be allowed when flammable gas is likely in the region of the transmitting antenna or if the antenna comes within the terminal hazardous area.
- Main transmitting antennae should be earthed or isolated when the tanker is alongside the berth.

If the tanker's radio transmitter needs to be operated in port for servicing, the tanker and terminal should agree on procedures to ensure safety in the pre-transfer conference (see chapter 24). Precautions might include operating at low power or using a dummy antenna load to eliminate all radio transmissions to atmosphere. A safe system of work should be agreed and implemented before turning the equipment on.

4.13.2.2 Very High Frequency/Ultra High Frequency equipment

Permanently and correctly installed VHF and UHF equipment are safe to use when the tanker is at the terminal, but it is recommended that the transmission is set to low power (one watt or less). The use of portable VHF/UHF radios in a terminal or on board a tanker presents no hazards if the equipment is certified and kept intrinsically safe and the power output is one watt or less.

The use of VHF/UHF radio equipment as a means of communication between tanker and terminal personnel is recommended.

4.13.2.3 Satellite communications equipment

Satellite communications equipment normally operates at 1.6GHz and the power generated is not enough to present an ignition hazard. Satellite communications equipment may be used to transmit and receive messages while the tanker is in port.

Long Range Identification and Tracking (LRIT) systems are normally integrated into satellite communication systems and also do not present an ignition hazard.

4.13.3 Tanker radar equipment

Marine radar systems operate in the 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 tanker's deck or jetty.

Radar sets, operating on 3cm and 10cm wavelengths, are designed with a peak power output of 30kW. If they are properly sited, they do not present a radio ignition hazard due to induced currents.

Radar radiation does not penetrate the human body, but at short ranges (up to 10m) can heat skin or eyes. Assuming sensible precautions are taken, e.g. 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 hazardous areas but are usually positioned above terminal hazardous zones, apart from on smaller vessels. It is, therefore, safe to test radars when alongside. 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.

4.13.4 Automatic Identification Systems

The Automatic Identification System (AIS) is required to operate while a tanker is underway and at anchor. Some port authorities may ask for the AIS to be kept on when a tanker is alongside. The AIS operates on a VHF frequency and transmits and receives information automatically, and the output power ranges between 2.0W and 12.5W. Automatic polling by another station, e.g. by port authority equipment or another tanker, could cause equipment to transmit at the higher (12.5W) level, even when it is set to low power (typically 2.0W).

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 inputted data that may be lost if the AIS is switched off. If necessary, the port authority should be informed.

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

At a Single Point Mooring (SPM) or Multi Buoy Mooring (MBM) terminal, the AIS may be kept on, if requested by the terminal, at an adequate power level to transmit information to the terminal safety monitoring system. Tanker and terminal representatives should agree on the AIS settings.

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

The use of AIS equipment may affect the security of the tanker or the terminal at which it is berthed. The use of AIS may be determined by the port authority, depending on the security level in the port.

4.13.5 Landline telephones

Telephone cables connecting the tanker and terminal should be routed outside the hazardous area. When this is not possible, the telephone cable should be routed and fixed in position by qualified terminal personnel and should be protected against mechanical damage so that no danger can arise from its use.

4.14 Tools

4.14.1 General

All tools should be used for the purpose that they were designed for, inspected before use and confirmed in good condition.

4.14.2 Hand tools

Hand tools, e.g. chipping hammers and scrapers for steel preparation and maintenance, may be allowed without a hot work permit.

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

Non-ferrous (also called non-sparking) tools are not recommended. They are softer (and less efficient) than ferrous tools and only slightly less likely to cause an incendive spark. Particles of concrete, sand or other rock-like substances are also likely to get embedded in the working face or edge of non-ferrous tools, which can then cause incendive sparks when they impact with ferrous or other hard metals.

4.14.3 Electrical tools

Inspection and maintenance of all electrical tools should be included in the PMS. The use of electrical tools in hazardous zones should be managed through a permit to work system. Battery powered hand tools should be considered electrical tools. These include:

- Portable drills.
- Angle grinders.
- Sanders.
- Nibblers.
- Heat shrink guns.
- Impact wrenches.

4.14.4 Mechanically powered tools and grit blasting

Mechanically powered tools, e.g. chisels, needle guns, angle grinders, cup brushes and grit blasters, have a significant potential for producing sparks and should be used under the control of a permit to work and the SMS.

The following precautions should be taken:

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

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

Pipelines can be perforated during grit blasting or chipping, so great care should be taken when planning such work. Similar precautions should be adopted for IG and COW lines.

4.14.5 Hydroblasting (high pressure water washing)

Hydroblasting (and slurry blasting) are hazardous activities and should be controlled through the SMS and permit to work process. There should be no cargo, bunkering, tank cleaning, gas freeing, purging or inerting operations in progress.

High Pressure (HP) washing uses pressures of between 700–1,700 bar. Above 1,700 bar is considered Ultra High Pressure (UHP) washing.

Hydroblasting presents two main hazards: personal injury and static electricity. The most common injuries are wounds caused by the water jet, musculoskeletal injury from use of the equipment and inhalation of harmful substances disturbed by the jet. Wounds caused by the water jet can have serious consequences and have been compared to gunshot wounds. Immediate medical attention is required.

Procedures should ensure that operators are suitably trained and provided with the correct PPE.

Because of the risk of static discharge from the nozzle, hydroblasting equipment should never be used where a flammable atmosphere is possible. Hydroblasting equipment should be electrically continuously conductive and earthed to the tanker structure or grounding point.

The area should be gas free and tests with a combustible gas detector should give a reading of not more than 1% LFL.

CHAPTER 5

Fire Protection

5.1 Theory of firefighting
5.2 Types of fire and appropriate extinguishing agents
5.3 Extinguishing agents
5.4 Portable fire extinguishers
5.5 International shore fire connection
5.6 Water borne firefighting equipment
5.7 Protective clothing
5.8 Automatic fire detection systems

This chapter describes the types of fire that may occur on a tanker or at a terminal and how to detect and extinguish them.

5.1 Theory of firefighting

Fires are a combination of fuel, oxygen, a source of ignition and a continuous chemical reaction, commonly known as combustion.

The main objective of firefighting is to extinguish the fire by reducing the temperature, removing the fuel, excluding the supply of air or interfering chemically with the combustion process as quickly as possible.

5.2 Types of fire and appropriate extinguishing agents

The classification of fires in table 5.1 conforms to those in the current ISO Standards and the IMO's *International Code for Fire Safety Systems (FSS Code)*.

5.3 Extinguishing agents

Extinguishing agents act by:

- Removing heat (cooling).
- Smothering (excluding the oxygen).
- Inhibiting flame (chemically interfering with the chemical chain reaction).

The extinguishing agents are applied via:

- Extinguishers, portable and wheeled – water, foam, dry or wet chemical, powder, CO_2.
- Fire hydrants and hoses with appropriate nozzle – water or foam.
- Monitors/cannons – water or foam.
- Nozzles from fixed installations – water mist, foam, CO_2, clean agent.
- Fixed deluge system – water spray and water curtain applications.

Appropriate fire extinguishers should be selected and used in line with table 5.1.

The firefighting equipment a ship must carry is determined by the regulations of the country where it is registered. These regulations are generally based on SOLAS principles.

Type	Material	Extinguishing methods	Extinguishing agents
Class A	Solid materials usually organic, e.g. wood, paper, cardboard, cloth, plastic, etc.	Cooling Smothering Flame inhibition	Water – in large quantities, continued cooling of the source of the flames and surrounding area to prevent re-ignition Foam Dry chemical
Class B	Flammable and combustible hydrocarbon liquids. Fires occur in the vapour/air mixture over the surface of flammable and combustible hydrocarbon liquids or liquefiable solids, e.g. crude oil, gasoline, petrochemicals, fuel and lubricating oils, tars, etc. An aspect to consider with liquid petroleum is the risk of re-ignition, a continuing watch should be maintained after the fire has been extinguished Class B liquids are divided into two broad categories of non-volatile and volatile	Removal of fuel source Smothering Flame inhibition	Foam – Low expansion foam, discussed in section 5.3.2.1, is an effective agent for extinguishing most hydrocarbon liquid fires CO_2 Dry chemical – 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 vapour Water mist – Water should only be applied to oil fires as a mist. The use of a water jet may spread the burning oil by splashing or overflow
Class C	Flammable gases, e.g. propane, butane, methane and hydrogen, 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	Removal of fuel source Smothering	Dry chemical
Class D	Metals, e.g. magnesium, titanium, lithium, zirconium, sodium and potassium. These metals burn at high temperatures and react violently with water, air and/or other chemicals	Smothering	Specialist dry powder, extinguishing agents for Class D fires are not of a multi-purpose rating and must match the type of metal involved
Class E	Energised electrical equipment fires may be caused by a short circuit, overheating of circuits or equipment, lightning or fire spread from other areas	De-energise Smothering Flame inhibition	CO_2 Dry chemical Clean agents The immediate action is to de-energise the electrical equipment. Once de-energised, a non-conductive extinguishing agent, e.g. CO_2 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
Class F (or Class K)	Cooking oils and fats, generally at a temperature higher than 360°C	Smothering	Wet chemical

Table 5.1: Classification of fires

5.3.1 Cooling agents

5.3.1.1 Water

Directly applying a water jet onto a fire is effective at fighting Class A fires only. A wetting agent added to water will lower its surface tension and increase the penetration of the water, potentially reducing the amount needed to extinguish fires in tightly packed Class A materials.

For fires involving hydrocarbon liquids, water is used mainly to cool exposed surfaces and prevent the fire from escalating. Water spray and water fog may also be used to form a heat screen between the fire and firefighting personnel and equipment. If foam is not available, a water mist can extinguish fires involving shallow pools of heavy oil.

Large fires in enclosed spaces can generate enough heat to turn water to steam on contact. Take precautions to protect personnel from steam burns when using water jets.

Do not use water in any form on fires involving hot cooking oil or fat, as it may cause the fire to spread.

Do not direct concentrated water streams at fires involving liquefied gas as more liquid will be vaporised, which will increase the size of the vapour cloud size and increase the hazard. Water spray or water fog can be used on liquefied gas fires and spills as they will cool the area, control the intensity of the fire and help disperse the vapour cloud.

Do not direct water jets at energised electrical equipment as this could create a path for electricity from the equipment, which will expose firefighting personnel to the danger of electric shock.

All tankers have a water firefighting system that consists of pumps permanently connected to the sea, a fire main with hydrant points and fire hoses with couplings and jet nozzles or, preferably, jet/spray nozzles. Hydrants are located to ensure that two jets of water can reach any part of the ship. Bulkheads are sometimes fitted with permanent water spray lines.

In cold weather, prevent the fire mains and hydrants from freezing by continuously bleeding water overboard from hydrants at the extreme end of each fire main. Alternatively, all low points of the fire main may be kept drained. Flush sea water fire suppression piping systems with fresh water after use to protect the internal pipeline from oxidation.

5.3.1.2 Water mist

Water mist fire protection systems use a spray mist to absorb heat and displace oxygen. They are effective in accommodation spaces and areas within the engine room. These systems consist of a water supply connected to an atomising distribution system that can deliver a water mist through one or more nozzles.

Several types of system are currently available, including:

- Low pressure and HP systems. HP systems produce a smaller droplet size and are sometimes known as water fog systems.
- Open nozzle systems. All the system nozzles activate if a fire breaks out in the protected space.
- Closed nozzle systems. The nozzles may open locally when a fire is detected in the protected space.
- Engineered systems. These are specific to certain applications. Detailed calculations are used to determine the design parameters, e.g. nozzle size and location, water pressure and flow rates.
- Pre-engineered (packaged) systems. These have their own water supply and are suited for local applications and single installations. Some ships have systems that protect specific parts of the engine room, e.g. oil fuel treatment spaces, boiler-firing platforms, small machinery spaces and pumprooms.

For further guidance, see the latest edition of *NFPA 750: Standard on Water Mist Fire Protection Systems*.

5.3.1.3 Water curtain

Some ships have a fixed system that provides a protective water curtain between the cargo deck and the superstructure.

5.3.1.4 Foam

Foam can absorb only a limited amount of heat, so is not considered a primary cooling agent.

5.3.2 Smothering agents

Tankers may have one or more of the following smothering systems.

5.3.2.1 Foam

Foam is an aggregation of small bubbles that have a lower specific gravity than oil or water. It flows across the surface of a burning liquid and forms a consistent smothering blanket.

High expansion foam systems can fight fires in the cargo spaces, on the cargo deck, in the pumproom or in the engine spaces. Storage tanks contain foam concentrate, which is picked up in the right amount by water from the fire pumps. The foam solution then moves through permanent supply lines to off-take points, fixed foam monitors or fixed dispersal nozzles.

A good foam blanket:

- Seals against flammable vapour loss.
- Absorbs some heat and so cools the fuel surface.
- Isolates the fuel surface from the oxygen supply.
- Eliminates combustion by separating the flammable vapour layer from other ignition sources, e.g. flames or hot metal surfaces.
- Resists disruption caused by the airflow, heat or flames.
- Reseals when its surface is broken or disturbed.

Foam is an electrical conductor, so it should not be applied to energised electrical equipment. Foam applicators should be directed away from liquid petroleum fires until any water in the foam system has been flushed clear, so that the water/foam mixture will blanket the burning liquid rather than the water dispersing the burning liquid.

5.3.2.1.1 Categories of foam

Two categories of foam concentrate are currently in use.

Protein Foam (P) concentrates are used at 3–6% by volume concentration in water. They include:

- P made from hydrolysed protein materials.
- Fluoroprotein Foam (FP) with added fluorinated surface-active agents.
- Alcohol Resistant Fluoroprotein Foam (FPAR), which is resistant to break down when applied to the surface of alcohol or other solvents.

Synthetic foam concentrates are used at 1–6% by volume concentration in water. They include:

- Aqueous Film Forming Foam (AFFF), based on a mixture of hydrocarbon and fluorinated surface-active agents.
- Alcohol Resistant Aqueous Film Forming Foam (AR-AFFF) for use with alcohols and fuels blended with large amounts of alcohol.

Tankers that handle biofuel or blends containing ethyl alcohol should use alcohol resistant foams.

When buying foam concentrates, ensure that dilution rates are compatible with the equipment used by the operator and local emergency services.

Environmental concerns have been raised about perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS), the fluorinated organic chemicals used in some foam concentrates. As a result, some countries have banned them. When choosing foam concentrates, operators should ensure the product meets all applicable environmental legislation. Alternative foam concentrates are now widely available.

5.3.2.1.2 Expansion ratios

Synthetic high expansion foam has expansion ratios between about 200:1 to 1,000:1. A foam generator, either fixed or mobile, sprays the foam onto a fine mesh net that has air driven through it by a fan.

High expansion foam has limited uses. It is most often used to rapidly fill an enclosed space, displacing free air and so extinguishing the fire. It is generally unsuitable for use outside as it is not easily directed onto hot, unconfined spill fires and is quickly dispersed in light wind.

Enhanced high expansion foam systems are increasingly in use on ships to protect enclosed areas such as pumprooms and engine room spaces. These systems (also known as hot foam systems) draw hot air from inside the space and have expansion ratios of 250:1 to 1,000:1. When activated, the systems release high expansion foam to flood the area, cooling the fire and displacing the air.

Medium expansion foam has an expansion ratio of 20:1 to 250:1. It can be protein or synthetic based and does not need a fan for aeration. Portable applicators can deliver a lot of foam onto spill fires, but their throw is limited and the foam can be dispersed in moderate wind.

Low expansion foam has an expansion ratio of about 3:1 to 15:1. Made from protein based or synthetic concentrates and used from fixed monitors or portable applicators, it can fight spill or tank fires. The applicators provide a good throw length and the foam is resistant to wind. It should flow evenly and progressively over a burning surface without becoming agitated or submerged. This is best achieved by directing the foam against any vertical surface next to the fire. This reduces the initial impact of the fire and builds up an unbroken smothering blanket. If there is no vertical surface, the foam should be applied in oscillating sweeps, in the direction of the wind and taking care to avoid letting the foam plunge into the liquid. Spraying foam streams and allowing them to run down the deck towards the fire is also effective but has a limited range.

5.3.2.1.3 Compatibility and storage

Different foam concentrates are generally incompatible with each other and should not be mixed in storage. However, some foams are compatible when applied to a fire in sequence or at the same time.

Most foam concentrates can be used in conventional devices that produce Ps. The systems should be thoroughly flushed out and cleaned before changing agents, as the synthetic concentrates can dislodge sediment and block the proportioning equipment.

Some foams produced from concentrates are suitable for combined use with dry chemical powder. The manufacturer's instructions should provide further guidance.

Bear in mind the compatibility of foam compounds when considering joint operations with other firefighters.

Foam concentrates may deteriorate over time, depending on how they are stored. High temperatures and exposure to the air will cause sludge and sediment to form and this may affect the extinguishing power of the expanded foam. A certified laboratory should periodically test samples of the foam concentrate.

5.3.2.2 Carbon dioxide

CO_2 is an effective smothering agent for extinguishing fires in enclosed spaces where it will not be widely diffused and personnel can be evacuated quickly, e.g. machinery spaces, pumprooms and electrical switchboard rooms. It is comparatively ineffective on open decks or jetties.

CO_2 will not damage delicate machinery or instruments. It is also non-conductive so can be used safely on or around electrical equipment, even when the equipment is switched on.

It can generate static electricity, so CO_2 should not be injected into any space that may contain an unignited flammable atmosphere.

CO_2 is asphyxiating and cannot be detected by sight or smell. All personnel should evacuate the area before CO_2 is discharged. Nobody should enter confined or partially confined spaces where the gas has been discharged unless they are supervised and are using suitable breathing apparatus and a lifeline. Any compartment flooded with CO_2 should be fully ventilated and verified as safe before anybody is permitted to enter it without a breathing apparatus.

A CO_2 system normally consists of a battery of large cylinders. The gas is piped from the cylinder manifold to diffusing nozzles. Before the CO_2 is released, an alarm should warn personnel in the compartment and give them time to evacuate.

5.3.2.3 Steam

Steam smothering systems are comparatively inefficient. They often take a long time to displace enough air from an enclosed space so that the atmosphere cannot support combustion. Steam can also generate static electricity, so it should not be injected into any space containing an unignited flammable atmosphere. However, steam can be effective when discharged from a lance-type nozzle directly at a fire around a flange or vent. It is also used to fight main engine scavenge fires and vent mast riser fires.

5.3.2.4 Sand

Sand is relatively ineffective as an extinguishing agent and is only useful for small fires on hard surfaces.

5.3.3 Flame inhibiting agents

Flame inhibitors are materials that interfere chemically with the combustion process to help extinguish flames.

5.3.3.1 Dry chemical powder

Dry chemical powder is an efficient flame inhibitor but it has a negligible cooling effect. To prevent hot metal surfaces from re-igniting the fire, the fuel should be removed and/or the area cooled using water once the fire has been extinguished.

Certain types of dry chemical can cause a foam blanket to break down. Only those labelled as foam-compatible should be used with foam. The manufacturer's instructions should provide further guidance.

Dry chemical powder can be applied as a free flowing cloud from an extinguisher, a hose reel nozzle, a fire truck monitor or a fixed system of nozzles. It is most effective when dealing with oil spill fires. It can quickly knock down a fire and can also be used in confined spaces, but personnel may need protection against inhaling the powder. It is especially useful on burning liquids escaping from leaking pipelines and joints. It is non-conductive, so can be used on electrical fires. Dry chemical powder should be directed into the flames.

Dry chemical powder can clog and become unusable if it gets damp when stored or when extinguishers are being filled. It is also prone to settling and compacting when vibrated.

Maintenance procedures should include a schedule for inverting or rolling the extinguishers to keep powder free flowing. Follow the manufacturer's maintenance procedures for agitating the powder in large capacity fixed systems.

5.3.4 Clean agent fire suppression systems

A clean agent is an electrically non-conducting gaseous firefighting compound that does not leave a residue upon evaporation. These include chemical gases (halocarbons) and blends of IGs such as argon and nitrogen, marketed under various trade names.

Clean agent systems are most effective in enclosed spaces, including:

- Computer centres.
- Storage rooms.
- Engine rooms.
- Pumprooms.
- Generator rooms.

5.3.4.1 Halon and clean agents

Halogenated hydrocarbons, known as halons, are efficient fire-extinguishing agents. However, halon gases also deplete ozone, so their production was phased out in 2000. New halon firefighting systems have been prohibited on ships since July 1992. Some systems remain in service on a small number of ships and continue to provide adequate fire protection if correctly maintained.

International restrictions on producing and using halon fire-extinguishing agents led to the development of alternative clean agents, such as halocarbon based agents or IG agents.

Clean agents are compressed gases or vaporising liquids that extinguish fires either by chemically disrupting combustion, smothering or absorbing heat, or a combination of these.

Clean agents are toxic to some degree because contact with hot surfaces and flames causes them to break down. All personnel should evacuate the area before halons or their alternatives are used. It is possible to start discharging them before evacuation is complete because the toxic concentrations when extinguishing fires are tolerable for a short time. After the fire has been extinguished, the area should be thoroughly ventilated and confirmed safe for entry. If the area needs to be entered before this, suitable breathing apparatus should be used.

For further guidance, refer to latest edition of *NFPA 2001: Standard on Clean Agent Fire Extinguishing Systems.*

5.3.5 Inert Gas system

The purpose of an IG system is to prevent cargo tank fires or explosions. It is not a fixed firefighting system but it can be used to help to control fires and prevent explosions.

5.4 Portable fire extinguishers

Tankers and terminals have a range of portable fire extinguishers (see section 5.2 for information on the classification of fires and fire extinguishers). As well as the fire extinguishers in use, tankers are required to carry spare charges for refilling used extinguishers. Fully charged spare cylinders are carried for CO_2 extinguishers. Consider providing portable extinguishers that are suitable for use on Class A fires and can be deployed exclusively at the ship's manifold when in port.

All fire extinguishers should be maintained and available for immediate use. The system for managing safety should contain procedures for maintenance, including that done by service agents. As a minimum, all fire extinguishers should be formally checked once a year that they are in the right location, have the right charging pressure and are working properly. Guidelines for the maintenance and inspection of fire protection systems and appliances are in IMO publications, specifically the latest relevant Marine Safety Committee (MSC) Circulars.

Type of fire and fire-extinguishing mediums	Class A	Class B	Class C	Class D	Class E	Class F (OR K)
	Fires involving solid materials, usually of an organic nature, in which combustion normally takes place with the formation of glowing embers	Fires involving liquids or liquefiable solids	Fires involving gases	Fires involving metals	Fires involving energised electrical equipment, where the electrical non-conductivity of the extinguishing medium is of importance*	Fires involving cooking oils
Water/water with additives	✔					
Foam	✔	✔			*	
Dry powder/ dry chemical (standard Classes B, C)		✔	✔		✔	
Dry powder/ dry chemical (multiple or general purpose/Classes A, B, C)	✔	✔	✔		✔	
Dry powder/dry chemical (metal)				✔		
CO_2 gas		✔			✔	
Wet chemical	✔					✔
Fire blanket						✔

* *When electrical equipment is de-energised, extinguishers for Class A or B fires may be used safely.*

Table 5.2: Types of portable fire extinguisher

5.5 International shore fire connection

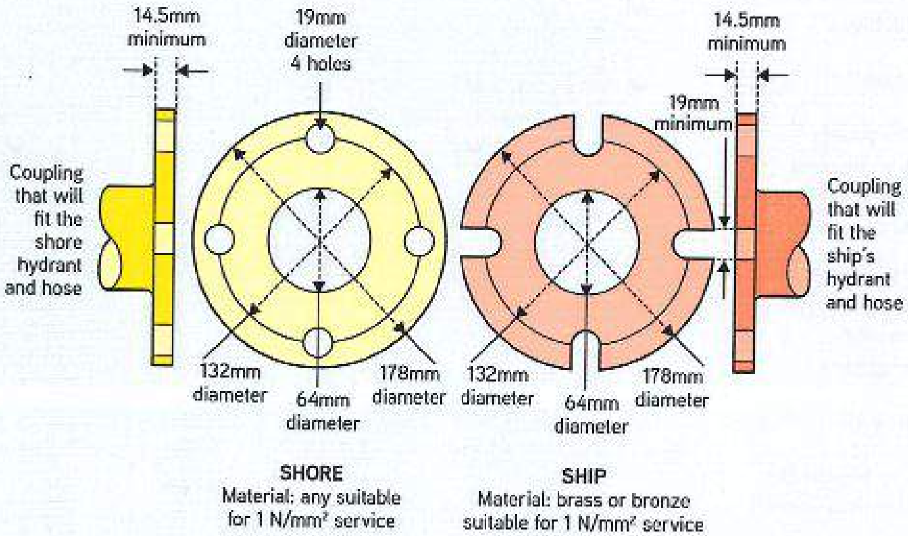
All tankers and terminals should be able to interconnect the fire mains on board and ashore so that an external water supply can be coupled to any hydrant in the ship's fire main. The international shore fire connection is a standardised way of connecting two systems that might have individual couplings or connections that do not match. This connection should be ready for immediate use (see section 19.4.3.1 and chapter 25).

The flanges on the connection should have the dimensions shown in figure 5.1. It should have a flat face on one side and a coupling on the other that will fit the hydrant or hose on the ship or shore.

If fixed on a ship, the connection should be accessible from both sides of the ship and its location clearly marked.

To interconnect the two fire mains, a fire hose with a shore connection led to its counterpart and the flange joints are bolted together.

The connection should be protected from the elements and located for immediate use. All appropriate staff should know the location and purpose of this connection. It should be discussed during the joint completion of the Ship/Shore Safety Checklist (SSSCL). Terminals should include emergency flanging of international shore fire connection in training plans.



Flange surface	Flat surface
Gasket material	Any suitable for 1 N/mm² service
Bolts	Four 16mm diameter/50mm long threaded to within 25mm of the bolt head
Nuts	Four to fit bolts
Washers	Eight to fit bolts

Figure 5.1: Details of the international shore fire connection

5.6 Water borne firefighting equipment

Water borne firefighting equipment, normally fire boats or firefighting tugs, can be very effective, particularly when they can manoeuvre upwind of a fire. This is often possible, especially at sea island berths.

If firefighting boats are well equipped, continuously available and can attend quickly, e.g. within 15–20 minutes of the call, this should be taken into account when assessing the firefighting equipment at a berth. If firefighting tugs cannot guarantee a response within a reasonable time, they should not be included in an assessment of a terminal's firefighting capability.

Water borne firefighting is best provided by working tugs or workboats fitted with firefighting equipment, including foam facilities. They should be capable of tackling a deck fire on the largest tanker likely to use the port.

Where firefighting tugs are part of a terminal's planned response to fires on tankers or the terminal itself, they should be made available as soon as they are needed if they are to be effective. If the tugs are helping a ship to berth or unberth at the terminal or they are working elsewhere in the harbour when a fire starts, procedures should allow them to be released as quickly as possible to help fight the fire. When idle between tasks, the tugs should have easily slipped moorings and be within reach of the terminal. They should keep a continuous radio and visual watch on the terminal.

Tugs could have varying firefighting (Fi-Fi) capabilities ranging from non-classed firefighting vessels (Fi-Fi 0) to having Class notations such as Fi-Fi I, II, III depending on Classification Society rules. Terminals should specify which level of firefighting capabilities are required for tugs included under their emergency response plans to tackle fires at the terminal.

In special circumstances, such as terminals handling a high number of tankers, or harbours with multiple terminals, a specially equipped firefighting boat should be considered.

The decision to use tugs to fight a fire on a tanker or the terminal, or to use them to unberth nearby ships, should be made by the person in overall charge of the firefighting and with the harbour authority. Firefighting tugs should have VHF/UHF radio with separate channels for towing and firefighting. When firefighting, they should be in direct contact with the person in overall charge of the firefighting.

Tugs with firefighting 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 and be ready for immediate use.

As part of the terminal emergency plan, it should be decided whether trained firefighters or the crew will fight the fire. Either way, the decision should be supported with appropriate training.

5.7 Protective clothing

All fire protective clothing protects firefighters from radiant heat and burns.

Fire protective clothing is made from lightweight, fire resistant fabric with an aluminium covering. It is also called a fire proximity suit. It is not suitable for direct exposure to fire. Heavier suits, known as fire entry suits, allow personnel wearing breathing apparatus and with rescue backup to withstand direct flames for a short time.

Depending on local firefighting arrangements, the terminal should provide a minimum of two complete sets of fire proximity and fire entry suits, including helmets, SCBA, gloves and boots.

All protective clothing should be kept serviceable and dry. It should be properly fastened when worn.

Tankers should have fire protective clothing in accordance with SOLAS.

5.8 Automatic fire detection systems

5.8.1 General

Automatic fire detection and alarm systems alert personnel so they can respond promptly to a fire with the aim of saving lives and property. These systems may have one or more circuits connected to automatic fire detectors and manual activation points. They may also have one or more indicating circuits connected to alarm signals, including control panel indicator and warning lamps, outdoor flashing lights, bells and horns.

5.8.2 Types of fire detectors

Automatic detection systems consist of mechanical, electrical or electronic devices that detect environmental changes created by fire or by toxic or combustible gases. Fire detectors operate on one of three principles: sensitivity to heat, to smoke or gaseous by-products of combustion, or to flame radiation.

5.8.2.1 Heat-sensing fire detectors

Heat-sensing fire detectors fall into two general categories:

- Fixed temperature devices that trigger an alarm at a pre-determined temperature.
- Rate of rise devices that have two thermocouples; one that monitors heat rise from convection or radiation and a second that monitors the ambient temperature of the space. If the first exceeds the second, an alarm will be triggered.

Some devices combine both principles and are known as rate compensated detectors.

Generally, heat-sensing detectors are suited to detecting fires in spaces, e.g. rooms, lockers, etc., that may be subject to rapid and high heat. They may also be used directly over hazards where hot flaming fires might occur or where the speed of detection is not the prime concern.

5.8.2.2 Smoke-sensing fire detectors

Smoke-sensing fire detectors operate on various principles, including ionisation of smoke particles, photoelectric light obscuration or light scattering, electrical resistance changes in an air chamber and optically scanning a cloud chamber.

5.8.2.3 Gas-sensing fire detectors

Gas-sensing fire detectors detect one or more of the gases produced during combustion. These detectors are seldom a preferred option as tests show that smoke is detectable before gases.

5.8.2.4 Flame-sensing fire detectors

Flame-sensing fire detectors use optical sensors to spot the radiant energy emitted by fire. Flame detectors that respond to IR or ultraviolet radiation, or a combination, are available. Ultraviolet sensitive, triple IR or multi-spectrum flame detectors are generally preferred.

5.8.3 Selection of fire detectors

Fire 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 are all factors to consider. Any replacement detectors should be like for like.

Heat detectors, including fusible plugs, cost the least and have the lowest false alarm rates, but they are also the slowest to respond. Heat generated by small fires tends to dissipate rapidly, so heat detectors are best used to protect confined spaces or positioned directly over hazards where a flaming fire might occur.

Smoke detectors respond faster than heat detectors. They are best suited to confined spaces and should be installed for known air current patterns, e.g. at air conditioning return ducts, or on a grid layout.

Photoelectric smoke detectors are best used in places where smouldering or low temperature fires might be expected. Where flaming fires are expected, ionisation smoke detectors should be used.

Flame detectors give a fast response but will warn of any source of radiation in their sensitivity range. False alarm rates can be high if they are not used properly. Their sensitivity is a function of flame size and distance from the detector. They are available in explosion-proof housings, so can be used to protect areas where explosive or flammable vapours are encountered.

5.8.4 Fire detection and alarm systems in terminals

Fire detection and alarm system selection and fitting at a terminal depends on the risks of the product being handled, tanker sizes and terminal throughput.

Since heat is carried and stratified by convection currents, the location of detectors should consider natural and mechanical ventilation effects. Before installation, seek the advice of manufacturers and fire and safety experts and check that detectors comply with local regulations.

CHAPTER 6

Security

6.1 General

6.2 Threat and risk assessment

6.3 Security risk assessments

6.4 Cyber safety and security

6.5 Security plans

6.6 Responsibilities under the International Ship and Port Facility Security Code

This chapter provides a brief summary of the requirements of the *International Ship and Port Facility Security (ISPS) Code* and industry best management practices and guidelines.

6.1 General

Internationally trading ships, and terminals handling such ships, are required to take measures to enhance maritime security and to comply with the provisions of the ISPS Code Parts A and B. The ISPS Code applies to shore based facilities in States that are party to the SOLAS Convention. Industry best management practice and guidelines for improving security should also be considered.

It is recommended that all tankers and terminals conduct a thorough security risk assessment and develop a security plan. Tankers should also develop a hardening plan. The security plan should include procedures, measures and controls to address all identified security risks.

Tankers and terminals that are not required to comply with the ISPS Code are still recommended to consider its requirements, along with industry best management practices, when developing their security plans.

6.2 Threat and risk assessment

To fully understand the security risk, conduct a risk assessment of all security threats. A threat is formed of capability, intent and opportunity, as shown in figure 6.1. The risk is a function of the threat, coupled with the vulnerability of the asset and the consequences of the incident.

Figure 6.1: The threat triangle

Removing one side of the triangle will minimise the risk.

Capability means attackers have the physical means to attack. Intent is demonstrated by the will and means to attack. Opportunity can be reduced by the company, tanker and terminal operators through security plans. Ask regional or local authorities for more information about threats, e.g. region specific threats, new tactics and mitigation measures.

6.3 Security risk assessments

The security risk assessment should include all tanker and terminal operations and should identify:

- Areas most vulnerable to attack.
- Key areas to be protected.
- Threats and likelihood of occurrence.
- Consequences of an attack, including to other tankers at berths or at anchor.
- Measures for preventing, mitigating and recovering from an attack, including provisions from the ISPS Code and other additional measures.
- Any weaknesses in existing security measures, procedures and operations, including human factors.
- Personnel responsible for carrying out security measures.
- Methods or means of communicating that an attack is underway.

6.4 Cyber safety and security

Cyber security is concerned with the protection of Information Technology (IT), Operational Technology (OT), information and data from unauthorised access, manipulation and disruption. Cyber safety covers the risks from the loss of availability or integrity of safety critical data and OT.

The cyber security risk assessment should consider threats to cyber safety and cyber security, because attacks on either can harm personnel, the environment and the tanker or terminal.

The IMO has adopted resolutions on Maritime Cyber Risk Management (see MSC-FAL.1/Circ.3 *Guidelines on Maritime Cyber Risk Management*). Effective cyber risk management starts with senior management, who should develop a culture of cyber risk awareness at all levels of an organisation. For practical guidance for Masters and ship's crew, see industry *Guidelines on Cyber Security Onboard Ships*, and ICS/BIMCO/Witherbys' *Cyber Security Workbook for On Board Ship Use*.

6.5 Security plans

A security plan should be written for each tanker and terminal and should describe:

- Who is responsible for carrying out security measures.
- Security organisation.
- Security training and drills.
- Basic security measures for normal operation.
- Additional measures that will allow the tanker and terminal to respond quickly to changes in threats, e.g. by reducing or increasing the level of security.
- Procedures for linking tanker and terminal security activities with the security activities of port authorities, other tankers, terminals and facilities in the region and other local authorities and agencies, e.g. police and coast guard.
- Arrangements for regular reviews of the security plan and for amendments based on experience or changing circumstances.
- Access control measures.
- Measures to prevent unauthorised weapons, dangerous substances or devices intended to harm people, tankers or terminals being taken onto the tanker or into the terminal.
- Procedures for responding to security threats or breaches of security, which may include evacuation.

6.6 Responsibilities under the International Ship and Port Facility Security Code

The port is responsible for security and must appoint a Port Facility Security Officer (PFSO) who may be designated one or more port facilities (terminals) and is responsible for the port security plan. The person should be trained and capable of implementing all security measures.

For tankers at a terminal, while the PFSO is responsible for the port security plan, the Master has overriding authority to make decisions about the safety and security of the tanker. A Ship Security Officer (SSO) should be appointed who is trained and capable of implementing the ship security plan and security measures on board. The SSO could be the Master but is often one of the senior officers.

CHAPTER 7

Human Factors

7.1 General

7.2 Identification and analysis of Safety Critical Tasks

7.3 Design

7.4 Risk assessment

7.5 Procedures

7.6 Leadership

7.7 Confidence to stop work or speak up

7.8 Fatigue

7.9 Manning levels

7.10 Individual training, experience and competence

7.11 Practising team skills

7.12 Human factors in investigation and learning

This chapter explains what human factors are and how they influence people's interaction with equipment, processes and other people. It provides ship and terminal personnel with specific guidance on safe operations, but also includes information for companies, management and designers.

7.1 General

Human factors are the characteristics that affect human interaction with equipment, processes and other people. They can include physical, psychological and social factors. The guidance in this chapter and throughout the publication shows how human factor considerations are used to improve safety through task and equipment design, leadership and SMSs. Humans contribute to most incidents and wherever people are involved in design, construction or operation of equipment and processes there is the likelihood for human error. This might lead us to think that people cause incidents, but they do not.

Human error, actions and decisions are often the result of the way the workplace is set up, i.e. how work, equipment and safeguards are designed and how leaders influence the culture in an organisation.

Incidents start as mistakes or workarounds that stem from:

- Problems with tasks.
- Unclear procedures.
- Difficult to use equipment.

- Workload fatigue.
- Lack of resources.
- Low quality or insufficient training.
- Improper communication.
- Improper situational awareness.

Tackling underlying conditions and hard to use systems that influence human error, actions and decisions can reduce the likelihood of incidents. People in leadership play an important role in this (see section 7.6), including ship's officers, supervisors and terminal management.

Human factor influences are summarised in the following principles:

- People will make mistakes.
- People's actions are rarely malicious and usually make sense to them at the time.
- Mistakes may be due to conditions and systems that make work difficult.
- Understanding the conditions under which mistakes happen helps to prevent or correct them.
- People know the most about their work and play a critical role in identifying solutions.
- Facilities, equipment and activities can be designed to reduce mistakes and manage risk better.
- People in charge of activities help shape the conditions that influence what other people do.
- It matters how those in charge respond when things go wrong and that they take the opportunity to learn.

7.2 Identification and analysis of Safety Critical Tasks

Where the actions or decisions of a human are the only protection against a serious incident, it may be only a matter of time before there is a mistake.

A Safety Critical Task (SCT) is a task related to the ship's main hazards where human error, action or inaction may cause or fail to avoid a serious incident.

Ships and terminals should:

- Identify which tasks are safety critical.
- For each task, identify opportunities for error and conditions that make human error more likely or the consequences more serious.
- Design tasks to eliminate or minimise error and error-producing conditions.
- Identify barriers for the SCTs to reduce the likelihood or consequence of human error.

The following areas of operation may include tasks where error has the potential to lead to a serious incident:

- Berthing and mooring operations.
- Cargo transfer operations.
- Double banking operations.
- Non-cargo related operations, including tank cleaning, bunkering, storing, tanker/terminal access, tending of mooring lines, hot work and maintenance activities.

Having identified SCTs, ships and terminals should use an SCTA approach to identify possible errors, the things that make error more likely and ways of making tasks more resistant to error.

The background conditions that increase the likelihood of human failure include:

- Tasks that are complex, difficult to understand or hard to perform.
- Insufficient training.
- Parts of a task that are inefficient to do in reality or where there is insufficient time available.
- Tasks or steps that are boring, trivial or repetitive, unusual, infrequent or involve unfamiliar situations.
- Inaccessible or hard to use controls, valves, platforms, steps or emergency stops along with access, operation and maintenance challenges from hazardous or moving equipment.
- Difficult system or equipment interfaces, labelling, controls or alarms.
- Unclear signs, signals, instructions or other information.
- Reliance on error-free communications in prevailing noise and light conditions.
- Working environment: noise, heat, lighting, ventilation, ease of access, visibility, line of sight.
- Over-reliance on recognising emerging hazards, risk or change in a dynamic situation.
- Multi-tasking or potential for interruptions or distractions.
- Fatigue, stress and preoccupation.

Ships and terminals should identify ways of eliminating a task or re-designing it to reduce the likelihood of error and increase the likelihood of detection and recovery.

When selecting ways of adapting a task to reduce error, the preference is to use the more reliable control measures at the top of this hierarchy of control (see section 4.2.3):

- Elimination (of hazard or task).
- Substitution (with less hazardous material or process).
- Engineering controls (such as reconfiguring a complex pipe manifold).
- Administrative controls (such as control of work procedures, signs, etc.).
- PPE.

This hierarchy of control recognises that eliminating a task altogether may provide the best protection against the risk from that task, especially when compared to the less effective controls of additional procedures or signage.

7.3 Design

Both ships and terminals can reduce risk by reviewing their design or considering the opportunities during modifications, but this is largely outside the scope of this publication.

Taking the viewpoint of people operating equipment and controls can help to make them intuitive and resistant to error. Human-centred design ensures that human factors are considered at each stage of the design and implementation of a piece of equipment including MOC (see chapter 4). Human-centred design aspects that may be considered include:

- The usability of permanent equipment used in the ship/terminal interface.
- Layout and equipment issues that emerge from the combination of tanker and terminal equipment (e.g. landing areas, gangway placement, manifold access).
- The modification of any piece of equipment.
- The introduction of automation or technology.

For ease of use, the right information needs to be available to people operating equipment and making operational decisions. Controls need to be intuitive, minimising the potential for confusion or mistakes. When designers are updating or modifying an existing design, they should consult users. Where users report that existing equipment seems to be leading to mistakes or difficulties, design can include ways of reducing or detecting errors or minimising the consequences.

When introducing automation and technology, the impact on users should be carefully considered. While automation can bring considerable advantages to tanker and terminal operators, the side-effects of introducing technology should also be considered (see chapter 8).

Humans may be better than machines for several reasons:

- People can reach conclusions and make decisions based upon little data or unusual/unexpected circumstances.
- Equipment designers cannot foresee all future situations and operating conditions that their equipment may be used in, but skilled operators can complement the design and make it work in practice.

Automation and technology can have unintended consequences, for example:

- Simplifying or eradicating one task may increase the number and complexity of other tasks.
- Reducing workload may:
  - Reduce the operator's monitoring of a situation or system.
  - Reduce the crew's manual skills or their ability to effectively manage when things go wrong.
  - Lead to boredom and lack of engagement in the task.
  - Trigger over-reliance on the new technology or automation.
  - Lead to lost opportunities arising from human involvement, i.e. suggestions for optimising or improving a task.

7.4 Risk assessment

Risk assessments are an important part of safe operations and maintenance. Ship and terminal risk assessments should address the possibility that even competent and experienced people make mistakes that could:

- Lead to hazards or risk situations.
- Reduce the effectiveness of a control/safeguard relied on by the risk assessment (use the hierarchy of controls, see chapter 4).

7.5 Procedures

Shipboard and terminal procedures are instructions that help trained and competent personnel to conduct tasks. To improve the effectiveness of procedures, ships and terminals should consider:

- Involving the people who will be using the procedures in the creation and updating of them. This will improve accuracy, ownership, compliance and conformance.
- Well presented procedures are more effective. A procedure should help users, but cannot replace training or experience.
- Essential hardware and task step components of an operation should be covered, highlighting key critical issues and hazards.

Procedures should highlight steps where an error could:

- Occur.
- Be detected.
- Be recovered from.

Where a ship or terminal has a problem with procedural compliance or conformance, efforts should address the following:

- Are important SCTs covered by procedures?
- Are procedures available, accessible and usable?
- Are there multiple or conflicting procedures for a task?
- Are procedures clear and understandable?
- Are procedures accurate/correct/complete and workable?
- Are procedures current and valid?
- Have procedures been communicated to, or trained for by, the workforce?
- Is the requirement to follow procedures clear?

7.6 Leadership

Leaders have a significant impact on the safe operation of ships and terminals. Evidence shows that incidents of all types are reduced when those in leadership work to build trust and respect between themselves and the workforce, by:

- Promoting speaking up.
- Respecting and acting on concerns of junior team members.
- Encouraging everyone to resolve safety issues.
- Promoting, supporting and communicating continuous proactive improvement.
- Encouraging learning when things go wrong, not reacting with blame.

Those with leadership roles should be alert to junior crew or team members being unwilling to challenge those in senior positions, or those in senior positions ignoring the challenges of junior members. This is particularly relevant because of:

- The strongly hierarchical tradition in shipping and terminal operations.
- The different cultures when a tanker engages with a terminal.
- The multinational nature of ships' crews, with varying degrees of willingness to speak up or challenge.

Everyone who works on a ship or terminal has a responsibility for their own and their colleagues' health and wellbeing at work. Poor health and wellbeing can cause incidents and accidents. Healthy and happy crews and teams are more likely to identify opportunities to enhance the operation through improvements in equipment design, improved controls or safety management procedures.

Those with leadership roles on ships and terminals can address these issues by:

- Making themselves available to the workforce. This could be through walkabouts and discussion where they set expectations and standards, but also listen and learn what makes work difficult.
- Collaborating with those who do the job, tackling the problems they encounter.
- Resisting the temptation to blame, and instead looking for the systems and conditions that set the stage for people to make mistakes (see section 7.12 on investigation and learning).

7.7 Confidence to stop work or speak up

Tanker and terminal operators should emphasise to their personnel that everybody has SWA (see chapter 4).

There are many reasons why a person might not speak up or stop work:

- They see others not acting and think they have a reason.
- More experienced people around them are not doing anything.
- They think they have misread the situation.
- They worry about upsetting a co-worker by calling attention to an unsafe situation.
- They think they do not have authority.
- They feel if they are wrong it could get them into trouble.
- They think they could make a situation worse.

Those with leadership roles on ships and terminals should build people's confidence to act by:

- Taking action themselves to step back, slow, pause or stop.
- Encouraging people to ask for help and work as teams to solve problems.
- Always supporting a decision to step back, slow, pause or stop.
- Thanking and recognising even when it turns out that there is not a problem.

7.8 Fatigue

Fatigued people are more likely to make mistakes due to mental and physical impairment. Fatigue can be caused by lack of sleep, poor quality sleep or being awake for too long. It can accumulate over time with unsociable working hours or shift patterns. Fatigue can be caused by a lack of staffing, poor adherence to work/rest periods and extended operations (for example, from lengthy river passages/port approaches/long loading operations/terminal operations at unsociable hours).

Workload can increase due to extended in-port operations, poorly planned work and/or difficult to use equipment/tools. High or low temperature extremes, or exposure to poor lighting, noise and inclement weather can also contribute to performance impairment. Additionally, a fatigued person may be a poor judge of their own level of fatigue or impairment.

Ships and terminals should:

- Determine operational workload and required competencies and match manning levels and support resources.
- Manage workload, hours of work and rest.
- Understand and safeguard tasks where fatigue could increase mistakes.
- Consider the scheduling of SCTs or duties to avoid times when people may be less alert due to fatigue.
- Train personnel in the causes and effects of fatigue.
- Ensure there is sufficient opportunity to rest when planning work.
- Maintain a healthy exercise, nutrition and stress-aware environment.
- Monitor fatigue symptoms.
- Investigate fatigue-related causes of accidents and incidents.
- Consider suspending complex or extended operations to make sure that people, especially those most heavily involved, get enough rest.

The *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1979 (STCW)* and the *Maritime Labour Convention (MLC)* require ships' crews to have enough hours of rest to be fit for duty and able to carry out their duties safely. Ships are also required to maintain individual records of hours of work and rest for everyone on board.

Detailed guidance on how to mitigate and manage fatigue is contained in the IMO's *Guidelines on Fatigue*.

Terminals are not subject to global regulation on hours of work and rest, but local legislation often ensures that personnel are rested and fit for duty.

7.9 Manning levels

Not having enough people available on board or at the terminal can lead to accidents or incidents. Marine regulations require:

- Flag States to issue ships with a minimum safe manning document.
- Ships to be appropriately manned to undertake all aspects of safe operations on board.

Terminals are not subject to global regulation on manning, but local legislation often requires a minimum safe manning level to be maintained at all times (see OCIMF's *Manning at Conventional Marine Terminals*).

Both ship and terminal should consider how many people are needed for both regular operations and any emergency that might be encountered.

7.10 Individual training, experience and competence

With ship/terminal operations, the competence of the other party may be unknown. Demonstration of competence requires four things:

- Training and familiarisation for knowledge.
- Practising in order to build skills.
- Accumulating experience.
- Demonstration of being able to apply these in real life.

Both ship and terminal need to account for the possible limitations of the other party during the operation. Competent people can, and do, make mistakes. The assumption that we may have to detect and recover from others' mistakes is an important aspect of staying safe.

For ships, international conventions 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 and this includes tanker familiarisation.

Terminals are not subject to global regulation on training and competence, but local legislation often requires minimum training and competence levels.

It is recommended that ship and terminal operators have a Competence Management System. For terminal operators, this would be the *Marine Terminal Operator Competence and Training Guide (MTOCT)* (see chapter 15). For ship operators, this would fall under the STCW Convention. These systems would include the following to develop and assure competence:

- Underpinning knowledge of the job (e.g. awareness and familiarity of operations).
- Technical competencies, which are task related and enable the job to be functionally completed. They are typically job or occupation specific and the objective is to meet minimum standards of performance (e.g. ship or company specifics regarding each piece of equipment). SCTs may be an input to this.
- Non-technical competencies, which are skills that enable delivery of the role. Examples include the ability to plan effectively, work well with other team members, coach or motivate others, and communicate effectively.

7.11 Practising team skills

In the marine industry, while regulations and guidance provide important boundaries, ship crews and terminal teams are often dealing with dynamic situations influenced by weather, sea state, and equipment and process changes.

Teams need to learn and practise the skills that help them to work effectively as a team, including:

- Communication.
- Understanding and decision making.
- Team problem solving.
- Balancing formal authority and assertiveness – confidence to put forward views and speaking up.

Building these skills involves practising dynamic, realistic, scenarios together as a team, learning and practising tools and techniques that aid team performance. The mechanisms to deliver this can range from desktop exercises, discussing hypothetical scenarios, through to drills or highly accurate simulation.

Tankers and terminals should regularly exercise teams to practise the skills described above.

7.12 Human factors in investigation and learning

Human factors can be the reason why an incident or accident has happened, but the investigation may miss this by focussing on what happened and how.

To get into the real 'whys', an investigation needs to understand what was going on in the world of those involved. The investigator should understand the context of people's actions. To get to this level of understanding requires both:

- Well trained investigators who understand human factors.
- A culture where those involved in an incident feel that they can cooperate fully with an investigation.

It is important that investigations are undertaken post incident and that they dig deep enough to understand the human factors that influenced the undesired event. However:

- Most investigation reports describe 'what' – what happened, what broke, what was the outcome.
- Some investigations reveal 'how' – this rule was broken, that procedure was not followed, this person pressed the wrong button (human error was to blame).
- Very few investigations get to the 'why' – why did the Master press the wrong button on the console, why did the crew feel they couldn't follow that procedure, why did an error occur?

SCTA techniques can also be viewed as a way of learning about the errors and workarounds that eventually lead to incidents, so are an effective way of getting ahead of incidents.

Guidance on improving human factors in investigation is available from IOGP Report 621 – *Demystifying Human Factors: Building Confidence in Human Factors Investigation*. Further advice on learning from incidents is available from IOGP Report 552 – *Components of Organizational Learning from Events*.

CHAPTER 8

Alternative and Emerging Technologies

8.1 Definition

8.2 Examples

8.3 Due diligence process

This chapter describes how alternative and emerging technologies can be assessed to make sure they do not affect safety on tankers and terminals. The due diligence process can be used in the tanker's SMS and safety manuals on the terminal. For more detail on alternative and emerging mooring technologies, see OCIMF's *Mooring Equipment Guidelines.*

8.1 Definition

Alternative technologies are technologies that have a documented track record in another sector but are not yet adopted in the tanker and terminal sector.

Emerging technologies are technologies that do not have a documented track record in any sector but could be developed in the future to improve the safety and the efficiency of the tanker and terminal sector.

In both cases, no known best practice would exist for the tanker and terminal sectors.

8.2 Examples

At the time of publication, the following alternative or emerging technologies exist:

- Marine Autonomous Surface Ships (MASS).
- Autonomous Underwater Vehicles (AUV).
- Marine mobile technology, e.g. intrinsically safe electronic tablets and telephones.
- Aerial drones.
- Robotic crawlers.
- Cold ironing.
- Methanol bunkering.
- Hydrogen fuel cell management.
- Electric cell propulsion power supply.

The list is not exhaustive. This guide does not endorse or oppose the listed technologies, but they may be considered for use following a structured due diligence and formal risk assessment process.

8.3 Due diligence process

8.3.1 Evaluation

Before considering the adoption of an alternative or emerging technology, a preliminary design review should be completed to evaluate the:

- General description and its equivalency to existing technologies.
- Functional description and its equivalency to existing technologies.
- Interface with existing technologies.
- Interface with existing systems and operational processes.
- Preliminary documentation, design drawings, general arrangements, product specifications and applicable codes and standards.
- Detailed formal safety and operational risk assessment plans, including assessments of human factors.
- Any additional design basis documentation.
- Consistency with other industry reference materials, e.g. the World Association for Waterborne Transport Infrastructure (PIANC) or the International Association of Classification Societies (IACS).

8.3.2 Impact

The tanker and terminal should complete an impact assessment before agreeing to use an alternative or emerging technology at the marine interface. This process should be documented and ensure that both parties have assessed and understood the risks of using the alternative or emerging technology.

If either the tanker or terminal is unable to complete the impact assessment, they should tell the other party what technology is being used and share any relevant documentation to support its use, e.g. the risk assessment and evaluation reports of design and product specifications.

If the alternative or emerging technology only affects the tanker or the terminal, the above exchange does not need to happen unless a general understanding would be useful.

8.3.3 Equivalency

Equivalency should be demonstrated through detailed data analysis of engineering or design studies, prototype and/or on-site testing and experience. Compare the data analysis of the alternative or emerging technology with the existing technology it is replacing or being used alongside.

Equivalency should show that the alternative or emerging technology is at least as good as the existing technology in delivering:

- The safety of tanker and terminal personnel.
- The assurance that the risks continue to be effectively managed.
- Suitable margins of safety that include the probability and consequence of system failure.
- Operational effectiveness and integrity.
- Compliance with applicable regulations, standards and recommended industry guidance and best practices.

8.3.4 Formal safety risk assessments

Formal, documented and detailed safety risk assessments should be carried out to understand the risks of using alternative or emerging technologies. It is recommended that personnel conducting these risk assessments:

- Are experienced in the methods of risk assessment being used.
- Have a detailed working knowledge of the alternative or emerging technology, the equivalent existing technology and industry best practices.

Classification Societies, marine consultants or other organisations may provide an independent formal safety risk assessment or guidance on how to effectively evaluate alternative and emerging technologies.

The IMO also provides guidance to administrations for approving alternatives and equivalents in MSC.1/Circ.1455 *Guidelines for the Approval of Alternatives and Equivalents as Provided for in Various IMO Instruments.*

Factors to consider in a formal safety risk assessment of an alternative or emerging technology include:

- Hazards associated with the alternative or emerging technology and/or its equivalency.
- Safeguards incorporated into the design of the alternative or emerging technology, including measures to ensure the safety of personnel.
- Human factors and any risk reducing benefits from adopting the alternative or emerging technology.
- Risk modelling to identify frequencies and potential consequences of hazards.
- Risks related to the local conditions and locally required operations.
- Issues that may require further detailed analysis and testing/evaluation.
- Issues that may require special attention with respect to operations, inspection and maintenance, including personnel, equipment and systems redundancy.
- How the alternative or emerging technology works under different environmental conditions, e.g. air temperature, marine spray or ice.

8.3.5 Stakeholder engagement

The number and type of stakeholders involved in evaluating an alternative or emerging technology will depend on its impact and the complexity of its implementation.

Stakeholder mapping is recommended for identifying stakeholders who are important to the evaluation and success of the alternative or emerging technologies.

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Tanker Information

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CHAPTER 9

Management of Safety and Emergencies

9.1 The International Safety Management (ISM) Code

9.2 Safety Management Systems

9.3 Work planning and permit to work systems

9.4 Hot work

9.5 Electric welding equipment

9.6 Other hazardous tasks

9.7 Management of contractors

9.8 Managing Simultaneous Operations

9.9 Hazards on ships with exposed transverse frames

9.10 Repairs at a facility other than a shipyard

9.11 Shipboard emergency management

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*.

It gives guidance on risk assessment and risk management processes and provides information on the practical application of these processes for managing hot work and other hazardous tasks on board.

Safety 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 emergencies.

9.1 The International Safety Management (ISM) Code

All tankers, as defined in the *International Convention for the Safety of Life at Sea (SOLAS)* and the *International Convention for the Prevention of Pollution from Ships (MARPOL)*, of 500 tonnes DWT and over are required to comply with the ISM Code. Ships that the ISM Code does not apply to 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 (see chapter 4).

The purpose of the ISM Code is to provide an international standard for safely managing and operating ships and for preventing pollution.

The ISM Code requires ship operators to:

- Provide safe practices in ship operation and a safe working environment.
- Establish safeguards against all identified risks.
- Continuously improve the safety management skills of the ship's crew and shore personnel, including preparing for emergencies related to safety and environmental protection.

The ISM Code defines a ship operating company and requires it 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 about how a ship is managed. It is left to the operator to develop the SMS elements suitable to the operation of a specific ship.

In developing their SMS, operators are encouraged to refer to applicable industry publications and guidelines.

The International Maritime Organization's (IMO) guidelines for the ISM Code identify that cargo loading and discharge operations, including those related to dangerous goods, should be included in the scope of the operator's documentation.

9.2 Safety Management Systems

The SMS enables effective implementation of the operator's health, safety and environmental protection policy. Regular audits of the SMS verify its suitability to deliver the requirements of the ISM Code and to confirm that it is effective and that stated procedures are being followed. OCIMF's Tanker Management and Self Assessment (TMSA) is an example of a system that offers the opportunity to verify system effectiveness via self assessment and also promotes continual improvement.

Although the ISM Code specifies a range of safety management topics, the operator should develop the content and form of its SMS. This should show that acceptable levels of safety management are in place to protect the ship, its personnel and the marine environment.

To deliver the required levels of safety, the SMS needs to address all activities undertaken in the operation of the ship, together with the possible situations that could affect its safety or 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 can then be applied to ensure safe completion of the work and compliance with the SMS and provide the objective evidence needed for verification, such as:

- Documented policies, procedures and instructions.
- Documentation of the verification of day to day operation that is carried out by the Responsible Person, relevant to ensure compliance.

The result of an effective SMS is a safe system of work.

Refer to the latest edition of the International Chamber of Shipping's (ICS) *Guidelines on the Application of the IMO International Safety Management (ISM) Code*.

9.3 Work planning and permit to work systems

While operators will develop their own procedures for managing all aspects of operations and tasks, many choose to incorporate work planning meetings and a permit to work system into their SMS to manage hazardous tasks.

Refer to section 4.7, which provides further guidance on these topics.

9.4 Hot work

Hot work has caused fires and explosions in, on or near cargo tanks or other spaces that contained, or have previously contained, flammable substances or substances that emit flammable vapours. In such spaces, hot work should be considered only if there are no alternative means of repair.

9.4.1 Definition of hot work

Hot work is any work that involves sources of ignition or temperatures high enough to ignite a flammable gas or liquid or material. This includes, but is not limited to:

- Welding (electric arc or gas).
- Cutting, burning, gouging (electric or gas).
- Heating (blow torch or heat gun).
- Soldering (electric or blow torch).

Use of the following temporary/portable equipment in a hazardous area should be classed as hot work:

- Power tools (electric or electric power tools).
- Non-intrinsically safe electronic equipment.
- Internal combustion engines (driving air compressors, pumps, pressure washers, etc.).

9.4.2 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 section 9.2). An absence of guidance should be taken to mean work is prohibited rather than approved.

Welding should only be carried out in ventilated areas. If exposure controls are not adequate, workers should wear suitable Respiratory Protective Equipment (RPE) to minimise the risk from the residual fumes.

9.4.3 Hot work inside a designated space

A space where conditions are safe for hot work should be designated, such as the engine room workshop. Whenever possible, hot work should be carried out in that space.

The designated space should be assessed for possible risks and the SMS should define the conditions for carrying out hot work in that space, including additional controls such as notifications, fire watches or restrictions. Hot work should be prohibited during bunkering, cargo operations, Crude Oil Washing (COW), tank cleaning operations and whenever cargo tank vapours are released. If it is necessary for hot work to be done, these operations should stop until the hot work is completed.

For hot work such as electric welding (see section 9.5) or gas cutting, establish a safety boundary inside the designated space to prevent arc flash and contain sparks. This area should be bound by curtains or another barrier. Other factors, such as fuel tanks or electric cables, may also require a safety boundary. Work outside the boundary, but inside the designated space, may be allowed with additional controls identified by a risk assessment or as part of the operator's SMS procedures.

If the designated hot work area includes a bunker tank bulkhead, the work should not be allowed within 500mm of that bulkhead (see section 9.4.5.1).

9.4.4 Hot work outside a designated space

9.4.4.1 General

Hot work done outside the designated space should be controlled under the SMS by a permit to work system and defined requirements as in section 9.2.

Figure 9.5 shows how guidance for hot work on an inerted ship may be presented in an SMS. This is an example for operators to tailor to their own requirements.

A flowchart for guidance is in figure 9.5. The flowchart 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.

The Master should initially decide whether hot work is justified and whether it can be done safely. The departmental heads should assess all proposed work within their departments before the work starts.

A risk assessment should identify the hazards and the risks involved. This will produce risk-reduction measures that need to be taken to allow the work to be done safely.

The risk assessment should identify hazards to fire watch personnel and how they will be evacuated in an emergency. It should also identify the extra Personal Protective Equipment (PPE) that will ensure risk levels are acceptable.

A written plan for undertaking the work should be completed, discussed and agreed by everybody who has responsibilities connected to the work.

This plan should define the preparations needed before work starts, the procedures for carrying out the work and the safety precautions. The plan should also identify the person authorising the work and the personnel responsible for carrying out the specified tasks, including contractors (see section 9.7).

A designated Responsible Officer not directly involved in the hot work should ensure that the plan is followed.

Personnel carrying out the work should be adequately trained and competent to carry it out safely and effectively.

The usual resource limitations on board a tanker mean that only one hot work operation at a time should be carried out. A separate hot work permit should be approved for each intended task and location.

The work area should be carefully prepared and secured before hot work starts.

Fire safety precautions and fire-extinguishing measures should be reviewed. Adequate firefighting equipment should be prepared, laid out and be ready for immediate use.

Fire watch procedures should be established for the area of hot work and for adjacent spaces where heat transfer 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 hot work and act if residues or paint coatings ignite. Effective ways to contain and extinguish welding sparks and molten slag should be established.

The atmosphere of the area should be tested and be less than 1% Lower Flammable Limit (LFL).

The hot work permit should be issued just before the work is to be done. If the start of the work is delayed, all safety measures should be rechecked and recorded before it begins.

Permits are issued under specific conditions, but if these change hot work should stop immediately. The permit should be withdrawn or cancelled until all conditions and mitigations have been checked and reinstated, allowing the permit to be re-issued or re-approved.

The work area should be adequately and continuously ventilated and the frequency of atmosphere monitoring should be established. Times and results of atmosphere monitoring should be recorded on the hot work permit.

Isolation of the work area and fire safety precautions should continue until the risk of fire no longer exists.

If hot work needs to be done in a dangerous or hazardous area (see section 9.4.5) when alongside a terminal, it should be permitted only in line with prevailing national or international regulations, port and terminal requirements and after obtaining all necessary approvals.

9.4.4.2 Hot work in a gas safe area

A dedicated area outside the engine room may be considered for hot work, e.g. on the poop deck aft of the accommodation and well clear of any oil tank vents. Such an area should be marked accordingly. Any work at this location should have a risk assessment and the precautions set out in section 9.4.4.1 should be taken.

9.4.4.3 Hot work inside the machinery space

Hot work in the main machinery space should have a risk assessment and the precautions set out in section 9.4.4.1 should be taken.

When the hot work is associated with fuel tanks and fuel pipelines, consider the potential for hydrocarbon vapours in the atmosphere and the existence of ignition sources.

No hot work should be carried out on or within 500mm of bunker tanks unless that tank is cleaned to meet the requirements in section 9.4.5.1. A risk assessment should cover any proximity to fuel or other hydrocarbon piping.

9.4.4.4 Hot work over the side

Hot work on the outside hull, that does not fall within the dangerous or hazardous areas described in section 9.4.5, may present unique hazards and should be risk assessed before the work starts. Examples are hot work on anchors or chains (from a barge or other vessel) or the aft area of the hull for stern seal or propeller work. The procedures outlined in section 9.8 should be followed, with particular attention to section 9.10.13.

Hot work that would be conducted on the hull, such as ballast or other tanks within the cargo tank area, is to be treated as work in dangerous or hazardous areas (see section 9.4.5). When work is done over the side, the SMS may require additional permits.

9.4.5 Hot work in dangerous or hazardous areas

9.4.5.1 General

Dangerous or hazardous areas are those locations on board or within the terminal where an explosive atmosphere could be present (as defined in section 4.11.2). For ships, this effectively means an area larger than the cargo tank deck, which includes cargo tanks, ballast tanks, pumprooms and the atmospheric space around and above them. No hot work should be done in a dangerous or hazardous area until it has been made safe, tested and all appropriate approvals obtained.

Hot work in a dangerous or hazardous area should be subject to a risk assessment and the guidance in section 9.4.4 followed. The potential for hydrocarbon vapours and ignition sources should be considered.

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 operations and when tank cleaning, gas freeing, purging or inerting. If hot work needs to be interrupted to carry out any of these 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 reapproved or a new procedure developed.

Where hot work involves entry into an enclosed space, follow the procedures in chapter 10. A compartment where hot work is to be done should be cleaned and ventilated. Particular attention should 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 500mm of 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 they are found to contain hydrocarbon liquid or vapours, they should be cleaned and gas freed or inerted.

9.4.5.2 Hot work in cargo tanks

Sludge, cargo impregnated scale, sediment or any other material likely to give off flammable vapour should be removed from the work area. The extent of the cleaned area should be established following a risk assessment of the work to be done. The opposite sides of frames and bulkheads need special attention. Other areas that the hot work may affect, e.g. immediately below the work location, should also be cleaned.

Table 9.1 shows the safe distance for areas to be cleaned and the minimum requirements that may need to be extended based on the results of the risk assessment. Cleaning distances are based on the type of work and the height above the tank bottom.

Consider using fire resistant blankets or putting a water bottom in the tank to prevent sparks falling onto coatings.

All cargo pipelines to other compartments should be flushed through with water, drained, vented and isolated from the compartment where hot work will take place. They may be subsequently inerted or completely filled with water.

Height of work area	Operator's side			Opposite side		
	Gas cut	Welding	Gouging	Gas cut	Welding	Gouging
0–5 metres	1.5m	5.0m	5.0m	7.5m	2.0m	2.0m
5–10 metres	1.5m	5.0m	5.0m	10.0m	2.0m	2.0m
10–15 metres	1.5m	5.0m	7.5m	15.0m	2.0m	2.0m
>15 metres	1.5m	5.0m	10.0m	20.0m	2.0m	2.0m

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 to ensure they are 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. No hot work should be carried out on bulkheads of bunker tanks or within 500mm of the bulkheads unless that tank has been cleaned for hot work.

Tankers without an Inert Gas system

The compartment where hot work is to be done should be cleaned, gas freed to meet hot work requirements and continuously ventilated.

Adjacent cargo tanks, including those positioned diagonally, should either have been cleaned and gas freed to meet hot work requirements 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 30m 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 vent main and isolated from the piping system for the duration of the hot work.

Vapour or vent lines to the compartment should be ventilated to not more than 1% LFL and then isolated.

The possibility of using an external source of Inert Gas (IG) should be considered.

Tankers with an Inert Gas system

The compartment where the hot work is to be done should be cleaned, gas freed to meet hot work requirements and continuously ventilated.

Adjacent cargo tanks, including those positioned diagonally, should be either:

- Cleaned and gas freed, with hydrocarbon vapour content reduced to not more than 1% LFL and maintained at that level.
- Emptied, purged and the hydrocarbon vapour content reduced to less than 2% by volume and inerted.
- 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 500mm of such a bulkhead, the space on the other side should also be cleaned to meet hot work requirements.

IG pressure should be reduced for the duration of the hot work to prevent uncontrolled venting.

Cargo piping and IG lines to the compartment should be purged with IG, to reduce the hydrocarbon level to less than 2% by volume, and isolated.

All slops should be removed from the ship or securely isolated in a non-adjacent tank at least 30m from the hot work location.

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.

Gas testing should be done before starting hot work and there should be continuous monitoring of the atmosphere in the vicinity during the entire duration of hot work.

9.4.5.3 Hot work in ballast tanks

Ballast tanks located in the cargo tank area should be treated as dangerous or hazardous areas, similar to cargo tanks.

Hot work in ballast tanks, e.g. the fore peak and after peak tanks, that fall outside the dangerous or hazardous area and have no adjacent cargo, slop or bunker tanks, may be treated as work outside a designated space, but no hot work should be carried out unless all spaces within 30m are either:

- Gas freed.
- Hydrocarbon vapour content reduced to 2% by volume and inerted.
- Completely filled with water.

9.4.5.4 Hot work in pumproom

The pumproom should be treated as a dangerous or hazardous area, similar to cargo tanks.

Adjacent tanks should be either:

- Cleaned and gas freed, with hydrocarbon vapour content reduced to not more than 1% LFL and maintained at that level.
- Emptied, purged and the hydrocarbon vapour content reduced to less than 2% by volume and inerted.
- Completely filled with water.

Pipelines, strainers and cargo pumps should be gas freed, inerted or filled with water. The bilge and work areas should be cleaned to meet hot work requirements.

All slops should be either removed from the ship or securely isolated in a non-adjacent tank at least 30m from the hot work location.

9.4.5.5 Hot work within the cargo tank deck area

On the tank deck

Any hot work on the tank deck or less than 500mm above the tank deck should be classed as hot work within that tank, so it will need to comply with the appropriate measures (see section 9.4.5.2).

On the cargo tank bulkhead or within 500mm of the bulkhead:

- The space on the other side should also be cleaned to meet hot work requirements.
- Reduce IG pressure for the duration of the hot work to prevent uncontrolled venting.
- Cargo piping and IG lines to the compartments should be purged with IG to not more than 2% hydrocarbon by volume and then isolated.
- All slops should be either removed from the ship or securely isolated in a non-adjacent tank at least 30m from the hot work location.

Above the tank deck

If hot work is to be done above the tank deck (higher than 500mm), any cargo and slop tanks within a radius of at least 30m around the working area should be either:

- Cleaned and gas freed, with hydrocarbon vapour content reduced to not more than 1% LFL and maintained at that level.
- Emptied, purged and the hydrocarbon vapour content reduced to less than 2% by volume and inerted.
- Completely filled with water.

All other cargo tanks should be inerted with openings closed.

All slops should be either removed from the ship or isolated in a tank as far from the hot work location as is practicable.

Alternatively, for tankers without an Inert Gas system

All cargo tanks within 30m of the work location, including those positioned diagonally, should be either 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 30m) from the hot work location. Vapour or vent lines to the compartment should be ventilated to not more than 1% LFL and then isolated.

The possibility of using an external source of IG should be considered.

9.4.5.6 Hot work in the vicinity of bunker tanks

Hot work near bunker fuel tanks should be treated in the same way as hot work on or above the tank deck. No hot work should be carried out on the deck, or within 500mm of the deck, unless the tank has been cleaned to meet hot work requirements.

Bunker fuel tanks should be clearly identified to avoid any misunderstanding about their location and extent.

9.4.5.7 Hot work on pipelines

Sections of pipelines, strainers, valves, etc. should be removed from the system and repaired in the designated space whenever possible (see section 9.4.3). Any breaking of lines should comply with the permit to work system for the control of hazardous energy.

Where repairs on pipelines and valves need to be done with the equipment in place, the item needing hot work should be removed by cold work and the remaining pipework blanked off. The item should be cleaned and gas freed to meet hot work permit requirements.

If the location where the hot work is to be done is not close to the disconnected pipeline, consider providing 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 to ensure they are clear of hydrocarbons.

9.4.5.8 Hot work diagrams

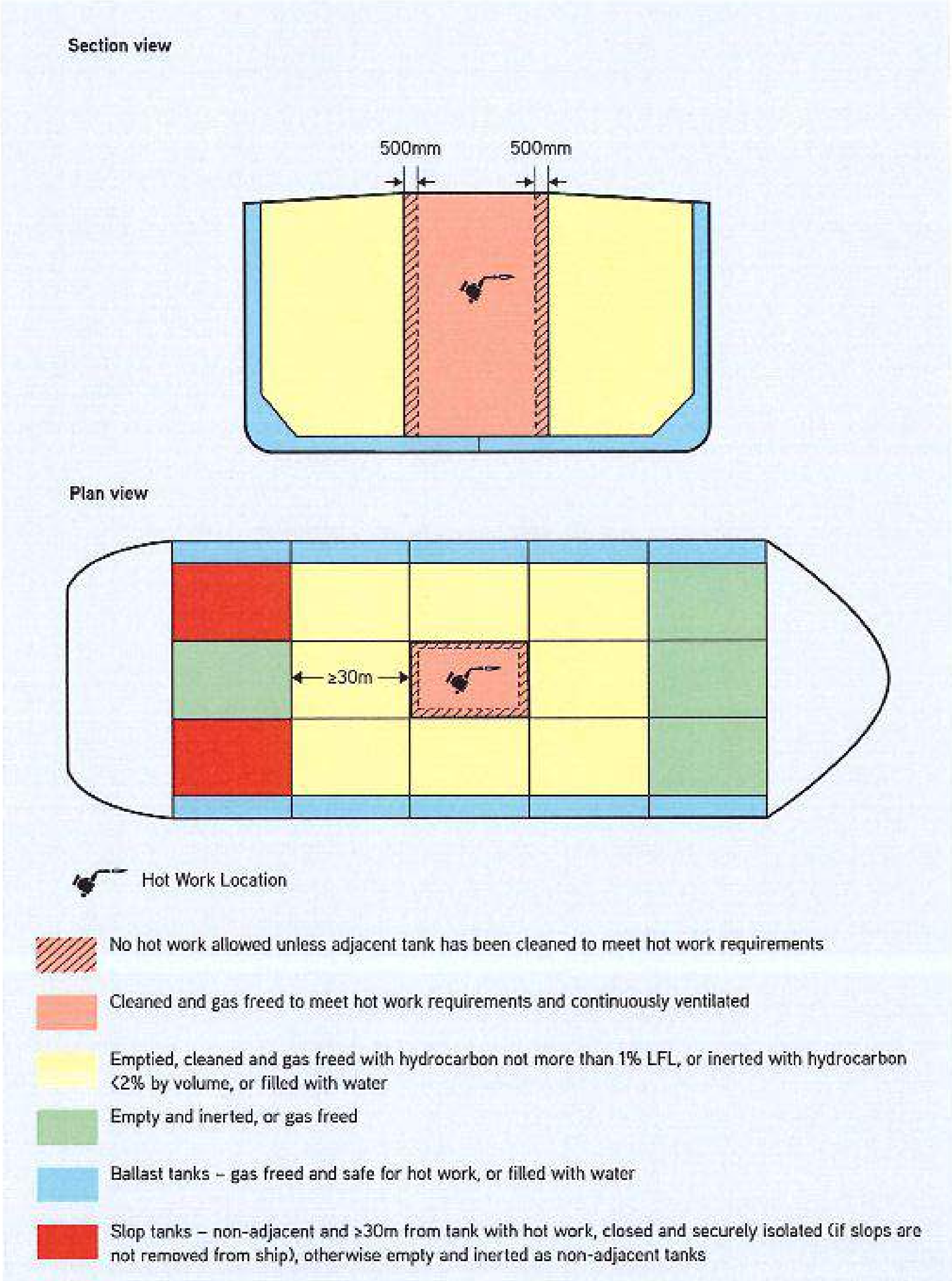


Figure 9.1: Hot work being carried out in a cargo tank

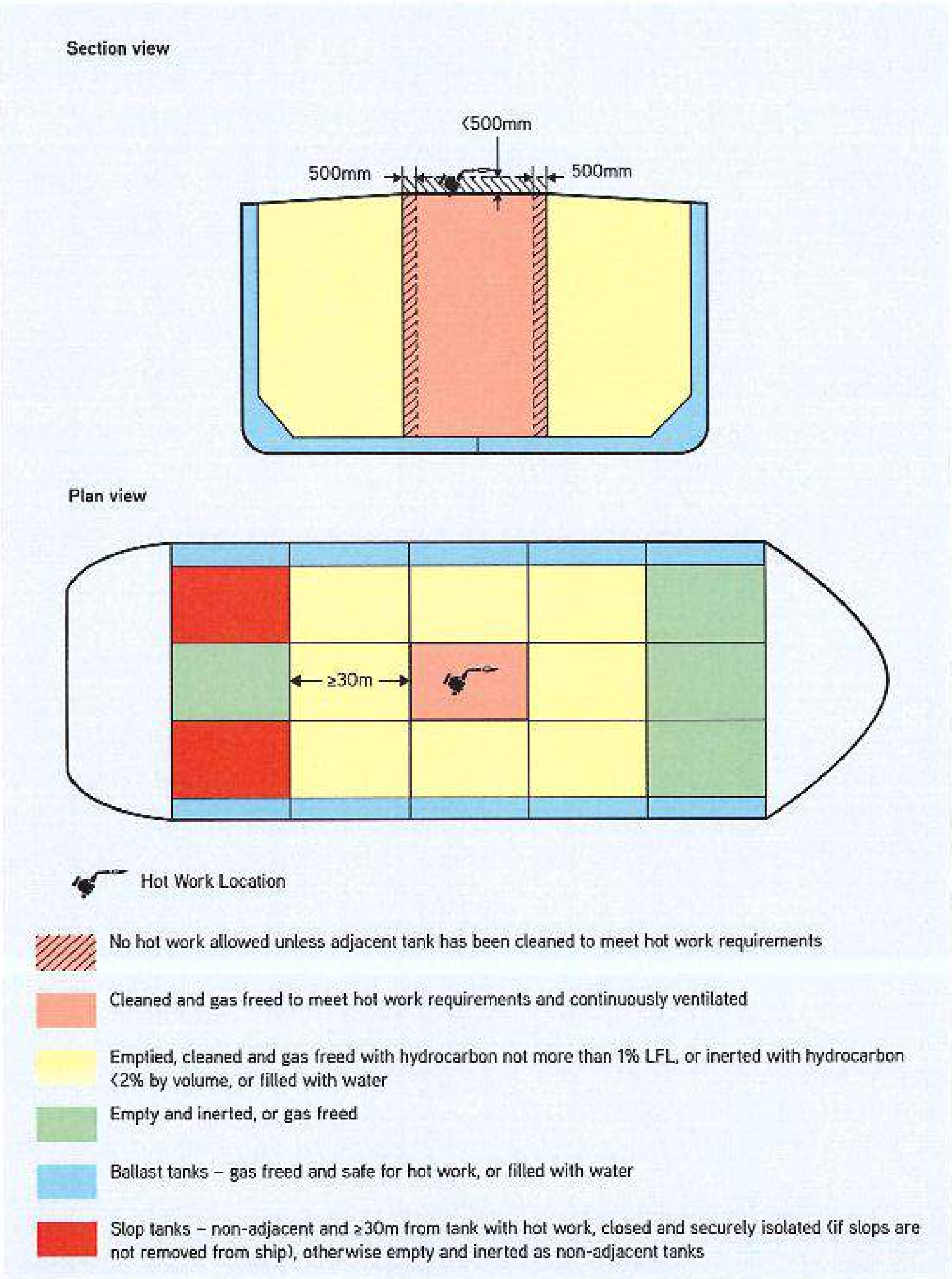
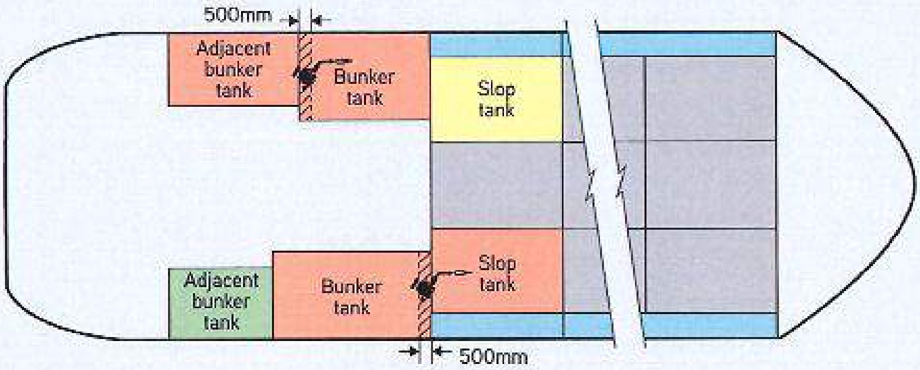


Figure 9.2: Hot work being carried out on cargo tank deck or within 500mm of it (to be treated as hot work in tank)

Plan view



Hot Work Location

<500mm from adjacent tank bulkhead

- No hot work allowed unless adjacent tank has been cleaned to meet hot work requirements
- Bunker tank where hot work will be performed – cleaned, gas freed to meet hot work requirements, hydrocarbon <1% LFL, continuously ventilated
- Adjacent bunker tanks – cleaned, gas freed to hydrocarbon <1% LFL, continuously ventilated
- Adjacent slop/cargo tanks – cleaned, gas freed to meet hot work requirements, hydrocarbon <1% LFL, continuously ventilated

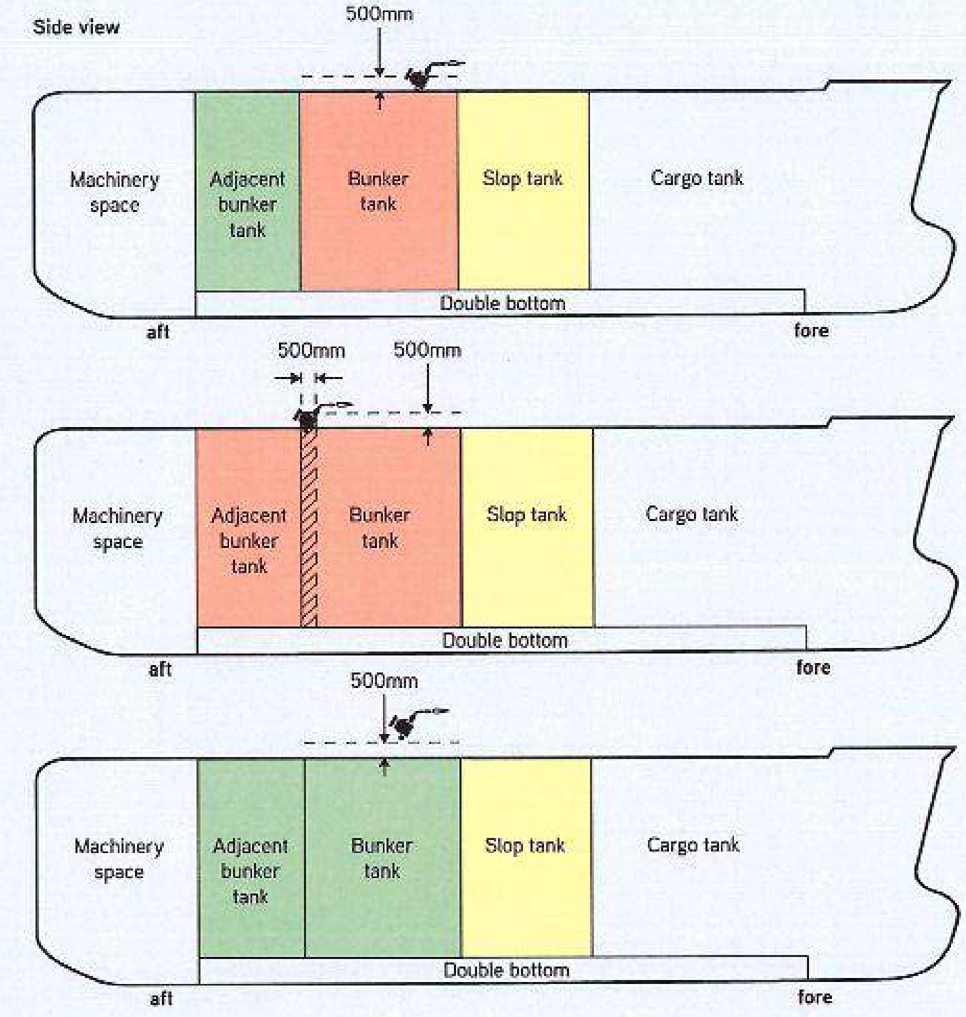
  All slops/cargo should be either removed from the ship or securely isolated in a non-adjacent tank >30m from hot work location
- Non-adjacent cargo tanks – empty and inerted
- Ballast tanks – gas freed or completely filled with water, adjacent ballast tanks should be tested to ensure they are safe for hot work

>500mm from adjacent tank bulkhead

- No hot work allowed unless adjacent tank has been cleaned to meet hot work requirements
- Bunker tank where hot work will be performed – cleaned, gas freed to meet hot work requirements, hydrocarbon <1% LFL, continuously ventilated
- Adjacent bunker tanks – hydrocarbon <1% LFL in the vapour space of the bunker tank
- Adjacent slop/cargo tanks – cleaned, gas freed to meet hot work requirements, hydrocarbon <1% LFL, continuously ventilated, or emptied, purged with hydrocarbon <2% by volume, or completely filled with water

  All slops/cargo should be either removed from the ship or securely isolated in a non-adjacent tank >30m from hot work location
- Non-adjacent cargo tanks – empty and inerted
- Ballast tanks – gas freed or completely filled with water, adjacent ballast tanks should be tested to ensure they are safe for hot work

Figure 9.3: Hot work inside a bunker tank



Hot Work Location

<500mm from tank deck

No hot work allowed unless adjacent tank has been cleaned to meet hot work requirements

Bunker tank above which the hot work to be performed – cleaned, gas freed to meet hot work requirements, hydrocarbon <1% LFL, continuously ventilated

Adjacent bunker tanks – cleaned, gas freed to meet hot work requirements, hydrocarbon <1% LFL

Adjacent slop/cargo tanks – cleaned, gas freed to meet hot work requirements, hydrocarbon <1% LFL, continuously ventilated, or emptied, purged with hydrocarbon <2% by volume, or completely filled with water

All slops/cargo should be either removed from the ship or securely isolated in a non-adjacent tank >30m from hot work location

>500mm from tank deck

Bunker tank above which the hot work to be performed – hydrocarbon <1% LFL in the vapour space

Adjacent bunker tanks – hydrocarbon <1% LFL in the vapour space

Adjacent slop/cargo tanks – cleaned, gas freed to meet hot work requirements, hydrocarbon <1% LFL, continuously ventilated, or emptied, purged with hydrocarbon <2% by volume, or completely filled with water

All slops/cargo should be either removed from the ship or securely isolated in a non-adjacent tank >30m from hot work location

Figure 9.4: Hot work in the vicinity of a bunker tank (treated as hot work over tank deck)

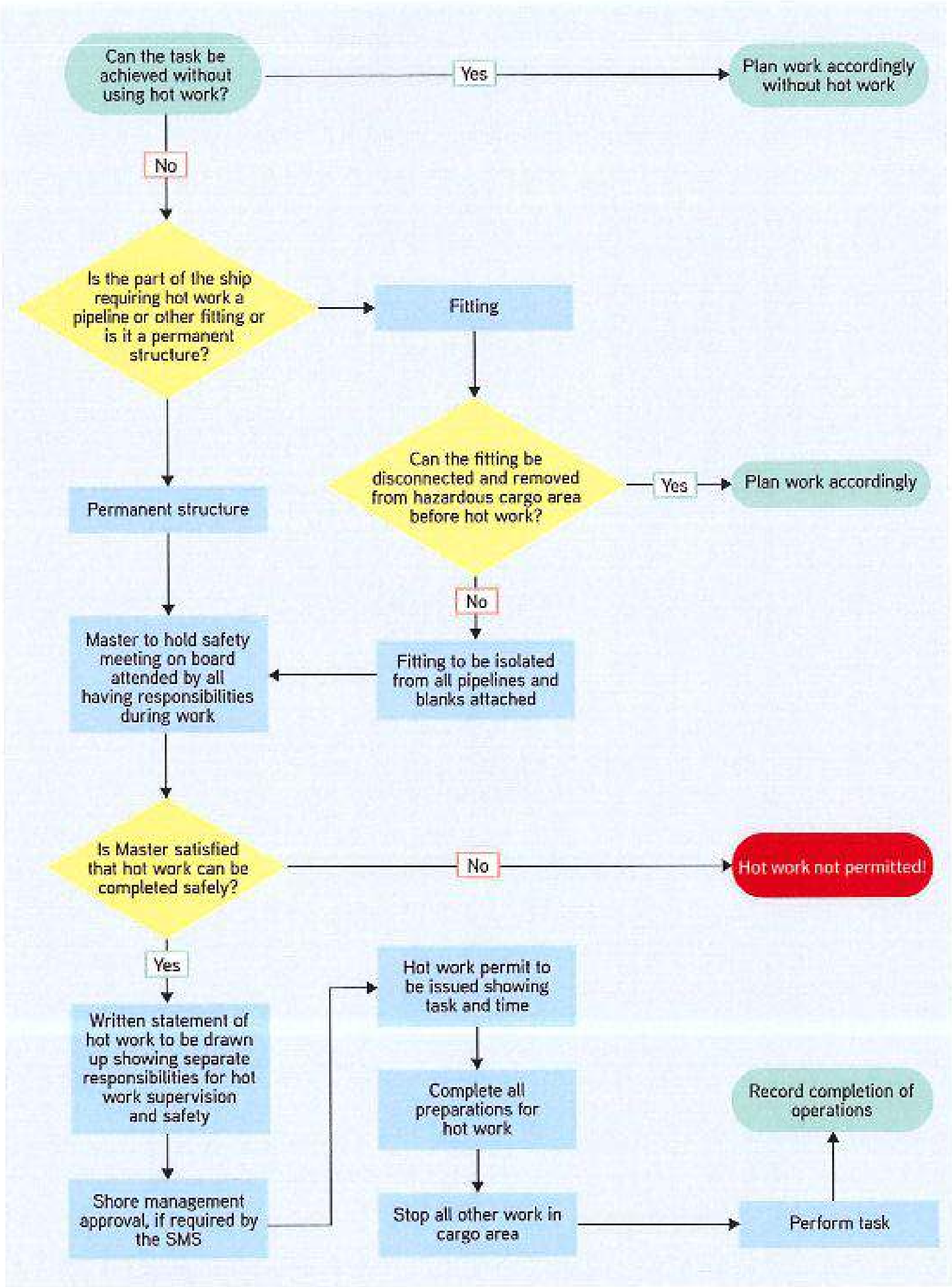


Figure 9.5: Hot work flowchart

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 including 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% oxygen and not more than 2% hydrocarbon					✔	✔	✔	✔	✔
Work to be carried out further than 500mm from the tank deck or bulkheads				✔		✔		✔	
Work to be carried out more than 500mm 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 9.6: Example of SMS guidance for hot work on an inerted ship

9.5 Electric welding equipment

Electric welding equipment should be carefully inspected before each use to ensure it is in good condition. If necessary, it should be correctly earthed. When using electric arc equipment, pay special attention to ensure:

- 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.
- Cable route to the work site is the safest possible, only passing over gas freed or inerted spaces.
- Earthing connection is next 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 anything other than hot work that presents a hazard to the ship, terminal or personnel and that needs to be controlled by a risk assessment process, e.g. a permit to work system.

A work permit or controlled procedure should be developed and approved for each hazardous task. The permit or controlled procedure should follow the process in sections 9.3 and 4.7 and should be discussed with the personnel performing the task.

The procedure, approval and record of compliance should be kept with the SMS records.

While a ship is alongside a terminal, hazardous tasks should only be undertaken with the prior agreement of the Terminal Representative.

Examples of such tasks are:

- Enclosed space entry.
- Tank inspections.
- Diving operations.
- Blanking sea chests.
- Work on critical equipment and systems.
- Extended work aloft or over the side.
- Electrical work.
- Heavy or unusual lifting operations.
- Work on or next to a pressurised system.
- Testing and launching of lifeboats.

9.7 Management of contractors

The Master should be satisfied that when contractors or work gangs are employed, arrangements are made to ensure they understand and comply with all relevant safe working practices. A formal safety induction should be completed. A Responsible Officer should supervise and control contractors. The ship's crew should inspect contractors' equipment, which should also have the necessary certificates.

The contractors should take part in relevant safety meetings to discuss the arrangements for work. Where applicable, contractors should sign the formal approval relevant to the work, including any relevant permits to work, verifying they are aware of the hazards and safety precautions required to reduce the risks to an acceptable level.

The ship remains responsible for approving and completing any work permits required before or during contractor work.

9.8 Managing Simultaneous Operations

Simultaneous Operations (SIMOPS) are activities that take place at the same time in the same area or that could directly or indirectly affect the safety of any other activity on the ship or terminal.

SIMOPS should be identified early to understand the impact one operation has on the other.

They should be discussed during work planning meetings (see section 4.7.5). A risk assessment is needed to identify the hazards and control measures.

The risk assessment should look include:

- Schedule clashes.
- Resources.
- Supervision.
- Distraction.
- Communications.
- Skills.
- Fatigue.
- Critical tasks.
- Maintenance activities.
- Contingency plans.

Toolbox talks should include discussion on SIMOPS. These should cover the control measures and any potential conflicts or challenges.

Be aware of critical phases of activities that may be compromised by SIMOPS, e.g. topping-off cargo and bunker operations at the same time, Ship to Ship (STS) operations while alongside a berth working cargo (double banked).

Wherever possible, SIMOPS should be avoided if they may affect safety.

Refer to section 4.6 for further guidance on the topic.

9.9 Hazards on ships with exposed transverse frames

9.9.1 Manifold platform

The design of product and chemical tankers has evolved, leading to external transverse stiffening on the tank deck. The deck areas of these tankers are more cluttered and less accessible in some cases.

Extra elevated platforms are needed to access key work areas such as the manifold.

The manifold working platform has steel grating and, usually, a drip tray/saveall. Sometimes this platform is higher than two metres and may not have effective edge protection. Where fitted, edge protection may be temporarily removed to allow a hose connection. This risk of falling from height means adequate safety precautions are needed.

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Given the hazards of working on these platforms, the work should be properly planned and effectively supervised. Personnel supervising the work should assess the suitability and safety of the platform. Work management should include a detailed risk assessment that covers the weather, training, fall protection devices and the slip/trip hazards and evaluates the edge protection.

9.9.2 Sampling and measurement points

On ships with deck transverse stiffeners, access around the deck in general, and to sampling and measurement points in particular, can be difficult. Wet or bad weather could pose additional hazards. Escaping from these areas in an emergency could also be challenging.

Safe access to sampling and measurement points is needed. Consider the following:

- Arranging safe access to the sampling and measurement points.
- The danger of creating semi-enclosed spaces with deck frames, which can be difficult to ventilate or may trap cargo vapours in light winds.
- Emergency access and exit for personnel wearing breathing apparatus and other restrictive equipment.

9.10 Repairs at a facility other than a shipyard

9.10.1 Introduction

This section deals with repairs on board a tanker at a facility other than a shipyard. It supplements but does not replace the guidance elsewhere in this publication. Guidance for when a ship is at a shipyard is provided in OCIMF's *Health, Safety and Environment at New-Building and Repair Shipyards and During Factory Acceptance Testing*.

9.10.2 General

When a ship is at sea or in port, the crew carry out their duties in line with the ship's SMS. When a ship is at a shipyard it is not operational and the work is carried out and managed primarily by the shipyard. While the ship's crew may monitor this work, the safety of the ship and anyone on board generally depends on the shipyard's SMS. Occasionally, an operational ship will need to carry out repairs using shore labour outside a shipyard or dry dock facility. In these cases, the safety of all on board depends on the ship's SMS and so all work should be carried out in compliance with the SMS.

Repairs may be done while the ship is:

- At anchor.
- Alongside at a layby berth that is not normally used for cargo operations.
- Alongside a commercial jetty.
- At sea.

Such repair work is only done on an exceptional basis, but the scope of the ship's SMS should include the planned activities and the risks to the shore labour employed.

9.10.3 Supervision and control

The Master, Company Superintendent or other appointed person should maintain full control of the repair work. They should ensure that the ship is in a safe condition at all times and that all work is carried out in a safe and proper manner.

Specific procedures are needed when the ship is to be repaired in a 'dead ship' condition or when the electrical power is limited.

9.10.4 Pre-arrival planning

Before arriving at the repair berth, anchorage or other facility, the initial planning should consider the:

- Type and location of the berth or anchorage.
- Moorings – numbers, type.
- Condition of the ship, e.g. gas free or inert.
- Safe access, e.g. launch, gangway or other means.
- Port and ship security arrangements, including ship and port security level.
- Number of personnel involved, including contractors.
- Location of the work, e.g. engine room, cargo spaces, above deck, accommodation, etc.
- Facilities for slop or sludge disposal.
- Arrangements for permits and certification, including using a chemist where appropriate.
- Port or terminal requirements.
- Availability of main power or main engine(s).
- Emergency procedures on board and ashore.
- Availability of assistance, e.g. firefighting, medical, etc.
- Connection to shoreside services, e.g. water, power, etc.
- Weather.
- Draught and trim limitations (to avoid unnecessary ballast handling).
- Restrictions on smoking and other naked lights.

9.10.5 Mooring arrangements

When moored to a repair berth, the number and size of mooring lines should be adequate for all likely weather and tidal conditions.

An alternative power source should be provided for the deck machinery, whenever practicable, so that moorings can be adjusted if the main power is unavailable.

On repair berths, crane movements or other activity on the dock side may restrict the mooring pattern. Take such restrictions into account when planning the berthing.

Moorings should be clear of hot work areas or other locations where the lines may be damaged by the repair work.

When at anchor, using an extra anchor cable may be necessary, particularly if the main engine(s) will be unavailable at any time.

9.10.6 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 need to be done at the same time as cargo handling operations, the terminal management needs to give specific permission.

The Master should establish whether any significant operations involving other ships are to take place near the berth where repairs are being done, e.g. departures/arrivals, bunkering, fuel oil transfer, etc.

The Master should be familiar with any specific safety requirements of the facility and/or harbour authorities.

Safe access should be available at all times with appropriate guard rails and safety nets. The number of access points should allow the quick evacuation of everyone on board. The gangway should be monitored at all times and a watch should control access to the ship (see chapter 6).

Port security plans should be followed as appropriate. A security risk assessment should be undertaken (see chapter 6).

On a non-hydrocarbon berth where the ship is not gas free, place a sign at the foot of the gangway to say: 'Warning! This ship is not gas free'.

Contractors should advise the Master of the number and movement of workers on board each day during repairs.

Procedures for using cranes or other lifting equipment should be decided on arrival.

The ship and the facility should agree garbage disposal procedures. These should comply with MARPOL Annex V.

Emergency alarm signals should be agreed and, if possible, a drill held before repair work starts. Further drills should be arranged if the repairs should be extended.

Any restrictions on activities such as bunkering, storing or taking lube oils are to be agreed. Be aware of the potential risks of SIMOPS (see section 4.6).

9.10.7 Work planning meetings

Work planning meetings should be held before starting any work and on each workday. They normally involve representatives from the ship and all the contractors.

These meetings ensure that all personnel involved are aware of the daily schedule, the interrelation between contractors, areas of concern and any special precautions, including permit requirements and the method of control.

9.10.8 Permits to work

Permits should be issued for the relevant repair jobs, including any repairs by the ship's crew. In particular, permits (see chapter 4) should be issued for:

- Enclosed space entry.
- Hot work.
- Electrical isolation.
- Hazardous energy.
- Lock-out/Tag-out (LO/TO).
- Other hazardous tasks as in section 9.6.

Copies of all permits should be posted as necessary. The Person In Charge (PIC) of the operation should also keep copies.

All personnel involved should be made fully aware of the requirements of the work permit system and its benefits. They should also be advised of restrictions on starting work until the appropriate permit has been issued.

If contractors provide any tools or equipment, it should meet the tanker's SMS requirements for safety, condition and calibration.

9.10.9 Tank condition

Whether the ship is gas free will depend on the work being done and the port or facility regulations.

All cargo/ballast spaces should be tested for oxygen and hydrocarbon content. The person responsible for the measurements should include the condition of all tanks and void spaces within the gas hazardous/dangerous area on the certificate. Some port or facility regulations may require these measurements to be carried out by a certified chemist.

If a ship is required to be gas free, certificates should be issued daily as a minimum.

If cargo tanks do not need to be gas free and the ship is inerted, positive IG pressure should be maintained within the tanks at all times.

9.10.10 Cargo lines

When the tank condition is to be gas free, cargo lines on deck, in the tanks and in the pumproom, including those lines and pumps that have not been used for recent cargo or tank cleaning operations, should be thoroughly washed and drained. This includes any dead ends in the system.

As well as the cargo suction and discharge lines (including stripping lines), slop tank balance lines or similar fittings between slop tanks should also be cleaned and drained when preparing for repair work.

The hydraulic valve system should be isolated in a way that prevents unintentional operation of cargo valves during the work. Post appropriate notices and advise the people in charge of the relevant repair team(s).

9.10.11 Firefighting precautions

9.10.11.1 Fire water

Fire mains should be continuously pressurised, either by the ship's pumps or from a shore supply.

Agree a pressure for the fire main and maintain this at all times.

9.10.11.2 Fire patrols

Agree a procedure for fire patrols on board. Either the ship's staff or shore contractors can provide fire patrols. Each member of the patrol should be fully aware of the procedure for raising the alarm and the action to take in an emergency.

The fire patrol should constantly monitor any area where hot work is being carried out.

9.10.12 Safety Officer

The Master should appoint a dedicated Safety Officer to coordinate the permit and certification processes for the repair period. The Safety Officer should be fully aware of all duties and responsibilities.

9.10.13 Hot work

The following supplements and does not replace the guidance in section 9.4, which should be followed for any repairs 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 before entering the berth or facility and all the special conditions have been met.

Use of electrical welding equipment should be controlled and correct earthing cables used. The welding current should not be returned to the transformer via the ship's hull.

No hot work should be done within 30m of any non-gas free space unless the controlling authority for the port has given specific permission.

Post notices to indicate the state of any tank or void space, e.g. whether it is either gas free and suitable for hot work or only safe for entry.

Suspend hot work immediately if any of the specific safety requirements agreed with the controlling authority cannot be met.

Tank pressures should be monitored to ensure that any hot work on or above the weather decks is stopped before the inert pressure reaches the relieving pressure of the Pressure/Vacuum (P/V) valves. If tank pressure needs to be released to the atmosphere, suspend all work until this operation is completed. Consider clearing the deck area of personnel during venting, especially when there is the possibility of toxic gas, e.g. H_2S. A new permit should be issued before resuming work.

9.11 Shipboard emergency management

9.11.1 General

The ISM Code requires the operator to establish procedures to identify, describe and respond to potential shipboard emergencies. This includes adequate manning to respond to emergencies while at sea or in port. This section provides guidance on meeting this requirement.

9.11.2 Tanker emergency plan

9.11.2.1 Preparation

Planning and preparation are essential for personnel to successfully mitigate potential incidents on board tankers. The Master and other officers should consider scenarios, e.g. fire in the cargo tanks, engine room or accommodation, somebody collapsing in a tank (see chapter 10), the ship breaking adrift from her berth and the emergency release of a tanker from her berth.

Although they will not be able to foresee every detail, walking through these scenarios will help to develop initial response plans that can be incorporated into shipboard training and exercises.

The following onboard information should be readily available:

- Type of cargo, amount and disposition.
- Location of other hazardous substances.
- General arrangement plan.
- Stability information.
- Firefighting equipment plans.

9.11.2.2 Emergency organisation

The operator and Master should ensure that manning levels, in terms of numbers and qualifications, are adequate for the safety and security of the ship and its crew, as specified in the ship's Safe Manning Document as issued by the ship's Flag State administration. It should be noted that the number of crew may need to be increased to support the current mission, trade patterns, need for additional security and operational requirements, STS lightering or sea conditions (including ice conditions).

At all times during the stay at a terminal, enough crew should remain on board to manage any emergency.

Establish an emergency organisation structure with clear mobilisation protocols to include raising an alarm, locating and assessing incident potential and identifying hazards to respond with manpower and equipment.

Planning an emergency organisation should cover four elements:

Command centre

One group should be in control of the response to the emergency, with the Master or the senior officer on board in charge. The command centre should have internal and external communication.

Emergency party

This group should assess the emergency and report to the command centre, advising what action to take and what assistance to provide, either on board or from ashore. It should be under the command of a senior officer.

Backup emergency party

This group should stand by to help the emergency party as instructed by the command centre and provide backup services, e.g. equipment, stores, medical services including cardio-pulmonary resuscitation, etc. (see chapter 10). It should be under the command of an officer. Medical services and equipment should be clearly identified on board and ashore to include the nearest hospital or clinic equipped to manage potential injuries, i.e. burns unit and other specialties.

Engineering group

This group should provide emergency help as instructed by the command centre. Its prime responsibility is to deal with any emergency in the main machinery spaces. It may need to provide additional manpower elsewhere. It should be under the command of the Chief Engineer or the senior engineering officer.

The plan should ensure that all arrangements apply equally well, whether the ship is in port or at sea.

9.11.2.3 Preliminary action

The person who discovers the emergency should raise the alarm and inform the duty officer about the situation before attempting to isolate and take initial response actions. Once the alarm is raised, the duty officer should activate the emergency organisation to gather at the designated assembly point and brief them on the situation. Crew members not involved in the initial response should stand by to assist as directed.

9.11.2.4 Ship's fire alarm signal

When a ship is in port, sounding the fire alarm system should be supported by a series of long blasts on the whistle, at least ten seconds each, or by some other locally required signal.

9.11.2.5 Fire control plans

Fire control plans should be permanently displayed in key positions, showing clearly for each deck the location and details of all firefighting equipment, dampers, controls, etc. When the ship is in port, these plans should be displayed outside the accommodation block for the benefit of shore based firefighting personnel.

9.11.2.6 Inspection and maintenance

Firefighting equipment should be ready for immediate use. It should be checked frequently, with dates and details of the checks recorded. Where appropriate, the equipment should be marked with these details. A Responsible Officer should inspect all firefighting and other emergency equipment and any maintenance work completed without delay.

9.11.2.7 Training and drills

The ship's crew should be familiar with the theory of firefighting in section 5.1 and should be instructed how to use firefighting and emergency equipment. Regular practices and drills will help 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, the Master should make an officer available to show them the location of portable and fixed firefighting equipment on board. The officer should also inform them about any design features of the ship that may require special attention in a fire.

9.11.3 Action in an emergency

9.11.3.1 Fire on a tanker at sea or at anchor

Whoever discovers an outbreak of fire should immediately raise the alarm, indicating the location of the fire. The ship's fire alarm should be operated as soon as possible.

Any crew near the fire should use the nearest suitable extinguishing agent to attempt to limit the spread of the fire, to extinguish it and then prevent re-ignition (see section 5.3). If unsuccessful, their actions should quickly be superseded by the tanker's emergency plan.

Any cargo, ballast, tank cleaning or bunkering operations should stop immediately and all valves should be closed. Any vessel alongside should be removed.

Once all crew have been evacuated from the area, all doors, openings and tank apertures should be closed as quickly as possible and mechanical ventilation should be stopped. Decks, bulkheads, other structures near the fire and adjacent tanks that contain petroleum liquids or are not gas free should be cooled with water.

The tanker should be manoeuvred to stop the spread of the fire and to allow the fire to be attacked from windward.

9.11.3.2 Emergencies in port

Emergencies either on board or next to the tanker when in a port are covered in section 20.3. Any action taken will be the joint responsibility of the Master and the port or terminal authority.

9.11.3.3 Jettison of cargo

Jettisoning cargo is an extreme measure justified only for the purpose of securing the safety of a ship or saving life at sea. A decision to jettison should not be taken until all the alternative options have been considered. This should be discussed with shore management and port or coastal State authorities. Written approval should be obtained.

If it is necessary to jettison cargo, take the following precautions:

- Alert engine room personnel. Depending on the circumstances, consider changing 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.
- Close all non-essential inlets.

- If the discharge needs to be from the deck level, rig flexible hoses to extend below the water surface.
- Observe all safety precautions for operations involving flammable gas in the vicinity of the deck.
- Broadcast a radio warning.
- Maintain records in relevant log books.

9.11.3.4 Follow-up

As soon as possible after an incident, review and identify potential gaps in contingency plans, response tactics and equipment with the response or emergency organisation. Also capture best practices and lessons learned for inclusion in plan upgrades or next revisions. Post response, an inventory of equipment should be conducted and supplies replenished, e.g. breathing apparatus bottles or spill response gear. Flush systems and conduct necessary maintenance, e.g. foam.

CHAPTER 10

Enclosed Spaces

10.1 Introduction to enclosed space entry safety

10.2 Safety management for entering enclosed spaces

10.3 Identifying enclosed spaces

10.4 The hazards of enclosed space atmospheres

10.5 General precautions

10.6 Authorisation of entry

10.7 Requirements for enclosed space entry

10.8 Precautions during entry into enclosed spaces

10.9 Work in enclosed spaces

10.10 Entering enclosed spaces with atmospheres known or suspected to be unsafe

10.11 Rescue and evacuation from enclosed spaces

10.12 Cargo pumproom entry precautions

10.13 Respiratory Protective Equipment

This chapter describes the hazards associated with entering enclosed spaces and the tests to be carried out to determine whether an enclosed space is safe to enter. The conditions for entry are set out, as well as the precautions to take before entering and while work is being carried out in an enclosed space.

> **Masters should be aware that national legislation may mean that terminal requirements for enclosed space entry might differ from this guidance.**

10.1 Introduction to enclosed space entry safety

Despite the precautions that operators take to protect personnel entering enclosed spaces, deaths and injuries still happen. This chapter recommends protections and controls that can reduce the risk from entering enclosed spaces.

The most effective way to eliminate the risk is not to enter an enclosed space. Given this:

- Ship operators and Masters should ensure that personnel enter enclosed spaces only when there is no practicable alternative.
- Where there is no alternative, the operator should ensure that procedures for safe entry are in place.
- Masters should verify that procedures for entering enclosed spaces are fit for purpose, robustly implemented and followed and that every entry is planned in line with these procedures, no matter how often they happen.

Enclosed space incidents tend to fall into two categories:

1. Controlled entries: the entry is intended but the preparation and execution of the entry plan is not robust enough. This leads to an incident involving workers inside or outside of the space, including those carrying out gas testing. This category includes intentional entries to respond to emergencies.
2. Accidental entries: while doing routine tasks such as taking items from a storage locker, checking spaces or looking into a tank, personnel unwittingly enter an enclosed space that is unable to support life.

The Master and key crew members involved in the steps for entering enclosed spaces are:

- Responsible Person: a person authorised to permit entry into an enclosed space and having sufficient knowledge of the procedures to be established and complied with on board to ensure that the space is safe for entry.
- Competent Person: a person with sufficient theoretical knowledge and practical experience to make an informed assessment on the likelihood of a dangerous atmosphere being present or subsequently arising in a space.

  The Competent Person and the Responsible Person may be the same person.
- Attendant: a person who is suitably trained in the procedures within the SMS, maintains a watch over those entering the enclosed space, maintains communications with those inside the space and initiates emergency procedures in the event of an incident occurring (IMO Resolution A.1050(27)). An Attendant has no other duties besides those listed.

10.2 Safety management for entering enclosed spaces

10.2.1 General

The operator's procedures need to identify those spaces on board that are enclosed spaces. The spaces will have one or more of these characteristics:

- Limited openings for entry and exit.
- Poor natural ventilation.
- Not designed for continuous worker occupancy.

Without effective ventilation any enclosed space may become hazardous (see section 10.4). A hazardous space is an enclosed or confined space where the atmosphere may endanger the life or health of any person entering it. The hazards are:

- Oxygen deficiency.
- Toxic and/or flammable gases, including hydrocarbon vapours and toxic contaminants.
- IG, including nitrogen.
- Oxygen enrichment.

All operator and tanker specific procedures should also refer to established national requirements.

To safely manage any entry into an enclosed space, crew members should be trained and regularly drilled in enclosed space safety. This should include familiarisation with atmosphere testing instruments and onboard procedures for recognising, evaluating and controlling the associated hazards.

All procedures and measures to mitigate hazards should account for the possibility that simple human error can reduce their effectiveness (see chapter 7).

The nature of the enclosed space will determine the particular hazards. All enclosed spaces should be marked with clear signs and procedures should be drawn up to ensure that any entry is done safely. Identifying these spaces and procedures means that all the personnel involved, including those entering any of the spaces, should understand the:

- Nature of the atmosphere.
- Mitigating measures.
- PPE requirements.
- Emergency action.

All operator and tanker procedures should clearly identify those personnel whose roles are important to ensure the safe management of enclosed spaces. These are:

- Responsible Person.
- Competent Person.
- Attendant.
- Duty officer/engineer.
- Personnel entering space.

Any decision that entry is necessary should first be reviewed, by the Competent Person, against possible alternatives that remove the need for personnel to enter the space. If after this detailed review the entry is still necessary, no attempt should be made to enter the space, even under controlled conditions, until its atmosphere has been tested as safe.

10.2.2 Managing controlled entry into enclosed spaces

Several factors, either independently or collectively, could influence the successful outcome of an entry. They need to be taken into account so that measures can be put in place to mitigate them.

The measures include:

Avoid entry where there are alternatives

The most reliable way to reduce risk from enclosed spaces is to avoid entry. The need to enter enclosed spaces can be eliminated by design and potential entries can be kept to a minimum by removing any need to enter, e.g. relocating stored items, essential equipment or controls, planning for internal work to be done in dry-dock and using technology such as drones for survey work. This may include challenging unnecessary operational activity, such as tank washing.

Leadership should demonstrate standards and listen to concerns

Those with influence over other members of crew can make entries safer. They promote and oversee the standards set out in the operator's procedures and should live by those standards and never enter an enclosed space or ask anybody else to enter until all the requirements have been met. They should demonstrate that their decisions are for the benefit of safety, overriding commercial or time pressures. Finally, they need to listen and respond when a more junior member raises a concern (see chapter 7).

Allow plenty of time

Time pressure can affect the behaviour of those entering the space and those planning to enter. They can be influenced by a desire to be efficient or by external pressures. This should be anticipated and guarded against. When it is not possible to avoid a long or complex task, the Responsible Person and other supervisors should take measures to mitigate the particular risks caused. In all cases, external pressure from the port or terminal should be resisted in the planning and conduct of such operations.

Plan and test rescue provisions

Early in the planning stage, the equipment necessary for the safe entry should be identified, rigged and tested. The personnel entering the tank should have been properly trained and regularly drilled in using the equipment, including for emergencies or tank rescue. This training should be undertaken before entry is authorised to remove any hesitation in the equipment's use.

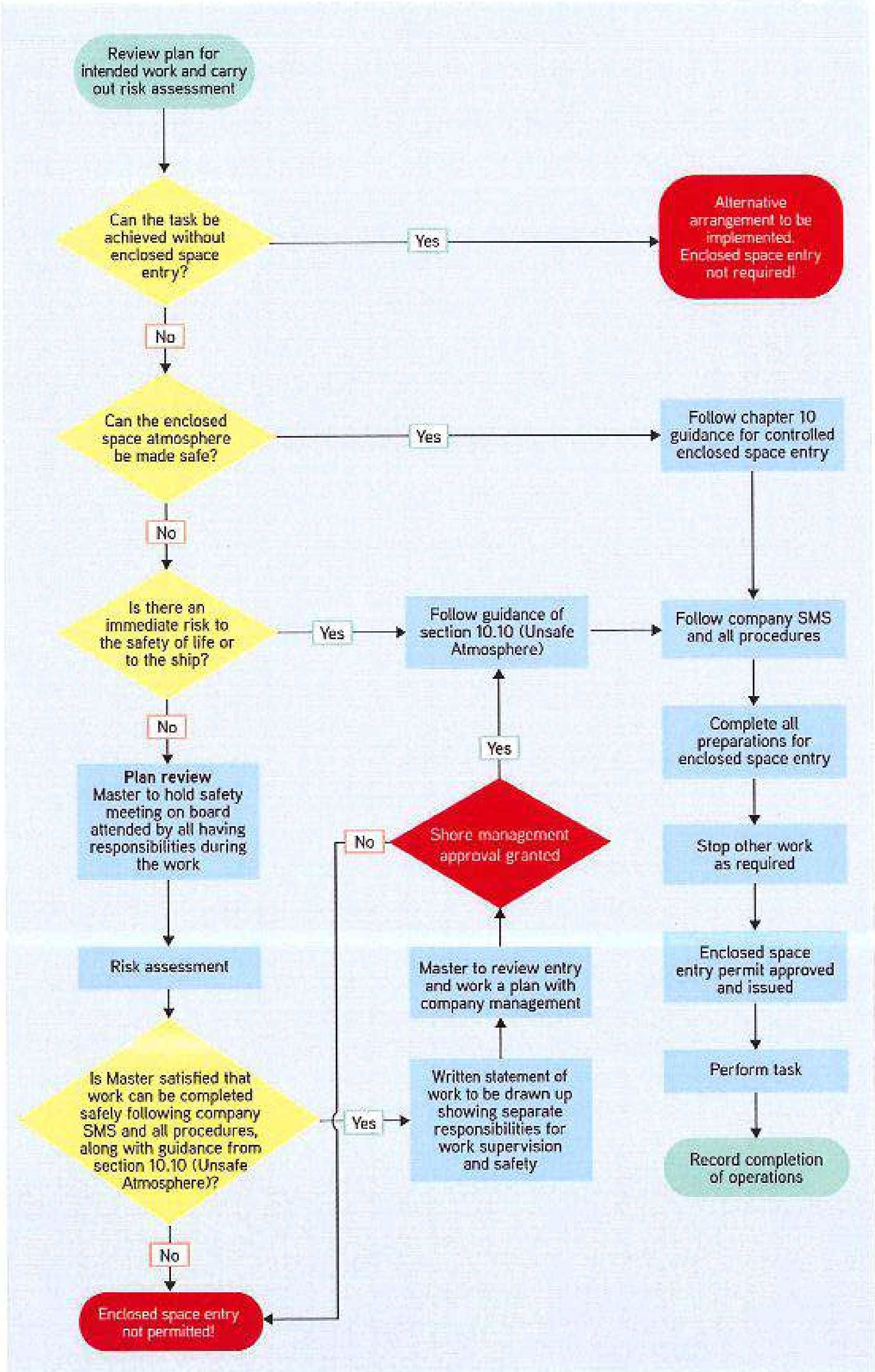


Figure 10.1: Enclosed space entry decision flowchart

Prepare the space

All spaces to be entered should be fully prepared in line with the assessed risks and the agreed plan. The space may need cleaning and should be gas tested to confirm the preparation has been successful. It may also need to be isolated to ensure it remains at the required standard for entry:

- Cleaning: all spaces need to be assessed to see if their current or previous use has the potential to create an unsafe atmosphere. If the result leaves any doubt, the space should be cleaned to eliminate the components that create the uncertainty.
- Testing: the atmosphere should be fully tested, which may include several locations and remote areas in the space. The first test can pose the greatest risk from an unknown atmosphere or fumes. To mitigate this, only personnel trained to use gas detection equipment should test atmospheres.
- Isolation: where possible, use the most reliable methods of isolation. Removing pipe spools or fitting in-line spades eliminates the consequences of accidentally opening valves into the space. Isolate all lines that enter a space, e.g. ballast water, bunker, utilities, etc., to reduce the chances of introducing a hazardous material. To avoid errors, isolations should be double-checked independently by two people.

Keep access secure

Clearly identify any space that is to be entered but remains open in the meantime, e.g. for gas freeing. Warning signs are useful but often not enough on their own. Consider using physical barriers such as a barricade or net.

Safe and secure breathing

Inadvertent connections to non-breathing air systems, accidentally closing an air supply or a diminishing supply can all create risks. Personnel connected to any air supply, e.g. fixed air-line or Self-Contained Breathing Apparatus (SCBA), should monitor the supply and the safe escape route in case of air supply failure.

The risk increases significantly when entering spaces where the atmosphere is harmful or unknown. Protective equipment (even SCBA) is a less reliable control than a proven safe atmosphere. Spaces where the atmosphere will not support life or where it is uncertain should not be entered except under exceptional circumstances, e.g. an emergency. If this is the case, the highest level of scrutiny is required and entry should only be undertaken with SCBA under strictly controlled conditions (see section 10.10).

Control the work

Any planning should consider the possibility of personnel in the space being unaware that they are getting into difficulty. This can be a result of the nature of the work (hot, heavy, noisy, with lighting and/or communications difficulty) or due to the hazards such as oxygen deficiency.

A risk assessment should account for these factors and build suitable controls into the plan. This way anybody in trouble can be spotted and removed as quickly as possible.

The challenges of being an Attendant

The role of the Attendant, keeping watch outside the space, is vital. However, it can be a monotonous task that is prone to declining alertness and communication issues.

Keeping the Attendant engaged and alert is critical to the safety of the personnel in the space. The Attendant should have clear instructions on what they should and should not do. They should maintain their attention and they should not be distracted by other activities.

Regular communication and status checks with the command centre, e.g. bridge, and personnel in the space is one way to achieve this. A protocol or checklist may also be helpful.

Reliability of communication

Those inside and outside the enclosed space should be able to communicate with each other at all times. Regular communication checks should be made at pre-agreed intervals. A failure to respond is cause to raise the alarm.

Very High Frequency/Ultra High Frequency (VHF/UHF) communication may not be suitable where it is known that reception may be unreliable or noisy. In this case, consider and test the possibility of positioning Attendants with line of sight to workers or using other remote communications or monitoring.

Responding to a crisis

Injuries and deaths from entering enclosed spaces often occur when personnel give in to a strong instinct to help. A delayed response from the rescue team can make this worse. It may take them several minutes to muster and ready themselves, during which time Attendants may become increasingly concerned for those in the space. They may believe – wrongly – that they can hold their breath or are fit enough not to be affected in the same way as those inside. Giving them a clear list of tasks at this time, e.g. raise the alarm but do not enter the space/opening, keep talking to the personnel inside, set up equipment outside or brief the command centre and rescue team when they arrive, is a proven technique for keeping them focussed. Reinforce this during the toolbox talk with scenarios asking them what they would do if someone collapsed and if the rescue team were delayed.

10.2.3 Managing enclosed spaces not planned for entry

Use physical barriers to stop accidental or unauthorised entry to enclosed spaces. During the planning phase, consider the circumstances that might lead to these incidents.

Systematic identification

All spaces with a hazardous or potentially hazardous atmosphere, e.g. chain lockers, should be clearly identified and ship's personnel should be made aware of them during their induction.

Systematic elimination

Use a hierarchy of control processes (see section 4.2.3) to reduce the number and/or dangers from these enclosed spaces, e.g. alternative storage solutions or regularly opening spaces to natural ventilation.

Preventing accidental entry

Several methods can help to prevent accidental entry.

Where tools are needed to open the compartment, a sign alone may be effective but should be clear:

'Entry under a permit only'

Where a compartment can be opened with quick release latches/handles/wing nuts/motorised latches, the hatch/door should be secured against accidental entry.

Where hatches, tank lids or any other openings need to be open for checks, e.g. gas levels, positive means should be provided to prevent personnel putting their head or body into the space, e.g. grills or netting.

Responding in an emergency

Victims of accidental entries are likely to be discovered by passers-by, who should resist the desire to enter the space to attempt rescue.

All ship's personnel should be trained and tested in the specific tasks when somebody is in danger in an enclosed space. This includes raising the alarm and the importance of not entering the space.

Additional tasks, e.g. such as talking to the person in the space and briefing the rescue team when they arrive, are effective distraction techniques to prevent an individual from entering the space to help.

All personnel should be clearly instructed that they can do more to help the victim if they stay outside and help the rescuers. This training should not be restricted to Attendants.

10.3 Identifying enclosed spaces

Any area or space may have, or develop, some of the characteristics of an enclosed space and may present similar safety risks.

The SMS should identify potential locations, occasions and activities that may create an enclosed space.

The operator should carry out a risk assessment to identify all the enclosed spaces on board the tanker. This risk assessment should be available on board and periodically revisited to ensure it remains valid.

The operator should also clearly outline the process to determine a space as enclosed in the SMS.

A list of identified enclosed spaces should be available on board every ship and these spaces should be clearly marked. Examples include:

Cargo tanks	**Chain lockers**	**Duct keels**
Double bottoms	Freshwater tanks	Engine room bilge, sludge and other tanks
Fuel tanks	IG scrubber units	Boilers
Ballast tanks	Cofferdams	Engine crank cases
Cargo pumprooms	Void spaces	Engine scavenge spaces
Sewage tanks	Lube oil tanks	Thruster spaces

The Master should ensure that all entrances to unattended enclosed spaces on the ship are kept closed or otherwise secured against entry.

Although cargo pumprooms are defined as enclosed spaces, they have equipment, characteristics and risks that require additional special precautions and procedures. These are covered in section 10.12.

Some spaces that do not meet the criteria for an enclosed space may have an unsafe atmosphere and should be subject to the enclosed space entry procedures. A list should identify these spaces on every tanker. Examples include:

Forecastle store	Paint lockers	Battery lockers
Ballast water treatment room	Gas bottle storage lockers	Carbon dioxide (CO_2) rooms
Lockers within the cargo area	Crane motor trunks	Enclosed lifeboats
Tank cleaning heater rooms	Ballast pumprooms	Deck tunnel/trunk space

Other spaces, in either the cargo or non-cargo deck area during operations, may be identified by risk assessment.

10.4 The hazards of enclosed space atmospheres

One or more of the following conditions can make enclosed space atmospheres hazardous:

- Oxygen deficiency.
- Toxic and/or flammable gases, including hydrocarbon vapours and toxic contaminants.
- IG, including nitrogen.
- Oxygen enrichment.

10.4.1 Oxygen deficiency

When an enclosed space is left closed and unventilated, the natural process of oxidisation of steel, i.e. rusting, may reduce the oxygen within the space, causing the atmosphere to become oxygen deficient.

The use of IG or nitrogen will also reduce the oxygen content of a tank.

The risk of an oxygen deficient atmosphere will be increased when the spaces:

- Have contained water.
- Have been subjected to damp or humid conditions.
- Have contained IG.
- Are next to, or are connected to, other inerted tanks.

The nominal oxygen level in fresh air is 20.9% by volume (local atmospheric variations mean this reading may be impossible to obtain in practice, and modern digital instruments may put it between 20.80% and 20.95%). Any space with an atmosphere less than this should not be entered until the reason has been found and corrective measures that are shown to be effective have been taken.

When the oxygen supply to the brain is depleted, people become dizzy and disorientated and develop a headache before losing consciousness. By the time they are aware of the symptoms, they may not be able to act rationally or leave the space safely. Permanent brain damage is a risk after just four minutes in an oxygen deficient atmosphere.

At oxygen concentrations approximately:

- Between 20% and 16%: pulse and breathing rates drop and mental functions are impaired.
- Below 14%: severe symptoms, which include increasing fatigue, emotional upset, poor judgment and faulty coordination. Further reductions in the oxygen content lead to nausea, vomiting, permanent heart damage and loss of consciousness.
- Below 5%: a coma may rapidly occur, requiring emergency oxygen for any chance of survival.

People cannot detect these conditions and cannot react rapidly enough to escape the space or put on emergency equipment. The effects of oxygen depletion noted above will make it more likely that a person will be unable to react appropriately.

10.4.2 Presence of toxic and/or flammable gases

Spaces that have previously contained toxic and/or flammable cargoes are dangerous, even if the space has been cleaned, tested and previously found to be safe for entry. Examples include:

- Toxic and/or flammable cargoes that are absorbed by tank coatings (especially epoxy), which then release vapours after cleaning.
- Cargo residues trapped in tank fittings, e.g. heating coils or behind tank coatings. Cargo pumps and vapour lines may release vapours after initial cleaning.
- Cargo may have leaked into compartments, including pumprooms, cofferdams, permanent ballast tanks and tanks next to those that have carried cargo.
- Sludge and scale in a tank that has been declared gas free may give off further flammable gases if disturbed or subjected to a rise in temperature.

Suspect the presence of gas in empty tanks or compartments if non-volatile cargoes have been loaded into non-gas free tanks or if a common ventilation system could allow the free passage of vapours from one tank to another.

Carry out checks before entering any compartment where recent cargo may have contained toxic contaminants or gases, e.g. aromatic hydrocarbons, benzene, hydrogen sulphide (H_2S), mercaptans, as residues could be present.

When preparing to enter a ballast tank or void space, the space should be tested for hydrocarbon vapour and H_2S.

Technologies such as ballast water treatment systems introduce an additional risk of gases to enclosed spaces that would not normally be expected on tankers. For this reason, where ballast water treatment systems are fitted, the precautions noted in section 10.3 should be followed.

Some examples of ballast water treatment systems are:

- Electrolysis based systems that may generate hydrogen gas.
- Chemical injection systems that inject different chemicals.
- Ozone based systems.

10.4.3 Risk from Inert Gas including nitrogen

IG produced from boiler flue gas or an IG generator may contain carbon monoxide (CO) and CO_2, both of which can cause death.

CO is a toxic gas that may be present in cargo tank atmospheres after gas freeing and in spaces containing components of the IG plant.

CO_2 is not toxic but is 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.

Nitrogen is a colourless and odourless gas that will cause oxygen deficiency in confined spaces, and at exhaust openings on deck, during the purging of tanks and void spaces.

Air normally contains 78% nitrogen and 21% oxygen, with the remaining 1% made up of CO_2 and other gases. When breathing, part of this oxygen is absorbed by the blood inside the lungs while CO_2 passes from the blood back into the air.

The addition of nitrogen reduces the oxygen content and lowers CO_2 levels in the blood. CO_2 in the blood stimulates the breathing reflex and when nitrogen replaces it this reflex is inhibited. As a result, the lungs are not stimulated to work harder to compensate for the lack of oxygen and breathing stops.

People exposed to nitrogen gas are not aware of any danger and may even feel a state of euphoria before they lose the stimulus to breathe and are asphyxiated. Exposure to high concentrations of nitrogen is usually fatal unless immediate action is taken.

10.4.4 Oxygen enrichment

Even a small increase in the oxygen level in the air can create a hazardous atmosphere. It becomes easier to start a fire, which will then burn hotter and more fiercely than in normal air. It is also harder to put the fire out. A leaking valve or hose on an oxygen cylinder in a poorly ventilated room or confined space can quickly increase the oxygen concentration to a dangerous level.

The main causes of fires and explosions when using oxygen are:

- Oxygen enrichment from leaking equipment.
- Use of materials not compatible with oxygen.
- Use of oxygen in equipment not designed for oxygen service.
- Incorrect or careless operation of oxygen equipment.

10.5 General precautions

Entry doors or hatches leading to enclosed spaces should be secured against entry and when entry is not required warnings should be exhibited.

If a door or hatch cover is opened to naturally ventilate an enclosed space, it may wrongly be taken to indicate a safe atmosphere. A person stationed at the entrance or a physical barrier, e.g. a secured bar, rope or chain across the opening with an attached warning sign, could prevent accidental entry.

Remember that general working environment risks, including slips, trips and falls, are also risks in enclosed spaces. A number of accidents have involved falls from height inside enclosed spaces. It is important to look at rescue and recovery access to all appropriate parts of the enclosed space, as well as the entry and exit of rescuers and their equipment.

Regardless of the number of spaces being entered, each space should have its own designated Attendant.

The space to be entered should be segregated from all other spaces that contain or may contain a non-gas free atmosphere. All common line valves should be secured in the closed position and labelled.

Any pipelines in the space being entered should be prepared to allow safe entry, including water flushing and draining where necessary.

Suitable notices should be clearly displayed to warn and inform personnel about the dangers of entering enclosed spaces.

When entry is not required, doors or hatches leading to enclosed spaces should always be secured against entry and warning signs posted. The operator should ensure that their enclosed space entry procedures are available and understood by all personnel involved.

Where entry into enclosed spaces is required while a ship is alongside (e.g. into cargo tanks for cleaning or inspection), this should be discussed with the terminal and all procedures and precautions for entry agreed. This may, in certain circumstances, require the cessation of cargo operations while entry operations are underway to eliminate risks arising from:

- The incorrect operation of valves and lines on oil or products being handled.
- An inability to adequately manage all safety aspects arising from SIMOPS.
- The potential for resource limitations and work overload issues.

10.6 Authorisation of entry

No one should open or enter an enclosed space unless:

- Authorised by the Master or the nominated Responsible Person.
- Appropriate safety procedures have been followed.

An enclosed space entry permit should be issued by the Master or the nominated Responsible Person and completed by the personnel who are to enter the space before they enter.

10.7 Requirements for enclosed space entry

10.7.1 Control of entry into enclosed spaces

A Competent Person, designated by the company's SMS, should conduct a preliminary risk assessment (see section 4.2.2 risk assessment) to identify the potential hazards and appropriate safeguards. This should take into account previous cargoes carried, the ventilation, structure, coating type and other relevant factors.

The risk assessment should include a review of the task, the number of personnel needed to do it safely and requirements for an effective emergency response. This preliminary assessment should also determine the potential for a hazardous atmosphere developing due to leakage from an adjacent space.

The controls needed for safe entry vary according to the task and results of the risk assessment. In most cases, an entry permit is an effective way of ensuring and documenting that essential precautions have been taken and that these recognise the potential for changes in the tank atmosphere conditions to arise. Where necessary, physical safeguards should be put in place to ensure safety, which should include use of a LO/TO system for isolation for cargo tank valves, hydraulic systems and cargo pumps that could be hazardous if operated inadvertently.

Controls should also include physical barriers to prevent confined spaces being accidentally opened. Where tools are needed to gain access, a sign may be sufficient. Where access to an enclosed space can be opened by hand, it should be physically secured against unauthorised access.

10.7.2 Atmosphere tests before entry

No one should enter an enclosed space until the atmosphere is confirmed safe.

The atmosphere should be tested using suitable instruments for oxygen, flammable gases or vapours, CO, H_2S and other toxic gases as appropriate.

Before the space is entered it should be thoroughly ventilated. The length of time to ventilate depends on the size and construction of the space, the capacity and efficiency of the ventilation system, the level of contamination and the density of the vapour to be displaced.

It also depends on the size and position of openings to the space. Well placed openings improve the flow of air and will help ensure that all areas within the space are effectively ventilated.

Tank atmospheres may be contaminated by leaks from adjacent tanks or by the improper operation or failure of cargo, vapour and IG lines and valves.

For entry purposes, steady readings of all of the following should be obtained before the enclosed space entry permit can be approved and entry permitted:

- Oxygen: any space with less than 21% oxygen by volume should NOT be entered until the reason for the low level has been established and resolved. If any doubt remains about the causes of the oxygen deficiency, the space should still be considered hazardous.
- Flammable vapour: the concentration of flammable vapour is below 1% of the LFL before anybody can enter.
- Occupational Exposure Limit (OEL): no more than 50% of the OEL of any toxic vapours and gases.

If these conditions cannot be met, apply additional ventilation to the space and re-test after a suitable interval.

The potential for false or unrepresentative sample readings arising from eddies or pockets of gas, or for gas regeneration arising from sludge or scale, should be considered in the pre-entry testing phase. Ventilation should be stopped at least ten minutes before testing to ensure an accurate reading. Depending on experience, size of the space and potential risk factors, a longer period with ventilation stopped may be necessary to ensure accurate results.

In addition, the likelihood of isolated pockets of gas should always be considered and, therefore, samples should be drawn from many different locations and levels within the enclosed space using instruments with pumps and extension hoses. It is recommended that, as a minimum, this should be undertaken at top, middle and tank bottom levels, as well as in areas where personnel are expected to be present during entry.

The location of gas or vapour in a space will vary according to the relative density. When denser than air it will fall and when lighter than air it will rise. Gas and vapour will tend to remain where the ventilating airflow is least effective.

Testing and measuring should only be carried out by crew trained and proficient in using the instruments. Testing instruments should be maintained, calibrated and checked for correct operation in accordance with the manufacturer's instructions.

Testing instruments should only be used to measure the gases they are designed for and operated within the limits set by the manufacturer.

Even after a space has been made gas free and found to contain a safe atmosphere, local concentrations of gas may still exist.

The IG pressure of adjacent tanks should be lowered, but kept positive, to reduce the possibility of leaks between tanks. Personnel should remain alert to the possibility of hydrocarbon or IG leaks from adjacent spaces or from pipelines running through the tank.

10.7.3 Enclosed space entry permit

On completion of the initial gas testing the ventilation fans should be restarted and continue to operate throughout the period of the entry as a condition of the entry permit that should be approved and issued before allowing personnel to enter an enclosed space.

The entry permit should have a clear period of validity that does not exceed 12 hours and remain valid only as long as the permit conditions are met.

It should also state the maximum permitted time between atmosphere-testing of spaces and when they are entered by personnel, as well as the maximum time permitted between testing while the space is occupied. It is recommended this period should not exceed 30 minutes between testing and that records of the tests are maintained, and this should be defined in the operator's SMS. If two or more spaces are to be entered at the same time, ensure that enough resources, personnel, emergency/rescue equipment and gas monitoring equipment is available. No matter how many spaces are being entered, each should have its own designated Attendant (i.e. one person per space), who is in constant attendance at the entrance and is in direct contact with the Responsible Person.

During multiple simultaneous entries, consider monitoring the workload and its potential impact on Attendants and others involved in the operation.

The administrative burden can be simplified by restricting approvals, such as entry permits, so that all cargo tanks safe to enter are shown on one document. This can also avoid overlapping permits and reduce any possible confusion about which approval applies to which tank.

If such a system is used, it should be rigorously controlled to ensure that existing permits are cancelled and that the atmospheres of all named tanks are correctly tested at the time a permit is issued. This is to prevent an extension by default of a period of validity.

If one or more tanks named on the permit are tested and found to be unsafe to enter, the whole permit is cancelled. A new permit will then need to be issued for all tanks. The permit process should be supplemented by positively marking tank lids with notices indicating which tanks are safe to enter and negatively marking tanks that are not safe to enter. Indicate which cargo tanks are safe by marking (or tagging) all appropriate tank entry hatches. The marking should be unambiguous. The absence of a safe to enter mark should prohibit entry.

One condition of the entry permit should be that, if the named enclosed space is vacated for any reason, e.g. a refreshment break, ventilation should be continued during the break and the atmosphere of the enclosed space should be fully re-tested before re-entry. Unlike in the pre-entry testing phase (see section 10.7.2), once the space has been found to be gas free and the permit issued, ventilation should not be stopped for this testing unless the conditions for a safe re-entry have been broken.

Entry permits should be cancelled if any onboard emergency situation or emergency alarm is raised during the period of validity. Permits may only be re-issued once the emergency has been dealt with. Permits should be re-issued with the same tests and level of rigour as if it were an initial entry (see section 10.7.2).

The Responsible Person supervising enclosed space entry should confirm that:

- All permit conditions are implemented and functioning effectively.
- All crew entering the space are properly trained in enclosed space entry procedures and are familiar with the operator's safety and emergency procedures.
- The person entering the space has reviewed and signed the enclosed space entry permit.
- The completed enclosed space entry permit that authorises entry has been issued, filed and a copy(ies) posted.
- The scope of any other permits valid for work in the space during tank entry are understood. The withdrawal of the enclosed space permit will automatically cancel any other associated permits.
- A reliable system of communication has been established and tested and is understood by the Responsible Person, those entering the space and the Attendant.
- A system is in use to record crew members entering and leaving the space.
- The duty officer or duty engineer is aware of the enclosed space entry operations.
- A toolbox talk has been carried out with all parties on site.
- All personnel (crew members or outside contractors) entering the space understand that they should leave immediately if any gas detector alarm is activated.

Regardless of whether ship's crew or outside contractors are entering an enclosed space, the Attendant should always be a member of the crew who is familiar with the ship's emergency procedures.

All equipment used during the entry should be in good working condition and inspected before use.

A copy of the entry permit should be prominently displayed at the site entrance to the space to inform crew members of the precautions to take when entering the space and of any restrictions on the activities permitted within the space.

The entry permit should be cancelled if the ventilation of the space stops or if any condition required by the permit changes.

10.8 Precautions during entry into enclosed spaces

Once the tank has been confirmed as safe for entry with an entry permit issued, and before anybody enters to carry out work, an initial entry should be made to ensure the space is safe for work. This initial entry should be carried out by one or two crew members, depending on the size, nature and layout of the space. Each should carry an Emergency Escape Breathing Device (EEBD) and a personal gas monitor. They should check the tank atmosphere thoroughly, paying particular attention to the work locations and areas inaccessible for testing from the deck. The results of this local atmosphere test should be recorded as required by the SMS.

This is especially important in spaces with a complicated internal structure that is difficult to ventilate.

All personnel entering a space should be aware that the entry permit only certifies that the space has been tested as safe for entry. They should also understand that the tank conditions could change during the period of entry as a result of personnel moving around or undertaking work in an enclosed space. The dangers of isolated concentrations of gas that may be present, or arise from the stirring up of sludge or opening of lines or valves, should always be considered as this could result in a rapid rise of gas, making the space hazardous and requiring evacuation.

For this reason, ventilation should continue while the space is occupied and work is carried out within the space and all personnel in the space should wear a functioning personal gas monitor. It is essential that while personnel are in an enclosed space, further tests are regularly undertaken to determine if the levels of oxygen and contaminants remain within safe limits. Testing from outside should continue at appropriate intervals and should be undertaken before re-entry after a temporary break.

Provided the conditions for issuing the original entry permit have not changed (and permit cancelled), ventilation should not be stopped while the above mentioned re-entry gas testing is carried out.

If ventilation stops, or any of the criteria for entering the space are not maintained for any reason, the space should be evacuated immediately and the original permit cancelled.

Everyone entering the space should carry a personal multi-gas detector. Carrying a personal gas monitor is not a substitute for pre-entry, subsequent re-entry and ongoing testing from outside the space.

If there is any doubt about the oxygen level or the presence of toxic or flammable gases, the space should be evacuated immediately.

In an emergency, under no circumstances should the Attendant enter the space.

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 SMS. All conditions for entry, including the entry permit, should be observed.

Extra precautions may be needed to ensure there is no loose scale, sludge or combustible material near the work site, which, if disturbed or heated, could give off toxic or flammable gases. Maintain effective continuous ventilation. Direct it towards the work area if possible. Monitor the atmosphere externally at regular intervals. Also monitor the personal multi-gas detectors carried by the personnel entering enclosed space. Before re-entering the space after a break, the atmosphere should be re-tested. Personnel should leave the space immediately if they begin to feel dizzy or unwell, or when any alarm is activated.

10.9.2 Opening equipment and fittings

Before opening cargo pumps, pipelines, valves or heating coils, flush them thoroughly with water and drain. Even after flushing some cargo may remain, which could be a source of flammable or toxic gas. Whenever this equipment is to be opened, the risk assessment should identify the minimum safe working practices, including any need for additional gas tests.

10.9.3 Use of tools

Inspect all tools before they are used. Do not use worn or damaged tools. Tools should not be carried into enclosed spaces. Instead, to avoid them being dropped, they should be lowered in a plastic bucket or canvas bag. Before any hammering or chipping, or any power tool is used, the Responsible Person should be satisfied that there is no likelihood that hydrocarbon vapour is present in the work area.

10.9.4 Use of electric lights and electrical equipment

Use only approved safety lighting or intrinsically safe electrical equipment in enclosed spaces that are liable to hydrocarbon vapour re-contamination.

Non-approved lights or non-approved electrical equipment should not be taken into an enclosed space unless the compartment is designated safe for hot work by an approved safe system of work, including a hot work permit.

10.9.5 Removal of sludge, scale and sediment

When removing sludge, scale or sediment from an enclosed space, periodically test for gas and maintain continuous ventilation throughout the time the space is occupied.

Gas concentrations may increase in the immediate area around the work, so care should be taken to ensure that the atmosphere remains safe.

10.9.6 Use of work boats

Any work involving work boats in cargo tanks presents additional hazards that should be managed by the operator's SMS.

Work boats used for tank repair work and tank inspections should be fit for the task. Before and during their use in an enclosed space, observe all the conditions for entry, including an entry permit (see section 10.5). The following precautions should also be taken:

- Open all deck apertures, e.g. tank washing plates, and maintain effective continuous ventilation while personnel are in the tank.
- Use the work boat only when the water surface is calm.

- Use the work boat only in tanks containing clean ballast water.
- Check that the water level in the tank is stationary or falling. On no account should it be rising while the boat is in use.
- Ensure all personnel working in the space are wearing buoyancy aids.
- Appoint a Responsible Person to act as lookout at the top of the tank. If the boat is working at a point remote from the tank hatch, position an additional lookout a little way down the access ladder at a point that provides a clear view of the boat.

10.10 Entering enclosed spaces with atmospheres known or suspected to be unsafe

Entering any space that has not been proved safe should only be considered when no practical alternative exists.

In any situation, other than the safety of life or the ship where the Master has ultimate responsibility, it is essential that permission is obtained from the operator and a safe system of work is agreed for entering a space that has not been proved safe.

The Master should issue a written statement declaring that there is no practicable alternative to the proposed method of entering the space and that it is essential for the safe operation of the ship.

Except where there is an immediate risk to the safety of life or the ship and 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 operator.

Positive pressure type breathing apparatus should always be used during an emergency entry into a space that is known to contain:

- Toxic vapours or gas.
- Oxygen deficiency.
- Contaminants that cannot be effectively dealt with by air purifying equipment.

The Responsible Person should continuously supervise the operation and should ensure that:

- Requirements in section 10.7.3 are followed.
- Personnel involved are well trained in using breathing apparatus and aware of the dangers of removing their face masks while in the unsafe atmosphere.
- Positive pressure breathing apparatus is used.
- Number of personnel entering the tank is kept to a minimum.
- Personnel are in the space for the shortest time possible.
- Spare sets of breathing apparatus, a resuscitator and rescue equipment are outside the space, along with a rescue team wearing breathing apparatus.
- All essential work is carried out in a way that will avoid creating an ignition hazard.
- If personnel are not connected to a lifeline, another suitable way is used to locate them while they are inside the space.

10.11 Rescue and evacuation from enclosed spaces

If someone is injured in an enclosed space, the first action is to raise the alarm. While speed is often vital and it is a human reaction to go to the aid of a colleague in difficulty, rescue operations should not be attempted until proper help and equipment have been mustered. Impulsive and ill-prepared rescue attempts often cause additional and unnecessary casualties.

Carry out regular drills and exercises to practice rescues from enclosed spaces. It is essential that all members of a rescue team know what is expected of them.

10.11.1 Evacuation from enclosed spaces

If any of the conditions stated on the entry permit change or it is suspected that the conditions in the space have become unsafe after personnel have entered the space, they should be ordered to leave immediately. They should not be permitted to re-enter until the situation has been re-evaluated and the safe conditions stated on the entry permit have been restored.

10.11.2 Organising rescue and recovery from enclosed spaces

The rescue procedures for enclosed spaces should be well planned and regular drills held to improve their effectiveness. Regular training for the emergency rescue team is essential.

Emergency rescue team members should be:

- Prepared for the physical and technical demands of rescues in enclosed space.
- Well trained in all rescue team duties.
- Familiar with the rescue equipment, which should be easily deployable.
- Capable of fulfilling any role within the rescue team.

10.11.2.1 Composition of the rescue team

The rescue team should consist of dedicated team members with roles defined in the SMS. All rescue team members should be trained and experienced in rescue operations and be familiar with the ship's emergency procedures.

Although a designated team offers major advantages, it is essential that backup personnel are also identified in case somebody is unavailable.

10.11.2.2 Team roles

The rescue team should consist of:

- Team leader: this should be a senior officer whose role is to direct the rescue effort. The team leader should not be in the team that enters the enclosed space.
- Entry team: while the number should be kept to a minimum, at least two should enter the space to carry out the rescue.
- Backup team: these should rig the rescue equipment, ensuring that the entry team has the equipment and support necessary to carry out the rescue and to monitor the enclosed space atmosphere. One crew member should help the rescue team leader with communications and to maintain a record of events.

10.11.2.3 The rescue operation

As soon as they are aware that somebody in the space is in difficulty, the Attendant should raise the alarm. The method of raising the alarm should be agreed and tested in advance, together with a way to communicate the details of the emergency.

The rescue team needs to know the nature of the incident and how many people are affected. During an enclosed space entry, the rescue team personnel should not be carrying out any duties that would hinder their ability to respond immediately to an alarm. They should proceed straight away to the entrance to the space, taking any necessary additional equipment. Nobody should enter the space without the team leader's permission.

Unless it has been positively shown that the atmosphere in the enclosed space is safe to breath, the rescue team should wear appropriate protective equipment and use SCBAs. Only after a full test has confirmed that the enclosed space atmosphere is safe should the team proceed without breathing apparatus.

On reaching the casualties the team should check if they are still breathing. Any casualties not breathing should be removed as soon as possible for resuscitation.

Any casualties who are breathing should have their injuries assessed before they are removed from the space. If the condition of the atmosphere in the enclosed space is not verified as safe, the casualty should be given an independent air supply.

During the incident, the team leader and backup team should:

- Monitor the rescue team and ensure spare air supplies are available.
- Rig rescue equipment, e.g. hoists.
- Monitor the atmosphere of the space.
- Communicate with the ship's command team.
- Arrange additional lighting, ventilation and improve access to the space if necessary.

Casualties should be removed with the most appropriate equipment, such as stretchers, lifting harnesses and hoisting apparatus.

10.11.2.4 Resuscitation

Tanker and terminal personnel with safety responsibilities should be trained in resuscitating people who have been overcome by toxic gases or fumes, or whose breathing has stopped after an electric shock, drowning or some other cause.

Most tankers and terminals have a special resuscitation apparatus. The crew should be aware of its location and be trained in its proper use.

The apparatus should be stowed where it is easily accessible. It should not be kept locked up. The instructions should be clearly displayed. The apparatus and the contents of cylinders should be checked frequently in line with the Planned Maintenance System (PMS). Adequate spare cylinders should be carried.

PART 1 General Information
PART 2 Tanker Information
PART 3 Marine Terminal Information
PART 4 Ship/Shore (Tanker/Terminal) Interface

10.12 Cargo pumproom entry precautions

Cargo pumprooms should be seen as enclosed spaces and the recommendations of this chapter should be followed as closely as possible. However, because of their location, design and the operational need for crew to enter the space routinely, pumprooms present a particular hazard and require special precautions.

A cargo pumproom contains the largest concentration of cargo pipelines of any space within the ship and leaks of volatile products from any part of this system could quickly generate a flammable or toxic atmosphere.

10.12.1 Cargo pumproom entry procedures

Before anyone enters a cargo pumproom, it should be thoroughly ventilated, the oxygen content of the atmosphere verified and the atmosphere checked for hydrocarbons or any toxic gas associated with the current or recent cargoes.

Atmosphere testing should be conducted with portable gas equipment. A fixed gas detection system can be used if it:

- Is correctly calibrated and tested.
- Provides gas readings as a percentage of the LFL as accurately as portable gas equipment.
- Provides toxic gas readings equivalent to portable gas equipment.
- Provides oxygen readings equivalent to portable gas equipment.
- Is located at representative locations within the pumproom.

Written procedures should control pumproom entry. These procedures should:

- Be based on a risk assessment.
- Ensure that risk mitigation measures are followed.
- Ensure that entries into the space are recorded.

A communications system should provide links between the pumproom, navigation bridge, engine room and cargo control room. Audible and visual repeaters for essential alarm systems, e.g. the general alarm and the fixed extinguishing system alarm, should also be installed in the pumproom.

Crew members in the pumproom and those outside should be able to communicate at all times. Regular communication checks should be made at agreed intervals. Any failure to respond is a cause to raise the alarm.

Do not use VHF/UHF communication as a primary method if it is known that reception may be unreliable or noisy. Where communication by VHF/UHF is difficult, an Attendant should be positioned at the pumproom top and a visual and remote communication procedure should be in place.

With a view to minimising entry, review how often crew members enter the pumproom for routine inspection during cargo operations.

Notices should be displayed at the pumproom entrance prohibiting entry without formal permission and to indicate the presence of personnel in the space.

10.12.2 Cargo pumproom ventilation

Given the potential presence of hydrocarbon gas in the pumproom, mechanical ventilation by extraction is required in a safe atmosphere.

Ships built after July 2002 must have continuous monitoring of the pumproom atmosphere and an audible and visual alarm system that activates when the hydrocarbon gas concentration in the pumproom exceeds a pre-set level, which should not be more than 10% LFL.

The pumproom ventilation should be interlocked with the pumproom lighting so that the ventilation operates when the lights are switched on. This does not apply to emergency lighting.

During cargo handling, the pumproom ventilation system should be operating at the correct (lower) suction. If fitted, the gas detection system should be functioning correctly. Ventilation should be continuous until access is no longer required.

10.13 Respiratory Protective Equipment

Several different types of RPE are available on tankers.

Under the ISM Code, the operator is responsible for providing the level of equipment needed to manage all the operational and safety activities on the ship. In most cases, the RPE needed to do this will exceed the minimum requirements of SOLAS fire safety provisions.

Cartridge or canister face masks will not protect the user against concentrations of hydrocarbon or toxic vapours or against oxygen deficiency. They should never be used in place of breathing apparatus.

10.13.1 Self-Contained Breathing Apparatus

This is 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 gauge indicates the pressure in the cylinder and an audible alarm sounds when the supply is running low. Only positive pressure type SCBAs are recommended for use in enclosed spaces because they always maintain a positive pressure within the face mask.

When using the equipment:

- Check the pressure gauge before use.
- Test the audible low pressure alarm before use.
- Check the face mask and adjust it to ensure it is airtight. Facial hair may affect the mask's seal. In this case, another person should wear the apparatus and make the entry. Alternatively, use other specialist equipment that allows for facial hair.
- Monitor the pressure gauge frequently during use to check the remaining air supply.
- Allow plenty of time for leaving the hazardous atmosphere.
- Exit immediately if the low pressure alarm sounds. The duration of the air supply depends on the weight and fitness of the user and the extent of their exertion.

If users suspect at any time that the equipment may not be operating satisfactorily or are concerned about the integrity of the face mask seal, they should exit the space immediately.

10.13.2 Air-line breathing apparatus

Compared to using self-contained equipment, an air-line breathing apparatus enables personnel to stay in an enclosed space longer.

The equipment consists of a face mask supplied with air through a small diameter hose leading outside the space, where it is connected to compressed air cylinders or an air-line served by a compressor. If the ship's air supply is used it should be properly filtered and monitored for toxic or hazardous constituents. The hose is attached to the user by a belt or other arrangement, which can be quickly disconnected in an emergency. A flow control valve, or orifice, regulates air to the face mask.

If the air supply is from a compressor, it will include an emergency supply of air cylinders should the compressor fail. In an emergency, the user should leave the space immediately.

A trained and Competent Person should be in control of the air-line pressure. If normal working pressure cannot be maintained, they should make the change to the alternative supply.

When using the air-line breathing apparatus:

- Check and adjust the face mask so that it is airtight. Facial hair may make this harder to achieve.
- Check the working pressure before each use.
- Check the audible low pressure alarm before each use.
- Keep the air-lines clear of sharp projections to avoid any damage.
- Ensure the air hose does not exceed the manufacturer's maximum recommended length.

If there is any doubt about the efficiency of the equipment, the user should leave the space immediately.

Users should carry a reserve air cylinder that is permanently connected so that in the event of an interruption of airflow from the primary supply source, switchover to emergency air supply is immediately achieved, avoiding any interruption in the airflow. An EEBD is not recommended for this purpose.

10.13.3 Emergency Escape Breathing Device

EEBDs are for emergency escape and should not be used as the primary means for entering spaces or compartments with unsafe atmospheres.

This is a compressed air breathing set a person can use to escape a compartment where the atmosphere has become hazardous. It is required that EEBDs be provided for escape from fires in machinery or accommodation spaces. Additional sets should be provided as emergency escape equipment for enclosed space entry. Each set lasts a minimum of ten minutes.

The device can be one of two types:

Compressed air Emergency Escape Breathing Device

This consists of an air cylinder, reducing valve, air hose, face mask or hood and a flame retardant high visibility bag or jacket. It is normally a constant flow device, providing compressed air at a rate of approximately 40 litres per minute, giving a 10–15 minute duration, depending on the capacity of the cylinder. 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 Emergency Escape Breathing Device

This normally consists of a robust watertight carrying case, compressed oxygen cylinder, breathing bag, mouthpiece and a flame retardant hood. It is designed for single use. 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.

10.13.4 Equipment maintenance

A Responsible Person should examine all RPE at regular intervals.

Defects should be made good promptly and a record should be kept of inspections and repairs. Air cylinders should be recharged as soon as possible after use.

Air cylinders that are damaged or corroded should be removed from service and either repaired or replaced. All cylinders should be hydrostatically tested as required by the appropriate administration's regulation.

Masks and helmets should be cleaned and disinfected after use. Any repair or maintenance should be carried out strictly according to the manufacturer's instructions.

10.13.5 Stowage

Breathing apparatus should be stowed fully assembled in a place where it is readily accessible. Air cylinders should be fully charged and the adjusting straps kept slack. Units should be available for emergencies in different parts of the ship.

10.13.6 Breathing apparatus training

All crew members should receive practical demonstrations and undergo training in the use of breathing apparatus.

Formal shore based training may supplement onboard training and is particularly beneficial for personnel identified as potential members of the rescue team.

Only trained personnel should use self-contained and air-line breathing apparatus. Incorrect or inefficient use can endanger the user's life.

CHAPTER 11

Shipboard Systems

11.1 Fixed Inert Gas systems
11.2 Venting systems
11.3 Cargo and ballast systems
11.4 Power and propulsion systems
11.5 Vapour recovery systems
11.6 Volatile Organic Compound recovery systems
11.7 Stern loading and discharging arrangements

This chapter describes the main ship systems that are used during cargo and ballast operations in port.

11.1 Fixed Inert Gas systems

This section describes, in general terms, the operation of a fixed 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 health risks associated with operating IG plants.

Refer to the ship's operations manual, the manufacturer's instructions and the installation drawings, as appropriate, for details on the operation of a particular system. Consult the IMO publication *Guidelines for Inert Gas Systems* for a more detailed explanation of the design and operation of typical IG system.

See OCIMF's information paper *Inert Gas Systems* for guidance on using IG while carrying flammable oil cargoes.

11.1.1 General

Hydrocarbon gas in petroleum tankers cannot burn in an atmosphere containing less than about 11% oxygen by volume. One way to provide protection against fire or explosion is to keep the oxygen level below 11%. This is usually achieved by using a fixed piping arrangement to blow IG into each cargo tank to reduce the air content, i.e. the oxygen content, and render the tank atmosphere non-flammable.

See section 1.2.3 and figure 1.1 for detailed information on IG and flammability.

11.1.2 Sources of Inert Gas

Possible sources of IG on tankers and combination carriers are:

- Uptake gas from the ship's boilers.
- Independent IG generators.
- IG (or nitrogen) supplied from external sources.

11.1.3 Composition and quality of Inert Gas

SOLAS requires IG systems to deliver IG with an oxygen content in the IG main of not more than 5% by volume at any required rate of flow.

SOLAS also requires that IG systems keep positive pressure in the cargo tanks and have an oxygen content of not more than 8% (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 IG generator is installed, the oxygen content can be automatically controlled within finer limits, usually between 1.5% to 2.5% by volume.

In certain ports, the maximum oxygen content of IG in the cargo tanks may be set at 5% to meet safety requirements, e.g. the operation of a Vapour Emission Control System (VECS). When such a limitation is in place, the ship should be advised of the requirement in the pre-arrival information exchange.

Efficient scrubbing of the IG is essential, particularly for the reduction of the sulphur dioxide (SO_2) content. High levels of sulphur dioxide increase the acidic characteristic of IG, which may cause accelerated corrosion to the structure of the ship.

11.1.4 Methods of replacing tank atmospheres

If the entire tank atmosphere could be replaced by an equal volume of IG, the resulting tank atmosphere would have the same oxygen level as the incoming IG. In practice, this is impossible to achieve and a volume of IG equal to several tank volumes would need to be introduced into the tank before the desired result could be achieved.

A tank's atmosphere can be replaced with IG either by inerting or purging. These are distinct processes, where the atmosphere will either be diluted or displaced:

- Dilution: when the incoming IG mixes with the original tank atmosphere, the original gas decreases slowly. The incoming IG should have enough velocity to enter the bottom of the tank. Because of this, only one tank should be inerted or purged at a time when using this method.
- Displacement: because IG is slightly lighter than hydrocarbon gas, when the IG enters at the top of the tank the hydrocarbon gas escapes from the bottom. When using this method, it is important that the IG has a very low velocity. This method allows several tanks to be inerted or purged at the same time.

Inerting or purging through a series of tanks is called the cascade method, where the IG enters the first tank and exits to the second tank. Using this method, the tanks are inerted/purged from top to bottom or from bottom to top.

Whichever method is used, it is important that oxygen or gas measurements are taken at different heights and positions within the tank. A mixture of IG and petroleum gas can become flammable.

To achieve the protection of an IG system, it is important that the system is properly operated and maintained.

It is important to follow the safety precautions when petroleum gas is vented. The flame trap of the venting system should be kept in good condition. The purge velocity of IG should be sufficient to minimise the exposure of personnel working on deck. The operation should be stopped before lightning or a thunderstorm.

11.1.5 Cargo tank atmosphere control

11.1.5.1 Inert Gas operations

Tankers using an IG system should maintain their cargo tanks in a non-flammable condition at all times:

- 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 transition from an inert condition to a 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 IG until the hydrocarbon content of the tank atmosphere is below the critical dilution line (line GA in figure 1.1).
- When an oil tanker is in a gas free condition before arrival at a loading port, the tanks should be inerted before loading.

To maintain cargo tanks in a non-flammable condition, the IG plant should:

- Inert empty cargo tanks (see section 11.1.6.1).
- Be in operation, or be ready for immediate operation, during cargo discharge, de-ballasting, COW and tank cleaning (see sections 11.1.6.6 and 11.1.6.9).
- Purge tanks before gas freeing (see section 11.1.6.10).
- Top up the pressure in the cargo tanks when necessary during other stages of the voyage (see sections 11.1.6.5 and 11.1.6.7).

11.1.5.2 Inert Gas system maintenance

The deck and engine departments should cooperate closely to ensure the IG system is maintained and operated properly. It is important to make sure 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.

Dry and semi-dry type deck water seals present a higher risk of backflow. OCIMF's *Inert Gas Systems, Dry Type Deck Water Seals – Prevention of Inert Gas/Hydrocarbon Backflow* and *Inert Gas Systems, Semi-Dry Type Deck Water Seals – Prevention of Inert Gas/Hydrocarbon Backflow* provide guidance on how to reduce the risk of backflow. Operators should be aware of the safety risks and understand the information in these papers when fitting these types of deck water seals.

To demonstrate that the IG plant is fully operational and in good working order, a record of inspection of the plant, including defects and their rectification, should be maintained on board.

PART 1 General information

PART 2 Tanker Information

PART 4 Ship/Shore Tanker/Terminal Interface

11.1.5.3 Degradation of Inert Gas quality

Tanker personnel should be alert to the possible degradation of the quality of IG in tanks as a result of air being drawn in. This can happen when the IG or cargo systems are operated improperly or when petroleum product in a tank releases oxygen, e.g.:

- Not topping-up the IG promptly if the pressure in the system falls due to temperature changes at night.
- Opening tank apertures for too long when carrying out tank gauging, sampling and dipping.

When water is drained from a non-inerted tank, air will be mixed in with the drainings and released into an inerted slop tank. The volume of air drawn into the slop tank in this manner can be particularly high if an eductor is used to drain cargo tanks back to the slop tanks. When liquid is to be drained to the slop tank, the oxygen content of the IG should be closely monitored.

11.1.6 Use during cargo tank operations

Before the IG system is operated the tests required by the operations manual or the 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.

11.1.6.1 Inerting empty tanks

When inerting empty tanks that are gas free, IG should be introduced while venting the air in the tank. This operation should continue until the oxygen content throughout the tank is not more than 8% by volume. The oxygen level will not then increase if a positive pressure is maintained by using the IG system to introduce additional IG.

If the tank is not gas free, the precautions against static electricity in section 11.1.6.8 should be followed 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 IG main and the system pressurised with a minimum positive pressure of at least 100mm Water Gauge (WG). If individual tanks have to be separated from a common line, e.g. for product integrity, the tanks should have an alternative means of maintaining an IG blanket.

11.1.6.2 Loading cargo or ballast into inert tanks

When loading cargo or ballast, the IG 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 IG system restarted and re-pressurised, if necessary. The system should then be shut down and all safety isolating valves secured.

Local regulations may prohibit venting after COW (see section 12.5.8).

11.1.6.3 Simultaneous cargo operations

When loading and discharging cargo simultaneously, venting to the atmosphere can be minimised or even avoided by interconnecting the tanks through the IG main. Depending on the relative pumping rates, pressure in the tanks may be increased or reduced and it may be necessary to adjust the IG flow to maintain tank pressures within normal limits.

11.1.6.4 Vapour balancing

Vapour balancing is used to avoid the release of gases and to reduce the use of the IG systems when transferring cargo:

- For internal transfer of cargo, the ship's vapour return system (IG valve) will be connected between tanks being discharged and loaded.
- Vapour balancing to the shore or another ship involves a return of vapours to the Vapour Return Line (VRL) to shore or to the other ship using a flexible hose.

To ensure that vapour balancing operation is done safely, and cargo vapours are not accidentally released into atmosphere, the following recommendations should be followed:

Before cargo transfer:

- Use appropriate equipment to monitor the vapour stream. The oxygen analyser and alarms should be tested for proper function before each cargo transfer operation. Where local regulations require, the vapour stream should be monitored continuously, with audible and visual alarms, to ensure that the oxygen does not exceed 8% by volume.
- Before cargo transfer, the vapour space of the discharging facility and receiving tank should be inerted to less than 8% oxygen.
- The VRL pressure alarm setting should be lower than 80% of the P/V valve lowest release setting.
- If it is safe, the vapour transfer hose should be purged and inerted before the vapour transfer.

Do not open the vapour manifold valves until the IG pressure of the receiving ship exceeds that of the discharging ship.

During the cargo transfer:

- The IG system on the discharging ship should be operational and on standby, with the IG main deck isolating valve closed. Use the IG system if the IG pressure in the discharging ship falls below 300mm WG.
- The IG pressure in cargo tanks should be monitored and the information regularly exchanged between two ships or with a terminal.
- Do not let air enter the cargo tanks.
- Stop the transfer if the oxygen content of the vapour stream is above 8% by volume. It is only safe to continue the transfer once the oxygen content is 8% or less by volume.
- The cargo transfer rate should not exceed the designed rate for the vapour balancing hose.

11.1.6.5 Loaded passage

A positive pressure of IG should be maintained in the ullage space at all times during the loaded passage to prevent air from entering (see section 11.1.5.3). If the pressure falls below the low pressure alarm level, it will be necessary to start the IG plant to restore pressure to the system.

Loss of pressure is usually a result of leaks from tanks and low sea or air temperatures. It is important that tanks are always gas-tight. Gas leaks are usually easily detected by their noise. For safety reasons, every effort should 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, based on the toxicity or hazards created, so that they are sealed quickly and as soon as possible.

Certain oil products, e.g. jet fuel and diesel oil, can absorb oxygen during the refining and storage process. This oxygen can later be released into an oxygen deficient atmosphere, e.g. ullage space of an inerted cargo tank. The cargo tanks should be monitored to maintain the oxygen level below

8%. Purging, or any necessary precautionary measures, should be taken to maintain the oxygen level below 8%.

11.1.6.6 Discharge of cargo or ballast from inert tanks

The IG supply should be maintained throughout cargo discharge or, in exceptional circumstances, e.g. cargo tank ballast discharge operations, to prevent air entering the tanks. If a satisfactory positive IG pressure can be safely maintained without a continuous supply of IG, it is acceptable to recirculate or stop the supply of IG as long as the IG plant is kept ready for immediate operation.

On arrival in port, if the IG has to be de-pressurised for any reason it may be difficult, because of the low boiler load, to re-pressurise with IG that has low enough oxygen content. In this case, 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 IG quality is high enough.

Throughout the cargo discharge, particularly when the boiler load is low or fluctuating, the oxygen content of the IG supply should be carefully monitored. The oxygen content and pressure of the IG main should be continuously recorded during discharge. For the action to take if the IG plant fails during discharge from inerted tanks, see section 11.1.12.

In normal operations closed measurements should be taken. However, if hand dipping a tank is necessary, pressure may be reduced while dipping ports are open but care should 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. Discharge should be stopped immediately if there is a danger of the tanks coming under vacuum.

11.1.6.7 Ballast passage

During a ballast passage, cargo tanks (other than those required to be gas free) should remain inert and under positive pressure to prevent air entering. Whenever pressure falls to the low pressure alarm level (100mm WG minimum), the IG plant should be restarted to restore the pressure. Attention should be paid to the oxygen content of the IG delivered.

11.1.6.8 Static electricity precautions

In normal operations the presence of IG prevents the existence of flammable gas mixtures inside cargo tanks. However, hazards caused by static electricity may arise, mainly in the case of a failure of the IG system. To avoid these hazards, follow the procedures in chapter 3.

11.1.6.9 Tank washing, including Crude Oil Washing

Before a tank is washed, the oxygen content should be checked in two places – one metre below the deck and at the middle level of the ullage space. The oxygen content should never be above 8% by volume. If the tank has a swash bulkhead, the measurement should be taken at similar levels in each section of the tank. The oxygen content and pressure of the IG being delivered during the washing process should be continuously recorded.

If the oxygen content in the tank exceeds 8% by volume or the pressure of the atmosphere in the tanks is no longer positive, washing should be stopped until safe conditions are restored (see section 11.1.12).

11.1.6.10 Purging

When a tank needs to be gas freed after washing it should first be purged with IG to lower the hydrocarbon content to 2% or less by volume. This is to ensure that, during the gas freeing, no part of the tank atmosphere is brought within the flammable range.

The hydrocarbon content should be measured with an instrument specifically designed to measure the percentage of hydrocarbon gas in an oxygen deficient atmosphere.

If the dilution method of purging is used it should be with the IG system set for maximum capacity. This will give maximum turbulence within the tank. If the displacement method is used, the gas inlet velocity should be lowered to prevent undue turbulence (see section 2.1.2.4).

11.1.6.11 Gas freeing

Before starting to gas free, the tank should be isolated from other tanks. When fans connected to the cargo pipeline system are used to introduce air into the tank, the IG inlet should be isolated. If the IG system fan is used to put air into the tank, both the line back to the IG source and the line into each tank being inerted should be isolated (see chapter 3).

11.1.6.12 Preparation for tank entry

To ensure the toxic parts of IG are safely below their Threshold Limit Values (TLVs), gas freeing should continue until tests show a steady oxygen reading of 21% by volume and tests with a flammable gas indicator show not more than 1% of the LFL.

If the presence of a toxic gas such as benzene or H_2S is suspected, gas freeing should continue until tests show that its concentration is below its Occupational Exposure Limit – Time Weighted Average (OEL-TWA). (IMO Resolution A.1050(27) *Revised Recommendations for Entering Enclosed Spaces Aboard Ships*).

Positive, fresh air ventilation should be maintained throughout the time personnel are in a tank. The oxygen, toxic gas and hydrocarbon content of the tank atmosphere should be tested frequently.

When other inert tanks are either next to or connected to the tank being entered, personnel should be alert to the possibility of IG leaking into the gas free tank, e.g. through bulkhead fractures or defective valves. Special precautions should be taken, including monitoring the tank atmosphere while personnel are inside. For advice on entry into enclosed spaces, see chapter 10.

11.1.7 Precautions to be taken to avoid health hazards

11.1.7.1 Inert Gas on deck

Some wind conditions may bring vented gases down onto the deck, even from specially designed vent outlets. If gases are vented at a low level from cargo hatches, ullage ports or other tank apertures, the surrounding areas can contain harmful concentrations of gases and may also be oxygen deficient. In this case, all non-essential work should stop and only essential personnel should remain on deck, taking all necessary precautions.

If the last cargo carried was a sour crude, tests should also be made for H_2S around the deck area. If a level higher than 5ppm is detected, no personnel should be allowed to work on deck unless they are wearing suitable breathing protection (see sections 1.4.6 and 12.1.9).

11.1.7.2 Entry into cargo tanks

Entry into cargo tanks should be permitted only after they have been gas freed, as described in sections 11.1.6.10 and 11.1.6.11. The safety precautions in chapter 10 should be observed, including the carrying of a personal gas detector. If the hydrocarbon and oxygen levels specified in section 11.1.6.12 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 should wear breathing apparatus (see section 10.10 for further details).

11.1.7.3 Scrubber and condensate water

IG scrubber effluent and the condensate formed when the water vapour in the IG condenses inside the IG distribution piping are acidic and corrosive.

Care should be taken to avoid contact with either the effluent or condensate. Appropriate PPE that protects the eyes and skin should be worn.

11.1.8 Cargo tank protection against over/under pressure

Serious accidents have occurred on oil tankers as a result of cargo tanks being severely over or under pressure. Although SOLAS regulations have been modified to require tanks to be fitted with pressure monitors and safety devices, 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, e.g. unusual noises of vapour escaping under pressure or P/V valves lifting. See section 11.2.2 for more information on how to avoid over or under pressurisation.

A ship's personnel should be provided with clear operating procedures for properly managing the venting system and should have a full understanding of its capabilities and limitations.

11.1.8.1 Pressure/Vacuum breakers

P/V breakers provide another safety mechanism to prevent over or under pressurisation. Normally, one breaker is connected to the IG/vent main to protect the cargo tanks. P/V breakers are usually liquid filled and it is important that the correct density liquid is used and the appropriate level maintained. Evaporation, condensation and sea water can all affect P/V breakers. In heavy weather the pressure surge caused by the movement of cargo in tanks may cause a P/V breaker to blow out. In the case of excess vacuum, the liquid overflows to the IG main and is lost. Some types of P/V breaker can recover and reuse the liquid if lost by pressure. The P/V breakers should be marked with their High Pressure (HP) and vacuum opening pressures, the date of the last inspection, the type of anti-freeze and the lowest operating temperature.

11.1.8.2 Pressure/Vacuum valves

P/V valves are required on each tank, to provide for the flow of small volumes of tank atmosphere due to thermal variations, and are set to operate ahead of the P/V breakers. Some systems may also have a small capacity P/V valve fitted in a bypass across the mast riser isolation valve. However, it is common practice to install full flow P/V valves on each tank where only small capacity valves are required.

11.1.8.3 Full flow Pressure/Vacuum venting arrangements

Protection from over or under pressurisation of the cargo tanks may be provided by installing, on each tank, full flow P/V valves rated for 125% of the maximum loading/discharge rate. Where the mast riser is the primary vent, the P/V valve may serve as the secondary protection.

It is common on ships carrying non-homogenous cargoes to use the individual full flow P/V valves as primary venting while loading. These P/V valves are usually the high velocity type, which disperse the tank vapours by partially closing the outlet to increase the velocity of the vapour flow to more than 30m/sec. The high velocity flow means no flame screen is needed at the vapour outlet on this type of valve.

11.1.8.4 Individual tank pressure monitoring and alarm systems

A tank pressure monitoring and alarm system may be used as an alternative to P/V valves for the secondary P/V relief. These systems use individual tank pressure sensors connected to an alarm system that is monitored in the cargo control room or a location where cargo operations are normally carried out.

The set points for non-inerted ships should be 10% over or under the P/V valve settings. For inerted ships the set points should be 10% over the pressure setting and above zero for the low pressure (100mm WG) setting to prevent the tank from taking in air. When using a vapour return line for non-inerted ships, the HP setting will be set to 90% of the pressure valve. The low pressure (vacuum) setting will be set so that the alarm occurs before the vacuum valve relieves.

11.1.9 Product carriers fitted with an Inert Gas system

11.1.9.1 General

The basic principles of inerting for product carriers and crude carriers are similar. However, there are some differences, which are outlined in the following sections.

11.1.9.2 Carrying products with a flashpoint above 60°C

Tankers may carry petroleum products that have a flashpoint above 60°C, e.g. lubricating oils, Heavy Fuel Oils (HFOs), diesel fuels, etc., without needing an IG system fitted or, if fitted, without having to keep the tanks inerted.

However, when cargoes with a flashpoint above 60°C are carried at a cargo temperature higher than their flashpoint less 10°C, e.g. some residual fuel oils, the tanks should be inert because they could become flammable.

If IG systems are fitted the cargo tanks should be inerted where there is a possibility that the headspace atmosphere may become flammable (see section 1.6).

When a non-volatile cargo is carried in a tank that has not been gas freed, the tank should be inert.

11.1.9.3 Additional purging and gas freeing

Gas freeing is required on product carriers more frequently than on crude carriers because of the greater need for tank entry and inspection and for venting the vapours of previous cargoes. On inerted product carriers, purging should be done before gas freeing (see section 11.1.6.10).

Purging is not essential before gas freeing when the hydrocarbon gas content of a tank is below 2% by volume.

11.1.10 Cold weather precautions for Inert Gas systems

An IG system may not work properly in extreme cold weather.

11.1.10.1 Condensation in Inert Gas piping

SOLAS requires that the piping system is designed to prevent accumulation of cargo or water in the pipeline. However, in extreme cold any water in the IG may freeze in the IG main. The system should be operated to minimise residual water and it should be closely monitored.

11.1.10.2 Control air

Air operated control valves, where the control air has a high water vapour content, that are fitted to the IG system outside the engine room may not operate correctly if exposed to extremely low ambient temperatures. Air operated control valves should be exercised/operated regularly to ensure correct operation.

Water separators in control air systems should be drained frequently and the control air dryers should be checked regularly for proper operation.

11.1.10.3 Safety devices

In extremely cold weather, ice may prevent the P/V valves from operating and may block the flame screens on the P/V valves and mast risers.

Water filled P/V breakers should be filled to the appropriate level with anti-freeze liquid.

Deck water seals are fitted with heating coils that should be used before cold weather sets in.

11.1.10.4 Sea chests

To ensure that the water supply to the scrubber and deck seal is maintained in icy conditions at sea or in estuaries, low sea water suctions should be used. This will reduce the probability of ice slurry getting into the sea chest. Steam injection connections to sea chests can be used to help clear sea chests.

11.1.11 Inert Gas system failure

SOLAS requires that each ship fitted with an IG system has detailed instruction manuals covering operations, safety and maintenance requirements and occupational health hazards. The *International Code for Fire Safety Systems (FSS Code)* states, "The manual shall include guidance on procedures to be followed in the event of a fault or failure of the IG system".

11.1.11.1 Action to take should the Inert Gas system fail

If the IG system fails to deliver the required quality and quantity of IG, or to maintain a positive pressure in the cargo tanks and slop tanks, action must be taken immediately to prevent any air going into the tanks. All cargo and/or ballast discharge from inerted tanks must be stopped, the IG deck isolating valve closed, the vent valve between it and the gas pressure regulating valve opened and immediate action taken to repair the IG system.

National and local regulations may require the failure of an IG system to be reported to the harbour authority, terminal operator and to the port and Flag State administrations.

Section 12.8.3.1 gives guidance on special precautions to take if the IG system fails when loading static accumulator oils into inerted cargo tanks.

11.1.11.2 Follow-up action on crude oil tankers

Pyrophoric iron sulphide deposits (pyrophors, see section 1.5.3) may be present in the cargo tanks of crude oil tankers. If a tanker is carrying crude oil, the failed IG system must be repaired and restarted, or another source of IG provided, before discharge from inerted tanks is resumed.

11.1.11.3 Follow-up action on product tankers

Tank coatings usually inhibit the formation of pyrophors in the cargo tanks of product tankers. If it is impracticable to repair the IG system, discharge may be resumed with the written agreement of all interested parties, as long as an external source of IG is provided or detailed procedures are established to ensure the safety. The following precautions should be taken:

- Consult the manual referred to in section 11.1.11.
- Ensure that devices to prevent the passage of flame, or flame screens (as appropriate), are in place and check they are in a satisfactory condition.
- Open the valves on the vent mast risers.
- Permit no free fall of water or slops.
- Introduce no dipping, ullaging, sampling or other equipment 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 after the injection of IG has stopped. See section 11.1.6.8 for static electricity precautions relating to IG, and section 12.8 for static electricity precautions when dipping, ullaging and sampling.
- Ensure that all metal components of any equipment to be introduced into the tank are securely electrically earthed. This restriction should be applied for at least five hours after the injection of IG has stopped.

11.1.12 Emergency Inert Gas supply

SOLAS requires that suitable arrangements are provided to enable the IG system to be connected to an external supply of IG.

These arrangements should consist of a 250mm nominal pipe size bolted flange, isolated from the IG main by a valve and located forward of the Non-Return Valve (NRV). The design of the flange should be compatible with the design of other connections in the ship's cargo piping system.

11.1.13 Inert Gas plant repairs

As IG causes asphyxiation, great care should be taken to avoid the escape of IG into any enclosed or partly enclosed space.

No one should be allowed inside the scrubber or deck water seal until the atmosphere has been tested and an oxygen level of 21% by volume obtained (see chapter 10). While personnel are working inside such spaces the oxygen content of the atmosphere should be continuously monitored and the personnel should be under constant supervision.

Before opening the IG system it should be gas freed and any enclosed space should be ventilated to avoid any risk of oxygen deficiency.

Continuous positive ventilation should be maintained before and during the work.

11.2 Venting systems

11.2.1 General

Venting systems are required to meet SOLAS regulations. Venting systems are necessary for achieving safety on board a tanker and it is essential that they are operated to meet their design requirements and that they are properly maintained.

To ensure hydrocarbon vapours are diluted into the atmosphere clear of the tanker's deck, venting systems allow vapours to be released either at:

- Low velocity high above the deck from a vent riser.
- High velocity from a high velocity valve closer to the deck.

Vents are installed 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 2.1.3).

The ship's personnel should be fully trained on the operation and maintenance of the venting system and should be aware of its limitations to prevent over or under pressurisation of tanks (see section 11.2.2).

11.2.2 Tank over pressurisation or under pressurisation

11.2.2.1 General

Over pressurisation of cargo and ballast tanks is caused by compression of the ullage space through the inadequate release of vapour or by overfilling the tank. Under pressurisation can be caused by not allowing IG 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 or pollution (see section 11.1.8).

11.2.2.2 Causes of tank over pressurisation

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 IG isolating valve to the vapour line or IG line.
- Failure of an isolating valve to the vapour line or IG line.
- Failure of the vent valve or high velocity valve.
- Choked flame trap or screen in a mast riser or vent stack.
- Loading or ballasting the tank to a level greater than its venting capacity (see section 11.3.3.1).
- Ice forming on the vents, freezing of the P/V or high velocity valves or ice on the surface of the ballast (see section 11.1.10.3).
- A restriction in the vapour lines caused by wax, residues or scale.
- Not monitoring the pressure or controlling vent valves during loading.

11.2.2.3 Tank over pressurisation – precautions and corrective actions

The best way to protect against over pressurisation is by following effective procedures:

- A procedure to control the setting of the isolating valves on the vent 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.
- Where isolating valves are fitted to the branch line to each tank, they should be provided with locking arrangements that are under the control of the ship's Responsible Officer.
- A method of recording the status of all valves in the cargo system and preventing them from being incorrectly or casually operated.
- Setting the valves in the correct position and making sure that they remain correctly set.
- Restricting the operation of the valves to authorised personnel only.

Regular maintenance, pre-operational testing and operator awareness of isolating valves, P/V valves or high velocity vents can guard against failure during operation.

To protect over pressurisation through filling tanks too quickly, all ships should have maximum filling rates for each individual tank and these should be available to the ship's personnel (see section 11.3.3). Tank vents should be checked to ensure that they are clear when the operation begins. During freezing weather, they should be inspected regularly throughout the operation.

When over pressurisation of a tank or tanks is suspected, loading or ballasting of the tanks should stop immediately.

11.2.2.4 Tank under pressurisation – causes

The causes of under pressurisation are similar to those of over pressurisation:

- An incorrect setting of the tank's vapour or IG isolating valve to the vapour line or IG line.
- Failure of an isolating valve on the vapour line or IG line.
- Failure to operate the IG fan due to breakdown or other reasons.
- Failure in one of the IG supply valves.
- A choked flame screen on the vapour inlet line.
- Ice forming on the vents of ballast tanks during cold weather.
- Not monitoring and/or controlling vent valves during discharge.

11.2.2.5 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 11.2.2.3).

Where under pressurisation of a tank or tanks is suspected, discharge should stop immediately.

To reduce a partial vacuum in tank, the liquid level is raised by pumping into the affected tank, or IG or air is put into the ullage space. However, be careful with the following:

- On a ship with an IG system, it is possible that air leaks may mean the quality of the IG is low.
- Giving IG a high velocity could cause an electrostatic hazard.
- Observe the precautions in section 12.8.3 when measuring and sampling.
- On ships without an IG system where it is not possible to reduce the partial vacuum by raising the liquid level, ensure that the rush of air does not put foreign objects into the tank.

11.3 Cargo and ballast systems

This section describes the pipelines and pumps used for loading and discharging cargo and ballast. For the purpose of this guide, the cargo heating system and COW system are part of the cargo system.

The cargo system is one of the prime areas where a breach 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.

11.3.1 Operation manual

The ship's crew should have access to up-to-date drawings and information on the cargo and ballast systems as well as an operation manual.

11.3.2 Cargo and ballast system integrity

The cargo and ballast systems are subjected to many conditions that may ultimately lead to a loss of containment. These include:

- 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.
- 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.
- When handling cargoes that the system has not been designed for, 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 rusting when pipe systems are used for both water and oil.

Local 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, with sulphurous products from cargo or IG, or if electrolytic corrosion cells that are set up when pipeline connections are not securely bonded.

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.

Any latent defect in the ballast system will usually reveal itself when the system is being used during the de-ballasting 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. Where a single ballast pump is fitted, company procedures should address use of alternative means of ballasting/de-ballasting.

11.3.3 Loading rates

Masters should be provided with information on maximum 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 will ensure 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 in section 11.3.3.2.

11.3.3.1 Venting arrangements

Venting capacity is based on the maximum volume of cargo entering a tank, plus a 25% margin for gas evolution (vapour growth).

When loading cargoes with a very high vapour pressure, gas evolution may be excessive and the allowance of 25% may not be enough. To ensure the capacity of the venting system is not exceeded, closely monitor the vapour line pressures on inerted ships and limit loading rates on non-inerted ships. The vapour growth increases when the liquid levels in the tank are above 80%. On inerted ships IG system pressures should be closely monitored, particularly when topping-off during loading operations or when starting COW during discharge operations.

When calculating loading rates a maximum venting line velocity of 36m/sec 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.

11.3.3.2 Flow rates in loading lines

Depending on the trade of the tanker, different loading rates need to be determined for each cargo tank. These loading rates depend 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 1m/sec at the tank inlet for the initial loading of static accumulator cargoes into non-inerted tanks.
- A loading rate based on a linear velocity of 7m/sec for bulk loading of static accumulator cargoes into non-inerted tanks.
- A loading rate based on a linear velocity of 12m/sec for loading non-static accumulator cargoes and for loading static accumulator cargoes into inerted tanks. This velocity is for guidance only and is generally considered as a rate above which pipeline erosion may occur at pipe joints and bends.

When 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 at once and that a proper loading rate is determined for the loading operation.

Offshore floating hoses that meet OCIMF guidelines (see bibliography) and have a nominal diameter of less than 400mm are suitable for continuous operation at a flow velocity of 21m/sec. Offshore floating hoses with a diameter greater than 400mm are suitable for continuous operations at a flow velocity of 15m/sec. However, the maximum loading rate may be controlled by the size of the ship's loading line inboard of where the hose is connected.

11.3.3.3 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 in order to accommodate certain operations, such as recirculatory COW 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 for the tanker to set the loading rate to limit the rate of rise of liquid in a cargo tank.

11.3.3.4 Loading rates for ballast tanks

Loading rates for ballast tanks should be determined in the same way as cargo tanks, considering the size of vent outlets using a velocity of 36m/sec. Liquid filling rates can be calculated using a pipeline flow rate of 12m/sec and are subject to a similar rate of rise as in section 11.3.3.3.

11.3.4 Monitoring of void and ballast spaces

Void and ballast spaces in the vicinity of the cargo tank deck should be regularly monitored for leaks from adjacent tanks. Monitoring should include regular atmosphere checks for hydrocarbon content and regular sounding/ullaging of the empty spaces (see also chapter 12).

11.4 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 21.7.1.1 for advice on planned immobilisation.

A terminal may allow some degree of immobilisation of the propulsion plant while the ship is alongside. However, the tanker should obtain permission from the Terminal Representative or the local authority pre-arrival before taking any action affecting the readiness of the ship to move under its own power.

The terminal should always be notified of any unexpected event that affects operations and their safety.

11.5 Vapour recovery systems

Vapour recovery systems fall into two categories:

- Those systems conforming to IMO guidelines that provide a system for returning cargo vapours to the shore for reclaiming or incinerating. These are known as VECSs (see section 23.7.7).
- Proprietary systems for recovering petroleum liquid or vapour that would otherwise be vented during the loading operation or during the loaded passage. These are known as vapour recovery systems.

Personnel who operate VECSs and vapour recovery systems should be fully trained to use them.

11.6 Volatile Organic Compound recovery systems

During loading, Volatile Organic Compounds (VOCs) are normally vented to the atmosphere unless a VOC recovery system is used to recover them. A VOC recovery system may be based on active or passive technology – see figure 11.1.

VOCs are mixtures of light hydrocarbons, such as methane, ethane, propane and butane, that evaporate within the range of normal atmospheric conditions. VOCs are generated when cargo flashes. The flash produces vapour due to depressurisation in the piping system from the source to the cargo tank and from evaporation from the oil surface inside the cargo oil tanks during and after loading. The level of evaporation depends on the volatility of the cargo loaded. See section 1.1.

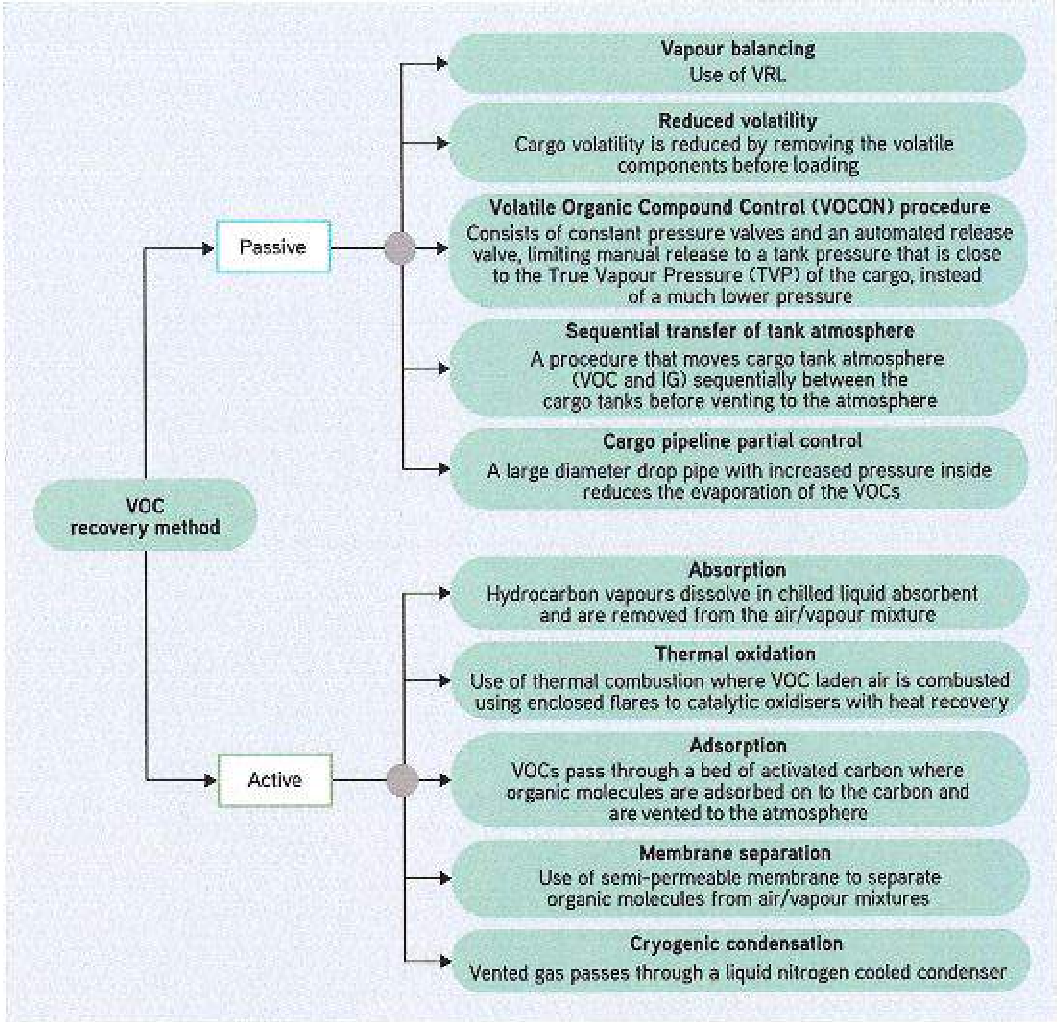


Figure 11.1: Examples of passive and active VOC recovery methods

11.7 Stern loading and discharging arrangements

Using a stern manifold for cargo transfer operations introduces additional hazards and operational concerns. Procedures should address the following:

- The requirement to monitor the stern manifold and the cargo tank deck area at the same time.
- The dangerous area extending at least three metres from the manifold valve should be clearly marked. No unauthorised personnel should be allowed in this area during the entire cargo operation.
- 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. Air inlets and doors to enclosed spaces should be kept closed.
- Connection and disconnection of hoses where no lifting gear is available.
- Firefighting equipment should be laid out and ready for use close to the stern manifold.
- Continuous watch by a responsible crew member at the stern throughout the cargo operation.

(See sections 12.1.6.9, 12.1.13.9 and OCIMF's *Guidelines for Offshore Tanker Operations*.)

CHAPTER 12

Shipboard Operations

12.1 Cargo operations
12.2 Stability, stress, trim and sloshing considerations
12.3 Tank cleaning
12.4 Gas freeing
12.5 Crude Oil Washing
12.6 Ballast operations
12.7 Cargo leaks into double hull tanks
12.8 Cargo measurement, ullaging, dipping and sampling
12.9 Transfers between ships
12.10 Personnel transfer
12.11 Liquefied Natural Gas fuelled ship alongside a terminal
12.12 Lifting equipment

This chapter covers the full range of shipboard operations, including loading and discharging cargo, hose clearing, tank cleaning and gas freeing, ballasting, STS transfers and mooring.

The chapter also looks at the safe handling of particular cargoes, such as static accumulator oils, those having a high vapour pressure and those containing H_2S.

Other operations addressed include the use of VECSs and COW.

12.1 Cargo operations

12.1.1 General

All cargo operations should be carefully planned and documented well in advance. The plans should be discussed with all personnel on the ship and at the terminal and may require modification after this consultation. Plans may also need to be modified after consultation with the terminal and following changing circumstances, either on board or ashore, and these changes should again be communicated and understood by ship and terminal personnel, and formally recorded. Chapter 21 contains details of cargo plans and relevant communications. The company's SMS should include guidance on the requirements outlined below to ensure that these are implemented.

12.1.2 Setting of lines and valves

Before starting any loading or discharging, the ship's cargo pipelines and valves should be set in line with the loading or discharging plan and checked independently and by other personnel under the control of the Responsible Officer. If a change in the line-up is required during a change of grades, the valves should be checked in the same way. The Responsible Officer should document the completion of the task and sign it.

12.1.3 Valve operation

Valves at the downstream end of a pipeline system should not be closed against the flow of liquid, except in an emergency, to avoid the risk of pressure surges. This should be emphasised to all personnel responsible for cargo handling operations on the ship and at the terminal (see section 12.1.4).

In general, where pumps are used for cargo transfer, all valves in the transfer system (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 then opened slowly. When ships are loading by gravity, the final valve to be opened should be 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 that it takes for power operated valves to move from open to closed, and from closed to open, should be checked regularly at their normal operating temperatures.

12.1.4 Pressure surges

The incorrect operation of pumps and valves can produce pressure surges caused by the kinetic energy of the liquid flow in a pipeline system.

These surges may be severe enough to damage the pipeline, hoses or Marine Loading Arms (MLAs). One of the most vulnerable parts of the system is the ship/shore connection. Pressure surges are produced upstream of a closing valve and may become excessive if the valve is closed too quickly. Pressure surges are more likely to be severe where long pipelines, high flow rates or significant differences in elevation between the ship and shore tank are present.

The risk of pressure surges means the ship and terminal need to exchange information and draw up a written agreement on the control of flow rates, the rate of valve closure and pump speeds. This should include the time that remotely controlled and automatic shutdown valves take to close. The agreement should be part of the operational plan, discussed at the pre-transfer conference and documented in part 8 of the Ship/Shore Safety Checklist (SSSCL).

12.1.5 Butterfly and Non-Return (check) Valves

The risk of butterfly and NRVs slamming shut against high flow rates should be considered. This can cause very large surge pressure and lead to line, hose or MLA failures or even structural damage to jetties. These failures are usually because the open valve disc is not completely parallel to, or fully withdrawn from, the flow. This can create a closing force that may shear either the valve spindle of butterfly valves or the hold-open pin of pinned back NRVs. To prevent damage, it is important to check all valves are fully open when they are passing cargo or ballast.

12.1.6 Loading procedures

12.1.6.1 General

The responsibility for safe cargo handling is shared between the ship and the terminal and rests jointly with the Master and the Terminal Representative. How this responsibility is shared should be agreed at the pre-transfer conference so that all aspects of the operations are covered.

12.1.6.2 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.

12.1.6.3 Emergency Shutdown plan

The ship and the terminal should have agreed an Emergency Shutdown (ESD) procedure and alarm and recorded it on an appropriate form. This agreement sets out those circumstances when operations should stop immediately. It also accounts for the possible dangers of a pressure surge caused by an ESD procedure (see section 16.8).

12.1.6.4 Supervision

The following safeguards should be maintained throughout loading:

- A Responsible Officer should be on watch and enough crew members should be on board to deal with the operation and security of the ship.
- A watch of the tank deck should be maintained.
- The agreed ship to shore communications system should be maintained in good working order.
- At the start of loading, and at each change of watch or shift, the Responsible Officer and the Terminal Representative should each confirm that the communications system remains operational.
- All personnel concerned should fully understand the agreed standby notice period for the normal stopping of shore pumps on completion of loading and the emergency stop system for both the ship and terminal.

Many terminals require a standby period for stopping pumps that should be understood and noted (section 21.4.2).

For instructions for completing the SSSCL, see section 25.4.

12.1.6.5 Inert Gas procedures

Before loading starts, the IG plant, if operational, should be stopped and the IG pressure in the tanks reduced as per company procedures unless cargo is to be simultaneously loaded and discharged.

12.1.6.6 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 a mast riser, VRL or a high velocity or constant velocity vent valve. Devices fitted to mast risers or vent stacks that prevent the passage of flame should be checked regularly to confirm they are correctly installed, clean and in good condition.

To undertake closed loading the ship should have ullaging equipment that can monitor the tank contents without opening tank apertures (closed gauging and sampling are discussed in section 12.8.1). Most ships are also fitted with a remote gauging system that uses floats, radar or another sensing method that can be read in the cargo control room.

The loading rate should not be substantially changed without informing the ship.

12.1.6.6.1 Risk of overfilling

Loading a cargo tank under normal closed conditions comes with a risk of overfilling. The reliance on closed gauging systems means it is important they are fully operational and an independent overfill alarm arrangement should provide backup.

Two alarm points should be fitted. The first is known as 'high level' and is normally set to alarm at 95% capacity. This may be activated from the tank level gauging system or from a float switch. A 'high-high level' or 'overfill' alarm is normally set at 98% capacity and should be independent of the tank gauging system. This alarm is normally activated by a float switch. The high-high level/overfill alarm should be audible and visible in the cargo control room and on deck. Cargo tanks should not be filled higher than the high-high level/overfill alarm as this is the last barrier and no further warnings will be given before the tank overflows.

Before any cargo operation, individual high level and overfill alarms should be tested at the tank to ensure they are working properly.

On ships without IG systems, this equipment should comply with the precautions in section 12.8.2.

Ships with IG are considered capable of closed loading at all times.

12.1.6.7 Starting to load alongside a terminal

When all necessary terminal and tanker valves in the loading system are open, and the ship has signalled its readiness, loading can start. The initial flow rate should be slow. Whenever possible, it should be by gravity and to a single tank. The shore pumps should not be started until the system has been checked and the ship advises that the correct tank(s) are receiving the cargo. 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.

12.1.6.8 Starting to load at offshore buoy berths

Before loading starts at a buoy berth offshore, the ship should confirm its full understanding of the communications system that will control the operation. A secondary communications system should be ready for immediate use should the primary system fail.

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 around the seabed/Pipeline End Manifold (PLEM) to check for leaks. If safe and practical, during darkness a bright light should be shone on the water in the area of the hoses.

12.1.6.9 Starting to load through a stern manifold

Before loading starts through a stern manifold, the dangerous area that extends at least three metres from the manifold valve should be clearly marked. No unauthorised personnel should be allowed in this area during the loading operation.

A close watch should be maintained for any leaks. All openings, air inlets and doors to enclosed spaces should be kept tightly closed.

Firefighting equipment should be laid out ready for use near the stern manifold:

- The cargo hose connection should be carefully inspected for correct alignment and secure coupling. Where possible, a water pressure test of the coupling seals should be made.
- If fitted, any Emergency Release Systems (ERSs) for the mooring and cargo connection should be operational. These systems should be tested before mooring.
- All primary and secondary communication links with the loading terminal should be tested, including any telemetry control system.
- Smoking and naked light requirements should be strictly enforced.

A responsible crew member should keep continuous watch at the stern throughout loading. During darkness, the lighting on and around the ship's stern should allow an effective visual watch to be maintained on the mooring point, mooring system, cargo hose connection, loading hoses and water around the stern.

12.1.6.10 Starting to load through a bow connection

Bow loading ships, which will be designed to work at particular terminals (normally Single Point Moorings (SPMs)), will have their own specific and detailed operating and safety procedures.

However, in general, the following checks should be carried out before loading:

- The mooring system should be inspected for a secure connection.
- The cargo hose connection should be carefully inspected for correct alignment and secure coupling. Where possible, a water pressure test of the coupling seals should be made.
- Any ERSs provided for the mooring and cargo connection should be operational and should be tested before mooring.
- Mooring load monitoring systems should be activated and tested.
- All primary and secondary communication links with the loading terminal should be tested, including any telemetry control system.

A responsible crew member should keep continuous watch on the bow throughout loading. During darkness, the lighting on and around the ship's bow should allow an effective visual watch to be maintained on the mooring point, mooring system, cargo hose connection, loading hoses and water around the bow.

12.1.6.11 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 directly through drop lines within the cargo tank area. All pumproom valves should be closed.

12.1.6.12 Cargo sampling at the start of loading

Where facilities exist, a cargo sample should be taken as soon as possible after the start of loading. The product's visual quality should be checked to ensure the correct grade is being loaded. This should be done before opening up subsequent tanks for loading (see section 12.8).

When loading static accumulating cargoes, follow the precautions against static electricity hazards when taking the sample (see section 12.1.7).

12.1.6.13 Periodic checks during loading

Throughout loading, monitor and regularly check all full and empty tanks to confirm that cargo is entering the designated cargo tanks only and that no cargo has escaped into pumprooms or cofferdams or through sea and overboard discharge valves.

Tank ullages should be checked at least hourly and a loading rate calculated. 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, observation and recording of the shear forces, bending moments, draught and trim and any other relevant stability requirements. This information should be checked against the loading plan to confirm that all safe limits are being met 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 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.

Frequently inspect the cargo deck and pumproom for any leaks. Overside areas should also be checked regularly. During darkness, where safe and practical, illuminate the water around the ship.

12.1.6.14 Topping-off on board the tanker

The ship should advise the terminal when tanks are to be topped-off. It should ask the terminal, giving plenty of warning, to reduce the loading to a rate that allows 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 cargo flow has stopped so that leaking valves or incorrect operations do not cause overflows.

The number of valves to be closed during the topping-off should be kept to a minimum.

Not all of the tanker's valves should be closed against the flow of oil. The minimum number of tanks to be kept open during topping-up should be established.

Before loading is completed, the ship should advise the shore to standby for stopping cargo, including stopping pumps and closing valves. From this moment, the loading rate should be reduced and done by gravity where possible 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.

12.1.6.15 Blending operations

SOLAS VI, Regulation 5-2, prohibits the physical blending of bulk liquid cargoes during a sea voyage. Physical blending is when the ship's cargo pumps and pipelines internally circulate two or more different cargoes to produce a cargo with a new product specification.

This does not prevent the Master from undertaking cargo transfers for the safety of the ship or protection of the marine environment in an emergency. Circulating cargo is also permitted for cargo conditioning.

Blending operations in port should be planned to ensure they comply with the applicable MARPOL regulations and local port requirements. A risk assessment that considers the grades to be loaded, vapour pressure of the cargoes, compatibility of the grades and the crew's experience of blending should be completed.

12.1.6.16 Doping and additives: anti-static, inhibitors, dyes, hydrogen sulphide knockdown

Doping is when cargoes are treated with small quantities of specialised additives and fluids, such as dyes, liquid markers, anti-static agents and lubricants, during loading or before leaving the port.

As far as possible, doping should be carried out ashore or in closed in-line condition. When the cargo or additives are flammable or toxic, a closed doping operation is recommended. However, some terminals do not have a closed in-line additive injection system, so the additives have to be added manually. Any manual doping activity should be risk assessed. Appropriate procedures should be in place to control the associated hazards. Manual doping operations should be carefully planned to minimise the health, safety and environmental impact.

The associated risk assessment should include a review of the Safety Data Sheet (SDS) of the cargo and the additive, suppliers' instructions, PPE, physical and operational hazards, supervision, weather, equipment, resources and contingency measures. Any free fall of additives into non-inerted cargo tanks should be avoided.

The supplier/contractor should draw up a doping plan and communicate this to the ship's Master before any doping. On receiving the plan, the Master should carry out their own onboard risk assessment and check that all relevant items have been addressed and the risks reduced to As Low As Reasonably Practicable (ALARP).

The flowchart in figure 12.1 outlines a doping plan that should contain the three main priorities to be considered and the associated minimum precautions to consider when preparing the risk assessment. These are:

Type of cargo additive:

- SDS should be reviewed for flammability and toxicity information.
- Required PPE and handling equipment should be identified and made available.
- Storage requirements for any additive to be carried on board.
- Considerations for any spillages during operation and method of clean up.
- Requirements for diluting the additive prior to doping.
- Confirm the tank coating is compatible.

Method of doping under consideration:

- Preference is for injection at a shore location or via an in-line injection system, e.g. via a spool piece at the ship's manifold:
  - Pressure test records for the injection system should be verified prior to commencing cargo operation.
- Where injection is required via a cargo tank vapour lock:
  - No doping should be undertaken on a live (loading) tank.
  - Personnel undertaking the operation should stand upwind of the tank opening to minimise gas exposure.
  - PPE is required to be fully implemented, including use of a personal gas monitor.
  - Anti-static precautions are to include ensuring the doping pump/container is properly grounded and the hoses are of an anti-static type.
  - Doping should only be undertaken one tank at a time.
  - When the ship has IG:
    - The tank branch line should be shut and the tank depressurised prior to doping.
    - After the doping operation, the tank oxygen content is to be reconfirmed and the tank re-pressurised.
  - When the ship does not have IG:
    - Free fall of additive into the cargo tank is prohibited.
    - When no full depth sounding pipes are provided, a minimum 30 minute relaxation period is required before and after the addition of additives.
- In exceptional cases only, when doping is required via an open tank lid:
  - All cargo operations should be halted.
  - Non-essential personnel should not be allowed on deck.
  - Personnel undertaking the operation should stand upwind of the tank opening to minimise gas exposure.
  - PPE is required to be fully implemented, including use of a personal gas monitor and (where necessary) use of:
    - SCBA.
    - EEBD.
    - Chemical resistant suits, face masks, etc.
    - Doping should only be undertaken one tank at a time:

- When the ship has IG:
  - The tank branch line should be shut and the tank de-pressurised before doping.
  - After the doping operation, the tank oxygen content is to be reconfirmed and the tank re-pressurised.
- When the ship does not have IG:
  - Free fall of additive into the cargo tank is prohibited.

Mixing ratio of the additive:

- Identify when the additive should be added and the required mixing ratio.
- Understand final sampling requirements for any confirmatory testing.

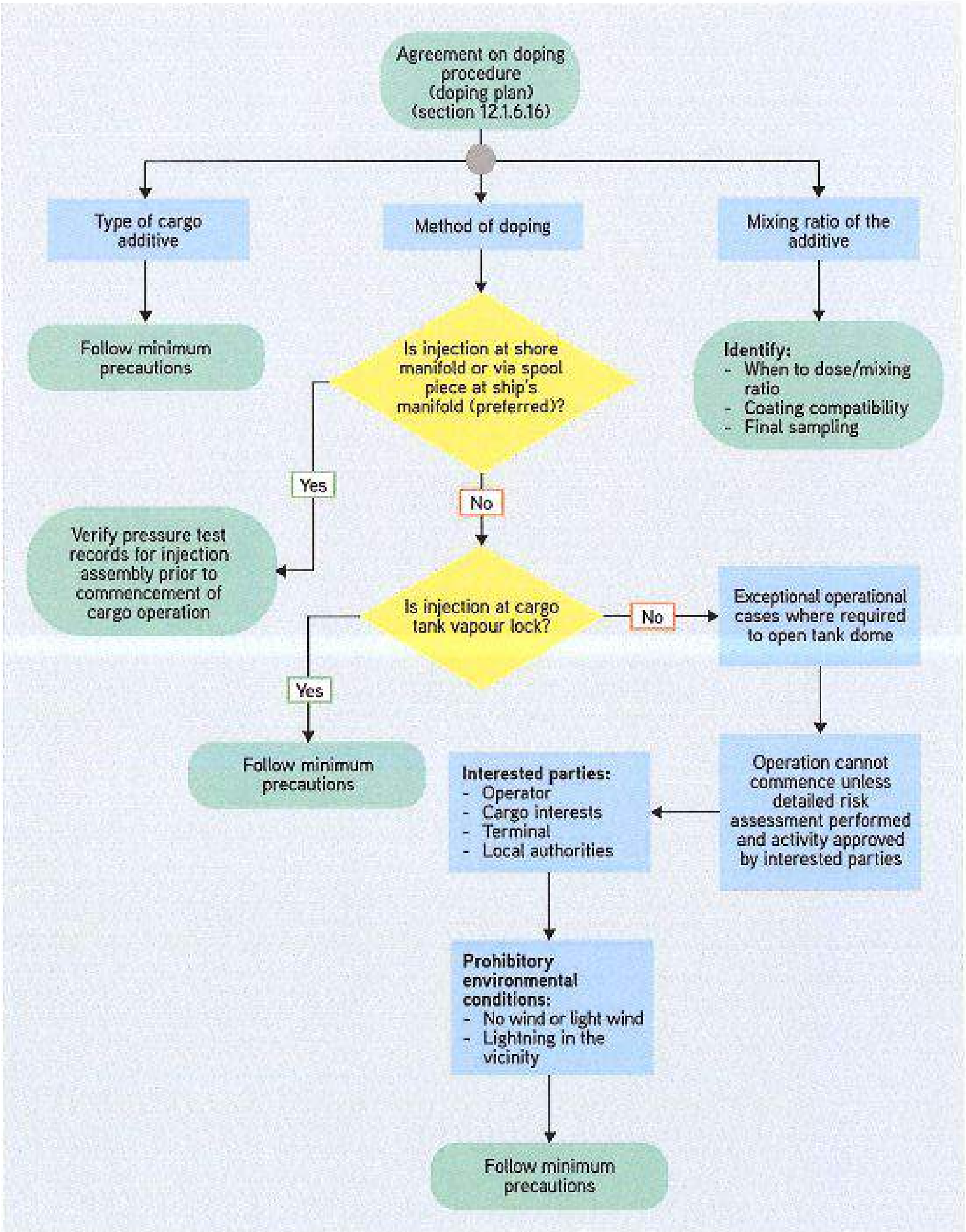


Figure 12.1: Cargo doping flowchart

The doping plan should be discussed by all personnel involved on the ship and in the terminal. As a minimum, the plan should include the method of doping, PPE to be used and the contingency measures.

The SDS for any additives should be reviewed as part of the risk assessment process regarding hazard identification and risk mitigation measures. A copy of the SDS should be kept in the vicinity of the doping operation.

If additives are to be stowed on board, they should be well secured; see section 13.5 for further guidance.

12.1.6.17 Checks after loading

After loading is completed, a Responsible Officer should confirm that all the required valves are closed and P/V valves are set correctly.

12.1.7 Loading static accumulator oils

12.1.7.1 General

Petroleum distillates often have electrical conductivities of less than 50 picoSiemens per metre (pS/m) and so fall into the category of static accumulators.

Since the conductivities of distillates are not normally known and may not be included in an SDS or other common documents, they should all be treated as static accumulators unless they contain an anti-static additive that raises the conductivity above 50pS/m (for cautions on the effectiveness of anti-static additives, see section 12.1.7.9). A static accumulator may carry enough charge to be an incendive ignition hazard during loading and for up to 30 minutes after loading.

Bonding (see section 3.2.2) is an essential precaution for preventing electrostatic charge accumulation. Its importance cannot be overemphasised. However, while bonding helps relaxation it does not prevent accumulation and the production of hazardous voltages so it is not a universal remedy for eliminating electrostatic hazards. This section describes ways to control electrostatic generation by preventing charge separation, which is another essential precaution (see section 3.1.2).

12.1.7.2 Controlling electrostatic generation

Failure to follow the guidance in this section will lead to the hazardous conditions that can cause electrostatic ignition accidents.

Electrostatic discharge has long been known as a hazard associated with handling petroleum products.

If a flammable atmosphere is possible within the tank, specific precautions are required for maximum flow rates, safe ullaging, sampling and gauging when handling static accumulator products.

Mixtures of oil and water are a potent source of static electricity. Take extra care to prevent excess water and unnecessary mixing.

When a tank is verified as inert, no anti-static precautions are necessary.

12.1.7.3 During the initial filling of a tank

The generally accepted way to control electrostatic generation in the initial stages of loading is to restrict the velocity of oil entering the tank to one metre per second (m/sec) until the tank inlet and any other structure on the base of the tank has been submerged to twice the diameter of the filling pipe. This will stop all splashing and surface turbulence in the tank (see section 3.2.1).

The 1m/sec limit applies in the branch line to each individual cargo tank. It should be determined at the smallest cross-sectional area, including valves or other piping restrictions in the final section before the tank's loading inlet.

Minimum diameter of piping* (mm)	Approx. flow rate (m^3/hr)
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

** The diameters given are nominal diameters, which are not necessarily the same as the actual internal diameters.*

Table 12.1: Rates corresponding to 1m/sec

Table 12.1 shows the approximate volumetric flow rates that correspond to a linear velocity of 1m/sec in piping of various diameters.

The reasons for the low linear velocity at 1m/sec are:

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 are a 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 12.2 is a flowchart to help identify the precautions needed when loading static accumulator cargoes.

12.1.7.4 Minimising hazards from water

Mixtures of oil and water are a potent source of static electricity, so 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. Water should not be allowed 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 12.1.14.2).

Any water remaining in the shore or ship pipeline system after the initial filling 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 1m/sec). The resulting mixing and agitating of 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 necessary to ensure that, as far as practicable, all excess water lying in low spots in the pipelines has been flushed out of the system either before loading started or during the initial filling of the tank (for more on this process, see section 12.1.7.3).

Under normal circumstances, and provided the above precautions to prevent excess water have been taken, the amount of water still present in the system after the initial filling will not be enough to increase static generation when the loading rate is increased. However, if there is reason to believe excess water may still be in the shore pipeline the recommended action is to either:

- Keep the product velocity in the shore pipeline below 1m/sec throughout loading to avoid flushing the water into the ship's tank(s).
- Keep the product velocity at the tank inlet(s) below 1m/sec throughout loading to avoid turbulence in the tank(s).

Whichever option gives the higher loading rate consistent with safety should be used.

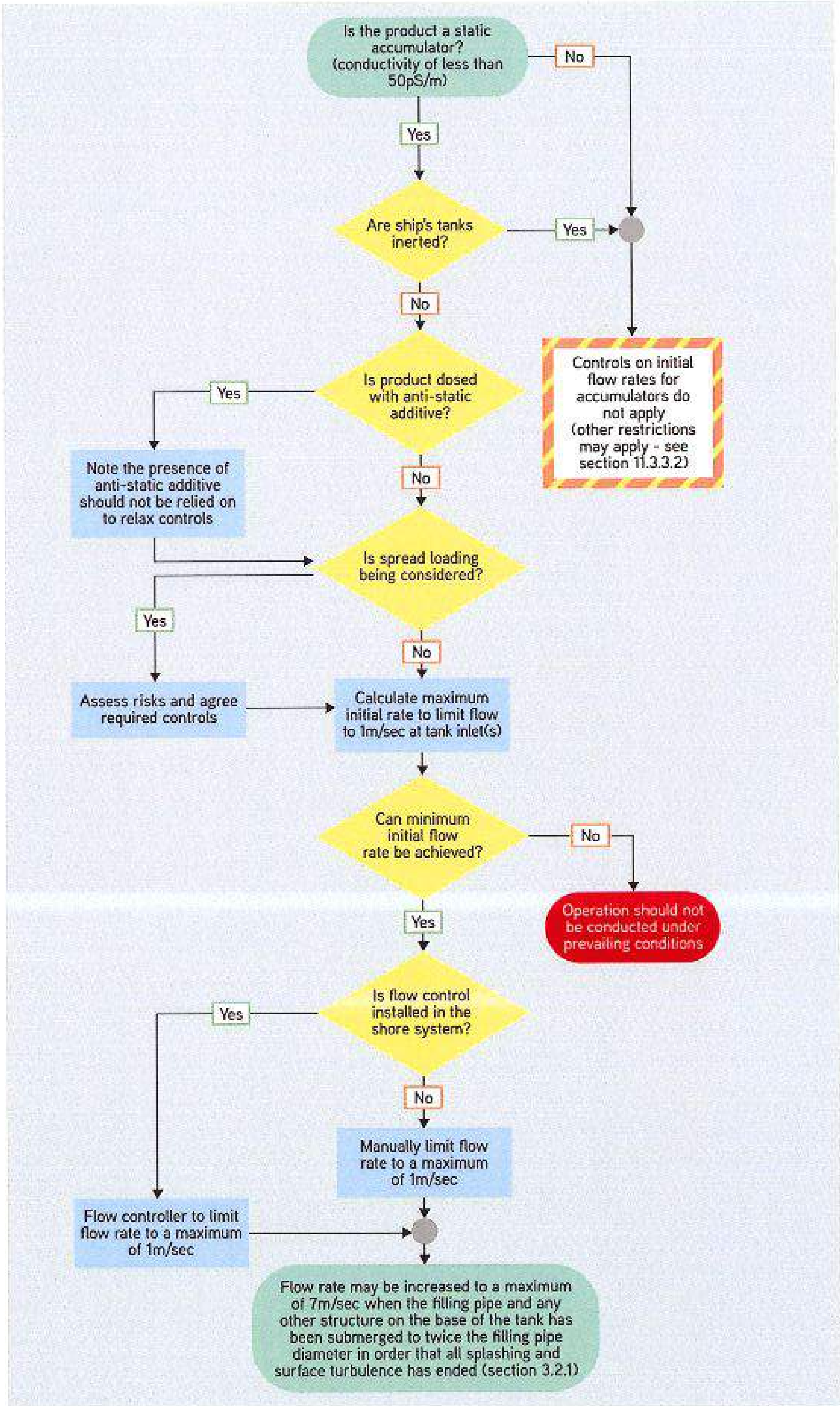
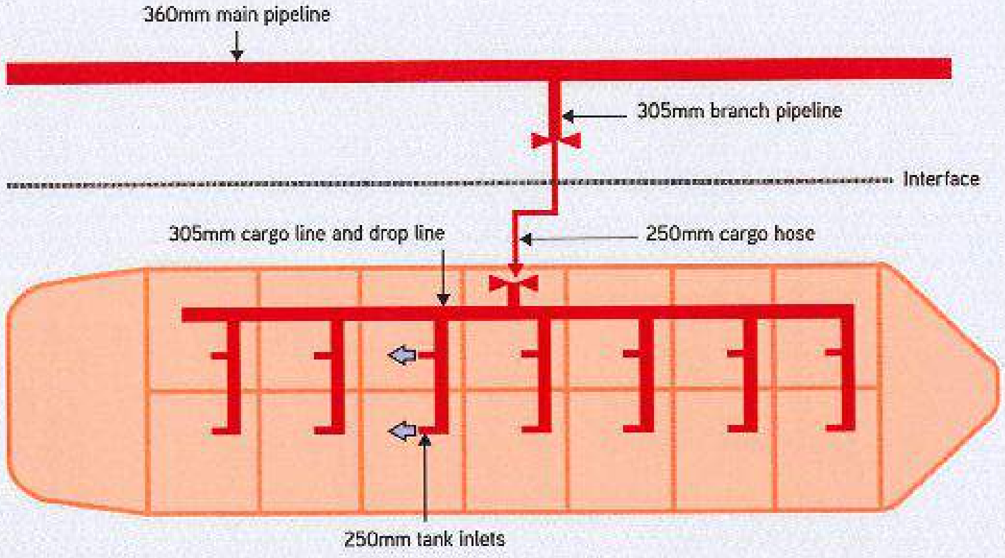


Figure 12.2: The control hazards associated with the initial loading of static accumulator cargoes flowchart

12.1.7.5 Examples

Initial loading phase

Figure 12.3 shows the pipeline arrangements for a ship loading a static accumulator product at a berth. The table defines the pipeline sizes and the volumetric flow rates at a velocity of 1m/sec. For initial loading to two cargo tanks in the example, the limitation will allow a loading rate of 366m^3/hr.



Determining the initial loading rate

Line	Diameter, mm	Flow rate (m^3/hr) at 1m/sec flow
Main shore pipeline	360	320
Shore branch line	305	262
Cargo hose	250	183
Ship's cargo and drop line	305	262
Tank inlets	250	183 x 2 = 366

Controlling parameter: velocity of product entering the tank

Therefore, an initial loading rate of not more than 366m^3/hr should be requested for loading to two tanks simultaneously. This will result in the shore line flowing at more than 1m/sec which would clear any water lying in the line while the velocity at the tank inlets is 1m/sec.

Figure 12.3: Initial loading to two cargo tanks

12.1.7.6 Practical considerations

In practice, not all terminals have flow control devices to regulate the loading rate, so they may not be able to set a loading rate to one cargo tank equivalent to 1m/sec. Some terminals achieve, or try to achieve, a low loading rate by starting to load by gravity flow alone.

12.1.7.7 Spread loading

Spread loading is the practice of mitigating a terminal's lack of flow control by starting to load via a single shore pipeline to several of the ship's cargo tanks simultaneously. The aim is a loading rate that will give a maximum velocity of 1m/sec at each of the tank inlets.

Spread loading can present significant static generation risks that should be assessed and properly managed if the 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 receiving product. This eductor effect creates a two phase mixture of product and vapour that results in increased turbulence and mist formation in the tank.
- There is a possibility of more than 1m/sec 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 chosen to ensure a maximum product velocity of 1m/sec into any one tank, assuming an 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 tanks.
- Not more than four cargo tanks should be loaded during spread loading. Referencing figure 12.3, if the shore line were increased in size to 510mm diameter and it was suspected that water is in the line, the ship would need to load four tanks simultaneously to ensure that the water content could be safely removed and so an initial loading rate of $676m^3/hr$ should be requested. This will allow the water to be cleared from the shore line while keeping the velocity at the tank inlets below 1m/sec.
- Tank inlet valves should not be used to control cargo flow during the initial loading phase. They will reduce the cross-sectional area of the inlet, resulting in a higher tank inlet velocity and so more turbulence and mist formation. If valves have to be throttled to control flow rate, this should be done upstream of the tank valves.

Managing the risks inherent in spread loading requires a risk assessment. This should consider:

- Terminal's piping configuration, including flow control capability.
- Ship's piping configuration.
- Ship's cargo tank condition, e.g. previous cargo, tank atmosphere or physical condition, e.g. the integrity of heating coils.
- Product to be loaded and the potential for generating a flammable atmosphere.

Spread loading should only be done 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.

12.1.7.8 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 turbulence at the tank bottoms, are suppressed by the rising liquid level and concern switches to ensuring that excessive charge does not accumulate on the bulk liquid. This is also done by controlling the flow rate, although the maximum acceptable velocity is now higher 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 flow rate limitations throughout loading (see section 12.1.7.4).

When the tank bottom is covered, after all splashing and surface turbulence has stopped and all water has been cleared from the line, the rate can be increased to the lesser of the ship or shore pipeline and pumping system maximum flow rates consistent with proper control of the system. Established practice and experience indicates that hazards do not occur if the product velocity is less than 7m/sec. Some national codes of practice also suggest 7m/sec as a maximum value. However, some industry documents acknowledge that 7m/sec is a precautionary limit and imply that higher speeds may be safe without specifying what the real limits are (all the evidence for safe loading has come from experiments limited to a maximum flow of 7m/sec).

Higher velocities can replace the 7m/sec limit only when well documented evidence shows they can be safely used.

Operators should be aware that the maximum velocity might not occur at the minimum diameter of a pipeline that 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 150mm diameter pipeline feeds three 100mm branch lines, the highest velocity will be in the 150mm pipeline and not the branch lines.

Figure 12.3 shows that the smallest diameter section of piping in the system is the cargo hose, with a diameter of 250mm. If a loading velocity of 7m/sec is acceptable to the ship and shore, a maximum loading rate of 1,281m^3/hr should be requested.

12.1.7.9 Anti-static additives

If the oil contains an effective anti-static additive, it is no longer a static accumulator. While this suggests the precautions applicable to a static accumulator can be relaxed, it is still advisable to observe them. The effectiveness of anti-static additives depends on how long since the additive was introduced to the product, proper mixing, other contamination and the ambient temperature. It can never be certain that the product's conductivity is above 50pS/m unless it is continuously measured.

12.1.7.10 Loading 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 case, reduce charge generation by avoiding splash loading and other generating mechanisms such as filters in the pipeline. The flow rate should be restricted during initial and bulk loading, as in sections 12.1.7.3 and 12.1.7.8.

Product specification and quality requirements normally mean that switch loading does not occur on tankers handling finished products. However, it may occur when handling cargo slops or off-grade product that require no tank preparation, as the grades can be mixed without risk of contamination. In this case, use the precautions outlined above for switch loading.

12.1.8 Loading very high vapour pressure cargoes

Cargoes with high vapour pressure (see section 2.2.2) introduce problems of cargo loss from excessive vapour release. They can also gas-up cargo pumps, causing discharge difficulties. Special precautions may be necessary, e.g.:

- Permitting only closed loading (see section 12.1.6.6).
- Avoiding loading when the wind speed is less than five 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 pipelines exposed to the sun. If unavoidable, this oil should be loaded to tanks that vent well clear of the superstructure, e.g. forward tanks.
- Providing extra supervision to monitor gas dispersion and to ensure compliance with all safety requirements.
- Monitoring IG main pressure where this indicates the cargo tank pressure. A maximum pressure of around 1,000mm WG should be used and the loading rate adjusted accordingly.

To prevent gassing-up of cargo pumps, the expected TVP of the cargo at the discharge port should, under normal circumstances, not exceed 0.7 bar either for crude oil or products. A TVP of up to 0.8 bar may be considered if the ship is fitted with an IG system, or if some other acceptable method of pressurisation is to be used during discharge.

12.1.9 Loading cargoes containing hydrogen sulphide

12.1.9.1 General

Increasing numbers of cargoes contain significant and increasing quantities of H_2S. Guidance on H_2S toxicity is in section 1.4.6 and guidelines on gas measurement and gas testing are in section 2.4.

This section gives practical guidance on operational measures to minimise the risks associated with loading cargoes containing H_2S, commonly known as sour cargoes.

12.1.9.2 Precautions when loading cargoes containing hydrogen sulphide

Consider the following precautions when preparing to load cargoes containing H_2S:

- Before arriving at the loading port, ensure the cargo system is free of leaks from the cargo piping, tank fittings and the venting system.
- Test the heating coils to prevent any transfer of H_2S to the low pressure steam system.
- Check any liquid filled P/V breakers to ensure they are correctly filled.
- Check that all doors and ports can be securely closed to stop the ingress of H_2S vapour into the accommodation.

When loading a cargo containing H_2S:

- Produce a safety plan for the loading operation. It should include guidance on the venting procedure, vapour monitoring, PPE to be used, ventilation for accommodation and the engine room and any emergency measures.
- Use the closed loading procedures described in section 12.1.6.6.
- Avoid venting to the atmosphere at a relatively low tank pressure, particularly in calm wind conditions.
- Stop cargo loading if there is no wind to disperse the vapours or the wind direction takes vapours towards the accommodation.
- Allow only personnel actively engaged in ship security and cargo handling on open decks. Regular maintenance on deck should be limited or postponed until cargo operations have finished. Visitors should be escorted to and from the accommodation spaces and briefed on the hazards of the cargo and the emergency procedures.
- H_2S is highly corrosive, so mechanical gauges are more likely to fail than is usual. Check their condition frequently. If a gauge fails, do not repair it unless an appropriate permit has been issued and all necessary precautions observed.
- H_2S is heavier than air, so in STS transfers and at terminals where there is a significant difference in freeboard, vapour may not be dispersed freely. Keep vent velocities high on the receiving ship and, if possible, turn the ships to allow the wind to carry vapour away from the accommodation.

12.1.10 Benzene and mercury

12.1.10.1 Cargoes containing benzene

Guidance on benzene toxicity is in section 1.4.5. Cargoes containing benzene should be loaded using the closed operation procedures in section 12.1.6.6 as this will significantly reduce any exposure to benzene vapour. Where a VECS is available ashore, it should be used (see section 23.7.7).

Operators should have procedures to verify the effectiveness of the closed loading system in reducing the concentrations of benzene vapours around the working deck. This will involve checks to determine the potential for exposing personnel to benzene vapour during operations such as loading, discharging, sampling, hose handling, tank cleaning, gas freeing and gauging. Similar checks should check vapour concentrations when cleaning, venting or ballasting tanks that previously held a cargo containing benzene.

The ship's crew should use detector tubes and pumps, toxic analysers or an electronic detector tube to check if vapour concentrations are remaining within OEL-TWAs and whether they should require additional PPE.

These precautions should also be followed to minimise exposure when measuring and sampling cargoes containing benzene.

12.1.10.2 Cargoes containing mercury

Some crude oils and condensates contain high levels of mercury. It may be found either in suspension in cargoes or settled at the bottom. It may also be in the vapour space. It can bond with bulkheads, pipelines, pumps and uncoated structures. Mercury is a health hazard if the body repeatedly absorbs it over a period of time (chronic exposure) via inhalation, absorption or ingestion, or following sudden exposure to high concentrations (acute exposure).

The operator's SMS should contain robust procedures to protect personnel against exposure to mercury. When carrying cargoes containing mercury, take a risk-based approach. As a minimum, the precautions to include are hazard awareness, personnel control, exposure control, vapour control and PPE. Personnel working where mercury might be present should be fully trained in safe practices and provided with appropriate PPE.

Mercury is not soluble in water, so any bound to steel surfaces cannot be easily removed by COW or water washing. Attempts to dilute mercury levels in the tank by carrying subsequent low mercury cargoes is also ineffective.

Any work in contaminated tanks should be carefully risk assessed and exposure minimised. The volume of in-tank waste/residues should be minimised by COW cycles for at least two voyages.

OCIMF's *Safety, Health, Environmental Issues and Recommendations for Shipboard Handling of Elevated Mercury Crude Cargoes* contains guidance on impacts, monitoring, training, cargo operations, contaminated residue handling, repairs and medical surveillance.

12.1.11 Loading heated products/cold oil cargoes

12.1.11.1 Loading heated products

Unless the ship is specially designed to carry very hot cargoes, such as bitumen, high temperature cargoes can damage a tanker's structure, the cargo tank coatings and equipment such as valves, pumps and gaskets.

Some Classification Societies have rules on the maximum loading temperature for cargoes. Masters should consult the ship operator whenever the temperature of the cargo is more than 60°C.

Precautions that may help to ease the effects of a hot cargo are:

- Spreading the cargo throughout the ship as evenly as possible to dissipate the heat and avoid local heat stress.
- Ensuring that tanks and pipelines are completely free of water before receiving any cargo with a temperature above the boiling point of water.

12.1.11.2 Loading cold oil cargoes

Loading cargoes with a temperature below that allowed by Class rules for the grades of steel used on the ship is a violation of Class that could lead to insurance coverage being withdrawn.

Cold climate oil and gas production continues to increase, along with the expansion and use of cold climate ports and sea routes. Oil tankers typically use grade A steel and it is generally assumed the cargo temperature will be above zero degrees Celsius. Steel becomes brittle at low temperatures, so structures can fracture or shatter when loaded to stress levels that would cause no concern at normal temperatures. A brittle fracture is generally characterised by little or no deformity of the metal around the fracture.

Loading cold cargoes introduces the risk of a brittle fracture to the steel structure and cargo piping. By their nature, brittle fractures occur suddenly and without warning. They may appear as soon as cold cargoes are loaded, resulting in spills from either the tanks or pipework.

Ship operators and Masters should consider the structural hazards and restrictions of carrying cold oil cargoes. In drawing up a safe operating plan they should consult experts, the Classification Society and insurers. Based on this guidance and endorsement, a procedure for sub-zero cargoes should be developed. The areas this covers should include:

- Suitability of tank coatings.
- Cargo tank venting system.
- Cargo valves.
- Cargo pumping system.
- Cargo stripping system.
- IG system.
- Gauging system.
- Cargo tank alarm systems.
- Ballast piping.
- Ballast venting system.

12.1.12 Loading over the top (or loading overall)

Loading over the top should not be done unless supported by a full risk assessment.

Volatile petroleum or non-volatile petroleum with a temperature higher than its flashpoint minus 10°C should never be loaded over the top into a non-gas free tank (see chapter 1).

Ballast or slops should not be loaded or transferred over the top into a tank that contains a flammable gas mixture.

12.1.13 Discharging procedures

12.1.13.1 Joint agreement on readiness to discharge

Before starting to discharge cargo, the Responsible Officer and Terminal Representative should formally agree that the tanker and the terminal are both ready to do so safely.

12.1.13.2 Operating pumps and valves

Throughout pumping operations, make no abrupt changes in the rate of flow.

During discharge the ship should control the flow of cargo in line with the agreement with the terminal. The discharge rate should not be substantially changed without informing the terminal.

Centrifugal pumps should be operated at speeds that do not cause cavitation, which can damage the pump and other equipment on the ship or at the terminal.

Reciprocating cargo pumps can set up excessive vibration in loading/discharging arms, which, in turn, can cause leaks in couplers and swivel joints and even mechanical damage to the support structure. If possible, do not use such pumps. If they are used, take care to select the least critical pump speed. If more than one pump is used, choose a combination of pump speeds that give an acceptable level of vibration. Keep a close watch on the vibration level throughout the cargo discharge.

12.1.13.3 Closed discharging

Ships that correctly use their IG systems are considered to be conducting closed discharging.

When non-inerted ships are discharging, gauging and sampling, all ullage, sounding and sighting ports should be closed. Air should be admitted to the tanks only by the approved venting system.

If the venting system cannot cope with the discharge rate, the rate should be reduced to match the capacity of the venting system and going below the 100mm WG in the tanks should be avoided.

12.1.13.4 Inert Gas procedures

An IG system must be fully operational and, while discharging, produce IG with an oxygen content of not more than 5%. For more on the operation of an IG system, see section 11.1.

Cargo discharge should not start until:

- All relevant cargo tanks, including slop tanks, are common with the IG main.
- All other cargo tank openings, including vent valves, are securely closed.
- The IG main is isolated from the atmosphere and from the cargo main if a cross-connection is fitted.
- The IG plant is operating.
- The deck isolation valve is open.

A low but positive IG pressure after discharging will allow the manifold drip tray to be drained into a tank. The IG pressure in the tanks should not be less than the safety settings on any associated pumping arrangements.

12.1.13.5 Failure of the Inert Gas system during cargo discharge

If the IG plant breaks down during discharge, suspend operations. If air has entered the tank, do not introduce any dipping, ullaging, sampling or other equipment into the tank until at least 30 minutes after the injection of IG has stopped. After this, equipment can be introduced provided that all metallic components are securely earthed. This earthing is necessary for up to five hours after the IG injection stopped.

When a tank is re-inerted following a failure or repair to the IG system, or when a non-gas free tank is initially inerted, do not insert dipping, ullaging, sampling or other equipment until the tank is inert. Check this by monitoring the gas vented from the tank. If it is necessary to insert a gas sampling system into the tank to establish its condition, leave at least 30 minutes after stopping the IG injection. Any metallic components of the sampling system should be electrically continuous and securely earthed (see section 11.1.11 for IG failure).

12.1.13.6 Crude Oil Washing

If some or all of the ship's tanks need a crude oil wash during discharge, the Responsible Officer should add a COW plan to the discharge plan set out in section 21.6.

A full description of the requirements for COW is in section 12.5.

12.1.13.7 Starting discharge alongside a terminal

The ship should be informed when the shore tanks are higher than the ship's manifold and whether NRVs are fitted.

Before the ship's manifold valves are opened, shore valves should be fully open to receiving tanks.

The tanker's manifold valves should not be opened until the pumps have developed enough pressure to prevent backflow.

Start the discharge at a slow rate and only increase it to the agreed rate once both parties are satisfied that the flow of oil to and from the designated tanks is confirmed.

12.1.13.8 Starting discharge at an offshore terminal

Before discharge starts at an offshore terminal, communications between ship and shore should be fully tested. The ship should 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 should start slowly until the system has been tested and then gradually brought up to the maximum agreed flow rate or pressure. Keep a close watch on the sea around the hoses for any leaks. During darkness, and if safe and practical, light up the water around the hoses (see OCIMF's *Single Point Mooring Maintenance and Operations Guide, Guidelines for the Design, Operation and Maintenance of Multi Buoy Moorings* and *Guide for Offshore Tanker Operations*).

12.1.13.9 Starting discharge through a stern line

Before discharge starts through a stern line, a dangerous area that extends for at least three metres from the manifold valve should be clearly marked. No unauthorised personnel should be allowed in this area during the discharge operation.

Maintain a close watch for any leaks. All openings, air inlets and doors to enclosed spaces should be kept tightly closed.

Firefighting equipment should be laid out and ready for use near the stern manifold:

- The cargo hose connection should be carefully inspected for correct alignment and secure coupling. Where possible, a water pressure test of the coupling seals should be made.
- If fitted, any ERSs for the mooring and cargo connection should be operational. Test these before mooring.
- All primary and secondary communication links with the loading terminal should be tested, including any telemetry control system.
- Smoking and naked light requirements should be strictly enforced.

A responsible crew member should maintain a continuous watch by the stern throughout discharge. During darkness, the lighting on and around the ship's stern should allow an effective visual watch to be maintained on the mooring point, mooring system, cargo hose connection, loading hoses and the water around the stern.

12.1.13.10 Periodic checks during discharge

Throughout discharging, monitor and regularly check all full and empty tanks to confirm that cargo is only leaving the designated cargo tanks and is not escaping into pumprooms, cofferdams or through sea and overboard discharge valves.

Check tank ullages at least hourly and calculate a discharge rate. Compare cargo figures and rates with shore figures to identify any discrepancy. If possible, these checks should include observations and recordings of the shear forces, bending moments, draught and trim and any other relevant stability requirements specific to the ship. Check this information against the required discharging plan to see that all safe limits are met and that the discharging sequence can be followed or amended as necessary. Immediately report any discrepancies to the Responsible Officer.

Any pressure drops or 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.

Frequently inspect the cargo deck and pumproom for any leaks. Overside areas should also be checked regularly. During darkness, if safe and practical, illuminate the water around the ship.

12.1.13.11 Stripping and draining cargo tanks

When the main bulk of cargo is being discharged and a slop tank or other selected tank is receiving drainings from tanks being stripped, personnel should be alert to the fact that the ullage in the receiving tank will be decreasing. Take great care to avoid an overflow and ensure proper precautions are in place in case any vapours are emitted.

Air or gas bubbles in a liquid can generate static electricity so, as far as possible, stripping pumps and eductors should be operated to avoid trapping air or gas in the liquid stream.

12.1.14 Pipeline and hose clearing after cargo operations

12.1.14.1 General

The procedure for clearing the pipelines and hoses or arms between the shore valve and ship's manifold depends 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 be a factor.

12.1.14.2 Line displacement with water

On ships with a segregated ballast system, avoid the practice of using cargo pumps on a sea suction. However, at the end of cargo operations, some terminals require ships to displace the contents of the hoses or MLAs, and perhaps the shore pipelines, with water. This practice risks pollution, so it should be done only if essential and should be carefully planned and executed. Before starting the displacement the ship and terminal should agree the procedures to be used, particularly the amount to be pumped and the pumping rate.

Pay particular attention to venting the cargo pumps and ensuring there is no outflow of oil when opening the sea valve.

Refer to OCIMF/ICS' *Prevention of Oil Spillages through Cargo Pumproom Sea Valves.*

12.1.14.3 Line draining

When loading is completed, the ship's cargo deck lines should be drained into appropriate cargo tanks to ensure that thermal expansion in the lines cannot cause leaks or distortion. The hoses or MLAs and sometimes part of the pipeline system between the shore valve and the ship's manifold, are also usually drained into the ship's tanks. Enough ullage space should be left in the final tanks to accept the cargo drained in this way.

When discharging is complete, the ship's cargo deck lines should be drained into an appropriate tank and then the contents will be discharged ashore or into a slop tank.

When draining is complete, and before hoses or MLAs are disconnected, the ship's manifold valves and shore valves should be closed. The drain valves at the ship's manifold should then be opened to drain into fixed drain tanks or portable drip trays. Draining any product from the MLAs or hoses into open drip trays should be avoided. Cargo manifolds and MLAs 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 container.

12.1.14.4 Clearing hoses and Marine Loading Arms to the terminal

If hoses or MLAs have to be cleared to the terminal using compressed air or IG, follow these strict precautions to avoid creating a hazardous static electrical charge or mechanical damage to tanks and equipment:

- The procedure should be agreed between tanker and terminal.
- There should be adequate ullage in the reception tank.
- To keep the amount of compressed air or IG to a minimum, the operation should stop when the line has been cleared.
- The inlet to the receiving tank should be well above any water in the bottom of the tank.
- The line clearing operation should be continuously supervised by a Responsible Officer.

12.1.14.5 Clearing hoses and Marine Loading Arms to the ship

Do not clear hoses and loading arms to the ship using compressed air because of the risks of:

- Static charge generation.
- Compromising IG quality.
- Over pressurisation of tanks or pipelines.
- Oil mists coming from tank vents.

12.1.14.6 Clearing ship's cargo pipelines

When compressed air or IG is used to clear the ship's pipelines, the hazards are similar to those above and the same precautions should be taken. Line clearing operations should be done in accordance with the specific operating procedures for the ship.

12.1.14.7 Gas release in the bottom of tanks

A pumproom contains the largest concentration of cargo pipelines in the ship. Leaks of a volatile product from any part of this system could quickly generate a flammable or toxic atmosphere. The pumproom may also contain a number of potential ignition sources. To control them, structured maintenance, inspection and monitoring procedures should be strictly followed.

Blowing air or IG into the bottom of a tank containing a static accumulator oil can generate a strong electrostatic field. If the cargo contains water or particulate matter, the effect is worse. The rising gas bubbles will disturb the particulates and water droplets and the settling contaminants will generate a static charge within the cargo. Allow a settling period of at least 30 minutes after blowing any lines to a non-inerted tank or a tank that could contain a flammable atmosphere.

Precautions should be taken to minimise the amount of air or IG entering tanks containing static accumulator oils and it is best to avoid the practice of blowing lines back to tanks containing such cargo.

Cargo lines should be drained by gravity whenever possible.

12.1.14.8 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 that 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 personnel entering the area can lose consciousness due to asphyxiation. 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 (see chapter 10).

If shore supplied nitrogen is used, e.g. to purge tanks, for padding cargo or to clear lines, be aware that this may be at HP (up to ten bar) and at a high flow rate, making it potentially hazardous because of the risk of over pressurising the cargo tanks. Carry out a risk assessment: the operation should only proceed if appropriate risk mitigations are in place. As a minimum, follow the precautions for over pressurisation in section 11.2.2.

One way to reduce the risk is to ensure the tank has vents with a greater flow rate capacity than the inlet, so the tank cannot be over pressurised. If vapour control and emission regulations require closed operation, the incoming flow of nitrogen should be restricted to a rate equal to or less than the maximum flow of vapour possible through the VRL. Measures to ensure this should be agreed. A small hose or reducer before the manifold can be used to restrict the flow rate, but the terminal should control the pressure. A gauge will allow the ship to monitor the pressure.

Attempting to throttle a gas flow with a ship's manifold valve designed to control liquid flow is inappropriate. However, the manifold may be used as a rapid safety stop in an emergency. Note that the effect of a pressure surge in a gas is not as violent as in a liquid.

Sensitive cargoes, e.g. highly specialised lubricating oils, may have to be carried under a pad or blanket of nitrogen supplied from the shore. In this case, it is better to purge the entire cargo tank before loading. After purging, loading the cargo in a closed condition will create the pad within the tank. This significantly reduces the risk of over pressurisation when padding with shore supplied nitrogen.

12.1.15 Pumproom operational precautions

12.1.15.1 General precautions

Before starting any cargo operation:

- An inspection should 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 regularly for leaks 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 should be checked for overheating. In the event of leakage or overheating the pump should be stopped.
- Make no attempt to adjust the pump glands on rotating shafts while the pump is in service.

12.1.15.2 Cargo and ballast line draining procedures

On some ships, no provision is made for effective line draining where the practice is to drain final line contents to the pumproom bilge. It is an unsafe practice and volatile product should not be drained to the bilge.

Consider 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.

After de-ballasting, if lines used for ballast have to be drained to the pumproom bilge, take care to ensure that the drainings do not contain cargo residues.

12.1.15.3 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 as soon as possible.

Pumproom bilges should be kept clean and dry. Particular care should be taken to prevent hydrocarbon liquids or vapour escaping into the pumproom.

Pipelines should be visually examined and routinely pressure tested to verify their condition. Other non-destructive testing or examination, such as ultrasonic wall thickness measurement, may be appropriate but should always be supplemented by a visual examination.

Procedures should be established to verify that mud boxes and filters are properly sealed after they have been opened for routine cleaning or examination.

Valve glands and drain cocks should be regularly inspected to ensure they do not leak.

Bulkhead penetrations should be routinely checked to ensure the seals are effective.

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. Include the requirements for examining them 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. Use of fire retardant materials should be considered for rescue harness and rope assembly.

Emergency escape routes should be regularly checked to ensure they are properly marked and clear of obstructions. Where an escape trunk is fitted, check doors for ease of operation. Door seals should be effective and lighting within the trunk should be operational.

12.1.15.4 Maintaining electrical equipment in the pumproom

Incorrect maintenance procedures may compromise the design integrity of explosion-proof or intrinsically safe electrical equipment. To ensure such equipment remains safe, even the simplest repair or maintenance task should be carried out in strict compliance with the manufacturer's instructions.

Only personnel qualified to undertake such work should carry out maintenance of explosion-proof and intrinsically safe equipment. This is especially vital with explosion-proof lights, where incorrectly closing them after changing a lamp could compromise their integrity.

To help routine servicing and repair, ships should have detailed maintenance instructions for the specific systems and arrangements fitted on board. The company's permit to work system should be followed, as applicable.

12.1.15.5 Inspecting and maintaining pumproom ventilation fans

Pumproom ventilation fans operate by drawing air out of the space. If a gas is in the pumproom and the blades of the fan impeller touch the casing, or the fan bearings or seals overheat, the vapours could ignite.

Pumproom extractor fans, including impellers, shafts and gas seals, should be inspected regularly.

Inspect the condition of the fan trunking and confirm that the changeover flaps and fire dampers are operating properly.

Consider routine vibration monitoring and analysis as an early way to detect component wear.

12.1.15.6 Testing of alarms and trips

If fitted, pump alarms and trips, level alarms, etc. should be tested regularly to ensure that they are functioning correctly. The results of these tests should be recorded.

These tests should be as thorough as possible to verify the complete operability of the system and should not be limited to an electrical function test of the alarm itself.

12.1.15.7 Miscellaneous

The safety of pumprooms can be enhanced in a number of other ways, some of which are mandatory for some tankers:

- A fixed gas detection system capable of continuously monitoring for hydrocarbon, oxygen and toxic gases that activate audible and visual alarms in the cargo control room, engine room and the navigating bridge. Where such equipment is fitted, procedures should be developed to ensure it is regularly inspected and calibrated. Procedures should also be developed for the action to take when an alarm is triggered, 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 monitor oxygen content within the pumproom from the deck by a portable meter before entering the pumproom. 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 to provide remote indication of the temperature of pump casings, bearings and bulkhead seals. Where such equipment is fitted, procedures should be developed for the action to take when an alarm is triggered.
- A high level alarm in pumproom bilges that activates audible and visual alarms in the cargo control room, engine room and the navigating bridge.
- Manually activated trips for the main cargo pumps at the lower pumproom level and at the top (main deck) level.
- Spray arresters around the glands of all rotary cargo pumps to reduce the formation of mists during minor leaks from the gland.
- Examining the feasibility of fitting a double seal arrangement to contain any leaks from the primary seal and to activate a remote alarm to indicate a leak. The impact of any retrofit on the integrity of the pump will need to be assessed in conjunction with the pump manufacturer.
- Particular attention to be given to the adequacy of fire protection in the immediate area of the cargo pumps.
- Given the problems associated with flashback re-ignition after using the primary firefighting medium, consider providing a backup system, such as high expansion foam or water drenching, to supplement the existing system.
- On ships fitted with an IG system, an emergency facility for inerting the pumproom could be an option, although careful attention should be paid to the safety and integrity of the arrangement.
- Providing the pumproom with readily accessible EEBDs.

12.2 Stability, stress, trim and sloshing considerations

12.2.1 General

Oil tankers usually have a high metacentric height in all conditions, so 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 seldom been a major concern. Masters and officers should account for free surface and sloshing effects during all stages of cargo and ballast operations. Double hull tankers, particularly those without centreline bulkheads in cargo tanks and/or having U-shaped ballast tanks, may face potential issues from large free surface effects influencing their stability.

12.2.2 Free surface effects

The main problem likely to be encountered is the effect on the Transverse Metacentric Height (GM) of liquid free surface in the cargo and double hull ballast tanks.

Depending on the design, type and number of these tanks, the free surface effect could significantly reduce the GM. The situation will be most severe in the case of a combination of wide cargo tanks with no centreline bulkhead and ballast tanks with no centreline bulkhead (U tanks).

The most critical stages of any operation will be while filling the double bottom ballast tanks during cargo discharge and emptying these tanks during cargo loading. If enough cargo tanks and ballast tanks are slack simultaneously, the overall free surface effect could reduce the GM to a point that threatens the transverse stability of the ship. This situation is further exacerbated, with large free surface areas especially likely to threaten stability at greater soundings, with an associated high vertical centre of gravity.

The combination of these factors could result in the ship suddenly developing a severe list or angle of loll and it is, therefore, imperative that tanker and terminal personnel involved in cargo and ballast operations are aware of this potential problem.

All cargo and ballast operations must be conducted strictly in line with the ship's stability booklet, approved by the administration, which provides information on any restrictions as well as standard operating conditions for developing acceptable loading, discharging and ballasting plans in accordance with applicable stability criteria. Additionally, the stability booklet must contain other necessary guidance for the safe operation of the ship under normal and emergency conditions. Where the information in the stability booklet identifies particular combinations of slack ballast and/or cargo tanks that could result in the development of stability issues that are outside of the ship's safe operating parameters, these should be clearly posted in the cargo control room along with guidance on action to be taken to mitigate any stability issues developing during non-standard or emergency situations.

12.2.3 Heavy weather ballast

Ship specific procedures should ensure that heavy weather ballast is taken in plenty of time for personal safety and that stability and hull shear forces and bending moments should be maintained within acceptable limits at all stages of the heavy weather ballast operation.

Masters and officers need to be aware that partially loading a cargo tank with heavy weather ballast may present a potential sloshing problem. The combination of free surface and the flat tank bottom can generate wave energy with enough power to severely damage the internal structure and pipelines.

The decision to take heavy weather ballast may also be guided by the need to mitigate the risk to the ship's machinery should the propeller clear the water and the engine overspeed when pitching.

12.2.4 Loading and discharge planning

Ballasting and de-ballasting should be planned and programmed around the cargo operations to avoid exceeding the specified draught, trim or list requirements, while at the same time keeping shear force, bending moments and metacentric height within prescribed limits.

12.2.5 Intact and damage stability

Complying with intact stability may not meet the damage stability criteria. This should be verified for the departure condition of the ship.

12.3 Tank cleaning

12.3.1 General

This section deals with procedures and safety precautions for cleaning cargo tanks after discharging petroleum products from cargo tanks. Guidance is also given on cleaning contaminated ballast spaces.

12.3.2 Tank washing risk management

All tank washing operations should be carefully planned and documented. The potential hazards of planned tank washing operations should be systematically identified and risk assessed. Appropriate preventive measures should be put in place to reduce the risk to ALARP.

In planning tank washing operations, the prime risk is a fire or explosion caused by a simultaneous flammable atmosphere and source of ignition. The focus should be on eliminating one or more of the hazards, namely the sides of the fire triangle of air/oxygen, ignition source and fuel, i.e. flammable vapours.

12.3.3 Supervision and preparation

Supervision

A Responsible Officer should supervise all tank washing operations.

Before starting the operation, all the crew involved should be fully briefed by the Responsible Officer on the tank washing plans and on their roles and responsibilities.

All other personnel on board should be notified that tank washing is about to begin. This should, in particular, be extended to those on board not involved directly in the tank washing operation but whose own concurrent tasks may affect its safety.

Preparation

Before and during tank washing operations, the Responsible Officer should be satisfied that all the relevant precautions set out in chapter 4 are being observed. If craft are alongside the tanker, their personnel should also be notified. They need to confirm their compliance with all appropriate safety measures. Before starting to tank wash alongside a terminal, the following additional measures should be taken:

- Observe the relevant precautions in chapter 23.
- Consult the appropriate personnel ashore to check that conditions on the jetty do not present a hazard and to get agreement that operations can start.

The method of tank washing used on board a tanker depends on how the atmospheres in the cargo tanks are managed and the equipment fitted to the ship.

12.3.4 Tank atmospheres

12.3.4.1 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 as non-flammable through the introduction of IG 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 11.1.5.1).

The lowest risk comes from washing the tank in an inert atmosphere. This is clear and causes no ambiguity. To be inert the tank must meet the SOLAS requirement for inerting cargo tanks and reducing the oxygen content of the atmosphere in each tank to a level that cannot support combustion.

If direct measurement fails to prove that the tank is inert, it should by default be considered non-inert.

The requirements for maintaining an inert atmosphere and the precautions to observe during washing are in section 11.1.6.9. These provide the most certain level of control of an atmosphere during tank washing.

In fire triangle terms, this method physically removes and controls the oxygen.

12.3.4.2 Non-inert

For this chapter, a non-inert atmosphere is where the oxygen content has not been confirmed as less than 8% by volume.

On ships with no access to IG, either on board from an IG plant or from the shore, only two sides of the fire triangle can be addressed – the fuel and the sources of ignition. In a non-inert condition there are no physical barriers that will ensure that either of these two hazards can be eliminated. Therefore, the safety of non-inert tank washing depends on the integrity of the equipment and implementation of strict procedures to ensure these two hazards are controlled.

Non-inert cargo tanks should only be washed when a combination of measures control the flammability of the tank atmosphere and sources of ignition.

To control tank atmospheres, tankers that operate in a non-inert condition should be designed and equipped to mechanically ventilate cargo tanks at the same time as tank washing.

Recognising that tank washing and gas freeing operations in non-inert atmospheres present an increased risk, extra control measures are required to reduce the risk to ALARP. These control measures should address two sides of the fire triangle, i.e. fuel and sources of ignition.

12.3.5 Tank washing

12.3.5.1 Washing in an inert atmosphere

Control measures for washing in inert atmospheres are in section 11.1.6.9.

During tank washing, verify that the atmosphere in the tank remains non-flammable (the oxygen content does not exceed 8% by volume) and is maintained at a positive pressure.

Cargo tanks can be purged during water washing to reduce the hydrocarbon content of the tank atmosphere.

12.3.5.2 Washing in a non-inert atmosphere

Non-inert cargo tank washing should only be done when both the source of ignition and the flammability of the tank atmosphere are controlled. To do this, the following precautions should be taken.

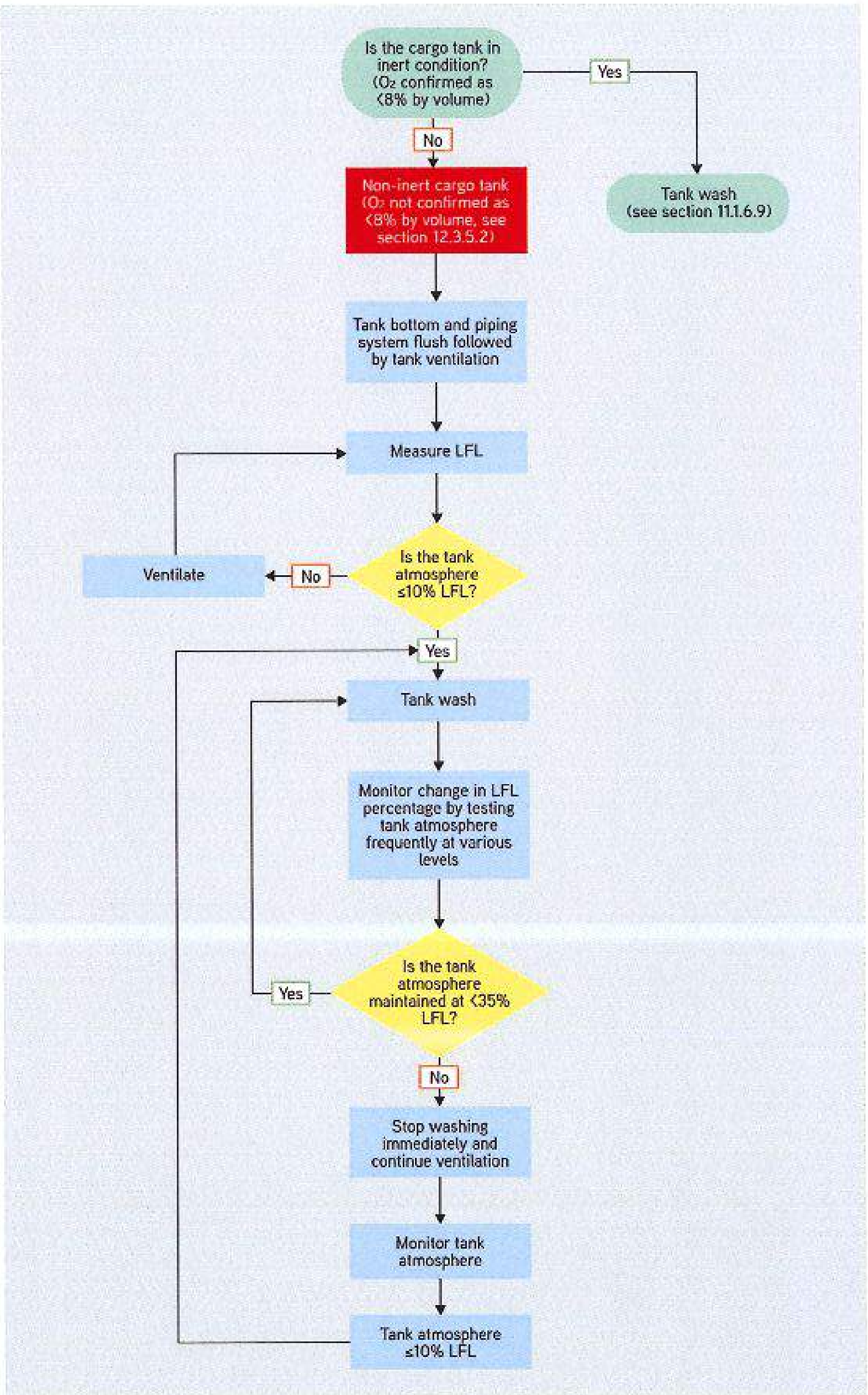


Figure 12.4: Steps to control the fuel (flammable vapours) while tank washing in a non-inert tank atmosphere flowchart

To control the fuel in the tank atmosphere (see figure 12.4)

Before washing:

- Flush the tank bottom with water, so that all parts are covered, then strip. To do the flush, use the main cargo pumps and lines. Alternatively, permanent pipework extending the full depth of the tank should be used. Do not use the tank washing machines.
- Flush the piping system with water (including cargo pumps, crossovers and discharge lines). Drain the flushing water to the tank designed or designated to receive slops.
- Ventilate the tank to reduce the gas concentration of the atmosphere to 10% or less of the LFL. Test for gas at various levels and be aware that pockets of flammable gas may exist, in particular near potential sources of ignition such as mechanical equipment that might generate hot spots, e.g. moving parts in submerged cargo pump impellers.
- Start washing only when the tank atmosphere reaches 10% or less of the LFL.

During washing:

- Monitor the change in LFL percentage by testing the atmosphere frequently and at various levels inside the tank.
- Consider suspending washing to take readings as water can affect the efficiency of gas measuring equipment.
- Provide a free flow of air from one end of the tank to the other, with continual mechanical ventilation whenever possible.
- Monitor the tank atmosphere more frequently if mechanical ventilation is not possible as the likelihood of rapid gas build-up is greater.
- Maintain the tank atmosphere at not more than 35% LFL. If the gas level reaches 35% at any measured location within a tank, immediately stop the washing in that tank.
- Only resume washing when continued ventilation has reduced the gas concentration to 10% or less of the LFL and is able to maintain it.
- Isolate any tank with a venting system that is common to other tanks to prevent gas leaking from other tanks.

To control the sources of ignition in the tank

- Restrict the throughput of individual tank washing machines to no greater than $60m^3/hr$.
- Keep the total water throughput per cargo tank as low as practicable. Do not let it exceed $180m^3/hr$.
- Different washing methods create different risks, so follow these precautions when tank washing in non-inert conditions:
  - Never use recirculated wash water.
  - Heated wash water may be used but stop if the gas concentration reaches 35% of the LFL. Use a hot wash for a low flashpoint product only after a full, i.e. top to bottom, cold wash cycle.
  - Increase the frequency of monitoring the gas concentration if the hot wash water temperature is above 60°C.
  - Only consider using chemical additives if the temperature of the wash water does not exceed 60°C.
  - Never inject steam into a tank that may contain hydrocarbon vapours and that is in a non-inert condition. Only consider injecting steam into a tank after it has been verified as being gas free (see section 3.1.2).
- Keep the tank drained during washing. Stop the washing to clear any build-up of wash water.
- Keep the discharge into the wash water reception/slop tank below the liquid level in that tank at all times.

- Make up and test the electrical continuity of all hose connections before introducing any portable washing machines to the tank. Do not introduce any portable washing machines until the LFL level is 10% or less.
- Do not break any connections before 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.
- Introduce sounding rods and other equipment into the tank using a full depth sounding pipe. If a full depth sounding pipe is not fitted, ensure that any metallic components of the sounding rod or other equipment are bonded and securely earthed to the ship before introducing them to the tank and that they remain earthed until removed.
- Observe this precaution during washing and for five hours afterwards to allow enough time for any mist carrying a static charge to dissipate. If the tank is continuously mechanically ventilated after washing, this can be reduced to one hour. During this time:
  - A metal interface detector can be used if earthed to the ship by a clamp or bolted metal connection.
  - A metal rod on the end of a metal tape can be used if earthed to the ship by a clamp or bolted metal connection.
  - Do not use a metal sounding rod suspended on a fibre rope, even if the end at deck level is fastened to the ship. The rope cannot be relied on to provide an earthing path.
  - Entirely non-metallic equipment may be used, e.g. a wooden sounding rod suspended on a natural fibre rope without earthing.
  - Do not use ropes made of synthetic polymers to lower equipment into cargo tanks.
- Take measures to guard against ignition from machinery defects, e.g. in-tank cargo pumps, tank washing machines, tank gauging equipment, etc.
- Take precautions to eliminate the risk of mechanical sparks from objects falling into the tanks, e.g. metallic objects, including hand tools, sounding rods and sample buckets, etc.
- Do not allow the use of non-intrinsically safe equipment, e.g. torches and inspection lamps, mobile phones, communications radios, handheld computers, etc.

12.3.6 Precautions for tank washing

12.3.6.1 Portable tank washing machines and hoses

The outer casing of portable machines should be made of a material that will not cause an incendive spark on contact with the internal structure of a cargo tank.

The coupling arrangement for the hose should give an effective bonding 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 a suitable connection or external bonding wire.

When suspended within a cargo tank, machines should be supported by a natural fibre rope and not by the water supply hose.

12.3.6.2 Portable hoses for 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 a way that ensures effective bonding.

Hoses should be indelibly marked for identification. A record should be kept showing the date and the result of electrical continuity testing.

12.3.6.3 Testing tank cleaning hoses

All hoses supplied for tank washing machines should be tested for electrical continuity in a dry condition before use. In no case should the resistance exceed six ohms per metre length.

12.3.6.4 Tank cleaning concurrently with cargo handling

As a general rule, tank cleaning and gas freeing should not run concurrently with cargo handling. If for any reason this is necessary, consult closely with both the Terminal Representative and/or the port authority and get their written agreement.

12.3.6.5 Free fall

It is essential to avoid the free fall of water or slops into a tank. The liquid level should always cover the discharge inlets in the slop tank to a depth of at least one metre to avoid splashing. This is not necessary when the slop and cargo tanks are fully inerted.

12.3.6.6 Spraying water

Spraying water into a tank containing a substantial quantity of static accumulator oil could generate static electricity at the liquid surface, either by agitation or water settling. Tanks that contain static accumulator oil should always be pumped out before they are washed with water, unless the tank is kept inert (see section 3.2.7).

12.3.6.7 Excluding cargo oil from the engine room

To prevent cargo oil from getting into the engine room, any part of the tank washing system that extends into the engine room should be blanked off as soon as tank cleaning operations have finished.

12.3.6.8 Special tank cleaning procedures

After carrying certain products, tanks can only be properly cleaned by steaming or adding tank cleaning chemicals to the wash water.

Steaming

The hazard of static electricity means that steam should not be introduced to cargo tanks if there is a risk of a flammable atmosphere. Bear in mind that a non-flammable atmosphere cannot be guaranteed in all cases where steaming might be thought useful.

Steaming can produce mist clouds that may be electrostatically charged. The effects and possible hazards are similar to those for the mists created by water washing, but levels of charging are much higher. The time to reach maximum charge levels is also much less. Although a tank may be almost free of hydrocarbon gas at the start of steaming, the heat and disturbance will often release gases, so 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. Before steaming, the concentration of flammable gas should not exceed 10% of the LFL. Precautions should be taken to avoid the build-up of steam pressure within the tank.

The static electricity precautions in chapter 3 should be strictly observed.

Using chemicals in wash water

Constraints on the use of chemicals in wash water will depend on the type of tank atmosphere (see section 12.3.5.2).

Certain tank cleaning chemicals may introduce a toxic or flammable hazard. Personnel should be made aware of the OEL of the product. Detector tubes are particularly useful for detecting the presence of specific gases and vapours in tanks. Tank cleaning chemicals that can produce a flammable atmosphere should only be used when the tank has been inerted.

Using chemicals for local cleaning

Some tank cleaning chemicals may be used to hand wipe tank bulkheads and blind spots, provided only a small amount is used and the personnel entering the tank observe all the requirements for entering an enclosed space.

Any manufacturer's instructions or recommendations for the use of these products should also be followed. If the ship is in port, local authorities may impose additional requirements.

An SDS for tank cleaning chemicals should be on board the ship before they are used. Its advice and precautions should be followed.

12.3.6.9 Leaded gasoline

Leaded gasoline is rarely used in most countries. It is, however, possible that gasoline containing tetraethyl lead (TEL) and tetramethyl lead (TML) could still be carried. When the ship's tanks alternate between different products, they present little risk. However, ships that regularly carry leaded gasoline should flush the bottom of the tanks with water after every cargo discharge.

12.3.6.10 Removing sludge, scale and sediment

Before removing sludge, scale and sediment by hand, the tank atmosphere is to be confirmed as safe for entry. Appropriate control measures are in place to protect the health and safety of personnel entering the space. The precautions in section 10.9 should be maintained throughout the work (see section 12.1.10.2 cargoes containing mercury).

Any equipment used for further tank cleaning, such as removing solid residues or products in tanks that have been gas freed, should be designed and constructed to introduce no risk of ignition.

12.3.6.11 Cleaning contaminated ballast spaces

If a cargo tank leaks into a ballast tank, both will need to be cleaned in order to comply with MARPOL and to carry out repairs.

This is a difficult task when the contamination is crude or black oils and especially difficult in a double hull or double bottom space.

As far as possible, and particularly during the initial stages, tank cleaning should be carried out by methods other than hand hosing. This may include using portable machines or detergents, or washing the bottom of the tank with water and detergent. Hand hosing should be permitted only for small areas of contamination or for final cleaning. Whichever method is used, the tank washings must always be handled in line with MARPOL regulations.

After a machine or detergent wash, prior to entry for final hand hosing, the tank should be ventilated in line with the procedures in section 12.4.7 until readings at each sampling point show that the atmosphere is safe for entry according to the criteria in chapter 10. Suitable control measures should be implemented to protect the health and safety of personnel entering the space.

If cleaning is to be done, the precautions in section 12.3.5.2 should be followed, including the monitoring of tank atmospheres.

12.3.7 Wash water analysis

Testing the wash water is a process that assesses the cleanliness of the cargo tank and cargo lines. It is an alternative to pre-loading inspection, with the benefit of reducing tank entry and unnecessary cleaning.

Wash water is continuously pumped out of the tanks while tank cleaning. Samples are collected at the manifold and analysed by UV spectrometer. A comparison between the wash water going into the tank and the sample indicates the trace level of previous cargo. When this shows that the cargo tanks and lines are clean enough for the next cargo, preparations for the new cargo can be done without entering the tank.

Bear in mind that a wash test may not detect the tank construction, cargo absorption by tank coatings and the cargo UV profile.

A wash water analysis process would include the following:

Wash water sampling

The wash water sampling should be done, drawing samples:

- From points at the end of the cargo system.
- During the last cleaning stages.

Wash water test

Testing the wash water should follow these steps:

1. Compare the wash water sample against the reference sample drawn directly from the tank cleaning line before it enters the cargo tank.
2. Depending on results, decide if tank cleaning needs to continue or stop.
3. Confirm analysis and document the results.

12.4 Gas freeing

12.4.1 General

Gas freeing is generally one of the most hazardous tanker operations, whether for entry, hot work or cargo quality control. The cargo vapours displaced during gas freeing are highly flammable, so good planning and firm overall control are essential. The extra risk from toxic petroleum gas cannot be overemphasised and should be impressed on all personnel concerned. All operations connected with gas freeing demand the greatest possible care. Regional and local regulations may prohibit the release of cargo vapours when in coastal or port areas.

12.4.2 Gas free for entry

To be gas free for entry without breathing apparatus, a tank or space should be ventilated until tests confirm that the concentration of hydrocarbon gas throughout the compartment is less than 1% of the LFL and that the oxygen content is 21% by volume. Toxic gases should also be tested and confirmed at acceptable levels as in chapter 10.

A water wash will improve the condition of a cargo tank or space containing hydrocarbons before entry. If entry is required without water washing, the SMS should have operational and contingency guidance to support safe entry. These should identify the entry as a non-routine operation and require a risk assessment that identifies the preparations needed to achieve safe entry.

Any entry should be based on the hazards and the associated safety and PPE requirements (see chapter 10).

12.4.3 Procedures and precautions

The following recommendations apply generally to gas freeing:

- A Responsible Officer should supervise all gas freeing operations.
- Check all local, regional, and national regulations on emissions of VOC or other limits.
- Notify all personnel on board that gas freeing is about to begin.
- Enforce all appropriate no smoking regulations.
- Before starting, all instruments to be used for gas measurement should be checked and tested in line with the manufacturer's instructions.
- Sampling lines should be entirely suitable for use with the gases present and impervious to their effects.
- Keep all tank openings closed until the actual ventilation of the individual compartment is about to start.
- Use the ship's approved method to vent flammable gas. Where gas freeing involves gas escaping at deck level or through hatch openings, control the degree of ventilation and number of openings to produce an exit velocity that will carry the gas clear of the deck.
- If possible, adjust the intakes of central air conditioning or mechanical ventilation to recirculate air within the spaces and so prevent the entry of petroleum gas (see section 4.8).
- If at any time it is suspected that gas is being drawn into the accommodation, stop the central air conditioning and mechanical ventilation systems and cover or close the intakes.
- Electrically disconnect any window-type air conditioning units that are not certified as safe for use in the presence of flammable gas, or that draw in air from outside the superstructure, and close any external vents or intakes.
- Clear gas vent riser drains of water, rust and sediment and test any steam smothering connections to prove they are satisfactory.
- If several tanks are connected by a common venting system, isolate each tank to prevent gas transferring to or from other tanks.
- If hydrocarbon vapours persist on deck in high concentrations, stop gas freeing.
- If wind conditions cause funnel sparks to fall on deck, stop gas freeing.
- Tank openings within enclosed or partially enclosed spaces should not be opened until the compartment has been sufficiently ventilated by openings that are outside these spaces. When the gas level in the tank has fallen to 35% of the LFL, or under, openings in enclosed or partially enclosed spaces may be opened to complete the ventilation. Test enclosed or partially enclosed spaces for gas during this subsequent ventilation.

When planning gas freeing:

- As a general rule, gas freeing should not take place at the same time as cargo handling. If for any reason this is necessary, consult the relevant authorities, including the Terminal Representative, and get their written agreement.
- Consult the Terminal Representative to check that conditions on the jetty do not present a hazard and to get agreement that operations can start.
- If craft are alongside the tanker, notify the personnel and get them to verify that they will comply with all safety measures.

Further considerations that apply when tanks have been inerted are in section 11.1.6.12.

12.4.4 Gas testing and measurement

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 further details of these instruments.

Test the atmosphere regularly during gas freeing to monitor progress.

Test at several levels and in each compartment of the tank if it is subdivided by a swash bulkhead. In large compartments, tests at widely separate positions.

Once gas freeing of any compartment is completed, leave about ten minutes before taking final gas measurements. This allows relatively stable conditions to develop in the space.

If the gas readings are not satisfactory, resume ventilation.

On completion of gas freeing, close or guard all openings except the tank hatch.

On completion of all gas freeing, carefully check the gas venting system, paying particular attention to the efficient working of the P/V valves and any high velocity vent valves. If the valves or vent risers are fitted with devices designed to prevent the passage of flame, they should be checked and, if necessary, cleaned.

12.4.5 Fixed gas freeing equipment

Fixed gas freeing equipment can be used to gas free more than one tank at the same time, but not if the system is being used to ventilate another tank where washing is in progress.

Where cargo tanks are gas freed by 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, flush the cargo piping system, including crossovers and discharge lines, through with sea water and strip the tanks. Then close and secure all valves on the cargo piping system, except those required for ventilation.

Not all fixed gas freeing lines have NRVs and there is a risk of cargo entering the fixed gas freeing line.

To avoid this, the connection between the fixed gas freeing line and the cargo system should be removed prior to cargo transfer. The Responsible Officer should also check that any isolating spool piece connections are removed and the fixed gas freeing line isolated from the cargo system.

12.4.6 Portable fans

Do not use electric portable fans or blowers. Air and water driven fan 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 used, take care to ensure that the exhaust does not vent into the cargo tank, where it could cause a build-up of static electricity.

The capacity and penetration of portable fans should be able to make the entire atmosphere of the tank non-flammable in the shortest possible time.

Extension tubes for the fans can be effective when gas freeing deep cargo tanks and tanks with deep structural members in the bottom. If these extension tubes incorporate synthetic materials, take care to ensure that they are effectively bonded to the ship's structure.

Portable fans and the ventilation openings should be arranged so that all parts of the tank are equally and effectively gas freed.

Ventilation outlets should, generally, be as far away as possible from the fans.

Portable fans should be connected to the deck so that an effective electrical bond exists between them.

12.4.7 Ventilating double hull ballast tanks

The complexity of the structure in double hull and double bottom tanks makes them difficult to ventilate. It is strongly recommended that the operator develops guidelines and procedures for ventilating ballast tanks that may include filling and emptying to ensure air is transferred efficiently.

The use of a ballast water treatment system may call for extra measures to ensure that the space is properly ventilated. Toxic gases in the tank atmosphere, or chemicals in the remaining ballast water, may mean precautions need to be taken before entering the tank.

Ballast water should be checked before de-ballasting. Any hydrocarbon leaks into the ballast tank will contaminate the ballast, which must then be handled in line with MARPOL regulations.

When filling a tank for ventilation, do not let it overflow onto the deck unless permitted by Class or the Flag State.

Procedures for ventilating ballast tanks should be developed. These should not be based purely on a volumetric capacity calculation but should also address the complexity of the tank's structure. They should give details of the configuration of each tank, the method of ventilation and the equipment to be used. The time required for each ventilation method to gas free the tank for safe entry should also be included.

The procedures should also include an effective method for checking the atmosphere of the tanks.

When portable fans are used for ventilation, this information should be provided for a range of drive pressures and for different numbers of fans.

If portable ducts or sleeves are used, take care to ventilate remote corners of the tanks.

Ships fitted with an IG system may be able to use the emergency connection to allow air from IG systems operating in the air mode to be blown into the water ballast tanks.

12.4.8 Gas freeing in preparation for hot work

The requirements in section 12.4.2 and chapter 9 should be complied with.

12.5 Crude Oil Washing

12.5.1 General

A crude oil tanker fitted with an IG system and approved fixed washing equipment in its cargo tanks can use crude oil from the cargo as the tank washing medium. This may take place either in port or at sea between discharge ports. It is most frequently done while the tanker is discharging cargo and means cargo residues remaining on tank surfaces can be removed. These deposits, which would normally remain on board after discharge, are discharged with the cargo. As a result, the need to water wash the discharged tanks during the ballast voyage to remove residues is much reduced and in some cases eliminated.

Refer to the IMO's *Crude Oil Washing Systems* and the tanker's approved operations and equipment manual for detailed guidance on the procedures.

12.5.2 Advance notice

When COW is needed during cargo discharge, the Master should inform the terminal (or other ship during STS transfer) at least 24 hours in advance, or in such time as required by the terminal. COW should only proceed when they give their written approval.

12.5.3 Tank washing machines

Only fixed tank washing machines may be used for COW.

12.5.4 Control of tank atmosphere

The oxygen content of the tank must not exceed 8% by volume, as described in section 11.1.6.9.

12.5.5 Precautions against leaks from the washing system

Before arriving in a port where it is intended to COW, the tank washing system should be pressure tested to normal working pressure and examined for leaks.

Drain down the system after testing to avoid the risk of thermal expansion causing leaks.

Any leaks found should be repaired, then the system re-tested to prove it is leak free.

During COW, the system should be kept under constant observation so that any leak can be detected immediately and action taken to deal with it.

When tanks for COW 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. This will minimise the potential for a surge pressure to cause any damage.

12.5.6 Avoiding oil and water mixtures

Mixtures of crude oil and water can produce an electrically charged mist during washing. The electrical potential of these mixtures is much higher than dry crude oil. The use of dry crude oil is therefore important. Before washing begins, any tank to be used as a source of crude oil for washing should be partly discharged by at least one metre of ullage to remove any water that has settled out during the voyage.

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.

12.5.7 Isolating the tank cleaning heater

If the tank washing water heater is fitted outside the engine room, it should be blanked off during COW to prevent any ingress of oil.

12.5.8 Supervision

The PIC of COW operations should be suitably qualified in accordance with the requirements laid down by the tanker's flag administration and any local port regulations.

12.6 Ballast operations

This section covers routine ballast operations for double hull tankers and non-routine operations such as taking heavy weather ballast in cargo tanks or meeting air draught restrictions for navigational purposes. Discharging dirty ballast to shore is also covered.

12.6.1 General

Before ballasting or de-ballasting in port, the Responsible Officer and Terminal Representative should discuss the operation and agree it in writing. Any discharge of ballast must comply with IMO and local port or State regulations. The ship's Ballast Water Management (BWM) plan should be followed and the ballast water record book maintained.

PART 1 General Information
PART 2 Tanker Information
PART 3 Marine Terminal Information
PART 4 Ship/Shore (Tanker/Terminal) Interface

The Terminal Representative should give a specific agreement before any simultaneous handling of cargo and non-segregated ballast can begin.

Ballast should be loaded and discharged in a way that avoids subjecting the ship's hull to excessive stress during the operation.

12.6.2 Loading cargo tank ballast

When loading ballast into cargo tanks, observe the following precautions:

- Before taking ballast into tanks containing hydrocarbon vapour, the Responsible Officer should consult with the Terminal Representative. Observe all safety checks and precautions for loading volatile petroleum. Follow closed loading procedures.
- On crude oil tankers, any tank to be ballasted should be crude oil washed beforehand unless discharge of ballast will be to an approved shoreside ballast water processing facility.
- When taking ballast into cargo tanks that contain hydrocarbon vapour, gas is expelled that may be within the flammable range on mixing with air. This gas should, therefore, be vented through the approved venting system.
- When taking ballast into tanks that previously contained cargoes requiring closed operations, the ballast should also be taken using closed loading. Follow the procedures in section 12.1.6.6.
- Ballast should not be loaded over the top (overall) into tanks containing hydrocarbon vapour.
- Follow the guidance in section 12.1.3 when operating ballast tank valves.

12.6.2.1 Operation of cargo pumps

When starting to ballast, operate the cargo pumps so that no oil is allowed to escape overboard when the sea suction valve is opened (see OCIMF/ICS' *Prevention of Oil Spillages through Cargo Pumproom Sea Valves*).

12.6.2.2 Sequence of valve operations

Use the following procedures when loading ballast into a non-inerted tank that contains hydrocarbon vapour:

- The first valve to be opened is the tank valve. The last one is the sea valve.
- Restrict the initial flow of ballast at the pump discharge so that the entrance velocity into the tank is less than 1m/sec until the bottom longitudinals are covered. If there are no longitudinals, restrict velocity until the depth of the ballast in the tank is at least 1.5m.

These precautions will avoid the spraying effect that may cause an electrostatic charge to build-up in a mist or spray cloud near the point where the ballast enters the tank (see chapter 3). When the charge is high enough, a static discharge and ignition is possible.

12.6.3 Loading segregated ballast

In general, there are no restrictions on ballasting segregated ballast tanks during the cargo discharge operation. However, be aware of the following:

- Confirm that the tank to be loaded is free of hydrocarbon.
- Take ballast as necessary to meet air draught requirements on the berth, particularly when MLAs are connected.
- Do not load ballast if it may cause the ship to exceed the maximum safe draught for the berth.
- Maintain hull shear forces and bending moments within allowable limits.
- Take care to ensure that excessive free surface is not allowed to occur as this may cause the ship to develop an angle of loll, jeopardising the integrity of the loading arms. This is particularly relevant to U-shaped ballast tank double hull tankers (see also section 12.2).

12.6.4 Discharging segregated ballast

To prevent contaminated segregated ballast causing pollution, where possible the surface of the ballast should be sighted before de-ballasting. When de-ballasting starts, a watch should be established to observe the ballast as it discharges into the sea. If any contamination is seen, stop the de-ballasting immediately.

12.6.4.1 Discharging segregated ballast to shore

At some terminals, environmental requirements mean that segregated ballast must be discharged into shore tanks. On tankers with segregated ballast, this requires the cross-connection of the cargo and ballast systems, which could create a risk of contamination between the systems unless a deck manifold for ballast is fitted.

Operators should draw up careful procedures for this operation, which should cover:

- Fitting the cross-connection.
- The loading and de-ballasting sequence.
- Draught and air draught requirements.
- Managing hull stresses.
- Setting the cargo lines.
- Operating the cargo pump(s).
- Segregating ballast and cargo.
- Draining the ballast tank(s).
- Removing the cross-connection and isolating the systems.

12.6.5 Ballast water exchange at sea

Ballast water is commonly exchanged at sea to comply with the BWM Convention regulations. In this case, the overall design, strength and stability of the ship should permit it to do so safely in the prevailing weather. If not managed carefully, emptying and filling tanks at sea may lead to lower stability, higher stresses, sloshing or excessive trim and reduced draughts. The tanker's approved BWM plan should set out the necessary procedures and precautions.

12.7 Cargo leaks into double hull tanks

12.7.1 Action to be taken

If a hydrocarbon leak is discovered, the first step is to check the atmosphere in the tank to establish the hydrocarbon content. Note that the atmosphere in the tank could be above the Upper Flammable Limit (UFL), within the flammable range, or below the LFL. Regardless of the number of samples taken, the complexity of the structure means any or all of these conditions may exist in different parts of the tank. Therefore, to establish the true profile of the tank atmosphere, take gas readings at different levels and from as many points as possible.

If hydrocarbon gas is detected in a tank, there are a number of options for maintaining a safe tank atmosphere:

- Continuous ventilation.
- Inerting.
- Filling or partially filling with ballast.
- Securing with P/V valves.
- Securing with vent valves fitted with flame screens.
- A combination of these.

The chosen option will depend on several factors, especially the degree of confidence in the hydrocarbon content of the atmosphere, bearing in mind the potential problems already identified.

If inerting, fitting a P/V valve will be a way of pressing up the tank with IG after inerting to less than 8% oxygen.

When ventilating the tank, consider fitting flame screens to allow air to flow safely and maintain a non-flammable atmosphere in the air space.

Operators should develop procedures that account for the tank structure and any limitations of the available atmosphere monitoring system. These procedures should help the crew to choose the most appropriate way to make the atmosphere safe.

Filling or partially filling the tank with ballast to make the atmosphere safe and/or stop any further leaks into the tank should take prevailing stress, trim, stability and load line factors into account. Bear in mind that MARPOL regulations class all ballast loaded into a tank after a leak, and all tank washings used to clean the tank, as dirty ballast. This means they must be processed in line with those regulations and be either transferred directly to a cargo or slop tank for further processing or, if discharged directly to sea, passed via the oil content monitor. The spool piece that connects the ballast system to the cargo system should be clearly identified and stowed close to its working position. It should not be used for any other purpose.

If the tank is ventilated or inerted instead of filling, sound it regularly to check the rate of liquid build-up and leakage. If the quantity of cargo leaking into the space is pumpable, transfer it to another cargo tank via the emergency ballast/cargo spool piece connection (see above) or other emergency transfer route. This will minimise contamination of the space and help subsequent cleaning and gas freeing.

Ships should have written procedures on board that set out the steps to take to safely transfer the cargo from the ballast space.

Nobody should be allowed to enter the tank until it is safe to do so and there is no further possibility of a hydrocarbon leak. If, for any reason, it is essential to enter the tank before it is safe, this should be done in accordance with section 10.7.

12.7.2 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. The operator should use these guidelines as a basis for developing procedures (similar to those in section 12.4.7) for inerting such tanks. If possible, the procedures should be developed with the ship builder and be based on actual tests and experiments as well as calculations. They should describe the process for each tank, the equipment to be used and its configuration, and the time it takes to reduce the oxygen level in the tank to less than 8% by volume.

For tanks that are identical in structure and size, and where the method of inerting is identical, the data can be taken from tests on a representative tank. Otherwise, the tests should be carried out for each tank.

Introducing IG into a tank may create electrostatic charging. The compartmentalised structure of the tanks means this charge is unlikely to reach incendive levels. However, certain areas within the tank may have a flammable atmosphere, so comply with all the electrostatic precautions set out in sections 3.2 and 11.1.6.8 throughout the inerting process and for 30 minutes afterwards.

Clearly identify the flexible hoses used for inerting double hull tanks. They should be dedicated solely to this use and stowed safely and correctly. The hose string should be electrically continuous. Verify this before putting hoses into service. Confirm that the string is properly earthed before inerting starts.

To minimise the transfer of hydrocarbon vapour from cargo tanks, temporarily close all cargo tank IG supply valves where fitted. Before connecting the hoses, purge the IG line with IG. The hoses should not be connected until needed.

Once the tank has been inerted, consider keeping the tank permanently connected to the IG system. This will enable constant pressure monitoring, over pressure protection via the deck water breaker and ease of topping-up. It will also enable protection against any potential problems of vapour transfer and vulnerability of the hose to heavy seas.

If the hoses remain connected, then all the cargo tank IG inlet valves should be re-opened. If the hoses are disconnected, the IG system should be returned to its original status.

If leaked oil is to be transferred from a ballast space that has been inerted, it is important to ensure that further inerting is carried out during the operation to avoid the introduction of oxygen into the tank. Once inerted, keep the tank topped up as necessary to ensure that a positive pressure is maintained and the oxygen content stays below 8% by volume.

During inerting, ventilate the exhaust vapour from the tank through an opening at least two metres above the deck. Use portable standpipes 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 above and in section 12.4.7 should cover methods for sealing openings that might let air into the tank and for ensuring 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, should be taken at all designated sampling points and with the IG supply stopped.

12.8 Cargo measurement, ullaging, dipping and sampling

12.8.1 General

Cargo measurement and sampling is undertaken using a variety of methods that should conform to the requirements for safe handling of the intended cargoes. Which system is used will be determined by the type of tanker, the toxicity and/or volatility of the particular cargo and associated regulatory requirements.

In general, there are three main methods of gauging – closed, open and restricted:

- Closed: a gauging device that penetrates the cargo tank, but which is part of a closed system maintaining the complete integrity of cargo containment. This device is designed and installed so as not to release cargo liquid or vapour in any amount to the atmosphere, e.g. automatic float, continuous tape (magnetic coupled), sight glass (protected), electronic probe, magnetic, differential pressure cell.
- Open: a gauging method that uses an opening in the cargo tank, such as a gauge hatch or ullage port. This method may expose the user to the cargo and its vapours.
- Restricted: a gauging device that penetrates the cargo tank and which, during operation, can allow the release of small quantities of cargo vapour or liquid. The amount of release is controlled by a small diameter tank penetration opening and by a locally operated valve (sometimes known as a vapour lock) or similar closure device in that opening. When not in use, this type of gauging device is closed to maintain the complete integrity of cargo containment, e.g. rotary tube, fixed tube, slip tube and sounding tube.

As a closed gauging system offers complete integrity and flexibility for varying cargo types and trades, its use is preferred at all times. Open gauging and restricted gauging should only be allowed where:

- Open venting is allowed by the relevant regulations, e.g. the IMO's *International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code).*
- Means are provided for relieving tank pressure before the gauge is operated.

In consultation with the terminal and cargo surveyors, remote gauging may be considered for cargoes with a toxic content. Evidence will be needed to demonstrate the accuracy of the remote gauging system, such as a calibration certificate and test records.

Cargo compartments may be pressurised, so only authorised personnel should open vapour lock valves, ullage ports or covers to control the release of any pressure.

Avoid escaping vapour and wear proper PPE if risk of gas exposure exists (see sections 23.3.1 and/or 23.3.2 and 24.2.1). 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. Depending on the cargo, consider using appropriate RPE (see sections 10.8 and 12.8.4).

When open gauging, the tank opening should be uncovered only for as long as it takes to complete the operation.

Cargo sampling

Sampling is an integral part of cargo operations. Taking clean, representative and uncontaminated samples is essential for all parties involved in the voyage (shipper, charterer, terminal, supplier or receiver).

Cargo dosing/doping (introducing additives) may also be needed for product quality, specification, operational or legal reasons.

These operations pose a potential hazard to personnel, exposing them to toxic and/or flammable cargo vapours, so they need to be done with care.

Closed sampling

All cargo sampling and additive handling should be under closed conditions and with dedicated closed sampling equipment. The focus should be on protecting personnel against the safety risks and minimising the operational and environmental hazards. The SMS should include procedures and guidance on closed sampling.

Open sampling

At times, despite taking precautions to ensure good quality samples, the samples drawn through the closed sampling method may be unsatisfactory. Viscosity and pour point issues can make closed sampling difficult.

In this case, the parties involved may consider open sampling.

Open sampling is an exception, not a readily available alternative. It risks exposing personnel to harmful cargo vapours and poses electrostatic hazards (see section 12.8.2).

If open sampling is needed, it should be done according to the operator's SMS and agreed by the Master and the Terminal Representative.

The risk of open sampling should be evaluated and risk assessed considering the characteristics of the cargo, personal exposure to toxic/flammable vapours, the electrostatic hazard and the weather.

Open sampling should not be carried out under no wind or light wind conditions or with lightning in the area.

To reduce the risk, ensure the level of PPE, including RPE, meets the requirements of the risk assessment. Isolate the IG branch valve and release the cargo tank pressure, open one tank at a time and stop any cargo operation. Use a toolbox talk to brief the crew involved in operation on the hazards and safety procedures.

Once the open sampling is complete, restore the system to normal operation and check the oxygen content to confirm the tank remains inert.

12.8.2 Measuring and sampling non-inerted tanks

12.8.2.1 General

Electrostatic discharges are possible whenever equipment is lowered into non-inerted tanks. They may come from charges on the equipment itself or from charges already in the tank, e.g. in the liquid contents or on water or oil mists. If a flammable mixture of hydrocarbon gas and air is possible, take precautions to avoid any incendive discharges throughout the system.

Precautions are needed to deal with two distinct types of hazard:

- Introducing equipment that may act as a spark promoter to a tank that already contains charged materials.
- Introducing a charged object to a tank.

Each requires different mitigation.

Table 12.2 summarises the precautions to prevent electrostatic hazards when ullaging and sampling non-inerted tanks.

12.8.2.2 Introducing equipment to a tank

Measures to avoid spark promoters

If any dipping, ullaging or sampling equipment is used in a potentially flammable atmosphere where an electrostatic hazard exists or can be created, take precautions to ensure they do not act as an unearthed conductor at any time during the operation. Before a sampling device is lowered into a tank, any metallic components should be securely bonded together and to the tank before the sampling device is introduced and should remain earthed until after removal. The bonding and earthing cables should be metallic.

Equipment should be designed to make earthing easy. For example, the frame that holds the wheel of a metal measuring tape should have a threaded stud that a sturdy bonding cable can be bolted to. 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 that can be attached to the rim of an ullage opening.

Companies that supply non-conductive and intermediate conductive equipment to ships should be satisfied that the equipment will not act as spark promoters. Non-conducting components should not insulate any metal components from earth. For example, if a plastic sample bottle holder includes a metallic weight, the weight should be bonded as above or be fully encapsulated in at least 10mm thick plastic.

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 (section 12.8.2.2)	Flow of static accumulator liquids (sections 12.1.7 and 12.8.2.3)	Water mist droplets (sections 3.2.7 and 12.8.2.5)
Precautions necessary for dipping, ullaging and sampling with:	(sections 12.8.2.3 and 12.3.5.2)	(section 12.8.2.3)	(sections 12.3.5.2 and 12.8.2.5)
i. metallic equipment not earthed or bonded	Do not use ropes or tapes made of synthetic materials for lowering into cargo tanks at any time	Not permitted at any time	Not permitted during washing and for five hours thereafter
ii. metallic equipment that is earthed and bonded from before introduction until after removal	"	Not permitted during loading and for 30 minutes thereafter	No restrictions
iii. non-conducting equipment with no metallic parts	"	If sampler is more than one litre capacity, Not permitted during loading and for 30 minutes thereafter	No restrictions
Exceptions permitted if:	"	Sounding pipe is used	a. Sounding pipe is used, or b. Tank is continuously mechanically ventilated, when five hours can be reduced to one hour

Table 12.2: Summary of precautions against electrostatic hazards when ullaging and sampling non-inerted tanks

Measures to avoid charged objects

The suitability of wholly non-metallic equipment depends on the volume and surface resistance of the materials and how they are used. Non-conducting and intermediate conducting materials may be acceptable in some circumstances, e.g. 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, has enough conductivity because 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. These materials should have a leakage path to earth so that they are not totally insulated, but this need not have the very low resistance normal for bonding and earthing metals.

In practice, such a path usually occurs naturally on ships, either by direct contact with the ship or indirect contact via the operator of the equipment.

12.8.2.3 Static accumulator oils

It is wise 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. However, the possibility remains of a brush discharge between the equipment and the charged liquid surface as the two approach each other.

After loading a tank, allow a settling time of 30 minutes before starting dipping, ullaging, sampling and any other operation that introduces equipment into the tank. This allows gas bubbles, water or particulate matter to settle in the liquid and any electrical potential to dissipate.

Since such discharges can be incendive, and because a flammable gas mixture may be present, no dipping, ullaging or sampling with metallic equipment should take place while a static accumulator is being loaded.

Figure 12.5 summarises the situations when these restrictions on metallic equipment should apply.

Non-metallic equipment

Discharges between the surface of a static accumulator oil and non-metallic objects have not been found to be incendive. Therefore, dipping and ullaging with non-metallic equipment lowered on clean natural fibre line can be done at any time.

Non-conductive (non-metallic) containers with a capacity of less than one litre may be used for sampling at any time, provided they have no conducting components and are not rubbed before sampling. Cleaning with a high conductivity proprietary cleaner or soapy water can reduce charge generation. To prevent charging, the container should not be rubbed dry after washing.

Refer to section 3.2.1 on the use of non-metallic sampling containers.

Sounding pipes

A sounding pipe is a conducting pipe that extends the full depth of the tank and is effectively bonded and earthed to the tank structure.

A sounding pipe can be used at any time because, as long as it is designed and installed properly, it is not possible for any significant charge to accumulate on the surface of the liquid within it. The pipe should be slotted to prevent any pressure differential between the pipe and the tank and to ensure that true levels are indicated.

The electrostatic field strength in a metal sounding pipe is always low due to the small volume and the shielding from the rest of the tank. This means dipping, ullaging and sampling within a metal sounding pipe can be done at any time, provided any metallic equipment is properly earthed. Sounding pipes may also use non-metallic equipment, in which case the precautions against introducing charged objects should be applied.

12.8.2.4 Static non-accumulator oils

A flammable atmosphere may be present above a static non-accumulator oil in a non-inerted or non-gas free environment. Follow the precautions in section 12.8.2 and figure 12.5.

12.8.2.5 Ullaging and dipping in water mists

During tank washing, no unearthed metallic conductor should be in the tank and none should be introduced while the charged mist persists, i.e. for up to five hours afterwards (see sections 12.3.5.2 and 12.3.6). 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. Intermediate conductors and non-conductors are acceptable, although certain materials, e.g. polypropylene (PP) ropes, should be avoided (see section 3.2.7).

All metallic components should be securely earthed. If there is any doubt about earthing, do not allow the operation.

Ullaging and dipping carried out via a full depth sounding pipe are safe at any time in a wash water mist.

12.8.3 Measuring and sampling inerted tanks

Ships fitted with IG systems should have closed gauging systems for taking measurements during cargo operations. Ships should have vapour locks to enable closed gauging and sampling for custody transfer.

Ships with a vapour lock on each cargo tank should measure and sample cargo without reducing the IG pressure unless needed for vapour emission control, e.g. high H_2S. Vapour locks are used with specially adapted measurement devices, such as 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. Take care to ensure that there is no blow-back of vapour. Open gauging or sampling should not take place on ships with vapour locks unless it is necessary to prevent cross contamination when sampling highly sensitive cargoes.

Sonic tapes, temperature tapes, etc. should be used in line with good safety practices and the manufacturer's instructions. The requirements for portable electrical equipment apply to these devices (see section 4.12).

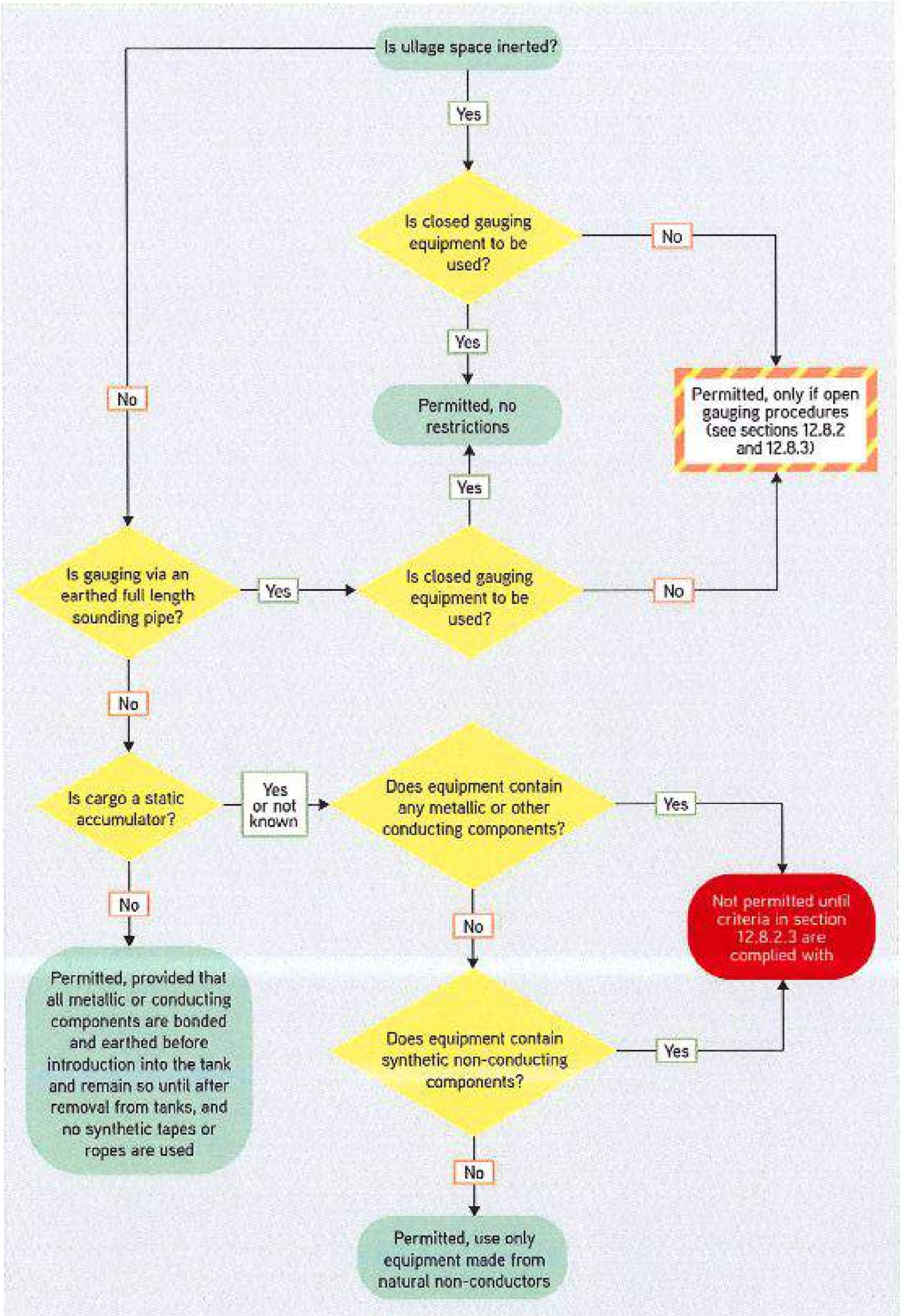


Figure 12.5: Precautions when using portable measuring and sampling equipment flowchart

On ships not equipped with vapour locks, or if highly sensitive cargoes need to be sampled, take the special precautions detailed in section 12.8.1. When the pressure in any tank needs to be reduced for measuring and sampling, take the following precautions:

- Maintain a minimum positive IG pressure when measuring and sampling. The chemical composition and low oxygen content of IG, and particularly nitrogen IG, can rapidly cause asphyxiation, so take care to avoid standing in the path of vented gas when measuring and sampling (see section 12.8.1). No cargo or ballast operations are permitted in cargo compartments while the IG pressure is reduced to allow measuring and sampling.
- Open only one access point at a time and for as short a time as possible. In the intervals between the different stages of cargo measurement, e.g. between ullaging and taking temperatures, keep the relevant access point firmly closed.
- After completing the operation and before starting to discharge cargo, secure all openings and re-pressurise the cargo tanks with IG (see section 11.1 for operating the ship's IG system during cargo and ballast handling).
- When mooring and unmooring or while tugs are alongside, do not carry out any measuring and sampling that require the IG pressure to be reduced and cargo tank access points opened. Note that if access points are opened while at anchor or moored in open waters any movement of the ship might result in the tanks breathing. To minimise this risk, maintain sufficient positive pressure within the tank being measured or sampled.
- When discharge is nearly complete and it is necessary to sound the tanks, the IG pressure can again be reduced to a minimum safe operational level to allow sounding through sighting ports or sounding pipes. Avoid air leaks or an excessive release of gas.

12.8.3.1 Static accumulator cargoes in inerted cargo tanks

Precautions are not normally needed against static electricity hazards when using IG because the IG prevents the formation of a flammable gas mixture. However, particulates suspended in IG mean high electrostatic potentials are possible. If a tank is no longer thought to be inert, then dipping, ullaging and sampling should be restricted as in sections 11.1.6.8 and 12.8.2.

Restrictions would be required in the event of a breakdown of the IG 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.

IG particulates may carry a very high potential, so do not assume that corona discharges from conducting equipment lowered into the tank will be non-incendive if the tank contains a flammable atmosphere. No object should be introduced into the tank until the very high potential has had a chance to decay. Allow 30 minutes after the IG injection has stopped. After this, equipment may be introduced provided all metallic components are securely earthed and subject to the same precautions for water mists caused by washing (see section 3.2.7). This earthing is required for at least five hours after the injection of IG stopped (see section 12.8.2.5).

If a tank needs to be re-inerted after a failure of the IG system, or a non-gas free tank is being initially inerted, no dipping, ullaging, sampling or other equipment should be inserted until the tank is inert.

12.8.4 Measuring and sampling cargoes containing toxic substances

Special precautions are needed when ships carry cargoes that contain toxic substances in hazardous concentrations.

Loading terminals are responsible for advising the Master, by providing the SDS, if the cargo to be loaded contains hazardous concentrations of toxic substances. Similarly, the Master is responsible for advising the receiving terminal, by providing the SDS, if the cargo to be discharged contains toxic substances. This is covered by the SSSCL (chapter 25).

The ship should 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 use closed sampling and gauging procedures if possible. In consultation with the terminal and cargo surveyors, remote gauging may be considered. Evidence needs to demonstrate the accuracy of the remote gauging system, e.g. a calibration certificate, vessel experience factor and periodic test records.

If remote gauging, closed gauging or closed sampling are not possible, a risk assessment should be carried out. Follow the precautions set out in section 12.8.1 for open sampling.

Tests should assess the vapour concentrations near each open access point to ensure they do not exceed the Occupational Exposure Limit - Short-term Exposure Limit (OEL-STEL) of the toxic substances. If monitoring shows the limit could be exceeded, personnel should wear suitable respiratory protection. 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 still air, consider suspending operations and closing all venting points until defects are corrected or the weather changes and gas dispersion improves.

Refer to section 1.4 for details of the toxicity of petroleum and its products.

12.8.5 Closed gauging for custody transfer

Gauging tanks for custody transfer should be done with a closed gauging system or via vapour locks. For the ullaging system to be acceptable, the gauging system should be described in the ship's tank calibration documentation. The ship's Classification Society should check and approve corrections for datum levels and for list and trim.

Temperatures can be taken using electronic thermometers inserted through the tanks' vapour locks. The thermometers should also be calibrated and have the appropriate approval certificates.

Samples should be taken using special sampling devices via the vapour locks.

12.8.6 Cargo tank monitoring systems

Tank monitoring equipment often has multiple functions, such as radar or other types of remote gauging, temperature measurement, tank pressure sensors and level alarms. It may be integrated with other cargo monitoring or control equipment or with loading computers or control systems. Manufacturers may refer to these multi-function units as cargo tank monitoring systems.

Whether provided as a complete system or as separate elements, planned maintenance procedures should be established to ensure maintenance, test and calibration of this equipment per the manufacturer's instructions.

A risk assessment should identify procedures to enable work to continue if tank monitoring equipment fails. If temporary exchange with a unit from another tank unit is considered, check the compatibility. The equipment may need to be re-calibrated.

12.9 Transfers between ships

12.9.1 Ship to Ship transfers

In STS transfers, both tankers should comply fully with the safety precautions for normal cargo operations. If either ship is not observing the precautions, the operations should not start or should be stopped if in progress.

STS transfers in port or at sea should be approved by the port or local marine authority, in accordance with MARPOL regulations. This approval may have specific conditions attached.

12.9.1.1 Transfer guide

STS transfers alongside a berth (also known as double banking – see section 16.3) may include a simultaneous cargo transfer to shore as well as between the participating tankers. These operations should be risk assessed (see section 4.2.2) taking into account applicable limiting conditions for operations alongside terminals (see section 16.1) and include, as a minimum, the following:

- Local port/coastal authority and regulatory approvals.
- Use of lightering advisors and the PIC of operations.
- SIMOPS considerations (see section 4.6).
- Numbers of crew (in addition to normal watchkeeping), their competency and experience.
- Environmental sensitivity of location.
- Metocean conditions: weather, waves and swell, currents and tides, etc.
- Communications.
- Terminal or port requirements.
- Notifications.
- Emergency and contingency planning.

12.9.2 Ship to barge and barge to ship transfers

In ship to barge or barge to ship transfers of hydrocarbons, only authorised and properly equipped barges should be used. Precautions similar to those in ICS/SIGTTO/CDI/OCIMF's *Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases* should be followed. If the barge or the tanker are not observing the precautions, the operations should not start or should be stopped if in progress. Ship Masters should be aware that barge crews may not be familiar with the requirements of the *Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases.*

The pumping rate from ship to barge should be controlled according to the size and nature of the barge, particularly if the freeboard difference is large. In any case, the barge crew should allow for sufficient space in tanks for hose contents to be transferred upon cargo completion.

An agreed method of communication should be established and maintained throughout the duration of operations.

Arrangements should be made to release the barge in an emergency, accounting for nearby shipping or property. If the tanker is at anchor, the barge may drop anchor clear of the tanker. It can remain secured there, waiting for assistance.

A barge should be cleared from the ship's side as soon as possible after it has finished loading or discharging volatile petroleum.

12.9.3 Ship to Ship transfers using vapour balancing

Specific operational guidance should be developed to address the particular hazards associated with vapour emission control during STS transfer using vapour balancing techniques. Such transfers should only be between inerted ships. Follow the recommendations in section 11.1.6.4.

12.9.4 Ship to Ship transfers using terminal facilities

When 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 terminal's cooperation in setting up these arrangements and procedures is vital. Consider appointing a responsible party to provide equipment and naming a PIC.

PART 1 General Information
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PART 4 Ship/Shore (Terminal) Interface

12.9.5 Ship to Ship electric currents

The principles for controlling arcing during STS transfers are the same as in ship to shore transfers.

In ships dedicated to STS transfers, an insulating flange or a single non-conducting length of hose should be used in the hose string. When transferring static accumulator oils, it is essential that these measures are not taken by both ships, leaving an insulated conductor between them that could accumulate an electrostatic charge. For the same reason, when a dedicated ship is transferring ship to shore, take care to ensure no insulated conductor is between the ship and shore, e.g. using two insulating flanges on one line (see *Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases*).

If the ships cannot be positively isolated, the electrical potential between them should be reduced as much as possible. This is probably best achieved if they both have working impressed current cathodic protection systems and they leave them running. Likewise, if one has an impressed system and the other a sacrificial system, the impressed system should remain in operation.

However, if one ship does not have cathodic protection, or its impressed system has failed, consider switching off the impressed system on the other ship well before the two ships come together.

For more, refer to sections 17.4.2, 17.4.5 and 18.2.

12.10 Personnel transfer

The transfer of personnel between ships should be kept to an absolute minimum. If a transfer is being considered, a risk assessment should evaluate how this is done, bearing in mind the residual risks may still be unacceptable. Abandoning the transfer should always remain an option.

When planning and carrying out personnel transfers, refer to OCIMF's *Transfer of Personnel by Crane between Vessels*, which covers hazard identification, equipment, maintenance and testing, training and contingency planning.

12.11 Liquefied Natural Gas fuelled ship alongside a terminal

Liquefied Natural Gas (LNG) is stored under cryogenic conditions in bunker tanks. While these are well insulated, an increase in the temperature and pressure of the fuel is possible. To avoid a release of natural gas through the pressure relief valve and vent stack, measures should be in place to manage the temperature and pressure.

Before arrival, the ship and terminal should exchange information on the type of fuel used during the stay alongside and on the emergency plan. The ship should confirm the ongoing integrity of the LNG containment, Boil-Off Gas (BOG) management and monitoring systems.

As a minimum, the Master and engineering officers on ships subject to the *International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels (IGF Code)* should receive training in line with the specific requirements of the *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1979 (STCW)* and hold a certificate of proficiency in LNG.

For more information, refer to the IGF Code, which requires the means to maintain the bunker tank pressure below the set pressure of the relief valves for a period of 15 days with the ship in idle condition, i.e. without consuming the BOG in the main engine. Methods of achieving this include pressurised tanks or cooling via top sprays (see section 24.3.2.4).

12.12 Lifting equipment

12.12.1 Inspection and maintenance

All shipboard lifting equipment should be examined at least once a year and load tested at least every five 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.
- Lifting points, e.g. pad eyes in the manifold area.
- Strops, slings, chains and other ancillary and portable equipment.

All equipment should be tested by suitably qualified individuals and be clearly marked with its Safe Working Load (SWL), serial number and test date.

All lifting equipment should be maintained in line with the manufacturer's guidelines. The ship's PMS should include periodic checks.

The ship's lifting equipment register should record all tests and inspections. These records should be available for inspection by Terminal Representatives when their personnel are involved in lifting operations using the ship's equipment.

For further guidance, refer to OCIMF's *Recommendations for the Tagging/Labelling, Testing and Maintenance, Documentation/Certification for Ships' Lifting Equipment*.

12.12.2 Training

Safe operation of all lifting equipment requires that all operators of lifting devices are correctly trained in their function and safe operation.

Appropriate training requirements should be established by the company based on the type of lifting equipment and the operations to be conducted.

Training may be undertaken in-house, on the job, e.g. by a supervisor, or externally, e.g. by the equipment manufacturer or an appropriate outside entity.

In addition, lifting equipment operators should be familiarised with the specific lifting equipment and operation planned prior to being assigned the task.

The following should be confirmed prior to operating lifting equipment:

- General operating principles of the applicable lifting equipment are fully understood by the operator.
- Operator is familiar with the specifics of the lifting equipment, e.g. manoeuvring handles and start/stop of the equipment, etc.
- Understanding of the limitations of the equipment, e.g. SWL, breaking strength, etc.
- Identify and understanding of the emergency stops and resetting method(s) (if fitted).
- Understanding of the risks and dangers with respect to the lifting equipment and its operation and the associated mitigating safety measures.
- Agreed method of communication between the operator and the signaller, where applicable.

In addition, a practical test should be performed prior to commencement of the lifting operation, where considered necessary.

CHAPTER 13

Carrying and Storing Hazardous Materials

13.1 Liquefied gases

13.2 Ship's stores

13.3 Cargo and bunker samples

13.4 Other materials

13.5 Packaged cargoes

This chapter looks at hazardous materials carried and stored on board tankers as cargo, ship's stores or cargo samples.

***ISGOTT* does not offer guidance on the many hazardous chemical cargoes that may be shipped from time to time. General guidance on the properties of such cargoes can be found in the ICS publication *Tanker Safety Guide: Chemicals*. The shipper must also supply an SDS for all chemicals. The *International Maritime Dangerous Goods (IMDG) Code* provides requirements and guidance on the handling and storage of packaged dangerous goods in accordance with the SOLAS Convention.**

13.1 Liquefied gases

As well as observing the general precautions in section 13.5 for handling packaged petroleum and other flammable liquids, follow these safeguards when handling packaged liquefied gas cargoes:

- Protect pressurised cylinders against physical damage from other cargo, stores or equipment.
- Do not over-stow pressurised cylinders with other heavy goods or items.
- Do not stow pressurised cylinders in positions where the safety relief device is in contact with the vapour space in the cylinder.
- Use a suitable protection cap to protect valves against physical damage when the cylinder is not in use.
- Cylinders stowed below deck should be in compartments or holds that can be ventilated and are away from accommodation, working areas and all sources of heat.
- Stow oxygen cylinders separately from flammable gas cylinders.

- Keep temperatures down. Do not allow hold temperatures to rise above 50°C. Check hold temperatures frequently. If they approach 50°C, take the following measures:
  - Ventilate storage areas.
  - Spray liquefied gas containers with water if loading or discharging in direct sunlight.
  - Create a shade for the gas cylinders, e.g. rig a cover over the hold.
  - Dampen the deck over the hold containing any cylinders, e.g. by spraying with water.

13.2 Ship's stores

13.2.1 General

Any chemical or hazardous material on board a ship as stores should have an SDS. If an SDS is not provided, the material should be isolated and stored in line with the guidance on its container or packaging. Do not use it until satisfactory user information is available.

Assess what PPE, first aid and eye wash equipment should be kept at each location. Ensure it is appropriate to the product stored.

All containers and packages should be stowed closed. Keep the storage location clean and tidy.

13.2.2 Paint

Stow paint, paint thinners and associated cleaners and hardeners in approved storage areas that are protected by fixed fire-extinguishing systems approved by the administration. (SOLAS Chapter II-2 Regulation 10, section 6.3 covers spaces containing flammable liquid.)

13.2.3 Chemicals

Stow all chemicals in a designated storage area. Take care to ensure that incompatible chemicals are stowed separately. Information on the firefighting medium for each chemical should be in the product SDS.

13.2.4 Cleaning liquids

Use non-toxic, non-flammable and environmentally friendly cleaning liquids where possible. If flammable liquids are used, they should have a high flashpoint. Never use highly volatile liquids, e.g. gasoline or naphtha, in engine and boiler rooms.

Keep flammable cleaning liquids in closed, unbreakable, correctly labelled containers. Store them in a suitable compartment.

Use cleaning liquids only in areas with good ventilation and take into account the volatility of the liquids. All such liquids should be stowed and used in line with the manufacturer's instructions.

Do not let cleaning liquids touch the skin or contaminate clothing.

13.2.5 Spare gear storage

Spare gear is not inherently hazardous. However, large items of spare gear stowed on deck have, on occasion, broken free of their lashings, damaging the ship and endangering the crew. When stowing spare gear, ensure that it:

- Gives safe access to any safety equipment.
- Does not interfere with mooring or other operations.
- Is properly lashed, especially in bad weather.

13.3 Cargo and bunker samples

The operator's SMS should include guidance on managing and storing cargo and bunker samples. The quantity of samples kept on board should be carefully managed and reduced to the minimum number required. When they are no longer required they should be disposed of in an appropriate cargo or slop tank on board or landed ashore.

13.3.1 Sample disposal

After the cargo has been discharged, unless the company or charterer says otherwise, it is suggested that cargo samples are kept for no longer than three months. MARPOL requires that bunker samples are kept on board for at least 12 months from the time of delivery.

If disposing into a cargo or slop tank, sections 12.8.2 and 12.8.3 cover the hazards of electrostatic discharges between two static accumulator surfaces and the necessary precautions. Use appropriate fixed full length piping, e.g. full length vapour lock piping, full length sounding pipes or similar. Manifold drip trays fitted with drainpipes leading to a cargo tank are also suitable. In both cases, precautions should be taken to ensure there is no vapour blow-back.

If landing samples ashore, records of disposal should be kept, along with landing receipts, in line with operator procedures.

13.3.2 Sample storage

All cargo and bunker samples should be stored securely in lockers that cannot be accessed from the accommodation. Consider storing samples in an area protected by a fire detection and fixed firefighting system, such as a paint locker or midship storeroom. If no fixed firefighting system is fitted, portable firefighting equipment should be provided nearby. Keep samples away from high temperatures and do not expose them to direct sunlight. Before entering any storage space, make sure it is properly ventilated.

In some cases, oil tankers may be equipped to carry certain MARPOL Annex II cargoes and have a relevant certificate of fitness. In such cases, follow the guidance in the IBC Code section 16.5, *Stowage of Cargo Samples.*

13.4 Other materials

13.4.1 Sawdust, oil absorbent granules and pads

Avoid using sawdust to clean up small oil spills on board, as moist sawdust is susceptible to spontaneous combustion (see section 4.10). If sawdust is carried on board, make sure it is stowed dry and in a cool location.

If sawdust is used to clean up a minor oil spill, store the contaminated product separately, in a sealed container and in a safe location, clear of the accommodation and hazardous areas.

Stow any oil impregnated absorbent granules or pads in dedicated containers, clear of the accommodation and hazardous areas.

Dispose of oil impregnated sawdust and absorbent granules as early as possible, ashore or in the ship's waste incinerator (if compatible).

13.4.2 Linseed and other oils

Rags soaked in boiled linseed oil can spontaneously combust when drying. Their temperature rises as a result of an exothermic reaction with the air. Place any rags or paper towels soaked with linseed oil in water filled metal cans until they can be incinerated or disposed of ashore.

Boiled linseed oil can be safely stowed in cans if kept away from heat sources (drying linseed oil is safe when used on wood because it is spread out and does not create enough heat to self-combust).

Other products that can produce heat and self-combust include turpentine, fish oil, lard, coconut oil, cod liver oil and castor oil. Rags soaked in these products should also be kept in water filled metal cans until they can be incinerated or disposed of onshore.

13.4.3 Garbage

The regulations for the handling, storage and disposal of garbage can be found in MARPOL Annex V, with further information in the ICS publication *Guidelines for the Preparation and Implementation of Garbage Management Plans.*

Carefully choose the storage areas for garbage to ensure it presents no potential hazard to nearby spaces.

Be particularly careful when storing garbage that is designated as special waste, e.g. batteries, sensors and fluorescent tubes) and ensure that only compatible materials are stowed together.

13.5 Packaged cargoes

13.5.1 Petroleum and other flammable liquids

Packaged petroleum cargoes are usually shipped in steel drums that can carry around 200 litres. Products transported in this way include gasoline, kerosene, gas oils and lubricating oil.

As well as complying with the IMDG Code and the general safety precautions for handling bulk petroleum, observe the following procedures when handling packaged petroleum products.

13.5.1.1 Loading and discharging

Handling steel drums increases the risk of spark generation. Do not handle packaged petroleum and other flammable liquids while bulk loading volatile petroleum, except with the express permission of both the Responsible Officer and the Terminal Representative.

13.5.1.2 Precautions during handling

A Responsible Officer should supervise the handling of packaged petroleum and other flammable liquids. Take the following precautions:

- When on board the ship they must comply with smoking restrictions and other safety regulations that are mandatory requirements.
- If no permanent hatch protection is fitted, provide temporary protection to avoid the risk of hoists striking the hatch coamings, hatch sides or hold ladders and causing sparks.
- All hoists should be able to pass through hatches with plenty of clearance.
- Handle loose drums with fibre rope slings, cargo nets, drum hooks on wire rope or chain slings. Include lifting gear in the equipment register and test it regularly.
- Goods should be palleted and secured. Use pallet lifting gear with safety nets to lift pallets. If goods are not on pallets, use cargo trays or fibre rope slings. Using cargo nets for packaged goods is generally discouraged as they may damage the packaging.
- Handle loose gas cylinders with cargo nets that have a suitably small mesh. Never handle cylinders by the valve or protection cap. Never use lifting magnets, chains, slings or strops to lift cylinders on board. Always use a cylinder trolley or similar device when moving cylinders, even over short distances.

- Before stowing, inspect each package for leaks or damage. Reject any that are defective and may pose a risk.
- Place packages on dunnage on the deck or in the hold.
- Do not drag packages across the deck or hold, do not allow them to slide or roll free.
- Stow cans and drums with caps and end plugs uppermost.
- When securing the cargo, separate each tier by dunnage. The nature, size and strength of the packages will determine the height to which cargo can be safely stowed. Seek advice from the terminal or shipper.
- Use enough dunnage to prevent possible damage during the voyage.
- Secure the cargo to prevent any movement during the voyage. If drums are stowed on deck, part-filled and empty ones may float free of the stow. Consider covering and lashing them with cargo netting.
- During darkness, provide sufficient approved lighting over the ship's side and into the hold.
- Treat empty cylinders as filled unless they have been gas freed.
- Do not use any materials susceptible to spontaneous combustion as dunnage and do not stow them in the same compartment as the packages. Be wary of combustible protective packaging, e.g. straw, wood shavings, bituminised paper, felts and polyurethane.
- After loading or discharging and before closing hatches, inspect the hold to check that everything is in order.

13.5.2 Dangerous goods

Dangerous goods are classified in Chapter VII of the *International Convention for the Safety of Life at Sea (SOLAS)*.

The Master should allow on board only packaged dangerous goods that have been properly identified by the shipper of the goods and declared as properly packaged, marked and labelled in line with the appropriate provisions of the IMDG Code, taking into consideration the IMO's *Recommendations on the Safe Transport of Dangerous Cargoes and Related Activities in Port Areas.*

Before accepting the cargo, the Master should have received the appropriate SDS from the shipper and be aware of advice on any special properties of the cargo, procedures for entering an enclosed space containing the cargo, and guidelines for dealing with any leak, spill inhalation, skin contact or fire.

See the advice for dealing with spills or fire in the IMO's *Emergency Procedures for Ships Carrying Dangerous Goods: Group Emergency Schedules.*

The Master should also ensure that dangerous goods loaded on the ship are properly stowed and segregated as recommended in the IMDG Code, taking into consideration the IMO's *Recommendations on the Safe Transport of Dangerous Cargoes and Related Activities in Port Areas.*

13.5.2.1 Tetraethyl lead and tetramethyl lead

Tankers may carry these anti-knock chemicals in small quantities as packaged cargo. Take extreme care when handling anti-knock compounds, as contact with the skin or vapour inhalation poses a toxic risk. Before handling packaged cargoes of TEL and TML, the Master should know the nature and properties of the substance and have the appropriate SDS from the product manufacturer.

13.5.2.2 Additives (anti-static, inhibitors, dyes, hydrogen sulphide knockdown)

These cargo additives are often loaded on tankers in small containers and delivered with the cargo. So that they can be stowed correctly, they should be accompanied by the appropriate SDS.

13.5.3 Entering holds and storage spaces

Before entering any hold or storage spaces that contain or have contained packaged petroleum and/or other flammable liquids, take all the precautions for entering enclosed spaces (see chapter 10).

Ventilate holds during all cargo handling operations. If handling is interrupted and hatches are closed, re-test the atmosphere before resuming work.

13.5.4 Portable electrical equipment

Other than approved air-driven lamps, portable electrical equipment is prohibited in holds or spaces containing packaged petroleum or other flammable liquids. It is also prohibited on deck or in spaces over or next to such holds or spaces unless the ship complies with the conditions for using such equipment on tankers (see section 4.12).

13.5.5 Smothering type fire-extinguishing systems

When handling packaged petroleum or other flammable liquids, make sure the control valves of any smothering system in the holds are closed and take precautions to prevent unauthorised or accidental opening of these valves.

When loading or discharging is completed, and after hatches have been secured, return any previously isolated fixed smothering system to operational readiness.

13.5.6 Firefighting precautions

As well as taking the precautions outlined in section 19.4 when handling cargo, have at least two dry chemical fire extinguishers and fire hoses equipped with spray nozzles ready for use.

13.5.7 Forecastle spaces and midship stores

Do not carry packaged petroleum or other flammable liquids in the forecastle spaces, midship stores or any other space unless they have been specifically designed and classified.

13.5.8 Deck cargo

Protect any drums or other receptacles carried on deck against the sea and weather. They should normally be stowed only one tier high.

Stow all packages well clear of 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. Use sufficient dunnage and secure them properly to strong points on the ship's structure.

13.5.9 Barges

Barge personnel should comply with the relevant requirements of chapter 4, particularly restrictions on smoking, naked lights and cooking appliances. When alongside a tanker they should also comply with the requirements in chapter 24.

During darkness, barges carrying packaged petroleum or other flammable liquids should remain alongside a tanker only if there is enough safe lighting and they can comply with smoking restrictions and other safety requirements.

CHAPTER 14

Special Ship Types

14.1 Combination carriers

This chapter adds guidance and recommendations for special ship types, including Oil/Bulk/Ore (OBO), frequently called combination carriers, which may differ from the recommendations for conventional tankers. An OBO carrier is a ship designed to carry oil, chemical or solid cargoes in bulk.

Other types of ship, which may, for example, carry oil in bulk at the same time as containers or general cargo, should be treated as a conventional tanker.

Some Liquefied Petroleum Gas (LPG) carriers are certified to carry other petroleum products, e.g. light naphtha, jet fuel and motor gasolines.

14.1 Combination carriers

A combination carrier is capable of carrying its full deadweight when trading as an ore carrier with cargoes of heavy ore concentrates. Other types of dry bulk cargo, e.g. grain, coal or liquid cargoes, can also be carried by these ships. Cargo tanks have smooth sides and bottom, similar to bulk carriers.

Combination carriers have a double hull construction. Side tanks and double bottom tanks are used for segregated ballast or arranged as void spaces. The double bottom, lower hopper, double side and top wing tanks have direct access to the weather deck, but there is no direct access from ballast tanks or void spaces to cargo holds.

A cargo pumproom type combination carrier would require a pipe tunnel located above the double bottom and combination carriers typically have deepwell pumps for each cargo hold.

Ballast piping is located inside the ballast tanks or pipe tunnels. Ballast pumps are, typically, located in a ballast pumproom.

Combination carriers typically have cargo holds without a centreline bulkhead.

Combination carriers above 70,000 tonnes DWT must have two protected slop tanks when carrying dry bulk cargo, but these tanks can be used for cargo when carrying liquid cargoes. The slop tanks are surrounded by cofferdams.

Conventional bulk carrier hatches, normally of the side rolling type, are fitted with special sealing arrangements that make them suitable for liquid cargoes.

14.1.1 General guidance

SOLAS prohibits the carriage of petroleum and dry bulk cargoes simultaneously.

The atmosphere in wing tanks should be monitored as any damaged bulkheads may allow flammable gas mixtures to enter the ballast tanks.

Void spaces around cargo holds can allow protected routeing of piping systems and provide access to tank valves and double bottom tanks.

A duct keel or pipe tunnel is fitted about the centreline. Such spaces may not contain cargo pipelines, but may contain:

- Ballast pipelines.
- Fixed washing systems.
- Fixed gas monitoring systems.
- Fixed lighting.
- Mechanical ventilation arrangements.
- Trollies on rails.
- Cargo hold bilge lines.

With restricted natural ventilation, these spaces may be oxygen deficient. As they are adjacent to cargo holds and ballast tanks, both hydrocarbon and IG may pass into them, making those spaces dangerous. Enclosed space entry requirements given in chapter 10 should be followed.

14.1.2 Slack holds in combination carriers

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.

14.1.2.1 Loss of stability

Particular care should be taken when loading or discharging liquid cargo and ballast on combination carriers to ensure that the total free surface effect of cargo and ballast tanks is kept within safe limits, or a sudden list may occur.

Stability data, loading and unloading instructions should be understood and complied with and should specify the maximum number of cargo holds or tanks that may be slack at any one time. It may be necessary to adjust the final quantity of cargo to be loaded 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 should be considered when creating the cargo plan.

Some combination carriers have a valve interlocking system that limits the number of tanks that may be loaded or discharged simultaneously. A notice should be clearly 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 time.

A pre-arrival cargo plan should show the loading or discharging sequence and the distribution and free surface effect of all cargo, fuel and ballast at each stage of the operation.

Terminal operators should understand that combination carriers may be subject to cargo transfer rate limitations for stability and free surface management requirements.

If a loss of stability becomes evident during cargo operations, all cargo, ballast and bunker operations should be stopped and the loading arms or hoses disconnected. A plan should be prepared for restoring positive stability and this should also be agreed with the terminal.

The ship's specific stability information for the condition should be used.

To prevent a loss of stability:

- The ship's vertical centre of gravity should be lowered in the quickest and safest manner.
- Slack double bottom tanks should be filled, starting with those on the low side, followed by those on the high side.
- Do not correct a list by initially filling compartments on the high side, as this may result in a violent change of list to the opposite side.
- If the filling of slack double bottom tanks does not regain stability, consider filling empty double bottom ballast tanks. This will initially result in a further reduction of stability caused by the additional free surface effect, but will quickly be corrected by the added mass below the ship's original centre of gravity.
- Control of a list by adjusting mooring ropes tensions could also result in a violent change of list to the other side, and very slack moorings, and should be avoided.

On completion of loading, the number of slack holds should be at a minimum and no more than that specified in the stability information book.

14.1.2.2 Sloshing

Sloshing is the movement of liquid within a hold when the ship is rolling or pitching. It can cause:

- Structural damage caused by the slamming effect of the liquid against the bulkheads or hatch covers.
- An electrostatically charged mist in the ullage space in holds partially filled with a mixture of oil and water, e.g. dirty ballast or retained tank washings. Cargo tanks and protected slop tanks should always be inerted except when empty and gas free.

Sloshing danger can be limited by reducing the number of slack holds. Cargo quantity may need to be limited to achieve this.

14.1.3 Longitudinal stress

Cargo care planning should address the distribution of the weights along the ship, taking account of the ship's longitudinal strength.

14.1.4 Venting of cargo holds

The vent system on combination carriers is similar to that of conventional tankers, with the vent lines from the cargo holds leading to either individual P/V valves on each tank vent outlet or to a main cargo vent/IG common line that expels the hydrocarbon vapour through a riser at a safe height above the deck or to an IG system pipeline. Typically, the P/V valves are located on the top of the hatch covers. They are disconnected and stored when carrying dry cargo. The cargo tank vent and IG line connection to the cargo holds is arranged to prevent liquid ingress.

During the carriage of dry bulk cargoes, the holds are isolated from the liquid cargo pipeline and gas venting systems.

14.1.5 Inerting of holds

Best practice is for OBOs to maintain their holds in an inerted condition. Agitation of slops or dirty ballast in a slack hold may result in the generation of static electricity. Slack holds should be avoided.

The cargo holds of OBOs are adjacent to ballast tanks, cofferdams, void spaces, duct keels and pipe tunnels. A fracture in the cargo hold boundary plating may cause oil, IG or hydrocarbon gas to enter. Although these spaces should be provided with fixed gas detection, personnel should be aware of the potential formation of gas pockets when ventilating them for entry.

If slops are retained on board due to a lack of reception facilities, the slop tank or tanks should be maintained in an inert condition and the oxygen level should be checked and maintained at not more than 8% under positive pressure.

When the ship is in the dry trade, the slop tanks containing oil or oil residue should be completely isolated from the cargo holds, with piping systems blanked off using blind flanges or line blinds. The P/V valves, IG supply and cargo tank monitoring system serving the slop tanks, as well as the gas detection system in the cofferdams surrounding the slop tanks, should be operational (see the IMO's *Inert Gas Systems*).

14.1.6 Hatch covers

The hatches of OBOs are much larger than on oil tankers, but as they need to remain gas and liquid tight when carrying oil cargoes they are normally of the dual seal type.

Closing device maintenance and operation is critical. Their tension should be checked regularly and adjusted evenly and the screw threads should be cleaned and lubricated.

When closing hatch covers, the closing devices should be evenly and progressively pulled down in the correct sequence and in accordance with the manufacturer's instructions.

The sealing arrangements should be positively tested prior to loading a liquid cargo, by pressurising the holds with IG and applying a soapy solution to the sealing arrangements. Any leakage noted should be fixed by further adjusting the closing devices in the affected area.

The cover joints should also be examined for gas leakage when the compartment is loaded with liquid cargo. Any gas or liquid leaks that cannot be stopped by adjusting the closing devices should be marked or noted, so that the jointing material can be examined at the earliest opportunity and the joint made good. Additional sealing, e.g. by tape or compound, may be needed. A risk assessment should be conducted to identify the measures necessary to mitigate the risk.

The gas-tightness of the hatch covers and vent system will determine the frequency with which the IG needs to be topped up.

It is normal to use synthetic rubber for the hatch seals and it is best practice to carry a stock of this seal material to allow repairs to be carried out as required.

The hatch covers on OBOs can move slightly against the coaming when the ship is flexing in a seaway. The steel hatch cover can rub on the steel coaming, or remnants of a previous dry bulk cargo, but this is unlikely to provide a source of ignition. To minimise wear on the seals it is important to keep hatch cover runways clear of foreign matter. Using a compressed air hose with a suitable nozzle can be an effective approach when clearing the trackways of foreign matter.

Owing to the height of hatch coamings, which can be partially filled when carrying a liquid cargo, all main deck openings into cargo holds may have to withstand positive pressure. All seals and gaskets on tank cleaning covers, access hatches, trimming hatches, etc. need to provide an oil tight and gas-tight seal. The seals should be cleaned when refitting and all securing bolts should be hardened down. The seals should also be tested with a soapy solution before loading a bulk liquid cargo.

14.1.7 Tank washing

Tank washing should be carried out after carrying oil, or when converting from oil to dry bulk cargoes, see section 11.3.

When non-oil cargoes are to be carried, all holds and cargo tanks, other than slop tanks, should be emptied of oil and oil residues and cleaned and ventilated until completely gas free. 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.

Holds should then be inspected internally to confirm their condition. All other 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 for a combination carrier preparing to load or discharge dry bulk cargo. Such certificates will normally relate to holds and other spaces, but not to pumps and pipelines.

14.1.8 Carriage of slops when trading as a dry bulk carrier

Before a combination carrier operates as a dry bulk carrier, any oil contained in the slop tanks should be discharged ashore. After discharging the slops, the empty tanks should be cleaned and inerted before loading any dry bulk cargo.

If slops cannot be discharged, the following precautions should be taken:

- The slop tank should be fully inerted at all times.
- All slops should be transferred to the slop tank designated for this purpose.
- Blanking plates, or similar, should be fitted in all pipelines, including common vent lines leading to or from this slop tank.

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.

14.1.9 Cargo leakage into ballast tanks

Leakage of oil from the cargo holds into the ballast tanks can create similar operational problems to those for a conventional tanker.

Further guidance can be found in section 11.7.

14.1.10 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 free and inspected. Hydrocarbon gas checks should be carried out daily in all empty cargo holds, cargo tanks, double bottom and ballast tanks, as well as pipe ducts, cofferdams, stool tanks and similar void spaces. If no hydrocarbon gas has been detected after 14 days, the checks can be every two days unless the ship passes through areas with higher sea or air temperatures, in which case daily checks should continue.

The readings can be taken every three days if the following voyage is to continue with dry bulk cargoes.

14.1.11 Cargo changeover checklists

The following checklists are a generic guide to help each OBO develop its own specific checklists.

14.1.11.1 Oil to dry bulk cargo

When changing the cargo from oil to dry, the following should be done:

- Wash cargo holds and tanks, including access trunks.
- Flush all main suctions into cargo holds and tanks and strip dry.
- Ensure all cargo holds and tanks are gas free.
- Ensure that cargo deck heaters or fixed heating coils are free of oil before blanking ends.
- Complete hand hosing and digging of holds and sumps.
- Drain cargo holds and cargo suction wells.

- Blank off cargo suctions and drop lines to holds by fitting watertight bolted covers inside cargo holds.
- Ensure sounding pipes to bilge wells are open and clear of obstructions.
- Fit main and stripping suction recess doors. Also, fit heating coil connecting pipe recess doors.
- Wash cargo pipeline system, including pumps, deck lines and bottom lines.
- Ensure gauging system is stowed or blanked as necessary, in accordance with manufacturer's recommendations.
- Drain, vent and verify all gas lines and risers are gas free.
- Blank off gas lines to holds.
- Set up venting system.
- Check hatch cover sealing arrangements and closing devices.
- Check ballast tanks, void spaces and cofferdams for flammable gas. Ventilate and verify as gas free.
- If slops are retained, ensure designated pipeline blanks are fitted, slop tanks are inerted and the venting system is in operation.

14.1.11.2 Dry bulk cargo to oil

When changing the cargo from dry to oil, the following should be done:

- Sweep holds clean, and lift cargo remains out of hold for disposal.
- Wash cargo remnants from bulkheads, stripping slowly to remove water, but let solid residues settle.
- Remove remaining solid residues from the tank top and sumps and verify that the stripping suction is clear.
- Remove suction doors and attach securely to stowage positions.
- Close off sounding pipes to sumps.
- Lower and secure heating coils in place, connect and ensure tight.
- Remove requisite blanks from gauging system and render fully operational.
- Remove blanks from main cargo suctions and stripping discharges to after hold.
- Wash all stripping lines thoroughly to remove solid residues. Check valve seats are not damaged by solid residues and test stripping valves for tightness.
- Check and clean all cargo system strainers.
- Check and clean all hatch cover sealing arrangements, closing devices, trackways, etc.
- Remove blanks from gas lines.
- Set up venting system.
- Prove all valves and NRVs in cargo system.
- Inert cargo holds prior to loading.
- Verify tightness of hatch covers, tank cleaning covers, access hatches and all openings into cargo spaces.

PART 3
Marine Terminal Information

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CHAPTER 15

Marine Terminal Administration

15.1 Marine Terminal Information System

15.2 Documentation

This chapter describes the Marine Terminal Information System (MTIS), which is designed to improve standardisation of the tanker/terminal interface and to act as a best practice guide to help terminals operate more safely.

This chapter gives guidance on maintaining documentation, including the terminal operating manual and Terminal Information Booklet (TIB).

15.1 Marine Terminal Information System

Terminals must comply with all applicable international, national and local regulations and with the terminal's own policy and procedures. Where a self-regulatory regime exists, terminals should meet the spirit and intent of applicable codes and guidelines for their implementation.

OCIMF has developed the MTIS, designed to standardise the tanker/terminal marine interface, filling the gaps that exist in the international standards for marine terminals and putting in place an accepted format of information collecting and sharing. MTIS also acts as a best practice guide to assist terminals in operating more safely and efficiently. The MTIS database serves as a consolidated safety system, providing terminal and ship operators, along with charterers and associated services, with a single, central storage of terminal specifics in a consistent format. Through MTIS, a range of terminal management documents should be used to assist the marine terminal operator in ongoing review and improvement efforts. These tools include:

- *Marine Terminal Particulars Questionnaire (MTPQ)* is an online tool that captures all relevant terminal information, making it easier for ship programmers, schedulers and terminal operators to share information and assess the suitability of the tanker/terminal interface.
- *Marine Terminal Management and Self Assessment (MTMSA)* is a best practice guide aimed at helping marine terminal operators assess and continuously improve their safety, reliability, efficiency and environmental performance.
- *Marine Terminal Operator Competence and Training (MTOCT)* is a guide aimed to assist marine terminal management assess competencies, identify gaps and develop training for terminal operators.

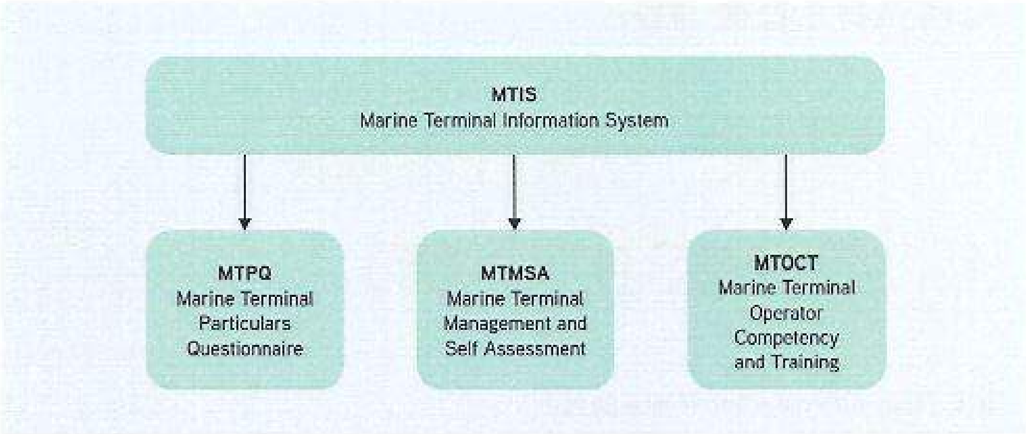

Figure 15.1: Schematics of the available MTIS documentation

15.1.1 Marine Terminal Particulars Questionnaire

The MTPQ is used to collect terminal information in a common format using consistent units of measurement. This collection of comprehensive marine terminal information is essential to:

- Prevent incidents that may harm people or the environment.
- Ensure the compatibility of tankers and terminals.
- Enhance operational efficiency and reliability.

MTPQ database information is available to terminal operators in a format that permits onward transmission. To support the collection of this compatibility information, key information will be input into the MTPQ database, which will assist with tanker to terminal decision making. Criteria for each berth includes as a minimum:

- Berth name.
- Berth type – e.g. jetty, quay wall, sea island or Single Point Mooring (SPM).
- Depth of water – Minimum controlled water depth alongside berth at chart datum.
- Minimum static Under Keel Clearance (UKC) at berth – UKC at berth is represented as a limit in either metres, percentage of draught or percentage of beam.
- Other UKC criteria.
- Length Overall (LOA) minimum or maximum.
- Alongside displacement – The displacement figures should be quoted to define the maximum size of tanker 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.
- Summer deadweight – Note: The use of deadweight as a parameter for setting tanker size limitations is not recommended because this, on its own, is not a measure of size or of total weight of ship for calculation of berthing energies.
- Maximum beam – This is required to manage restrictions imposed by a lock, dock or river transit.
- Bow to Centre of Manifold (BCM) – This is used to ensure alignment between tanker and terminal manifold connections.
- Manifold height above the water – maximum and minimum – This is to ensure that the tanker can keep the cargo transfer systems (arms/hoses) connected throughout the load or discharge and at all states of the tide. At some tidal locations it may be necessary to disconnect the Marine Loading Arms (MLAs) during tidal extremes.
- Stern to Centre of Manifold (SCM).

- Manifold presentation flange to ship side.
- Minimum Parallel Body Length (PBL) – This is used to verify whether the tanker will rest against the fenders under ballast or under loaded conditions, when in position with the cargo connection made.
- Minimum PBL forward of manifold centreline.
- Minimum PBL aft of manifold centreline.
- Security procedures.

In documenting 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.

Other criteria may be considered depending on the design configuration and the operation to be handled.

For more information on SPM, All Buoy Mooring (ABM) or Conventional Buoy Mooring (CBM) berths, refer to OCIMF's *Single Point Mooring Maintenance and Operations Guide* and *Guidelines for the Design, Operation and Maintenance of Multi Buoy Moorings.*

15.1.2 Marine Terminal Management and Self Assessment

Terminals should have a documented management system to demonstrate compliance with regulatory requirements and the terminal's policy and procedures. Terminal management should designate a person to be responsible for ensuring compliance with the regulations, company policy and procedures.

Terminal management should provide a healthy and safe work environment and ensure that all operations are conducted with minimum effect on the environment while complying with the regulatory system in force and recognised industry codes of practice. Reference should be made to the guidance contained in OCIMF's MTMSA. MTIS includes an MTMSA Site Verification Guideline (SVG) to help assessors review the self-populated MTMSA against the terminal site. Terminal operators are encouraged to keep a completed SVG as documented evidence of their self assessment.

The self assessment process covers principal areas of management practice together with supplementary elements that address buoy berths and operations in ice or in severe sub-zero air temperatures:

Element 1	Management, leadership and accountability
Element 2	Management of personnel
Element 3	Port and harbour operations
Element 4	Terminal layout
Element 5	Ship/shore interface
Element 6	Transfer operations
Element 7	Maintenance management
Element 8	Management of change
Element 9	Incident investigation and analysis
Element 10	Management of safety, occupational health and security
Element 11	Environmental protection
Element 12	Emergency preparedness
Element 13	Management system review

Supplementary Elements:

Element 14 Operations at buoy moorings

Element 15 Terminals impacted by ice or severe sub-zero air temperatures

15.1.3 Marine Terminal Operator Competence and Training

Terminal management should ensure that personnel engaged in tanker/terminal operations are trained and competent in their duties. Personnel should be aware of national and local rules and of port authority requirements that affect terminal operations and the way they are implemented locally.

OCIMF's *Marine Terminal Operator Competence and Training Guide (MTOCT)* helps marine terminal managers ensure the personnel operating the marine interface have all the necessary skills and experience. Terminal personnel should be familiar with the sections of this document that are applicable to their work location and duties.

MTOCT helps identify competences and knowledge requirements for roles, together with verification processes, enabling terminal managers to assess each member of staff against best practice, identify gaps and develop targeted operator training programmes. *MTOCT* includes guidance on training records and verifying that the training programme is achieving set goals.

15.2 Documentation

15.2.1 Terminal operating manual

Terminals should have a documented Terminal Operating Manual that is reviewed annually.

The Terminal Operating Manual is a working document that details procedures and drawings relevant to the terminal. The Manual should be available in the working language of terminal personnel.

The Terminal Operating Manual should define the roles and responsibilities of berth operating personnel and the procedures associated with emergencies such as fire, gas cloud, product spillage and medical emergencies. A separate emergency response plan 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 detailed guidance on emergency planning and response.

15.2.1.1 Operating procedures

Operating procedures provide personnel with access to documented instructions detailing how to safely operate the marine terminal. Procedures should be available, using simple language and, at a minimum, include:

- Terminal plan drawings.
- Vessel acceptance criteria (berth limits).
- Limiting weather conditions for operations (see section 16.1).
- Mooring guidelines.
- Safe tanker/terminal access.
- Cargo transfer.
- Cargo transfer equipment operating procedures.
- Static electricity precautions.
- Tanker/terminal electrical isolation.

- Fire and emergency response, including emergency evacuation plans.
- Environmental protection, including management of surface water, leakages, and spills.
- Hazardous products and vapours.
- Visitor induction and familiarisation.
- Shift handover.
- Gauging and sampling.
- Cargo line and sump tank draining.
- Routine cleaning procedures.
- Control and shutdown procedures, including Emergency Shutdown (ESD) and ship/shore link (where fitted).
- Bunker operations.
- Plan of firefighting systems locations.
- Standby tug operations.

15.2.1.2 Organisation roles and responsibilities

Clearly defined roles and responsibilities enable marine terminal management to ensure that personnel responsible for activities at the tanker/terminal interface are trained, qualified and supervised.

All roles and responsibilities for marine terminal personnel (employees and contractors) working within the tanker/terminal interface should be defined and documented. Delegation of authorities should also be documented. Personnel assigned to identified roles should be verified (using *MTOCT*) as competent. Manning levels should be sufficient to meet all operational requirements, considering:

- Effective monitoring and continuous supervision of operations.
- Size of the facility.
- Volume and type of products handled.
- Number and size of berths.
- Number, type and size of tankers visiting the terminal.
- Degree of mechanisation employed.
- Amount of automation employed.
- Ancillary duties for personnel.
- Firefighting duties.
- 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.
- 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. Note: If mooring boats and line handling are provided by the local port authority or by their contractor, they should comply with terminal safe mooring requirements. More information can be found in section 9.7 and in OCIMF's MTMSA.

When considering the effective monitoring of the tanker/terminal interface, good operating practice requires a competent member of the terminal organisation to be on duty in the vicinity of the tanker to terminal connections. This level of supervision should be aimed at preventing hazardous situations developing and be based on risk assessment.

In establishing manning levels, due account should be taken of any local or national legal requirements. Consideration should also be given to the avoidance of fatigue, which may result from extended hours of work or insufficient rest periods, by providing time off between shifts.

More information can be found in OCIMF's *Manning at Conventional Marine Terminals*.

15.2.2 Terminal Information Booklet

Terminals should have procedures in place to manage the exchange of information between the tanker and the terminal before the tanker berths. This will ensure the safe and timely arrival of the tanker at the berth, with both parties ready to commence operations.

Detailed information on communications at the tanker/terminal interface is given in chapter 21. More information can be found in chapter 6 on security at the tanker/terminal interface.

The format of the TIB should follow OCIMF's *Marine Terminal Information Booklet: Guidelines and Recommendations*. This guidance gives terminal operators a template for presenting important terminal and port information in a booklet, for easy and consistent reference by ship personnel, shipowners, operators, charterers and others.

The TIB can be stored as an attachment to the MTPQ to facilitate access for stakeholders and to ensure the latest version of the TIB is always available.

15.2.3 Documentation

Terminals should maintain a set of documents to ensure compliance with regulations, procedures and industry practices. These should provide comprehensive information on the facilities and equipment associated with the management of the tanker/terminal 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 and company policies.
- 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.
- Certificates for equipment and processes.

15.2.3.1 Inspection maintenance and repair documentation

Documentation should include a comprehensive set of 'as built' construction drawings and specifications for both berth and terminal facilities, including operating envelopes for MLAs or hoses and all modifications made since first commissioned.

A current record of equipment and structures important to the safe operation of the terminal should be maintained. This should include specifications, purchase orders and inspection and maintenance data. Examples of important items include:

- Dock and approach trestle structures.
- Fenders and mooring hardware.
- Safe access, including gangways and access towers, ladders, catwalks and handrails.
- Lifting equipment.
- Cargo transfer equipment, including MLAs/hoses, hydraulic systems, Vapour Emission Control Systems (VECSs), monitoring and warning systems, ESD systems, large valves, pumps, and meters.

CHAPTER 16

Marine Terminal Operations

16.1 Limiting conditions for operations

16.2 Electrical storms

16.3 Double banking

16.4 Tanker/terminal access

16.5 Over the tide cargo operations

16.6 Operations where the tanker is not always afloat

16.7 Generation of pressure surges in pipelines

16.8 Reduction of pressure surge hazard

16.9 Hot work in hazardous areas in terminals

16.10 Pigging

This chapter provides information on terminal procedures and activities that influence tanker/terminal operations. This includes the assessment of limiting environmental criteria for safe operations and provision for a safe means of access between the tanker and the terminal.

Operations requiring special procedures are described, including the double banking of tankers and the loading and discharging of cargo using tidal increases in depth of water (over the tide).

The chapter also includes an explanation of the phenomenon of pressure surge in pipelines and discusses the manner in which it may be assessed and controlled.

16.1 Limiting conditions for operations

Considering the existing restrictions on each berth, e.g. Safe Working Load (SWL) of the mooring system components and, if applicable, the operating envelopes of the MLAs and hoses. Terminal operators should establish Terminal Operating Limits (TOLs) defining the thresholds for:

- Manoeuvring during arrival and berthing.
- Berthing and mooring.
- Ceasing loading or discharging.
- Disconnecting cargo hoses or MLAs.
- Calling tug assistance.

- Removing the tanker from the berth.
- Manoeuvring during unberthing and departure.
- UKC limitations.

Operating limits should be based on prevailing environmental conditions, including:

- 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.
- Height of tide.

Information on environmental limits should be passed on to the tanker personnel in pre-arrival communications (as detailed in the TIB), verified at the pre-cargo transfer conference and, where applicable, be formally recorded in the Ship/Shore Safety Checklist (SSSCL) (see chapter 25). Local weather forecasts and weather alerts received by terminal personnel should be passed to tanker personnel and vice versa.

The terminal should, if possible, have a locally installed anemometer for measuring wind speeds.

Tanker and terminal personnel should use all available means to obtain early warning on metocean conditions. This includes local observations and the use of live information obtained from a competent agency.

Provision of weather monitoring stations, at strategic locations around the terminal, provides the capability to monitor weather conditions and predict the onset of weather that could impact the safety of tankers and personnel.

Availability of equipment for the measurement of other environmental factors, e.g. current meter, tidal gauge and wave buoy, should be considered where identified as critical by a risk assessment.

When berths are positioned in open water, passing ship(s) speed, tidal flow, interaction between moored ships, space between other moored ships, minimum safe passing distances, movement of other vessels in the area and weather conditions should be assessed. Excessive movement caused by passing ships can cause significant damage to tanker and terminal assets.

When berths are positioned in canals, inland waterways and rivers, the above should be assessed with respect to passing ships, including restricted movement caused by the width of canal banks and buoyed channels and any safe speed restrictions that may be in place. Terminal and tanker personnel should be aware of potential increases in interaction in a canal or inland waterway that may be caused by a reduction in width or depth of water (UKC) within a waterway.

16.1.1 Risk assessment

Tanker and terminal operators should assess, determine and have clear guidance on the following:

- Operations that need to immediately cease (in addition to operations described in the first part of this section) in the event of adverse metocean conditions.
- Operations that can continue with precautions.

The risk assessment should consider, but not be limited to:

- Personnel exposure in the specific operation and environment.
- Vulnerability of the people and assets.
- Availability and reliability of protection system.
- Risks associated with stopping an activity or operation.

16.2 Electrical storms

When an electrical storm is detected, the following operations should be stopped:

- Handling of flammable products.
- Ballasting of tanks not free of hydrocarbon vapour.
- Sampling, gauging, purging, tank cleaning or gas freeing after the discharge of flammable products.

All tank openings, open manifolds or hose connections and vent valves should be closed or blanked, including any bypass valves fitted on the tank venting system.

At terminals where a site risk assessment has determined an increased probability of electrical storms, consideration should be given to the installation of equipment or provision of forecasting services to provide early notification of approaching electrical storms.

16.3 Double banking

Double banking occurs when two or more tankers are berthed alongside each other in such a way that the presence or operations of one tanker act as a physical constraint on the other. Double banking is sometimes used as a means of conducting multiple transfers between the terminal and more than one tanker at the same jetty. The outermost tanker may be moored to an inner tanker or to the terminal itself and hose strings led from the terminal, across the inner tanker, to the outermost or between the two tankers. This causes additional risk in management of the tanker/terminal interface.

In addition to the SSSCL, the relevant guidance can be found in OCIMF's *Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases (STS Guide)* and *International Safety Guide for Inland Navigation Tank-barges and Terminals (ISGINTT).*

Documented procedures, derived from a risk assessment, should include:

- Designation of a responsible party for the supply of equipment and a Person In Charge (PIC).
- Relevant information from jetty structural and mooring analysis, including passing ship study.
- Relevant information from mooring compatibility assessment between ships.
- Safe arrival and departure operating limits, mooring fittings, mooring arrangements, personnel access, management of operational safety, liability, contingency planning, firefighting and emergency unberthing.
- Safe passage for other ships using the terminal berth(s) and port facilities.
- Transfer of personnel between double banked tankers.
- Pollution prevention.
- Provision of lighting.

16.4 Tanker/terminal access

16.4.1 General

Means of access between tanker and terminal are often addressed by national regulation, usually by the Port State or by the tanker's Flag State (see chapter 6 on security). Means of access must meet these standards and be correctly rigged by either tanker or terminal personnel, as appropriate.

Personnel should use the designated means of access between tanker and terminal.

16.4.2 Provision of tanker/terminal access

Responsibility for the provision of safe tanker/terminal access is jointly shared between tanker and terminal personnel. Requirements for provision of safe access should be detailed in the pre-arrival communications. The preferred means for access between tanker and terminal is a shore based gangway.

When terminal access facilities are not available and a tanker's gangway is used, the berth should 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 safe access is provided by the terminal or the tanker, the gangway should be subject to inspection as part of the ship/shore safety checks that are carried out at regular intervals throughout the ship's stay at the berth.

16.4.3 Access equipment

All means of access should meet the following criteria:

- Clear walkway.
- Continuous handrail on both sides.
- Electrically insulated to eliminate continuity between tanker and terminal.
- Adequate lighting.
- For gangways without self-levelling treads or steps, the maximum safe operating angle should be marked.
- Lifebuoys should be available with light and line on both tanker and terminal.
- Marked with SWL or maximum number of persons.
- Means of access should be placed as close as possible to crew accommodation areas and as far away as possible from the manifold.
- Provide, so far as practicable, safe access/egress to accommodations.
- Means of access also provide 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 20).
- The jetty area for landing a tanker's gangway should be open, clearly identified and unobstructed with access to the area maintained clear.

16.4.3.1 Shore gangway

When provided by the terminal, a gangway should allow safe access between terminal and tanker.

In addition to the criteria in section 16.4.3, shore gangways should meet the following additional criteria, as appropriate:

- Remain clear of the tanker when in the stored position.
- Provide for locking against motion in the stored position.
- Allow free movement after positioning on the tanker.
- Have backup power or manual operation in the event of primary power failure.
- Be designed for berth specific operating conditions.

Automatic gangways may be provided, consisting of a stairway tower with an adjustable bridge that spans from the tower to the tanker's deck. The bridge section is adjusted for height depending on the tanker's freeboard.

At some berths, it may be necessary to provide access from an internal stairway below the working level of the berth.

Tankers with external deck framing, more commonly seen on chemical tankers and product carriers, pose particular challenges in their ability to provide a suitable area for the placement of shore gangways.

16.4.3.2 Portable gangways (tanker or terminal)

A portable gangway consists of a straight, lightweight bridging structure with side stanchions and handrails. The walking surface has a non-slip surface or transverse bars to provide foot grips for when it is at an incline. It is rigged perpendicular to the tanker's side and the working deck of the berth.

Portable gangways should not be landed on tanker's handrails, unless the handrails are designed for this purpose. When gangways are mounted over the tanker's handrails, access steps with handrails (bulwark ladders) should be provided to enable safe access to and from the deck.

Where practical, the gangway should be deployed at a gate in the tanker's handrails.

Portable gangways provided should be of adequate minimum length to safely operate throughout all states of tide, changes in freeboard and motions of the tanker.

16.4.3.3 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 a large radius non-slip thread. The ladder is usually rigged 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's working deck.

16.4.3.4 Safety nets

Safety nets are not required if the gangway is fixed to the shore (see section 16.4.3.1) and provided with a permanent system of handrails. For other types of gangways and those fitted with rope or chain handrails or removable posts, correctly rigged safety nets should be provided.

The safety net should be rigged to prevent any person from falling into the water or directly onto the jetty/ground. It should extend from the ship's side at the boarding point to the bottom landing platform and suitability should be checked by a Responsible Person.

16.4.4 Alternative means of tanker/terminal access

If circumstances are such that a practical and safe means of access cannot be provided directly between tanker and terminal, the only safe alternative may be to use a boat to ferry personnel to/from the access point on the offshore side of tanker. If this means of access is used, an additional means of access and egress may also need to be provided for emergencies.

16.4.4.1 Personnel transfer by basket

Personal transfer baskets present unique safety risks and are not recommended except in specific circumstances. See OCIMF's *Transfer of Personnel by Crane between Vessels*.

16.4.5 Routine maintenance

All terminal gangways and associated equipment should be routinely inspected and tested. This requirement should be included in the terminal's planned maintenance programme. Mechanically deployed gangways should be function tested. Self-adjusting gangways should be fitted with alarms that should be routinely tested. More information can be found in OCIMF/SIGTTO's *Jetty Maintenance and Inspection Guide*.

16.5 Over the tide cargo operations

Over the tide cargo operations use tidal changes in water depth, either by finishing the loading of a tanker as the water depth increases towards high tide or discharging cargo to lighten a tanker before the low tidal level is reached.

Documented procedures should be established for terminals that require over the tide cargo operations. Procedures should be derived from a risk assessment process (see chapter 4).

The terminal should confirm that the tanker's equipment that is critical to the operation, such as cargo pumps and main engines, is operational prior to berthing and is kept available while the tanker is alongside at the critical stage.

16.5.1 Discharging over the tide

Discharge over the tide is where a tanker is required to use a berth where the laden arrival draught will exceed the available water depth at, or approaching, low water, but where it may be possible to discharge sufficient cargo to remain afloat. This procedure should be adopted where all parties concerned accept the risk involved and agree to adopt mitigating procedures to ensure that the tanker can be discharged in a timeframe to always remain afloat or be removed from the berth to a position where it can remain afloat.

16.5.2 Loading over the tide

Loading over the tide is undertaken where a tanker cannot remain safely afloat during the low water period. The tanker should stop loading at the draught at which it can remain afloat and recommence loading as the tide rises. Loading should not resume unless equipment critical for the departure of the tanker from the berth, e.g. main engine, is ready for use. The loading rate should allow the tanker to complete loading and allow time for cargo measurements, sampling, documentation, clearance formalities and unberthing while maintaining the required UKC.

16.6 Operations where the tanker is not always afloat

Operations where a tanker is not always afloat are considered exceptional and should only be permitted following a risk assessment and the implementation of all safeguards identified to deliver a safe operation.

The type of operation varies depending on circumstances, e.g. taking the ground for a brief period during its stay at the berth, or a tanker being completely out of the water. The following should be considered:

- There should be agreement between the port, terminal and tanker owner/operator before the operation takes place.
- Seabed should be surveyed and proved to be flat and with no high spots.
- Slope of the seabed should not result in any excessive upthrust on the tanker's structure or cause any loss of stability when the tanker takes the ground.
- Tanker's hull strength should be sufficient to take the ground without excessive stress being placed on the structure. This may require the tanker's design and scantlings to be augmented to allow it to take the ground safely.
- Operation should not result in the tanker losing any of its essential services, e.g. cooling water for the machinery or its firefighting capability. This may require the incorporation of special design features into the tanker.

- As it will not be possible to remove the tanker from the berth in the event of an emergency, port operations need to address specific emergency procedures and the provision of appropriate firefighting equipment.
- Contingency plans should address the possibility of structural failure on the tanker and resultant pollution.

16.7 Generation of pressure surges in pipelines

16.7.1 Introduction

A pressure surge occurs when the flow rate of a liquid rapidly changes and becomes unsteady. Variations in the flow rate of a liquid are caused by events, e.g. pump starting or stopping, a valve opening or closing or a reduction of pipeline diameter.

During cargo transfer operations, a pressure surge can result in a significant loss of cargo containment as the cargo transfer system is exposed to a peak pressure exceeding the design pressure rating of the cargo transfer system.

Pressure surges may:

- Rupture one or more of the cargo system components.
- Create an inertial force exceeding the structural design rating of the pipeline supports, resulting in displacement of the cargo pipelines and failure of pipeline couplings.

16.7.2 Generation of a pressure surge

When liquid flows from one tank down a pipeline and through a valve into another 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 any point in the system in question: when the atmospheric pressure is added to the hydrostatic pressure this becomes an absolute pressure.
- Hydrodynamic pressure generated by the pump: this is highest at the pump outlet and decreases along the line downstream of the pump and through the valve to the receiving tank.

The total pressure generated by the pump to overcome resistance in the pipeline system is the sum of the hydrostatic and the hydrodynamic pressures and is affected by:

- Length, internal surface roughness and directional changes in the pipeline.
- Viscosity of the liquid being pumped.
- Nominal bore (diameter) of the pipeline.

Rapid closure of the valve puts a brief additional pressure upon all three components, due to the sudden conversion of the kinetic energy of the moving liquid into pressure. When the valve closes, the liquid immediately upstream of the valve is brought to rest instantly.

The sudden stop of flow of liquid is transmitted back up the pipeline as a pressure wave travelling at the speed of sound. If the pressure is not relieved, the result is a pressure wave that moves back and forth throughout the length of the pipe until it finally decays.

In most cases, valve closure is not instantaneous and there is some relief of the surge pressure through the valve while it is closing. Worst case is a valve shutting instantly, where damage to expansion couplings and butterfly valves can occur.

The damage caused by a pressure surge can be further increased by a vapour cavity collapse, which occurs when vapour cavities or bubbles in the liquid collapse when exposed to the pressure surge wave. Vapour cavities may be present in the high points of the cargo transfer system, such as the apex swivels of the MLA.

Many marine terminals have installed remotely operated valves that shut when a high-high level alarm ullage is reached in a receiving shore tank. The activation of a remotely operated valve while a ship is discharging to a shore tank may result in the whole cargo system being exposed to a pressure surge.

16.8 Reduction of pressure surge hazard

16.8.1 General precautions

Operational parameters for maximum allowable flow rates and minimum valve closure times should be established based on an engineering surge analysis.

Where motorised valves are installed, several steps can be taken to reduce the risk of pressure surge problems:

- Reduce the 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. This will depend on the valve design but, in general terms, total closure times should be 30 seconds or greater.
- Use a pressure relief system, surge tanks or similar devices to absorb the effects of the surge sufficiently quickly.
- Provide a linked ship/shore ESD system including appropriate optional activators in the system to enable cargo pumps to be stopped immediately once a surge event is initiated. See chapter 18 for further information on linked ESD systems.
- Program valves to fail in last position to prevent unexpected and immediate closure due to power failure.

Where manually operated valves are used, good operating procedures should avoid pressure surge conditions. It is important that a valve at the end of a long pipeline should not be closed suddenly against the flow and so all changes in valve settings should be made slowly.

See chapter 12 for general guidance on correct operation of tanker valves.

16.8.2 Operational measures to reduce the risk of a pressure surge

In the operational context, the only practical precautions 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.

During the pre-transfer conference, tanker and terminal representatives should exchange information on managing the risks associated with pressure surge, including:

- Closure of automatic ESD valves.
- Rapid closure or opening of a manual or power operated valve.
- Sudden starting or stopping of a pump.
- Number of open cargo tank inlet valves.
- Elevation of shore tanks.
- Changes in pipeline and/or terminal tank that are planned to take place during cargo operations.

Terminals should have a documented tank changeover procedure, agreed during the pre-transfer conference, to reduce the risk of pressure surge.

Attention should be paid to whether the ship's pumps are positive displacement or centrifugal pumps, as this will impact surge risks related to unintentional closure of a terminal valve against the flow of cargo.

16.9 Hot work in hazardous areas in terminals

Hot work should not be allowed in the terminal while cargo operations are being carried out on a tanker, an adjacent tanker or in the terminal, without special precautions and the agreement of the tanker and terminal representatives.

It should be noted that dangerous or hazardous areas on the tanker and terminal may be wider than expected due to the alignment of the tanker alongside the terminal and the nature of operations taking place.

All hot work locations should be continuously monitored for the presence of flammable gas. The monitoring should take place in the immediate vicinity of the place or places where hot work is being carried out. If flammable gas is detected, all work should be immediately stopped, and the situation investigated before any approval to resume is authorised by the tanker and terminal managers.

When a risk assessment determines a fire watch is required, a fire watch with no other duties, except to watch for the presence of fire and to prevent the development of hazardous conditions, should be instituted. The fire watch team should have fire-extinguishing equipment readily available and be trained in its use. Before leaving the site and declaring the work completed, they should ensure that all hot surfaces have cooled and that no source of ignition exists.

16.10 Pigging

Pigging is a form of line clearing in which an object, often in the form of a rubber sphere or cylinder 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 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. In some cases, smart pigs, which may be self-propelled, are used to inspect pipeline condition for the purpose of renewal and preventing leaks.

A common arrangement for catching the pig is for the shore terminal to be outfitted with a pig receiver, which is mounted outboard of the tanker'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 on 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, terminal personnel 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 would also indicate that free movement of the pig has been restricted.

On completion of the pigging operation, terminal personnel should positively verify that the pig has arrived. Any residual pressure in the shore line should then be bled-off before opening the pig receiver or disconnecting MLAs or hoses.

Personnel at the receiving end should be aware that there may be sediment in the pig receiver unit and there should be procedures in place to deal with this, e.g., rags, absorbent material and drums. Considerations and measures should be in place for any toxic components that may be present during the retrieval.

CHAPTER 17

Marine Terminal Systems and Equipment

17.1 Electrical equipment

17.2 Lifting equipment

17.3 Lighting

17.4 Tanker/terminal electrical isolation

17.5 Earthing and bonding practice in the terminal

This chapter describes equipment that is available at the terminal, specifically at the tanker/terminal interface, including lifting, lighting, bonding and earthing equipment.

Emphasis is placed on ensuring that tankers and terminal remain electrically isolated and means of how that isolation is achieved.

17.1 Electrical equipment

The classification of hazardous areas for the installation or use of electrical equipment within a terminal is described in section 4.10.

Terminals should ensure that any electrical equipment provided is in accordance with a site specific electrical classification drawing, which shows hazardous zones at the berths in both plan and elevation format.

Electrical classification drawings should record the type and compliance of equipment installed within each zone. National legislation, international standards and company specific guidelines are to be complied with. A Planned Maintenance System (PMS) should address the continued integrity of the equipment installed and ensure it remains able to meet hazardous 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 either 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 chapter 4).

17.2 Lifting equipment

17.2.1 Inspection and maintenance

All cargo transfer lifting equipment and/or means of access to such lifting equipment 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. Visual inspections should be performed by the berth operator before each use. Maintenance should be conducted in accordance with OCIMF/SIGTTO's *Jetty Maintenance and Inspection Guide*, national regulations and the manufacturer's recommendations. Tests, inspections and maintenance should be recorded in the terminal's PMS.

Equipment to be tested and examined includes:

- Cargo hose handling cranes, derricks, davits and gantries.
- Gangways and associated cranes and davits.
- Stores' 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 qualified individual or authority and the equipment should be marked with its SWL, identification number and test date.

If lifting equipment is modified or repaired, it should be re-tested and re-certified before being placed back in service. Use of temporary mobile lifting devices should be risk assessed by terminal personnel, considering all operational hazards including structural jetty loads.

Defective equipment should be labelled as out of service, withdrawn from use immediately and only reinstated after repair, examination and, where required, re-certification.

17.2.2 Training in the use of lifting equipment

All personnel engaged in operating lifting equipment should be trained in its use. Training should be refreshed in accordance with local regulatory and company requirements. More information can be found in OCIMF's *Marine Terminal Operator Competence and Training Guide*.

17.2.3 Use of tanker lifting equipment

When terminals use a tanker's equipment for lifting hoses, terminal gangways, or other terminal equipment, checks should be made to ensure the equipment has an adequate SWL before its use. For hose handling, the terminal should establish a minimum SWL requirement based on the length of the hose to be lifted, including contents remaining when draining the hose. Terminal personnel should confirm that tanker cranes have been inspected and certified before use and this should be confirmed at the pre-transfer conference. The use of tanker cranes for lifting of submarine or floating hoses is referenced in OCIMF's *Single Point Mooring Maintenance and Operations Guide*, *Guidelines for the Design, Operation and Maintenance of Multi Buoy Moorings* and *Guidelines for Offshore Tanker Operations*.

17.3 Lighting

Terminals should have a level of lighting sufficient to ensure that all tanker/terminal interface activities can be safely conducted during periods of darkness.

Work areas designated for loading or unloading of cargo should maintain a minimum lighting level of 50 lux, or in accordance with local and national regulations. More information can be found in

EU standard 12464-2 and the UK Maritime and Coastguard Agency's (MCA) *Code of Safe Working Practices for Merchant Seafarers (COSWP).*

Other work areas at the terminal, outside of the manifold area, should maintain an adequate lighting level that, as a minimum, meets local and national regulation to ensure safe operations. Particular consideration should be given to lighting of the following areas:

- Berth or jetty-head working areas.
- Access routes.
- Tanker/terminal access.
- Berth or jetty perimeters.
- Boat landings.
- Mooring dolphins and walkways.
- Stairways to elevated gantries.
- Emergency escape routes.
- Water around berth, to detect spills and unauthorised craft.

Lighting should be included as part of the terminal inspection and maintenance plan. See OCIMF/SIGTTO's *Jetty Maintenance and Inspection Guide.*

17.4 Tanker/terminal electrical isolation

17.4.1 General

Due to possible differences in electrical potential between the tanker and the berth, there is a risk of electrical arcing at the manifold during connection and disconnection of the terminal hose or MLA. To protect against this risk, there should be a means of electrical discontinuity at the tanker/terminal interface. This should be available at the terminal.

It should be noted that the subject of tanker to terminal electric currents is separate from static electricity, which is discussed in chapter 3.

17.4.2 Tanker to terminal electric currents

Large currents can flow in electrically continuous pipework and flexible hose systems between the tanker and terminal. The sources of these currents include:

- 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.

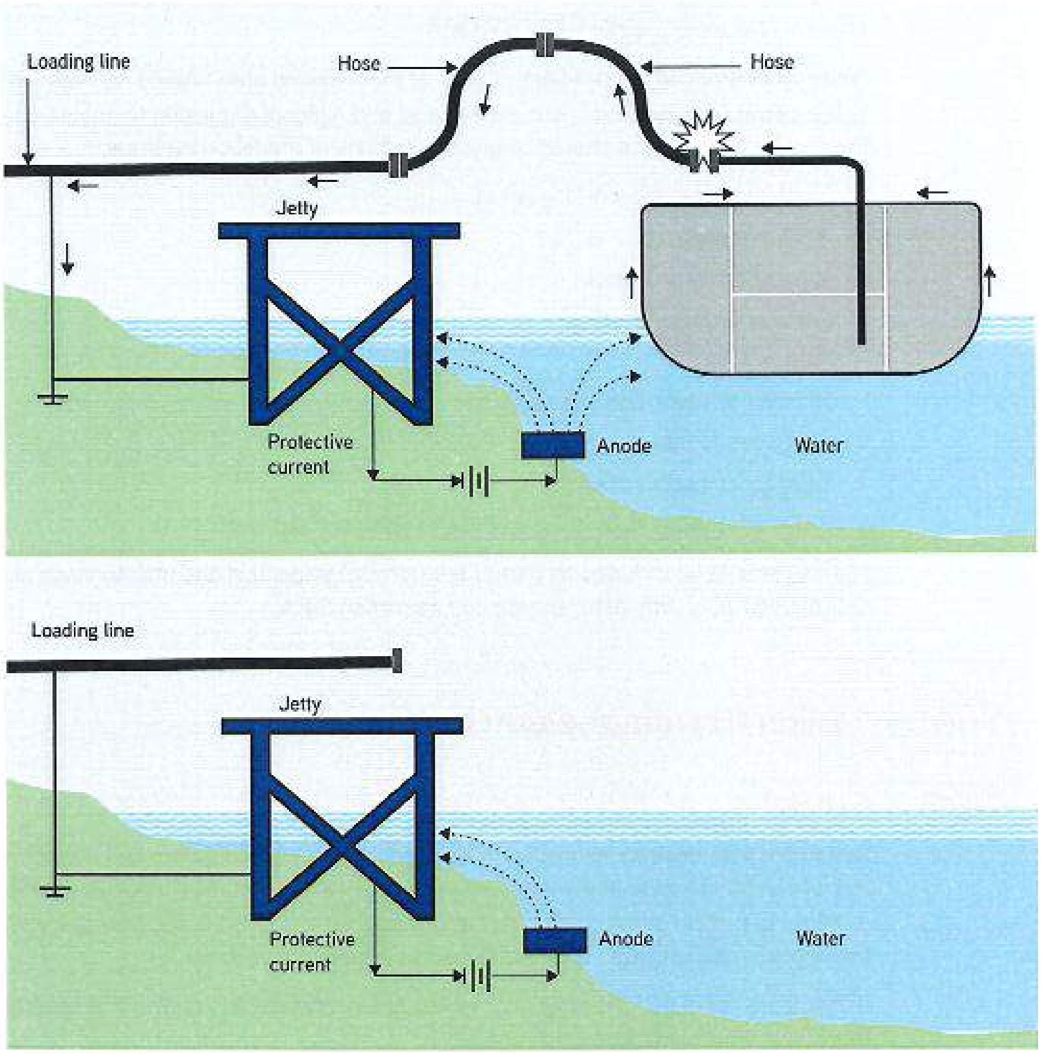

Figure 17.1: Stray currents from cathodic protection

An all metal MLA provides a very low resistance connection between tanker and terminal and there is a possibility of an incendive arc when the ensuing large current is suddenly interrupted during the connection or disconnection of the MLA at the tanker manifold. Similar arcs can occur with metallic connections between the flanges of each length of a flexible hose string.

To prevent electrical flow and subsequent arcing between a tanker and a terminal during connection or disconnection of the terminal hose or MLA, the terminal operator should ensure that there is sufficient electrical discontinuity between the jetty and tanker. This can be achieved by:

- Fitting MLAs with an insulating flange.
- Using Type R or Grade M (Type S or L) electrically continuous hoses with an insulating flange or insulating block fitted at one end of the hose string.
- Including one length only of electrically discontinuous hose in each continuous string.
- Using Grade Ω (Type S or L) hoses without an insulating flange and provided the resistance of each hose assembly has been tested and exceeds 25,000 ohms (see section 18.2.6.4). Note that Grade Ω hoses are not marked as electrically discontinuous and that test records should be checked to determine whether they provide adequate electrical discontinuity (see section 18.2.4).

A single length of electrically discontinuous hose is, typically, provided on the terminal side of the hose string, but may be provided at any location as long as all segments remain isolated from materials they could potentially touch, including the tanker hull and/or jetty deck. Use of more than one section of electrically discontinuous hose may result in electrically isolated sections that allow for the build-up of electrical potential within the isolated section. When non-conductive hoses are used for isolation purposes, care should be taken to ensure that conductive pathways are not introduced by lifting or support equipment, such as nylon or other non-conductive materials for lifting straps.

The additional resistance limits the flow of stray current, through the MLA or the hose string, to a safe level. However, the whole system should remain earthed, either to the tanker or to the shore. The above text refers to conventional alongside berths. OCIMF's *Single Point Mooring Maintenance and Operations Guide* 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 tanker and all metal on the landward side should be electrically continuous to the jetty's earthing system. This arrangement will ensure electrical discontinuity between tanker and terminal and prevent arcing during connection and disconnection. Loading arm swivels should include bonding wires across flanges to ensure electrical continuity. If hoses are used for draining or purging loading arm contents and/or for hydraulics or lubricating systems, then these should also follow the same continuity and isolation requirements as the arm itself. When hoses are deployed on reels they should be electrically isolated.

The insulating flange or single length of discontinuous hose should not be short circuited by contact with external metal.

It should be noted that the requirements for electrical discontinuity also apply to the vapour recovery connection.

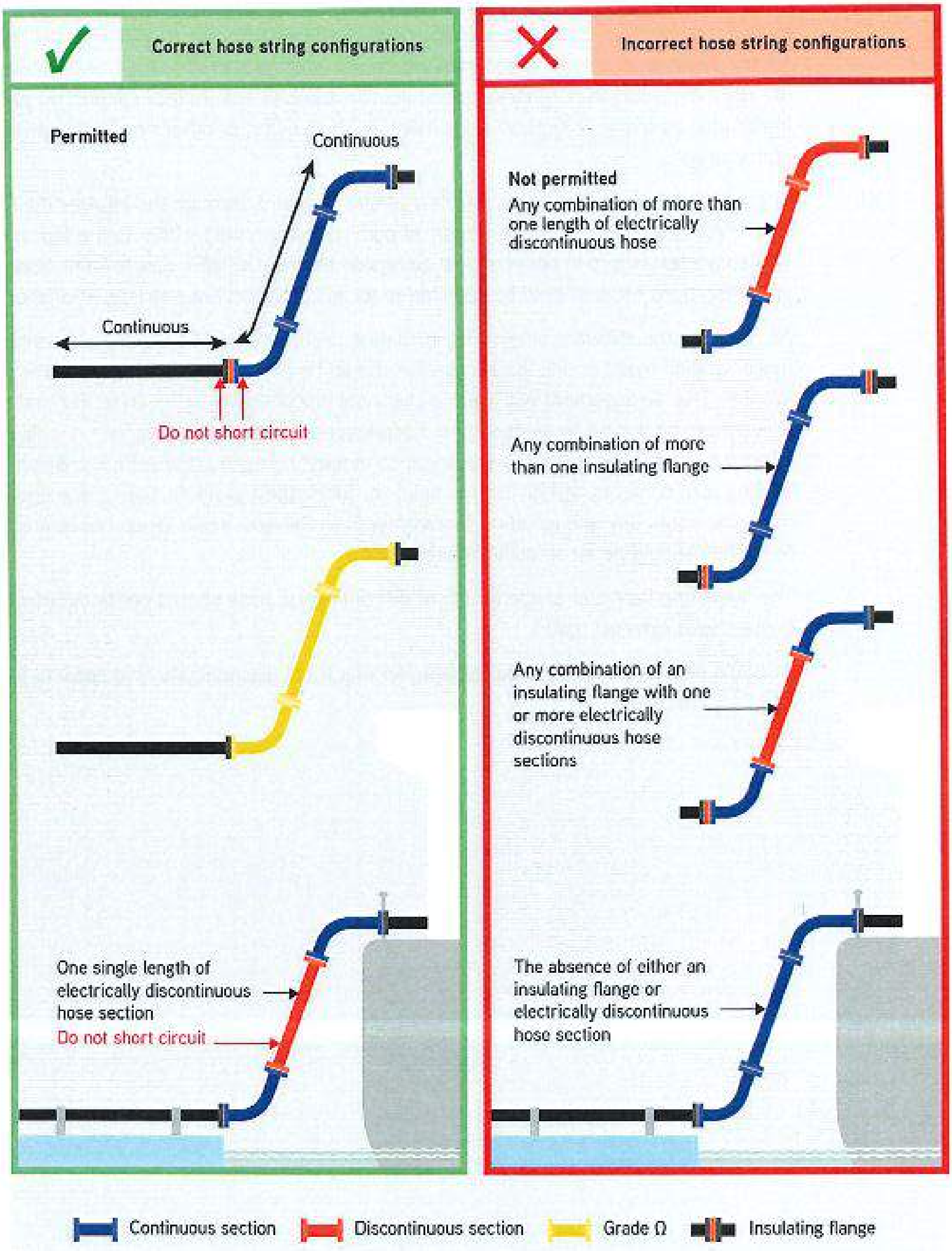

Figure 17.2: Hose string configurations for electrical isolation

Current flow can also occur through any other electrically conducting path between a tanker and terminal, for example mooring wires or a metallic ladder or gangway. These connections should be insulated to prevent further electrical interaction between the jetty and the tanker'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 tanker, is not considered a feasible method of minimising tanker/terminal currents in the absence of an insulating flange or hose. A jetty that is handling a succession of tankers would need to have this cathodic protection switched off almost continuously and would, therefore, lose its corrosion resistance. In addition, if the jetty system remains switched on, it is probable that the difference of potential between the tanker and terminal will be less if the tanker 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 tanker would have to be deprived of full protection not only while alongside, but also for a period before arrival in port.

17.4.3 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 (see section 17.4).

Switching off a cathodic protection system is not a substitute for the installation of an insulating flange or a length of non-conducting hose.

17.4.4 Tanker/terminal bonding cables

A tanker/terminal bonding cable does not replace the requirement for electrical discontinuity as described above. Use of tanker/terminal bonding cables may be dangerous and they should not be used.

While some national and local regulations still require mandatory connection of a bonding cable, it should be noted that the International Maritime Organization's (IMO) *Revised Recommendations on the Safe Transport of Dangerous Cargoes and Related Activities in Port Areas* urges port authorities to discourage the use of ship/shore bonding cables and to adopt recommendations concerning electrical discontinuity.

If a bonding cable is required by national or local regulations, it should 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 tanker, should the switch be closed. The cable should be attached before the cargo hoses or arms are connected and removed only after the hoses or arms have been disconnected.

17.4.5 Insulating flange

An insulating flange is designed to prevent arcing caused by low voltage/high current circuits (usually below one volt, but potentially up to around five volts and with currents rising to possibly several hundreds of amps) that exist between tanker and terminal due to stray currents, cathodic protection and galvanic cells. There are two types typically in use at marine terminals: a traditional insulating flange (see figure 17.3) and a cast-nylon insulating flange (see figure 17.4), neither of which are intended to give protection against the high voltage but from potential low current sparks.

Therefore, even if the resistance of the flange drops below the 1,000 ohms stated in section 17.4.5.2 because of, for example, 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 MLAs or hoses. Conversely, trying to earth 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 tanker and terminal from becoming zero and will render this circuit ineffective as a means of eliminating tanker/terminal currents in MLAs or hoses.

In the context of electrical isolation, the term insulating flange is used in alignment with other marine industry guidance documents, although the term isolation flange may also be used.

17.4.5.1 Precautions

It is recommended that the insulating flange is available at the terminal (shore side) rather than at the tanker and that, when fitting the insulating flange, the following should be considered:

- When the tanker to terminal connection is wholly flexible, as with a hose, the insulating flange should ideally be inserted at the jetty end where it is not likely to be disturbed. Flexible hoses should always be suspended or supported on non-conductive materials to ensure the hose to hose connection flanges do not rest on the jetty deck or other structure that renders the insulating flange ineffective.
- In place of a traditional insulating flange, a cast-nylon insulating flange joint can be used or bolted between two lengths of electrically conductive hose and/or flanges. The advantage of the cast-nylon insulating flange joint over an insulating flange is the wide gap between conductors that makes it is less prone to failure due to dirt, salt build-up or moisture accumulation. The non-conductive spool piece is also easy to install or replace.
- When the connection is a partly flexible and partly metal MLA, the insulating flange should be connected to the metal arm.
- For all metal MLAs, care should be taken to ensure that the flange is not short circuited by guy wires.
- The location of the insulating flange should be clearly labelled.

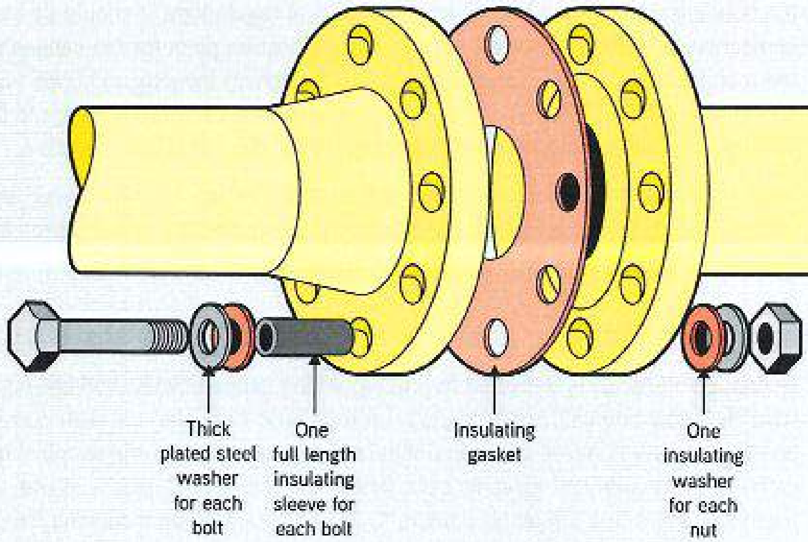

Figure 17.3: Typical insulating flange joint

While both types of insulating flange are effective and their use is accepted practice in the industry for safe transfer of cargo from ship to shore, a cast-nylon insulating flange has an advantage over the traditional insulating flange as it provides additional space between the two connecting flanges. This provides a benefit in the event of a failure that typically occurs when dirt/moisture accumulates between the two conductive flanges, circumventing the thinner traditional insulating flange joint.

However, the cast-nylon insulating flange joint has a disadvantage in that it is heavier than the traditional insulating flange, which adds weight at the joint and potentially contributes to a tighter bend radius in the hose at the interface joint due to loss of flexibility. This does not necessarily contribute to accelerated failure of the hose, but the terminal operator should be aware of this and plan it into the inspection and maintenance programme when handling hose with this joint.

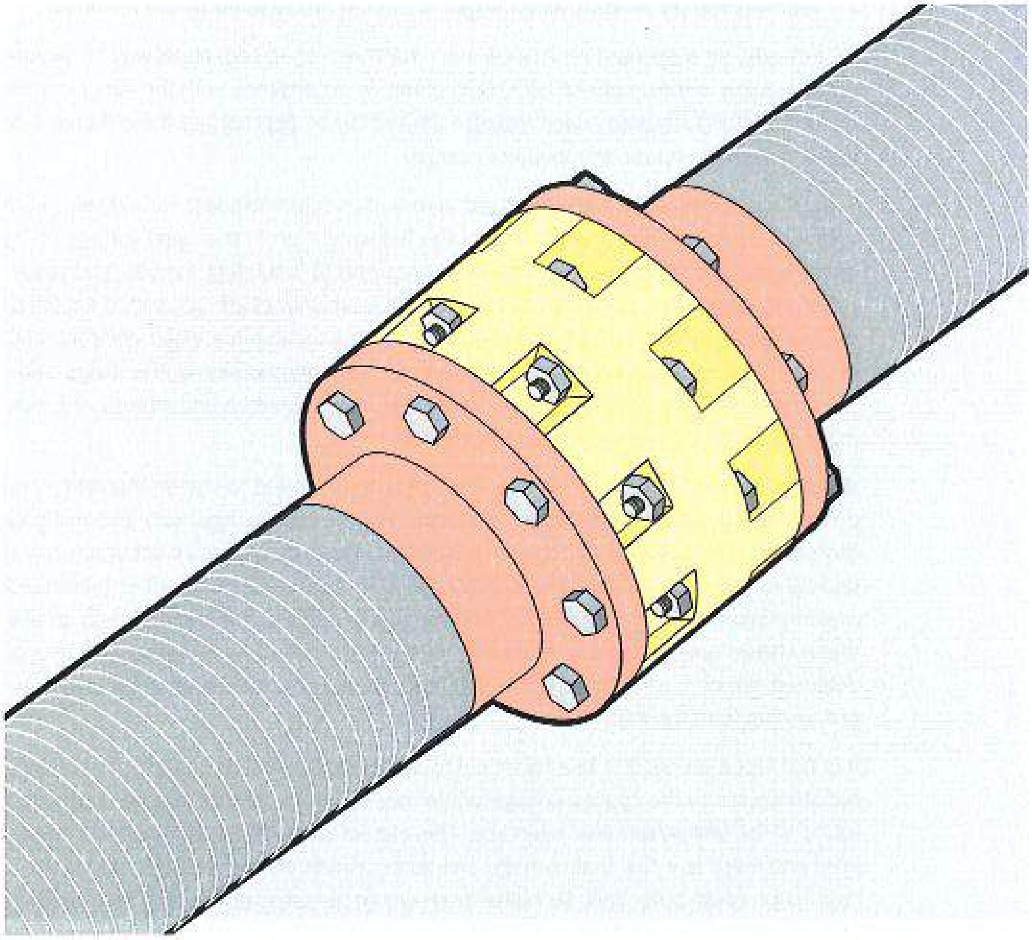

Figure 17.4: Cast-nylon insulating flange joint

17.4.5.2 Testing of insulating flanges

An insulating flange is designed to prevent the arcing caused by the voltage that can exist between tanker and terminal due to stray currents and other electrical phenomena. Such voltages are usually below one volt but can be up to five volts. Without an insulating flange (or other current limiting component, such as a discontinuous hose string) this voltage could result in a substantial current flowing between the tanker and terminal. This current flow could lead to arcing, creating an explosion risk if hydrocarbons are present.

If the resistance of the flange drops because of ice, salt spray or product residue, the current should still be limited to a few milliamps, which is considered low enough to prevent arcing during connection or disconnection of MLAs or hoses:

- Insulating flanges should be inspected and tested at least annually, but more frequent testing should be conducted based on the results of a risk assessment (see chapter 4). Factors to be taken into consideration when determining testing frequency should include the risk of deterioration due to environmental exposure, usage and damage from handling.
- Before testing, the atmosphere should be confirmed safe by means of atmosphere tests.

- The insulation flange should be clean and unpainted.
- Readings should be taken between the metal pipeline on the shore side of the insulation flange and the end of the hose or MLA when freely suspended. The measured value after testing should be greater than 1,000 ohms. A lower resistance could indicate damage or deterioration of the insulation.
- Test records for all insulating flanges should be maintained by the terminal.

Historically, no maximum resistance value has been specified. However, for avoidance of static accumulation, a maximum of 1,000,000 ohms, in accordance with the American Petroleum Institute's (API) *Recommended Practice 2003*, may be appropriate if the flange is to be used with a low conductivity (static accumulator) cargo.

Typical insulation testers are arranged with a user selectable test voltage, e.g. 1,000/500/250 volts DC. The test voltage is normally selected in relation to the rated voltage of the equipment under test. Since this consideration does not apply to insulating flanges, and since the acceptable resistance can be as low as 1,000 ohms, such instruments are not suited for on-site terminal routine testing. However, they can be used for type testing in a clean environment, e.g. at the manufacturer's workshop, where there will be no contamination of the flange and insulation readings will be many times higher. Routine testing should be undertaken at a lower voltage that is more suited to the expected resistance value.

When an MLA or hose is in service, it is not recommended to use an insulation tester with driving voltage above 50 volts DC (nominal). Higher test voltages can give misleading results at low resistances because of capacitive leakage. However, to ensure accuracy and repeatability, dedicated insulation testers are recommended for routine testing, rather than handheld multimeters. Insulating testers that operate at 50 volts DC are commercially available, but these should only be used after testing for the presence of hydrocarbons. If hydrocarbons are detected, either externally or within the hose, then a risk assessment should be carried out before proceeding with the test.

It is not recommended to use handheld multimeters for routine testing of insulating flange resistance, since the applied voltage when measuring resistance will be similar to that typically found at the tanker/terminal interface. This cannot be considered a true test of the insulation level and there is a risk that damage and deterioration will not be identified since the measured resistance could potentially be higher than would be achieved using a dedicated insulation tester. In any case, the test voltage applied should not be less than five volts DC (nominal).

17.4.5.3 Safety

Testing should be undertaken with instruments and methods selected to be compatible with any hazardous area associated with the location of the flange. When testing of an insulating flange is carried out in a hazardous area and/or 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 chapter 4).

17.5 Earthing and bonding practice in the terminal

Earthing and bonding minimise the dangers arising from:

- Faults between electrically live conductors and non-current carrying metalwork.
- Atmospheric discharges (lightning).
- Accumulations of electrostatic charge.

Earthing and bonding system requirements will depend on the results of a risk assessment.

CHAPTER 18

Cargo Transfer Equipment

18.1 Marine Loading Arms

18.2 Cargo hoses

18.3 Vapour Emission Control Systems

18.4 Cargo transfer drainage and containment

18.5 Emergency Shutdown systems

This chapter describes the MLAs and flexible hoses used to make the tanker/terminal connection, including drainage and containment equipment and practices. 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 integrity of the cargo systems and the drainage and containment of hydrocarbons.

18.1 Marine Loading Arms

18.1.1 Operating envelope

All MLAs have a specific operating envelope that considers the following:

- Tidal range.
- Minimum and maximum freeboards of the tankers for which the berth is designed.
- Height of the manifold centre presentation flanges above the waterline.
- Minimum and maximum manifold setbacks from the deck's edge.
- Limits for changes in horizontal position due to drift off and ranging.
- Minimum and maximum spacing when operating with other MLAs in a bank.

For manifold information see OCIMF/CDI's *Recommendations for Oil and Chemical Tanker Manifolds and Associated Equipment.*

The limits of the operating envelope should be understood by berth operators. MLA installations should have a visual indication of the operating envelope and/or be provided with alarms to indicate excessive range and drift.

The PIC 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 de-ballast in conjunction with cargo operations. For MLA design information see OCIMF's *Design and Construction Specification for Marine Loading Arms*.

18.1.2 Forces on manifolds

Most MLAs 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 is 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 by other external forces such as the wind. Where supports or jacks are used, 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 (see section 18.1.8).

The terminal operator should have detailed information on the forces exerted on the tanker's manifold by each MLA. This information should be readily available to the berth operator.

The berth operator's training should include the correct rigging and operation of MLAs. Berth operators should be aware of the consequences of inappropriate operation that may cause excessive forces on the tanker's manifold.

Some counterbalanced MLAs are made slightly tail heavy to compensate for clingage of oil residue to the manifold and to help the arm 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. Forces applied on manifolds by counterbalanced loading arms shall not exceed the allowable loading limits for manifold support. For manifold design information see OCIMF/CDI's *Recommendations for Oil and Chemical Tanker Manifolds and Associated Equipment.*

18.1.3 Tanker manifold restrictions

The material of manufacture, support and cantilever length of a tanker's manifold, together with the spacing intervals of adjacent outlets, should be checked for compatibility with the MLAs. Manifold flanges should be vertical and parallel to the tanker's side. The spacing of the manifold flanges will sometimes dictate the number of MLAs that can be connected, to avoid interference between adjacent MLAs. For recommendations regarding tanker manifold restrictions in terms of dimensions, materials and arrangement (see OCIMF/CDI's *Recommendations for Oil and Chemical Tanker Manifolds and Associated Equipment*).

18.1.4 Parking of arms

MLAs should be empty when parked and locked, but inadvertent filling may occur. The parking lock should only be removed after the arm has been checked and verified as empty.

If MLAs need to be moved for maintenance or inspection, the arms should be confirmed as depressurised and drained of product.

Parking locks secure the MLAs in the parked position. Slewing motion, as well as inboard and outboard arm movements, should be locked while parked. Slewing and inboard arms should be mechanically locked. The outboard arm may be hydraulically locked. Parking locks should be able to be operated by one person. The operator should be able to see if the parking lock is on. System pressure relief valves should operate if movement is attempted while the locks are engaged.

18.1.5 Ice formation

Ice formation will affect the balance of the MLA. Any ice should be cleared from the MLA before releasing the parking lock.

18.1.6 Mechanical couplers

Mechanical couplers need manifold flange faces to be smooth and free of rust to ensure a tight seal. Care should be taken when connecting a mechanical coupler to ensure that it is centrally placed on the manifold's flange, faces aligned, and that all claws or wedges are pulling evenly on the flange:

- Where O-rings are used in place of gaskets, these should be replaced according to the manufacturer's recommendations.
- Where gaskets are used, these should be replaced with new gaskets on each occasion.

18.1.7 Wind forces

Wind loading of MLAs may place an excessive strain on tanker manifolds, as well as on the arms, and the terminal operator should establish wind limits for operation. At terminals where wind loading is critical, a close watch should be kept on wind speed and direction. When terminal operating wind limits are reached, operations should be suspended and the MLAs should be drained and disconnected.

18.1.8 Precautions when connecting and disconnecting Marine Loading Arms

Operation of MLAs should be carried out from a location where connection flanges on the tanker are visible to the operator. Where necessary, wired and/or wireless remote control systems should be provided.

Operators should ensure that all personnel are clear of moving MLAs and do not stand between an MLA and the tanker's structure because of the risk of unexpected movements of both powered and unpowered MLAs during connection and disconnection. Where an elevated manifold platform is fitted, without fixed or movable protections, the area should be properly identified and marked by warning signs to prevent falls.

MLAs should be empty of product when manoeuvred for connection to the tanker. They should be drained after each operation, returned to the parked and locked position when empty and stowed empty. All parking locks, braces and any additional items used to secure the MLA ashore are removed.

The following should be considered when connecting/disconnecting powered and unpowered MLAs:

- Stored hazardous energy (see chapter 4) may cause the MLA to move on its own when parking locks and associated braces are removed or when disconnecting from the tanker manifold.
- A test of shore power, static and remote controls, as well as a test of backup power if applicable.
- Two guide ropes should be fitted, when connecting manually operated MLAs, to control the movement of the connection end. Guide ropes should be visually inspected before use.
- Creation of an exclusion zone around the MLA when it is being operated.
- Weather conditions at the time of operation of the MLAs.
- The type of product being transferred and any additional Personal Protective Equipment (PPE)/personal monitors and detection equipment required.
- Verifying that lines are drained before connection/disconnection of transfer of MLA.
- Checking the hydraulic system's integrity.

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18.1.9 Precautions while Marine Loading Arms are connected

The following precautions should be taken when MLAs are connected:

- The tanker's moorings should be monitored and tended as necessary, so that any movement of the tanker is within the working envelope of the MLA.
- If drift or range alarms are activated, all transfer operations should be stopped and remedial measures taken.
- The MLAs should be free to move with the motion of the tanker. Care should be taken to ensure that hydraulic or mechanical locks cannot be inadvertently engaged.
- The MLAs should not clash with adjacent MLAs and equipment.
- Excessive vibration should be avoided.
- Tanker/terminal pressures should not exceed Maximum Working Pressure (MWP).

18.1.10 Powered Emergency Release Couplings

A Powered Emergency Release Coupling (PERC) is a hydraulically operated device fitted as part of an Emergency Release System (ERS) to provide quick disconnection of an MLA in emergency situations. The PERC has a valve on each side of the release point to minimise spillage. On release, the lower part of the coupling and its valve remain attached to the tanker's manifold while the upper part and its valve remain attached to the cargo arm, which is free to rise clear of the tanker. The valves above and below the release point are hydraulically or mechanically interlocked to ensure they are fully closed before operation.

The PERC is initiated in the following ways:

- Automatically, when the MLA reaches the specified envelope limit. This is normally accompanied by an alarm.
- Manually, using a push button on the central control panel.
- Manually, using hydraulic valves in the event of a loss of electrical power supply ashore.

Once the emergency disconnection has been initiated, the ERS valves adjacent to the PERC will close rapidly (typically in less than five seconds) and precautions need to be taken to avoid a pressure surge (see section 16.8). The terminal should provide surge control facilities for this purpose.

18.1.11 Inspection, testing and maintenance

Operation of an MLA, either powered or unpowered, can be a dangerous task. Consequently, the MLA should be in full working condition. To ensure this, three areas should be considered:

- Inspection.
- Testing.
- Maintenance.

These areas should include a structured schedule of pre-use, weekly, monthly, three monthly, six monthly, annual and five yearly inspection, testing and maintenance. The maintenance cycles should follow the guidelines given by the manufacturers of the MLAs they have in operation.

Further guidance for inspection, testing and maintenance of MLAs can be found in OCIMF's *Design and Construction for Marine Loading Arms* and OCIMF/SIGTTO's *Jetty Maintenance and Inspection Guide*.

18.2 Cargo hoses

18.2.1 General

Cargo transfer hoses may be of several types, e.g. rubber, composite and metallic, used in different services (dock, Ship to Ship (STS), floating) and for the transfer of various petroleum products. This section includes specific guidance for oil cargo hoses, but users should always consult applicable hose construction standards and the manufacturer's guidance.

Oil cargo hoses should conform to recognised standard specifications, or as recommended by OCIMF/established hose manufacturers. Hoses should be of a grade and type suitable for the service and operating conditions in which they are to be used.

Special hoses are required for use with high and low temperature cargoes. Manufacturers' recommendations can be found in BS 13482: *Rubber hoses and hose assemblies for asphalt and bitumen* and in BS 4089: *Specification for metallic hose assemblies for liquid petroleum gases and liquefied natural gases*.

The information on cargo hoses in the following sections is condensed from BS EN1765: *Rubber hose assemblies for oil suction and discharge services* and in BS EN13765: *Thermoplastic multi-layer (non-vulcanized) hoses and hose assemblies for the transfer of hydrocarbons, solvents and chemicals*. This information is provided to give a general indication of hoses that may be supplied for normal cargo handling duty.

Reference may also be made to OCIMF's *Guide to Manufacturing and Purchasing Hoses for Offshore Moorings* for information on hoses commonly used at conventional buoys, SPM facilities and Floating Production Storage and Offloading Units (FPSOs).

18.2.2 Types and applications

For normal duty, there are four basic types of rubber, rubber compound or composite hoses:

Rough bore (R)	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. All Type R hoses are electrically continuous
Armoured rough bore (A)	In addition to an internal zinc coated steel wire helix, there should be an external helical armour of a similar material. Type A hoses are electrically continuous and may be lighter and more flexible than Type R
Smooth bore (S)	Used for dock operation where flexibility and lightness are important
Lightweight (L)	Used for discharge duty, STS transfers and bunkering, where flexibility and a light weight are important considerations

Type S and L hoses can be either electrically continuous or electrically discontinuous. Type S and L electrically continuous hoses are further subdivided into two grades, Grade M and Grade Ω. Grade M hoses are electrically bonded, with a maximum resistance of 100 ohms between end connections. Grade Ω hoses are electrically conductive, and the resistance between end connections can be as high as one million ohms. Grade Ω hoses are sometimes described as semi-continuous due to their intentionally higher resistance. However, it should be noted that there is no minimum resistance requirement for Grade Ω in the BS EN1765:2016 standard.

There are several special hose types of the same basic construction, but they are modified for specific purposes or service. These include subsea hoses or hoses for use in floating hose strings.

Figure 18.1: Differences in resistance between Grade M, Grade Ω and discontinuous hose types

Composite hoses

Specific types of composite hoses are generally designated for the properties of the cargo they are designed to carry/handle. Users should consult with the manufacturer for guidance on compatibility of hose and cargo.

Composite hoses may be used for the transfer of some petroleum cargoes, but may not be suitable for high viscosity cargoes. They are typically more flexible and lighter than rubber hoses. Composite hoses are constructed from materials, including:

- Galvanised, coated or stainless steel wire helices.
- Polypropylene (PP), polytetrafluoroethylene (PTFE) or polyethylene terephthalate linings.
- UV and chemically resistant PVC coated polyester covers.
- Galvanised or stainless steel outer helices.

Users of these hoses should ensure they understand the differences.

18.2.3 Performance

Rubber, rubber compound or composite 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 50%. Such hoses are normally suitable for sunlight and ambient temperatures ranging from -29°C to +52°C.

18.2.4 Marking

18.2.4.1 Rubber hoses

Each length of hose should be marked by the manufacturer, in accordance with BS EN1765, with:

- The manufacturer's name or trademark, e.g. XXX.
- Identification with the dated standard specification for manufacture, e.g. EN1765:2016.
- Type and designation, e.g. A15.
- Nominal bore, e.g. 75.
- MWP, e.g. 15 bar.
- Symbol to identify electrical conductivity, e.g. M and Ω respectively (type S and L only).
- Quarter and year of manufacture, e.g. 2Q-2015.
- Manufacturer's serial number, e.g. 005.

Example XXX/EN1765:2016/A15/75/15bar/Ω/2Q2017/005

Electrically discontinuous assemblies should also have the words 'electrically discontinuous'. The marking should be permanent and durable.

After testing, the temporary elongation value should be painted legibly at each end of the hose in diametrically opposite positions.

18.2.4.2 Composite hoses

Each hose should be permanently marked at an interval of not greater than one metre with lettering of a minimum height of 10mm and with at least the following information:

- The manufacturer's name or identification mark, e.g. XXX.
- Number and year of standard, e.g. EN 13765:2018.
- Hose identification-type, e.g. type 2.
- Internal diameter, e.g. 40mm.
- MWP, e.g. 10 bar.
- Working temperature range, e.g. -30°C to 80°C.
- Material of inner liquid barrier layer, as referenced in EN ISO 1043-1, e.g. PP (polypropylene).
- Quarter and year of manufacture, e.g. 2Q-2015.

Example XXX/EN13765:2016/type 2/40/10bar/-30°C to 80°C/PP/4Q2017

In addition, each composite hose shall be permanently marked on the ferrule at one end with the following:

- Assembler's name or identification mark.
- The hose assembly serial number.
- Maximum Allowable Working Pressure (MAWP) for the assembly.
- The test date of the hose assembly.
- Quarter and year of hose assembly manufacture.

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.

Acceptable flow velocities for rubber hoses are typically 15–21m/sec. The allowable flow velocity for a high velocity hose can be as high as 25m/sec.

Recommended flow velocities for composite hoses are lower as there is a helical wire in the bore, supporting the hose structure, which will result in much higher friction losses and drag. With higher velocities there is a risk of dislodging the internal wire in this hose design. Typical velocities are 7–9m/sec.

The limiting maximum flow velocity is often determined by the internal pipework of the tanker or terminal and depends on the nature of the product (see sections 12.1.7 and 11.3.3.2).

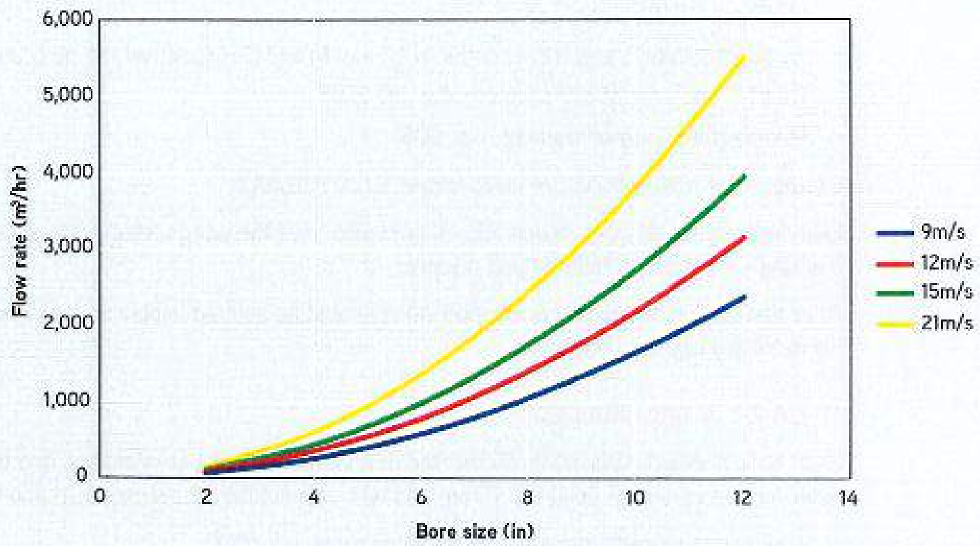

Figure 18.2: Maximum flow rate for given flow velocity and bore size

18.2.6 Inspection, testing and maintenance requirements for cargo hoses

18.2.6.1 General

Hoses in service should have a documented inspection at least annually to confirm their suitability for continued use.

Hoses should be retired in accordance with defined criteria (see section 18.2.6.5).

All hoses should be certified, fit for purpose, in good physical condition and should have been pressure tested. A record of all hose certificates should be maintained and made available for review by appropriate parties on request.

18.2.6.2 Visual examination

A visual examination should be carried out before each use and consist of examining the:

- Hose assembly for irregularities in the outside diameter, e.g. kinking.
- Hose cover for damaged or exposed reinforcement or permanent deformation.

- End fittings for signs of damage, slippage or misalignment.
- Internal liner, where applicable.
- Hose cover to determine if any cuts, gouges or abrasions have penetrated to a liquid barrier.
- For crushed or kinked areas, longitudinal ridges or bulges.

Additionally, for composite hoses:

- Pitch angle and spacing between wraps in outer helix wire, excessive corrosion, rust or scaling on wire helices.

A hose assembly exhibiting any of the above defects should be removed from service for a more detailed inspection to determine suitability for continued use. 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 Hydrostatic pressure test

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, for products at elevated temperatures or for older hoses.

If the rated pressure of a hose has been exceeded it should 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:

Rubber hoses

1. Lay out the hose straight on level supports that allow free movement of the hose when the test pressure is applied. Conduct an electrical continuity test.
2. 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 with fresh water until a constant stream of water is delivered through the vent.
3. Connect the test pump at one end and apply a pressure of 0.7 bar. Measure and record the overall length of the hose assembly between the measuring points.
4. Slowly increase the pressure up to the MWP. Hold this pressure for ten minutes.
5. Re-measure the length of the hose over the same surface as before.
6. Ascertain the temporary elongation and record the increase as a percentage of the original length.
7. Release the pressure to zero bar.
8. Leave the assembly relaxed for 15 minutes and then raise the pressure to 0.7 bar.
9. Re-measure the length of the hose over the same surface as before.
10. Slowly raise the pressure to 1.5 times the MWP and hold this pressure for five minutes.
11. 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.
12. Reduce the pressure to zero and drain the hose assembly. Re-test for electrical continuity.

Composite hoses

1. Lay out the hose straight on level supports that allow free movement of the hose when the test pressure is applied. Conduct an electrical continuity test.
2. 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 with fresh water until a constant stream of water is delivered through the vent.
3. Connect the test pump at one end and apply a pressure of 0.7 bar. Measure and record the overall length of the hose assembly between the measuring points.
4. Slowly increase the pressure up to 1.5 times the MWP. Hold this pressure for ten minutes.
5. Re-measure the length of the hose over the same surface as before.
6. Ascertain the temporary elongation and record the increase as a percentage of the original length.
7. Slowly lower the pressure to 0.7 bar and stabilise.
8. Re-measure the length of the hose over the same surface as before.
9. 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 is under test pressure, but the hose exhibits significant distortion or excessive elongation, the hose 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:

1. Remove the blanks used for the pressure test and fit suitable plexiglass plates to the hose ends.
2. Apply a vacuum of at least 510mb gauge for a period of ten minutes.
3. 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.
4. Release the vacuum.
5. 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

The electrical properties of a hose are determined during type testing of the hose design and verified through routine testing thereafter, in accordance with ISO 8031, as referenced by BS EN1765:2016.

Since electrical continuity can be affected by any of the physical hose tests, a check on electrical resistance should be carried out before, during and after the pressure tests.

Electrically discontinuous hoses should have a resistance of not less than 25,000 ohms, measured end flange to end flange.

Electrically continuous hoses (Type R, Type S Grade M, or Type L Grade M) should not have a resistance higher than 100 ohms, measured end flange to end flange.

Electrically continuous hoses (Type S Grade Ω, or Type L Grade Ω) should not have a resistance higher than 1,000,000 ohms measured end flange to end flange.

Electrical semi-continuous hoses have a resistance between 1,000 and 1,000,000 ohms, measured between nipples (end flange to end flange).

Composite hoses which are electrically continuous should have a resistance of less than 100 ohms, measured flange to flange.

18.2.6.5 Withdrawal from service

In consultation with the hose manufacturer, the 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.

A retirement register of hoses should be maintained, including the date and reason(s) for any hose retirement.

The retirement register should be made available for review by appropriate parties on request.

The retirement age should be based on a risk assessment that should consider the following as a minimum:

- Manufacturer's guidelines.
- Cargo type.
- Storage conditions.
- Hose handling and frequency of operation.
- Any experience of past failures.
- Any local regulatory requirements.

18.2.6.6 Explanation of pressure ratings for hoses

Figure 18.3 provides an illustration of the relationship between several definitions of pressure that are in common usage. The individual terms are briefly described below:

Maximum Working Pressure

The MWP is the maximum hose pressure capability. This pressure rating is expected to account for dynamic surge pressures and is used by BS and EN Standards for designing hoses.

Rated Working Pressure

The Rated Working Pressure (RWP) does not take into account dynamic surge pressures and is not to be confused with MWP. It is the working pressure expected during normal working conditions.

Factory test pressure

This is referenced in BS EN 1765 and is defined as equal to the MWP.

Maximum Allowable Working Pressure

The MAWP is used as a reference by the United States Coast Guard (USCG) and is commonly used by terminals to define their system equipment limitations.

Hydrostatic test pressure

This is the pressure at which the hose is tested at least annually.

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 MWP.

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 four 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.

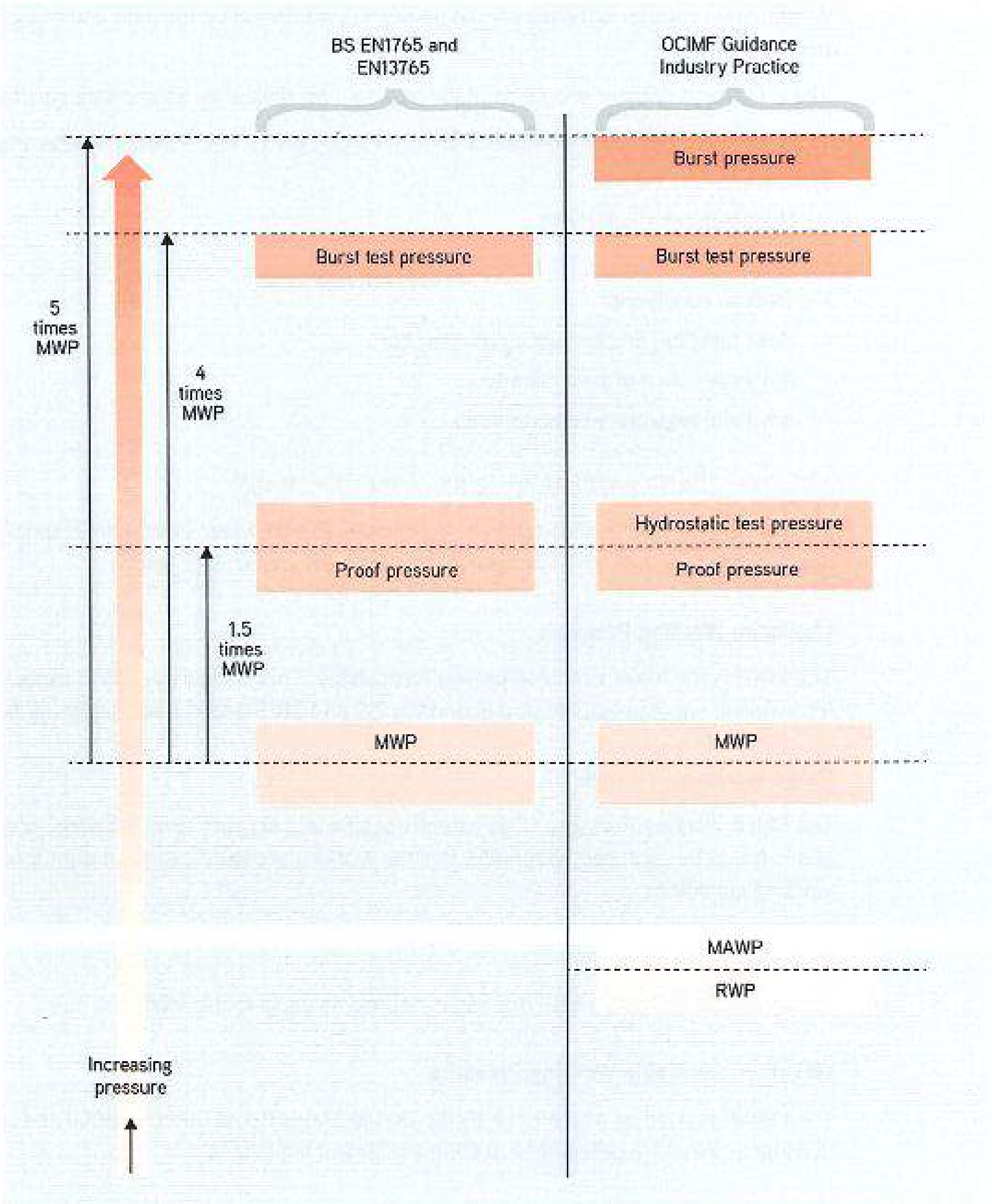

Figure 18.3: Illustration of terminology used for defining hose pressures

18.2.7 Hose flange standards

Flange dimensions and drilling should conform to OCIMF/CDI's *Recommendations for Oil and Chemical Tanker Manifolds and Associated Equipment*.

18.2.8 Operating conditions

Hoses should be selected according to the operating design conditions of the system in which they will be applied. Whenever the operating conditions may change, for example, product specification or temperature, flow rate or pressure, the compatibility of the hoses to be used should be verified.

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 storage 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.

Non-load bearing protective blanks (wood) with breathing holes should be fitted to prevent wildlife or other foreign bodies getting into the hoses.

If the hose is stored outside, it should be well protected from the ultraviolet rays of the sun. See BS 1435: *Rubber hose assemblies for oil suction and discharge services.*

18.2.10 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. Certified lifting straps should be used. They should be positioned so the hose will not fold over on itself (sharp kinks in the hose should be avoided). Lifting equipment used should be appropriately sized to accommodate the weight of the hose when full of product.

Straps should be placed strategically to allow the flange to align horizontally. This will improve hose connection efficiency.

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 hose crane, the hose string should be supported by bridles or webbing straps. Some hoses are specifically designed to be unsupported.

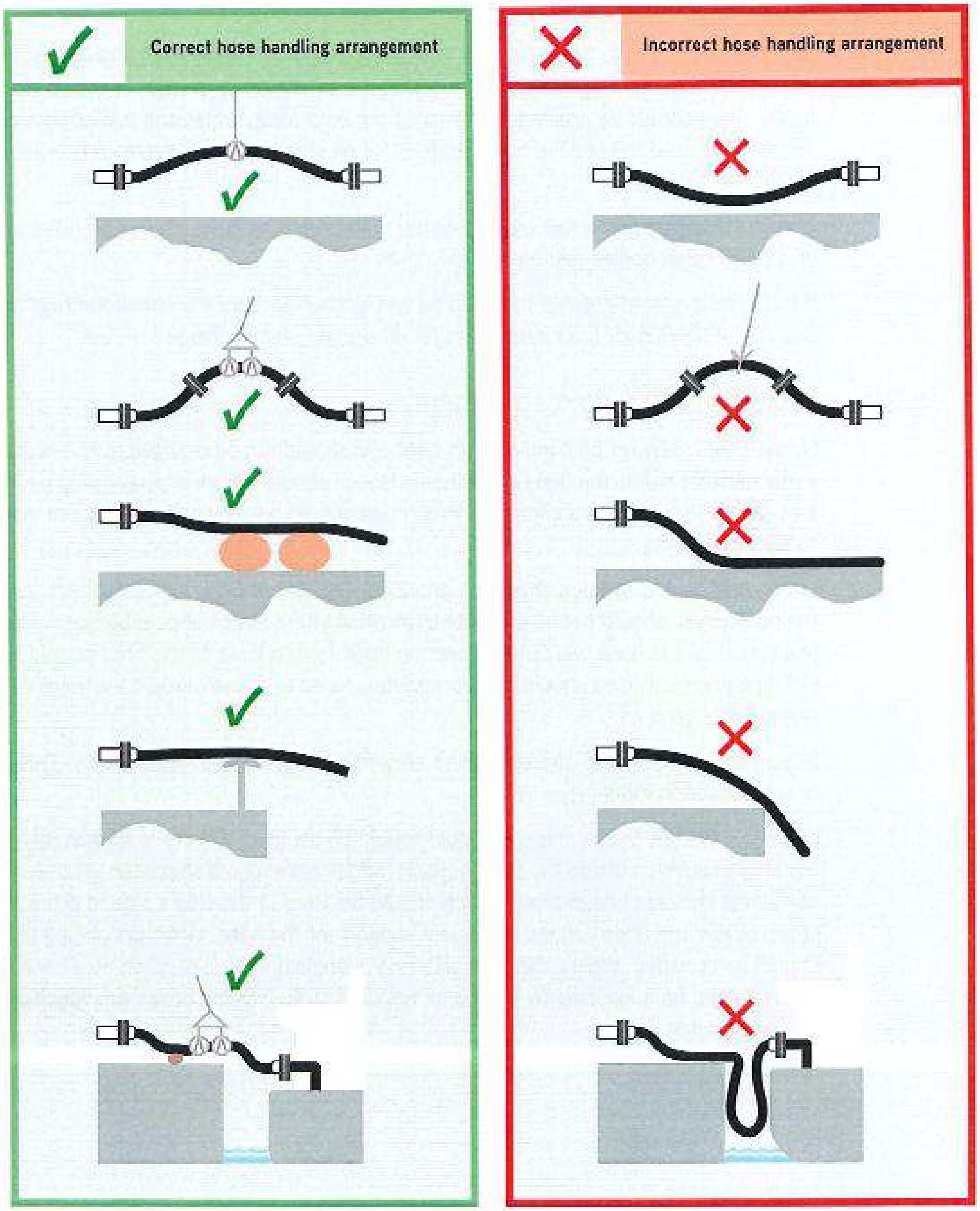

Figure 18.4: Hose handling arrangement

18.2.11 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 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. The minimum length of hose should be sufficient to cover all states of tide and tanker freeboard and motions.

18.2.12 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.

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 SWL of the ship's 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 eight metres above deck level for a tanker's manifold connection situated 4.6m inboard. In wave and/or swell conditions greater than one 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).

During the lifting of hose strings, contact with the ship's side and any sharp edges should be avoided.

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.

To prevent spills, the section between the last valve and the blank should be checked for oil under pressure before removing blanks from submarine or floating pipelines.

A visual inspection of each floating hose string should be made to check for damage, kinking or oil seepage before connecting it to the tanker's manifold.

If any damage to the hose is found that is likely to affect its integrity, the hose should be withdrawn from use to allow further inspection and repair.

See OCIMF's *Guide to Purchasing, Manufacturing and Testing of Loading and Discharge Hoses for Offshore Moorings* and *A Study into Crane Loads Associated with Hose Handling at Offshore Terminals.*

18.2.13 Hoses used in Ship to Ship transfers

Hoses for STS operations can be provided as pre-assembled strings, or in individual sections. There are advantages and disadvantages to both methods. Dedicated lightering vessels usually have their own hose strings and these hoses have to be inspected, tested and maintained.

Advantages of pre-assembled strings:

- The hoses are tested as a continuous string, which ensures liquid-tight integrity at each intermediate flange connection. This assurance is only applicable to the time of testing.
- The time required to connect hoses between two ships can be reduced.
- There is additional assurance that strings are assembled correctly when continuous and discontinuous hose sections are used.

Disadvantages of pre-assembled strings:

- Hoses may be folded when lifting them on board the ship.
- Fasteners may work loose as the hose strings are handled repeatedly and used for multiple operations.

Advantages of individually delivered hose sections:

- The inner liner of each hose can be inspected when the ends are open.
- Hoses are less likely to be bent beyond their Minimum Bend Radius (MBR) when lifted on board.
- Spreader bars can be used to support hoses during lifting.

Disadvantages of individually delivered hose sections:

- Connecting hose sections on board requires space.
- It can be difficult to reach and tighten fasteners underneath the hose and integrity of the flange connections is usually not verified by testing.

When composite hoses are used for STS, these hoses are usually manufactured to the length required and there are no intermediate flanges. Due to improved MBRs, composite hoses can be coiled.

The MBR for storage and operation should be confirmed with the manufacturer and adhered to when lifting or handling the hose. Some hoses are designed to be temporarily folded but should be returned to a straight position as soon as possible. Composite hoses used for STS should be well supported to prevent over bending, especially near end fittings.

A visual inspection of each hose string should be made before connecting it to the tanker's manifold to determine if damage has been caused by handling offshore or by contact with support craft structures. If the hose has been damaged it should not be used and a replacement should be provided.

When connecting the hose string to the tanker manifolds, the hose string should not twist between the two manifolds because this can restrict the flow of cargo. Some hose manufacturers embed a stripe in the outer hose cover to assist with alignment.

Hoses should be properly supported by straps and hose support ropes. Straps should be placed strategically to allow the flange connection to align horizontally. Hose support ropes prevent unnecessary stress on the manifold and ensure hose maintain correct bend radiuses where they cross the rail. The rope size should be the minimum required to support the weight of the hose and of a size to enable operators to turn the hose around a cruciform bit at the manifold.

18.2.14 Electrical isolation

Due to possible differences in electrical potential between two ships intending to undertake cargo or bunker transfers via a transfer system, e.g. cargo hoses, there is a risk of electrical arcing at the manifold during connection and disconnection of the transfer system.

To protect against this risk, there should be a means of electrical discontinuity in the connection interface and this is normally provided by an insulating flange. Provision of the method of isolation should be agreed between the two ships prior to connection (see section 12.9.5).

18.3 Vapour Emission Control Systems

Many terminals are equipped with VECSs to receive and process vapours displaced from a tanker 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, provided to visiting tankers for information, should also include details of the vapour recovery system.

All shore personnel in charge of transfer operations should complete a structured training programme covering the particular VECS installed in the terminal. The training should include details of typical equipment installed on board tankers and related operating procedures.

Tanker and terminal personnel should be aware of any constraints associated with the operation of the VECS during the pre-transfer conference. Confirmation that this information has been exchanged and agreed to will be included in the SSSCL (see chapter 25).

See section 23.7.7 for information on the primary safety issues relating to cargo transfer operations using vapour recovery.

Terminal vapour hoses should be marked in a similar way to a tanker's vapour manifolds as indicated in section 23.7.7.

18.4 Cargo transfer drainage and containment

Drainage and containment facilities at the cargo transfer areas of marine terminals are an important aspect of containing spills, controlling pollution and preventing the progression of fires. Marine terminals should have provisions for safely draining the cargo transfer system, i.e. MLAs and hoses and containing any operational spillages and hydrocarbon releases mixed with rainwater. For detailed guidance on the design of drainage and containment facilities, see section 18.4.2.

All cargo transfer drainage and containment equipment should be inspected, tested and maintained in accordance with OCIMF/SIGTTO's *Jetty Maintenance and Inspection Guide*.

18.4.1 Marine Loading Arm/hose clearing

Terminals should have adequate provisions for the clearing of MLAs and hoses. A documented operating procedure should be in place for the type of clearing used.

A backup plan should be considered in the event that the primary means of clearing the arm or hose fails.

Acceptable methods for clearing the MLAs and hoses include:

- Gravity drain from MLA/hose directly to a sump and/or tanker.
- Purging MLA/hose with nitrogen to tanker/terminal.
- Stripping MLA/hose back into shore cargo lines.

Facilities and operating procedures for clearing cargo transfer equipment may also need to consider the following:

- Lifting equipment is provided to aid gravity draining of cargo hoses. Suitable means of checking that cargo transfer systems are drained and confirmed zero energy prior to connection/disconnection, e.g. bleeder valve or pressure gauge.
- Means of verification to ensure drain valves are closed prior to cargo transfer operations, e.g. interlock system, critical procedure.
- Adequate supply of nitrogen is available where necessary, i.e. contingency plan for when nitrogen supply is lost.

18.4.2 Jetty deck containment

Each terminal should have a continuous curbed area for the containment of spills near cargo transfer manifolds, sample points, valves and other potential sources that could leak directly into the marine environment.

In addition to the cargo transfer lines and associated small bore piping, other potential sources include:

- Hydraulic fluids from reservoirs near equipment such as arms, cranes, gangways.
- Pressure relieving valves.
- Atmospheric vents, e.g. sumps.
- Transformer oil for electrical equipment.
- Other components with non-welded joints, e.g. flanges, valves.

The containment areas and minimum curb height should be suitably sized to contain the extent of a potential spill and consideration should also be given to storm/rain water management and the magnitude of the rainfall intensity for the location. This will be derived from the intensity of the design storm and its relationship to a specified return period and duration equal to the time of concentration of the drainage area.

The deck within the curbed areas should be sloped into a dedicated catch basin that drains to a sump, or be provided with other means of preventing accumulation of product and avoiding overflow.

If the terminal is equipped with scuppers to facilitate drainage and containment of surface content, a work procedure should be developed to ensure scuppers are in place during cargo transfer and ensuring no hydrocarbons are present in containment area prior to removal. Procedure should include provisions for removing only one scupper at a time and ensuring an operator remains present at all times while scupper is removed.

Valves such as vacuum breakers and sample valves should be self-closing to prevent the operator from leaving valves open, which may potentially lead to a loss of containment.

Unused hoses, MLAs, manifold connections, drains, vents and gauge connections should be suitably blanked or capped. If equipment is fully connected to the cargo's manifold, blank flanges should be fully bolted and have the same rating as the system to which they are attached.

For terminals that are not dedicated to the transfer of oils/chemicals, consideration should be given to containment curbing and methods for draining cargo transfer equipment. For locations with recessed manifold pits, regular operator checks should be in place to ensure appropriate containment and drainage of cargo content. Consideration should be given to hydrocarbon detection systems.

18.4.3 Hydrocarbon sump tanks

When required, hydrocarbon sump tanks should be suitably sized to contain operational spills and stormwater and to fulfil cargo transfer system drainage requirements.

Consideration should be given to segregating heated and low-flash product into different sumps, unless a proper inerted system is fitted.

18.5 Emergency Shutdown systems

ESD systems for cargo transfers are used to stop the flow of cargo liquid and vapour in an emergency and to bring the cargo handling system to a safe, static condition.

It is recommended that tankers and terminals are provided with the necessary equipment to enable interconnection of ESD systems.

As a minimum, ESD systems should:

- Stop all cargo transfer pumps when an ESD is activated on the tanker or terminal.
- Stop the tanker's cargo transfer pumps when a terminal high level alarm is activated.

Further information can be found in OCIMF/CDI's *Linked Ship/Shore Emergency Shutdown Systems for Oil and Chemical Transfers.*

CHAPTER 19

Marine Terminal Fire Protection

19.1 Marine terminal fire protection

19.2 Alarm and signalling systems

19.3 Detection and alarm systems at terminals

19.4 Firefighting equipment

19.5 Access for firefighting services

Marine terminal fire prevention and protection are key elements in reducing risk and improving safety.

This chapter contains general guidance and specific recommendations on fire protection at marine terminals, including the prevention, detection, signalling and operation of fire detection and protection systems.

In addition to national regulatory requirements, capability should be based on the guidance contained within this chapter and the outputs of a formal risk assessment.

The guidance on firefighting equipment in this chapter should be considered alongside chapter 5, which addresses firefighting theory.

19.1 Marine terminal fire protection

19.1.1 General

Fire safety at marine terminals is provided through overlapping levels of protection as follows:

- Prevention and isolation.
- Detection and alarm facilities.
- Protection equipment and systems.
- Fire proofing.
- Emergency and escape routes.
- Emergency planning.
- Fire protection philosophy.
- Evacuation procedures.

Fire safety at marine terminals is a balance between design features, operational procedures, emergency planning and training. Fire systems should be based on a designed risk assessment performed by experts in firefighting systems.

Fire protection alone will not provide an acceptable level of safety. Fire protection measures should not interfere with mooring or other operations.

Automatic detection of fire and rapid response of emergency personnel using fire protection equipment will limit the spread of fire and the hazard to life and property at all locations in a marine terminal.

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.

19.1.2 Fire proofing

Fire proofing makes equipment fire resistant by using non-combustible or limited combustible material.

To ensure availability of equipment in the event of a fire, terminal fire proofing should consider protection of the following:

- Fire water and foam system actuators.
- Emergency isolation valves.
- ERS for MLAs.
- Electrical switch gear rooms.
- Control rooms/buildings.

19.1.3 Location and spacing of fire detectors

Fire detection at marine terminals is usually provided in high risk areas, e.g. pumping stations, control rooms and electrical switch gear rooms. Detectors may also be fitted at valve manifolds, loading arms, operator sheds and on other equipment or in areas susceptible to hydrocarbon leaks and spills or that contain ignition sources.

To function effectively, fire detection devices should be properly positioned. Detailed requirements for detector placement in confined areas can be found in appropriate codes and standards. However, for flame detectors located outdoors, 3D flame detector mapping software is available that will ensure that the cone of vision covers the intended hazard that is being protected. Thermal radiation software may be used to determine the heat flux of a potential fire and assist in the locating of heat detectors.

Heat, smoke, gas and flame 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 flow patterns.

Detection systems that activate fire-extinguishing systems should be arranged using a cross-zone array. In a cross-zone array, no two adjacent ionisation or photoelectric type detectors should be in the same detection circuit zone. The first detector that is activated should start the fire alarm system, while a second detector, located on an adjacent circuit, should activate the fire-extinguishing system after a timer delay, which allows occupants to evacuate.

19.1.4 Fire-extinguishing system compatibility

When 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 19.4).

19.2 Alarm and signalling systems

Alarm and signalling systems have a number of significant functions:

- Rapidly transmit an alarm or signal to indicate the detection of fire before there is significant damage.
- Initiate emergency evacuation of personnel in the vicinity of the fire.
- Transmit an alarm to notify responsible parties and initiate an automatic extinguishing system, where fitted.
- Have the capability to stop product transfer, via the ESD system, where fitted.
- Be capable of automatically self-testing and warning of malfunction.

19.2.1 Types of alarm systems

Alarm systems are used to indicate an emergency and to summon assistance.

The various alarm systems range from a local system providing an alert signal at the facility, to one which alerts at a remote station attended by trained personnel 24 hours per day, e.g. 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 risk assessment (see chapter 4) with input from competent personnel in the field of fire protection considering applicable local regulations.

19.2.2 Alarm and signalling systems

Any variation or combination of the types of alarm and signalling systems previously described can be used to meet local circumstances. Alarm systems provide signals that can be audible, visual or both.

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 preferred. The facility should be divided into a grid system, with each grid area 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 activation points can be installed instead of, or to supplement, the telephone reporting system.

When a dedicated telephone system is used, a dedicated telephone should be installed in the control room or supervisory station to receive emergency calls. The telephone should only receive incoming calls and extensions should also be provided at other locations that have preliminary emergency responsibility.

The general alarm system should, at a minimum, consist of one or more air horns, electric horns or steam whistles that 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 heard throughout the terminal regardless of background noise.

Auxiliary alarms should be provided for indoor locations or remote areas where the general alarm cannot be heard. These alarms may be bells, air or electric horns. Whichever devices are provided, they should be the same throughout the facility and should be distinct from other alarms.

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19.2.3 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 an Emergency Power Supply System (EPSS) as a secondary power supply. The EPSS may be provided a trickle charger supplying an emergency battery system, or an uninterrupted power supply for standby power. In some locations, authorities may require an emergency generator as the EPSS a secondary power supply in case the primary supply fails.

The capacity of the EPSS varies with the type of alarm system and the requirements of local authorities. For local or proprietary alarm systems, when signals are registered only at the terminal or plant central control room or central supervisory centre, the EPSS usually provides for loss of primary power for a minimum period of 24 hours under quiescent load conditions, plus a minimum 15 minute supply under emergency conditions if an alarm is triggered.

If the EPSS is provided by a battery backup system, there should be a further 20% additional safety margin above the calculated amp-hour capacity provided to support alarms during evacuation.

Emergency power wiring from the EPSS shall not be routed in the same raceway or distribution routeing as the primary supply, to prevent fire damage to both primary and EPSS wiring and so losing power to the critical equipment.

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 with capacity to operate the entire system if the power is cut off over a weekend is usually required.

19.3 Detection and alarm systems at terminals

19.3.1 General

The specification for the detection and alarm systems on terminals should be risk assessed (see chapter 4) and depend on a number of factors including:

- Products handled.
- Tanker size and number berthed per year.
- Pumping rates.
- Proximity of hazardous equipment with respect to other equipment or hazards, i.e. equipment spacing and electrical area classification.
- Proximity of tankers to the terminal and to hazardous terminal equipment.
- Proximity of the terminal to residential, commercial or other industrial properties.
- Installation of emergency isolation valves.
- Length of pipeline and quantity of product between isolation valves.
- 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.
- Ability of the emergency response unit at the terminal, or within the terminal's organisation, to provide a timely and effective response. This could include consideration of any agreed external emergency response unit. Proximity and mutual aid agreement with any outside emergency response units and their capacity, availability and response time.
- Requirements imposed by local regulatory bodies.
- Desired degree of protection beyond regulatory requirements.
- Degree of effective protection that a manufacturer's detection and alarm system offers.

The alarm system should raise local audible and visual alarms, and possibly a general alarm if the terminal is manned, 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 detection equipment that is designed to activate fixed firefighting systems automatically is recommended where a terminal extends away from shore in such a way that manual firefighting is difficult, dangerous or ineffective. This is also recommended wherever firefighting boats are not available, accessibility to firefighting vehicles is poor or at locations where trained firefighting personnel is limited in number and/or not always available for rapid response.

For manually actuated fire protection systems, the detection system should sound a local alarm and send a signal to an attended control room upon activation.

Equipment and terminal areas that can be monitored with automatic fire or gas detection systems include transfer pumps, valve manifolds, MLA 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.

19.3.2 Control rooms/control buildings

Detection and alarm equipment in control rooms must meet local regulations. The installation of additional gas and fire detection devices with associated alarm equipment depends on site specific factors, e.g. control room pressurisation and attendance. Based on a risk assessment (see chapter 4), control rooms/buildings should be protected from fire by the installation of fire proofing, deluge systems and emergency air supply.

The following general detection and alarm facilities are recommended for control rooms or buildings:

- Manual fire alarm activation points should be provided at all exits, and along escape routes, spaced according to travel distances in appropriate codes and standards.
- A fire detection system should be installed in any area of a control building that is unattended. Each detector should raise a local alarm in attended control rooms and should activate an alarm at the main fire control panel.
- Combustible gas detectors should be installed in the fresh air intake vents of pressurised control rooms and inside non-pressurised control rooms. Each gas detector should sound a local alarm and a main fire control panel alarm.

For terminals handling low flash products, where control rooms are not continuously attended, a fixed fire-extinguishing system, activated automatically upon detection of fire, should be installed. The gas or fire detection system should then be arranged in a cross-zone array (see section 19.1.3).

19.4 Firefighting equipment

Terminal firefighting equipment is located throughout the facility and much of it is exposed to weather. Terminals should ensure that all firefighting equipment is maintained under a PMS, as per OCIMF/SIGTTO's *Jetty Maintenance and Inspection Guide*.

On the jetty, firefighting equipment should be ready for immediate use. While this may not involve the rigging of fire hoses, the preparations for emergency operation of the firefighting equipment should be apparent and communicated to tanker personnel. Consideration should be given to having portable extinguishers available for use adjacent to the jetty manifold area.

Any alternative or supplemental firefighting services provided should deliver at least the equivalent capability as required under the minimum provisions detailed in table 19.1.

Fixed firefighting systems should be capable of full operation within the first five minutes of a fire.

19.4.1 Terminal firefighting equipment

At some terminals, the local authority or port authority may provide the main firefighting capability. The type and quantity of firefighting equipment should meet the minimum requirements detailed in table 19.1 and be risk assessed (see chapter 4) based on the following factors:

- Sizes of tankers that can be accommodated.
- Location of terminal, berth and accessibility.
- Nature and quantity of the cargoes handled.
- Potential impact of oil spillage.
- Areas to be protected.
- Prevailing environmental conditions, including terminals located in cold climates where freezing of water occurs.
- Regional fire response capability, response times and access to terminal facilities/jetties.
- Reciprocal arrangements (mutual aid societies).
- Level of training and experience of local emergency response organisations.

19.4.2 Portable and wheeled fire extinguishers and monitors

Portable 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 and compatible with flammable liquid fires (see table 19.1).

Portable fire extinguishers should be located so that a fire extinguisher can be reached without travelling more than 15m. Wheeled extinguishers should 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 not be at a height of more than one metre.

Carbon dioxide (CO_2) 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 CO_2 extinguishers or should have a fixed CO_2 system installed.

Foam extinguishers with a capacity of at least 100 litre of pre-mixed low expansion foam solution are suitable for use at berths.

Portable foam/water monitors (see table 19.1) should have a discharge capacity of at least 115m^3/hr of foam and water in solution.

Fixed or portable water/foam monitors (see table 19.1) should be provided (one located on either side of the shore manifold) with the ability to reach the tanker and shore manifolds.

19.4.3 Terminal fixed firefighting equipment

19.4.3.1 Fire water supply

Fire water at marine terminals is often provided by the unlimited supply available from the sea, rivers or dock basin.

When fire water supply is obtained from static storage, e.g. a tank or reservoir, the reserve for firefighting purposes should be equivalent to at least four hours of continuous use at the maximum design capacity of the firefighting system. The reserve for firefighting should 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 organised to prevent use of the firefighting 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 cover both extinguishing and cooling water requirements for a fire that might realistically occur. In providing fire water, consideration of climatic conditions and risks from freezing should be assessed at the system design stage. For typical flow rates, more information is available in table 19.1.

Installation	**Minimum recommended provisions**
Barge berth, wharf, or jetty handling liquids with a flashpoint at or below 60°C including materials in drums, and any product heated above its flashpoint OR Tanker berth at a wharf or jetty handling ships of less than 20,000 tonnes DWT and less than one ship per week	Fire main incorporating isolating valves and fire hydrants with a pressurised water supply of not less than 115m³/hr Two fixed or portable water/foam monitors, one on either side of the shore manifold, capable of reaching the tanker outboard manifold Foam tank or totes to provide at least 15 minutes of foam coverage through two monitors 2 x 9kg portable dry chemical extinguishers 2 x 50kg wheeled dry chemical extinguishers 1 international shore fire connection
Tanker berth at a wharf or jetty handling ships of less than 50,000 tonnes DWT OR Tanker berth at a wharf or jetty handling ships of less than 20,000 tonnes DWT and more than one ship per week	Fire main incorporating isolating valves and fire hydrants with a pressurised water supply of not less than 350m³/hr Two fixed or portable water/foam monitors, one on either side of the shore manifold, capable of reaching the tanker outboard manifold Fixed supply of foam should be in place at the berth via a foam tank or totes to provide at least 30 minutes of foam coverage through two monitors 4 x 9kg portable dry chemical extinguishers 2 x 50kg wheeled dry chemical extinguishers 1 international shore fire connection
Tank berth at a wharf or jetty handling ships of 50,000 tonnes DWT or larger	Fire main incorporating isolating valves and fire hydrants with a pressurised water supply of not less than 700m³/hr Two fixed elevated water/foam monitors, one on either side of the shore manifold Fixed supply of foam should be in place at the berth via a foam tank or totes to provide at least 30 minutes of foam coverage through two monitors 6 x 9kg portable dry chemical extinguishers compatible with flammable liquid fires 2 x 50kg wheeled dry chemical extinguishers compatible with flammable liquid fires 1 international shore fire connection
Sea island	Fire protection facilities as above according to use and size of tanker Portable equipment: 6 x 9kg portable dry chemical extinguishers 2 x 50kg wheeled dry chemical extinguishers 1 international shore fire connection

Table 19.1: Minimum recommended provisions or equivalent (see section 19.4.3.7 for existing terminals with single monitor)

19.4.3.2 Fire pumps

Permanently installed fire pumps should be provided on a scale that will ensure adequate reserve capacity to allow for contingencies, e.g. fire pump maintenance, repairs or breakdowns.

Electric motor, diesel engine and steam turbine driven pumps are acceptable. All pumps should have a reliable power or fuel supply to meet the requirements in section 19.4.3.1 and table 19.1.

When the fire pumps are to be located on a wharf or jetty, a safe and protected location is essential 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.

To reduce the risk of a fire impacting the fire pumps, fuel tanks should be located remotely from the fire pump engine. Systems for fire detection and firefighting should be fitted to the tank.

When 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 or by installing the fire pump on a solid deck. Whenever electric motor driven pumps are installed, careful routeing and fire protection of power cables should be considered.

19.4.3.3 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 hydrants.

Fire hydrants generally consist of headers with individual valves fitted with a fire hose connection suitable for the type of fire hose coupling in use. Isolating valves should be fitted to prevent the loss of all firefighting systems because of 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. When the berth fire main is extended from a shore installation, an isolating valve(s) should be provided at the shoreside end of the wharf or jetty. Additional fire hydrants should be provided upstream of an isolating valve.

For 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 enough 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 depend on whether the system is to be used for cooling or production of foam (see table 19.1).

When freezing conditions are encountered, fire mains that are not maintained in the dry mode should be protected from freezing. In particular, when the fire water supply is obtained from an onshore 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.

19.4.3.4 Fire hydrants and hose reels

The number, location and spacing of fire hydrants or hose reels at marine terminals will be determined by the facilities to be protected. At the berth or MLA areas, it is often difficult to achieve uniform spacing of fire hydrants, whereas on approach or access routes, uniform spacing can usually be achieved. Hydrants should be spaced at intervals of not more than 45m in the berth or manifold areas and not more than 90m along the approach or access routes. Each fire hydrant should be equipped with a hose, nozzle and spanner.

Hose connections should be of a design compatible with those of the local or national fire authorities.

Fire hydrants should be readily accessible from roadways or approach routes and located or protected in such a way that they will not be susceptible to physical damage.

19.4.3.5 Pump-in points for firefighting boats

If tugs are used to berth or unberth, or standby tankers, at a terminal, they may be equipped to pump firefighting 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 firefighting 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 have at least 4 x 63mm hose inlets or the equivalent. The hose inlets should have screw-down valves and/or be fitted with Non-Return Valves (NRVs) and be installed to minimise the possibility of hose kinking.

The location of these inlets should be highlighted, e.g. by appropriate signage and white painted hydrants.

19.4.3.6 Foam systems

Foam concentrate should be properly proportioned and mixed with water at a point downstream of fire water pumps and upstream of foam making equipment and application nozzles and monitors. The flow rate may need to be increased if fluorine free foam is used.

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 the high friction losses through such systems.

The type of foam concentrate selected, i.e. protein, fluoroprotein, Aqueous Film Forming Foam (AFFF), or alcohol/polar solvent resistant type concentrate (hydrocarbon surfactant type concentrate), depends upon the fuel type and formulation, of whether aspirating or non-aspirating equipment is installed and ease of re-supply.

See section 5.3.2.1 for environmental issues with AFFF and Alcohol Resistant Aqueous Film Forming Foam (AR-AFFF).

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 described below.

Direct foam pick-up from atmospheric tanks

This method incorporates direct foam induction via a flexible pick-up tube connecting a monitor to either an adjacent foam storage tank at atmospheric pressure, a tank truck, a portable trailer or a 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 using pressure vessels

This unit may contain foam concentrate in one large pressure vessel, possibly of 4.5m^3 capacity, or two smaller pressure vessels of 2.3m^3. The foam proportioner unit is positioned between the fire pumps and the downstream foam making equipment. The system functions by using bypassed fire main water to pressurise a bladder inside the storage vessel and displace the foam concentrate from the storage vessel into a foam system 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 rotary gear electric motor/diesel driven or water turbine driven using a bypass from the fire main.
3. Pipeline grid, possibly of 75mm diameter, traversing the berth approach and the berth, providing numerous take-off points for the attachment of foam induction hoses for connecting portable or fixed equipment.

The foam concentrate grid to the take-off points should have a proportioner to proportion the exact amount of foam concentrate at the take-off point. The foam concentrate pressure at this point should be higher than the fire main pressure (typically 1-barg above the fire main pressure).

When pipelines for foam solution or concentrate are provided, the lines should have several accessible take-off (hydrant) points that should be spaced not more than two or three standard hose lengths apart. Isolating valves should be fitted 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 115m^3/hr.

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.

Supplies of bulk foam concentrate associated with any fixed foam monitor or foam/water sprinkler system should ensure continuous foam application until the arrival of adequate backup firefighting resources, either water borne or land based. The bulk foam concentrate supply should ensure continuous foam application at design flow conditions, as detailed in table 19.1.

19.4.3.7 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 portable unit. The provision of fixed monitors should be considered for tanker berths handling ships in excess of 20,000 tonnes DWT. The scale of provision should be related to the size, location and frequency of use of each individual berth (see table 19.1).

The number and capacity of foam monitors required will depend on local circumstances and conditions, including the capacity of the fire water supply system. Existing facilities may have a single elevated foam monitor provided for berth and tanker firefighting duty. The discharge capacity of a single monitor should not be less than 115m^3/hr and should meet the capacity requirements detailed in table 19.1.

The monitors should be supplied from the berth fire main and be either manually activated at each monitor riser or activated from a remote manual or motorised isolating valve controlling a group of monitors, depending upon the design. Manually operated monitors should be pre-positioned before transfer operations.

Monitors can be situated at berth or wharf deck level, e.g. at small terminals, or mounted on fixed towers. The effective height of the liquid stream required from a monitor is dictated by the particular use envisaged. Fixed monitors should be positioned on towers, or on top of gangway access towers, to ensure that foam discharge will provide unrestricted coverage of the marine transfer equipment and the tanker manifold in all laden and ballast conditions.

Monitors may be manually or remotely controlled either from the tower base or at a distance. Tower base controls may need special protection. Reduced visibility caused by smoke may limit the effectiveness of manually operated fixed towers. Remote control can be achieved by electronic means, hydraulically or with a mechanical linkage. The remote control point for elevated monitors should be 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 15m 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 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.

19.4.3.8 Below deck fixed protection systems

Below deck fixed protection systems are installed when the marine terminal extends over water and away from shore in such a way that firefighting would be difficult or dangerous, or when firefighting boats are not available. In these situations, this type of system will provide a safe base of operations during a large tanker fire and is especially useful where large spill fires on the sea beneath the berth are a possibility.

When firefighting boats are available to provide a quick response, a fixed water spray or deluge system may be installed below deck for cooling non-fire resistant, unprotected supports and exposed structures, should there be a local surface fire. The rate of discharge for such a system should be at least 10.2 litres per minute per square metre.

When firefighting 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.

19.5 Access for firefighting services

Parking areas should be provided for firefighting vehicles close to marine terminal approaches. The provision of a layby or passing area on jetty approach structures should also be assessed, including hazardous zone classification. Consideration should be given to any limitations regarding the maximum axle weights for vehicles accessing berth structures and the ability to turn and exit the jetty head.

CHAPTER 20

Emergency Preparedness and Evacuation

20.1 Overview

20.2 Hierarchy of emergency scenarios

20.3 Terminal emergency planning – plan components and procedures

20.4 Spill response plan

20.5 Emergency evacuation and personnel escape routes

20.6 Training for emergencies and emergency exercises

20.7 Emergency removal of tanker from berth

The first consideration in the event of a fire, explosion or other emergency at a terminal is the safety of personnel. A comprehensive and well exercised emergency and evacuation plan is essential for a terminal to respond to emergencies effectively.

This chapter provides guidance on the preparation of terminal emergency response, evacuation plans and important training and resources.

Detailed information on fire protection in terminals is contained in chapter 19.

20.1 Overview

All terminals should have procedures for immediate action in emergencies. A risk assessment (see chapter 4) should be undertaken to identify the emergencies at the terminal. Procedures and resources should cover all credible scenarios, or situations, identified for the terminal, including oil spillage, gas leak resulting in vapour clouds, fire, explosion and ill or injured persons. The plan should have information for the terminal to help visiting tankers, e.g. the ability to respond to fires on the tanker outboard manifold.

Personnel should be familiar with the emergency procedures, be trained and understand the actions required to respond to an emergency. This includes using alarms, creating a control centre and organising personnel.

Information on the hazards of the products handled at the terminal should be readily available in an emergency. The Safety Data Sheet (SDS) should be available to provide workers and emergency personnel with procedures for handling or working with each particular product. The SDS should include details of physical data (e.g. melting point, boiling point, flashpoint), toxicity, health effects, first aid, reactivity, storage, disposal and the PPE required.

Sufficient manpower is needed to properly respond to an emergency. A study should be made to determine the manpower required for the whole period of any emergency. Assistance may be from local emergency organisations, nearby airports, industrial plants or military installations. However, terminal manpower should be enough to mount a first response.

The most important parts of emergency plans are organisation and resources. The plan only works if these parts are checked during preparation and regularly practised, so that it fully meets the terminal requirements.

When creating the emergency plan, all groups involved should be consulted.

It is important to:

- Analyse credible emergency scenarios.
- Agree on the best way to respond to the scenarios.
- Agree on an organised plan with the necessary resources to complete the plan properly.
- Document training and practice schedules.

20.2 Hierarchy of emergency scenarios

20.2.1 General

The following guidelines are not prescriptive but intended to provide examples that can be customised for a terminal or specific scenario. For terminals that already have emergency plans, these guidelines provide a checklist for comparison.

20.2.2 Hierarchy of emergencies

Before creating a terminal emergency plan, a study should be made of the terminal, available resources checked (both in and outside working hours) and common scenarios reviewed. Based on this study, a risk-based hierarchy of emergencies should be created, e.g.:

- Local emergency.
- Terminal emergency.
- Major emergency.

20.2.3 Local emergency

A local emergency is a low risk to life and property that can be managed by terminal staff. This emergency does not affect operations in other parts of the terminal or in the port.

20.2.4 Terminal emergency

A terminal emergency is one that is more complex or larger. It can impact operations in the whole terminal, may affect more than one tanker and may influence the port.

20.2.5 Major emergency

A major emergency is a very high risk to life and property and the whole terminal as well as the neighbouring port is at great risk.

20.2.6 Escalation

Not every operational incident is as an emergency. However, an incident may change into an emergency, so the plan should describe how to raise the response to a higher level.

20.2.7 Assessing risks

The range of emergencies that a terminal may have to manage may include incidents at the terminal itself and those in the port environment that may threaten, or require major assistance from, the terminal.

Begin with a very wide view of risks and then prioritise them by the possible effect on the terminal operation, together with the chance it may happen. A review of incidents in the recent past can help with this.

20.2.8 Credible emergency scenarios

Incidents that should be covered within the scope of the terminal risk assessment include, but are not limited to:

- Fire or explosion at the terminal and on or around a berthed tanker.
- Release of flammable and/or toxic vapours, gases, oil or chemicals.
- Collisions and allision.
- A tanker breaking away from a jetty, dragging anchor or grounding.
- Major port accidents involving ships, tugs, mooring boats or ferries.
- Meteorological hazards, e.g. floods, hurricanes and electrical storms.
- Terrorist attack or security threat against tankers or the terminal.

20.3 Terminal emergency planning – plan components and procedures

20.3.1 Preparation

In developing a terminal emergency plan, it is important that the functions and stakeholders concerned at the terminal or tanker, e.g. operations, engineering, marine and safety, as well as the wider port area, e.g. port authority, fire brigade, police, Oil Spill Response Organisation (OSRO), and other emergency response providers, are involved. A group may be created, with one person leading communications with all other stakeholders involved.

As staff members and organisations change, the plan should be updated. It is recommended that one staff member is responsible for updating the plan, using a single master copy. Only this member can make changes to the emergency plan.

Everyone with a specific role in the emergency plan should have their own copy of it. Copies should also be available in control rooms. Keep a record of all copies, where they are and each time a change is made. Make written receipts each time a copy is given out.

When digital copies of plans are available to all personnel, e.g. on a local server, the digital version is the controlled copy and printed versions are uncontrolled.

One member should be nominated as room manager for the control centre. They will ensure that the centre has emergency materials and up-to-date documents and will also make sure that it is kept clean and ready for immediate use.

20.3.2 Format

The format of the terminal emergency plan depends on the local situation, the type of plan and its relationship to other documentation.

Personnel who use the plan should be able to read and understand the content. If more than one language version of the plan is used, one version, usually in the local language, should be designated as the original. If another language is required, and the emergency might involve a tanker, the recommended default language should be English.

- Use flowcharts and diagrams with symbols to reduce written text.
- Digital plans should be:
  - Available to all personnel.
  - Locked with passwords and anti-virus protection.
  - On a computer with an emergency power supply.

All terminals should create an emergency plan that covers all parts of the response in an emergency.

The plan should have:

- Methods to raise the alarm.
- First actions to control the incident.
- Mobilisation and demobilisation procedures.
- Evacuation procedures.
- Assembly points.
- Emergency organisation, including roles and responsibilities.
- Communications systems.
- Media response and public affairs.
- Emergency control centres.
- List and location of emergency equipment.
- Contingency plans.
- Procedure for returning to normal operation.

Each terminal should have an emergency response team with duties including planning, implementing, drilling/exercising and revising emergency procedures as well as executing them.

The main parts for first response to an emergency, e.g. reporting, actions and location of equipment, should be displayed at important locations in the terminal.

Tankers alongside should be advised of the aspects of the terminal's emergency plan that relate to their operations, including alarm signals and escape routes and how the tanker can ask for assistance in an emergency.

The terminal emergency plan should work with:

- Other parts of the company organisation and site facilities.
- Relevant outside organisations, including other companies and public bodies.

Outside organisations that may be involved in an emergency should be familiar with relevant sections of the terminal emergency plan and should participate in joint response exercises.

20.3.3 Control

The terminal emergency plan should identify the personnel who have overall responsibility for managing the emergency response. The responsibilities of other terminal staff should also be detailed.

If there is no control centre, an office should be designated as ready for use in an emergency. The location of the control centre and a list of all personnel assigned to it should be described in the plan. The control centre should be located at a central point that is not next to potentially hazardous areas.

During an emergency, the control centre should have personnel from the terminal, and those from the port authority, fire brigade, tug company, police or other appropriate civil authority. If the emergency involves a tanker, a Responsible Officer may attend the control centre to give advice. A Public Relations Officer should be chosen to relay information to the public, other port users and all involved groups.

During an emergency, it is important that key personnel are easily recognisable, e.g. by wearing different coloured safety helmets or vests. The emergency plan should include these details.

The plan should identify those authorised to declare that an emergency is over. See OCIMF's MTMSA.

20.3.4 Alarms and communications

20.3.4.1 Alarms

All terminals should have an emergency alarm system.

Alarm operation is different for each terminal. For example, a single alarm may be enough for a small terminal, but a large terminal may have a range of alarms for different levels of emergencies. The alarm operation should be described in the marine terminal manual and TIB.

It may be important to also include a silent alarm that secretly notifies a small number of personnel by telephone or radio in case of emergencies such as bomb threats or attacks.

20.3.4.2 Contact lists

The terminal emergency plan should include contact details, both during and outside office hours, for personnel who should be called in case of emergency.

Alternate emergency response staff should be identified in the contact list and they should know their responsibilities and be trained in their duties.

The contact list should be complete and up to date to make sure no other documents, e.g. telephone directories, are needed.

20.3.4.3 Communication system requirements

Reliable communications are essential for managing emergency situations. Backup power supplies should be available in case the primary system fails.

There are three basic parts to the system:

- Terminal emergency alarm.
- Requesting assistance.
- Coordination and control of all emergency activities.

The communications system should be able to cover operations on the jetty, on a tanker, on nearby waters or from other places at the terminal.

Small terminals should at least be able to provide a clear evacuation signal. However, radio and telephone communications are usually the first and best choices of communication.

Larger terminals should have a complete range of communication systems, including Very High Frequency/Ultra High Frequency (VHF/UHF) radio and public address equipment. Incident leadership personnel should have portable radio equipment. A communication centre should be established in the emergency control centre.

If dedicated telephone lines are not used, the emergency communications system should be able to stop other calls using the same line.

The emergency control centre should manage the direction, coordination and control of all emergency activities, including giving advice and information to other port users. For these purposes, it should have a proper communications system linking it with all contacts, both inside and outside the terminal.

20.3.4.4 Communications discipline

The emergency plan should include a set of communication disciplines, which may include code words for different types of emergency. These should also cover the use of personal social media platforms during emergency response. Media response teams should be provided with the equipment to actively monitor all media platforms, including digital and social media, to ensure all reports are effectively managed during the emergency response.

All personnel should understand the need to strictly observe established rules for communication during an emergency and receive training in the use of communications equipment and procedures.

Once mobilised, key staff involved in managing the emergency should limit their communications to that required for emergency response. Communications with the press and media should be managed by the designated media affairs team.

Media organisations play an important role in satisfying the public's demand for information. Managing their demands is challenging with technology, and particularly social media, allowing for instantaneous reporting of events. Handling media interest, particularly in major events when it can extend from local to national and international media organisations, can be a distraction to the incident response team. This will require the situation to be managed effectively to avoid hampering the emergency response.

When an emergency occurs the communications primary objective is to deliver accurate, clear and timely information to the public, to demonstrate that the incident is well managed.

Personnel trained in media response should be designated in the emergency plan. Communications with the media should follow documented media response protocols and be under the control of the central command organisation.

Digital and social media is widely used to provide information to the public. However, it is important to understand that information can be generated by official and unofficial sources, with the latter often being less factual and more speculative than official sources. This will need to be considered when developing a media communication strategy.

A log of events should be kept at the control centre and a record, written or recorded, should be kept of radio and telephone communications.

20.3.5 Site plans and maps

Plans showing firefighting equipment, major terminal facilities and road access should always be updated and available in an emergency, with copies kept in the control centre.

The locations and details of firefighting and emergency equipment on or near a berth should be displayed on the berth.

20.3.6 Access to equipment

All emergency equipment, including fire and lifesaving equipment, should be readily accessible and kept free of obstructions at all times.

20.3.7 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, including any road tankers delivering bunkers (see sections 24.1 and 24.6), should only be parked in designated areas and ignition keys left in the vehicle.

During an emergency, traffic into a terminal or onto berths should be restricted to vehicles and personnel needed for the incident response.

20.3.8 Outside services

The terminal emergency plan should make the best possible use of external services. It is important that external service providers are involved in joint emergency exercises. Combined exercises involving port authorities, tugs, tankers and shore emergency should be conducted at least once a year.

If the terminal is located in an area with other industry activities, consideration should be given to establishing a mutual assistance plan where other groups assist each other in an emergency.

20.3.9 Harbour authorities, vessel traffic control centres, police and fire services

The terminal emergency plan should inform the local harbour authority and vessel traffic control centre, if applicable, of any emergency involving the terminal, or tankers berthed at the terminal, including the details of the:

- Emergency.
- Tankers involved, with locations and cargo details.
- Assistance needed.

This information will let the harbour authority and vessel traffic control centre decide if they should stop navigation within the port area or close the port.

The emergency plan should make sure that any emergency that needs assistance beyond the resources of the terminal is immediately reported to the local fire services or police.

20.3.10 Pilots

If it is decided to partially or totally evacuate jetties, the local pilot organisation may need to be called upon at short notice to provide several pilots to advise on the handling of tankers not directly involved in the incident. The emergency plan should make provision for this eventuality.

20.3.11 Rescue launches

A launch or launches, if available and can be safely deployed, should be included in the plan, to assist with:

- Recovery of personnel in the water.
- Evacuation of personnel trapped on a tanker or on a berth.

Launches for these duties should have the following equipment:

- Communication link that can connect to the control centre's communication system.
- Fixed or portable searchlights for operations during darkness or reduced visibility.
- Thermal blankets.
- Equipment to assist in the recovery of personnel from the water.
- Resuscitation or lifesaving equipment.
- First aid kits.
- Lifejackets for personnel recovered from the water.

The crews of the launches should be trained in rescuing survivors from the water. This should include an awareness of how to handle casualties that may be seriously injured or suffering from extensive burns or hypothermia. Crews should also receive instructions in how to operate breathing assistance equipment including artificial respirators. Launch crews should understand that survival time in the water could be very short and that fast action can save lives.

20.3.12 Medical facilities

Depending on the emergency, it may be necessary to alert medical facilities within and outside the terminal. The emergency plan should include these details.

Medical facilities will need to know:

- The nature and location of the emergency.
- The nature of products involved.
- The expected number of casualties and injuries.
- If medical staff are needed at the location of the emergency.
- Details of the casualties, including names, as soon as these are known.

20.4 Spill response plan

Each terminal should have an approved spill response plan.

At least, the plan should include:

- Name of the plan owner.
- Document control section that identifies plan holders and updates.
- Details including operations, pollutants and a map of the area.
- Roles and responsibilities.
- Identification of the OSRO.
- Spill risk assessment section listing all credible spill scenarios.
- Definitions of tier 1, 2 and 3 spills. The definitions can be a combination of sizes, types of pollutant, repercussions and impacts to assist with spill classification.
- Description of the response plans for the tier 1 response, describing the pollutants.
- Action checklists for members of the spill response teams.
- Health and safety guidance, including SDS.
- Spill size assessment guide.
- Reporting procedures required by the company and authorities.
- Media response and public affairs.
- Contractor management and procurement.
- Notification section, including contact details.
- Inventory of tier 1 clean-up resources.
- Location of tier 2 and tier 3 spill resources.
- References to locations of hydrographic charts and sensitivity maps for the plan.
- A clear understanding of the expectations, that national government or other competent authority may have on the terminal, to respond to spills away from the terminal, e.g. passing traffic) and how far the terminal jurisdiction extends.

20.4.1 Tiered response

Tiered response is a term commonly used in relation to oil spill planning scenarios, oil spill incidents and response in terms of the scale and response capabilities, expertise and resources required.

Tier 1

Oil spill incidents that affect a localised area, being managed using response capabilities, expertise and resources often pre-positioned close by and managed by the terminal.

Tier 2

Oil spill incidents that involve a broader range of impacts and stakeholders. Tier 2 response capabilities, expertise and resources are available regionally and commonly provided by contractors or through mutual agreements between operators and/or other organisations.

Tier 3

Oil spill incidents that have the potential to cause widespread impact, affecting many people and overwhelming the capabilities of local, regional and even national resources. Tier 3 oil spill incidents require the mobilisation of substantial response capabilities (OSRO), expertise and resources, potentially across international borders, and integration into a coordinated response.

International Petroleum Industry Environmental Conservation Association (IPIECA) provide further information including *Report Series Volume 14: Guide to Tiered Preparedness and Response*.

20.4.2 Resource availability

It may be necessary to plan for use of additional outside resources, e.g. materials, equipment and manpower. The plan should include the accessibility and availability of the terminal and outside resources.

The plan should identify those responsible for calling on outside help and provide contact information. Additional resource needed may include:

- 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 firefighting foam concentrate.
- Self-Contained Breathing Apparatus (SCBA).
- Fire suits, helmets and other fire protective clothing.
- Rescue devices, such as hydraulic spreaders and jacks, lifelines, lifebuoys, ladders and stretchers.
- Emergency showers and eyewash stations.
- Medical resources and portable life support systems.
- Food and beverages.
- Human resources, e.g. drivers, electricians, mechanics and general manpower, to ensure material resources are successfully deployed and made operational.

For each resource group, the plan should list:

- Availability, amounts and numbers.
- Main details and performance data.
- Accessibility on a 24 hour basis.
- Addresses of people and location of stores, telephones and radios.
- Delivery time for supply or mobilisation.

20.5 Emergency evacuation and personnel escape routes

The main focus in the event of a fire, explosion or other emergency at a terminal will be the safety of personnel and how they can be safely evacuated.

20.5.1 General

To ensure the effective evacuation of personnel, all terminals should have evacuation facilities and a documented evacuation plan. The plan should be given to visiting tankers and included in the TIB.

The evacuation plan is different for each terminal and depends on the type and location of equipment. This should be checked with a site risk assessment and should include details such as site restrictions, e.g. access, egress and local security measures, weather conditions, e.g. wind direction and sea state, and availability of emergency response and assistance.

20.5.2 T-head jetties and finger piers

Terminal facilities with a shore connection, e.g. T-head jetties and finger piers, have the advantage of potential for evacuation by road transport. Some terminal facilities are designed with oil and gas pipelines supported on the underside of the pier. For this type of facility an evacuation route via water may be needed unless a second escape path via the shore is provided. A fixed means for embarking personnel into tugs, boats and other rescue craft should be provided in the event of the shore route being inaccessible.

20.5.3 Sea islands

From sea islands, the only way to evacuate is by water, although helicopter evacuation may be an option at very large terminal facilities at distant locations. Sea islands should provide fixed means for embarking personnel into tugs, boats and other rescue craft in the event of the shore route being inaccessible. The evacuation of tanker crews should also be considered.

Oil and gas operations do not require large numbers of operating personnel to be involved at marine terminals and it is probable that tanker crews will outnumber terminal personnel. It may also be possible that maintenance personnel will, on occasions, outnumber operational personnel and so the evacuation plan should recognise and cater for this.

20.5.4 Tanker evacuation

There should be an agreement between tankers and terminals in any evacuation plan, and it is important that Masters of all tankers using a terminal are aware of emergency evacuation plans. These agreements should be discussed at the pre-transfer conference and identified when the SSSCL is finished. If it is not involved in the emergency the best way to evacuate may be by the tanker leaving the terminal (see section 20.7).

20.5.5 Non-essential personnel

When an emergency situation may worsen, everyone not involved in safety or firefighting operations should be evacuated.

The decision to evacuate all non-essential personnel should be made early. Early evacuation is safer for personnel and allows the PIC to focus more on emergency response.

20.5.6 Primary and secondary escape routes

Terminal facilities and sea island structures should have emergency muster locations clearly marked and there should be at least two different evacuation routes from all occupied or work areas and from berthed tankers. Escape routes should be located so that, in the event of fire, at least one route provides a safe path, far enough from the source of probable fire to keep personnel safe during evacuation. Evacuation routes and secondary evacuation routes should be clearly marked, and numbered, so that clear instructions can be given to personnel. Evacuation routes should be detailed in the TIB.

If escape routes cannot be kept away from sources of probable fire, the route should be protected, where practicable, by fire walls/barriers or heat shields and should keep personnel safe 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 to prevent the need for personnel to jump into water to reach an area of refuge.

Berths and jetties can be difficult to escape from in the event of fire or other emergency. Escape routes should be designed carefully. Access ways to and from offshore berths and dolphins require special attention as people should not be left unattended on isolated dolphins. In addition, steps or steel ladders are usually needed between berths and the water level. On sea islands, access routes and assembly points for rescue craft, or dedicated lifeboats, may require fire walls, enclosures or barriers to provide extended personnel protection.

20.5.7 Availability of rescue craft

When rescue craft may be required for evacuating a terminal they should be kept as close as possible to the evacuation point. The rescue craft and crew should be mobilised early in the emergency and able to be on scene no later than 15 minutes from initial contact. The mobilisation of all available harbour or terminal rescue craft should 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 in the emergency plan. Early warning should be given for the assembly of all craft used for evacuation, which will then be under the control of the PIC of emergency response.

20.5.8 Survival craft

Remote sea islands may have dedicated emergency evacuation craft, commonly known as survival craft. Survival craft are motor propelled enclosed boats. They are self-righting with fire retardant rigid hulls that are protected by external cooling water sprays. Survival craft have the capability of being launched by remote control within the craft after people have embarked and can protect people when the craft passes through fire on water. The decision to use survival craft at marine terminals should be a local one based on a risk assessment of site specific criteria.

20.5.9 Lifesaving appliances

Every terminal and sea island installation should be equipped with lifesaving appliances for use in evacuation and rescue, such as lifebuoys, Personal Flotation Devices (PFDs) for every person located at the site and, where appropriate, liferafts or lifeboats. PFDs should be located in prominent and accessible positions.

Lifebuoys and liferafts are not suitable for use in evacuation in the case of fire on water, however such lifesaving equipment may be required under local regulations. These devices are typically used for emergency rescue from water in the case of someone going overboard.

20.6 Training for emergencies and emergency exercises

Training should be given for the following emergency activities:

- Firefighting using equipment available at the terminal.
- Transfer of hazardous materials away from the site of the fire.
- Fire isolation.
- Use of PPE.
- Media response and public affairs.
- Coordinated operation with outside bodies.
- Rescue, including training for selected personnel in lifesaving from water.
- Spill containment and clean up.
- Evacuation drills.
- Security threats and terrorist attacks.

The effectiveness of emergency and evacuation plans depends on the training and understanding of personnel.

Emergency and evacuation drills should be held frequently and all key and supervisory personnel at the facility should have a thorough understanding of the emergency and evacuation plans. The plans should be reviewed at least once per year, or after any changes that might affect the response, or findings from routine drills and exercises.

Records should be kept and areas that need improvement or lessons learnt should be recorded and formally followed up.

Individual training records should include details of additional training required after participation in exercises.

20.7 Emergency removal of tanker from berth

When the emergency is on a tanker, the safest course of action, for the tanker, the terminal and the port, is for the tanker to be kept alongside whenever possible. This allows shore based personnel and equipment to be used to support emergency response on board.

If a fire on a tanker or on a berth cannot be controlled, it may be necessary to consider whether it should be removed from the berth. Planning for such an event will require consultation between a port authority representative or Harbour Master, Terminal Representative, Master of the tanker and the senior local authority fire officer. Any consideration of removal of the tanker from berth requires the consent of all interested parties, including local or government authorities, and needs to consider the wider implications to the port.

In the event that an incident escalates, the plan should include the removal of unaffected tankers from adjacent berths.

PART 4

Ship/Shore (Tanker/Terminal) Interface

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CHAPTER 21

Communications

21.1 Procedures and precautions

21.2 Pre-arrival exchange of information

21.3 Pre-berthing exchange of information

21.4 Pre-transfer conference

21.5 Agreed loading plan

21.6 Agreed discharge plan

21.7 Agreement to carry out repairs

This chapter provides guidance for communications between the tanker and terminal and pre-arrival communications between the tanker and local authorities. It addresses communication exchanges between tanker and terminal before berthing and mooring and before and during cargo, ballast or bunkering operations, including emergency communication procedures.

21.1 Procedures and precautions

21.1.1 Communications equipment

Telephone and portable Very High Frequency/Ultra High Frequency (VHF/UHF) and radiotelephone systems should comply with the appropriate safety requirements.

The terminal is responsible for providing the means of communication, including a backup system.

When dedicated telephones are used between the tanker and terminal, they should be continuously monitored by personnel on board and ashore, allowing immediate communication according to agreed procedures. Most mobile telephones and pagers are not intrinsically safe and are only considered safe for use in non-hazardous areas (see section 4.12.5 on mobile telephones and pagers).

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 personnel who can contact them immediately. When fixed systems are used, they should be continuously monitored by tanker and terminal personnel.

The system of communication, together with the necessary information on telephone numbers and/or channels to be used, should be agreed and documented during the pre-transfer conference. Representatives of both parties should sign the agreement form.

21.1.2 Communications procedures

To ensure operations are safely controlled, both parties are responsible for establishing, agreeing in writing and maintaining a reliable communications system. Exchange information in English and/or the common working language.

The primary system should be tested before loading or discharging starts and at intervals, as agreed, during the pre-transfer conference throughout cargo transfer operations.

A secondary standby system, that is separate and independent of the primary system, should also be established, agreed and tested. Allowance should be made for the time required for action in response to signals.

Emergency signals, and any other necessary signals, should be agreed during the pre-transfer conference before the start of cargo transfer.

When handling different products or grades, their names and descriptions should be clearly understood by tanker and terminal personnel assigned to cargo handling.

Avoid using a single VHF/UHF channel for more than one tanker/terminal combination.

English is the international language of the sea and should be used for verbal communication between the tanker and terminal. Any difficulties can be overcome by appointing a person with adequate technical and operational knowledge and a command of a language understood by tanker and terminal personnel (refer to the International Maritime Organization's (IMO) *Standard Marine Communication Phrases*, Resolution A.918(22)).

21.1.3 Compliance with terminal and local regulations

Tanker and terminal personnel must comply with the terminal's security, safety and pollution regulations. Terminals should make tankers aware of regulations by transmitting the Terminal Information Booklet (TIB) well in advance of arrival, together with any regulations issued by the port authority.

OCIMF's Marine Terminal Information System (MTIS) database provides terminal and ship operators, charterers and associated stakeholders with a single, central storage of terminal specific data in a consistent format (see chapter 15).

21.2 Pre-arrival exchange of information

Before the tanker arrives at the terminal, it should provide any information demanded by local, regional, national and international requirements.

The pre-arrival exchange of information between the tanker and terminal should cover items required in the Ship/Shore Safety Checklist (SSSCL) (see section 25.4), including the following detailed information.

21.2.1 Security information

Security protocols need to be agreed between the tanker and the port or terminal security officer. They should establish these during pre-arrival communications.

In addition to International Ship and Port Facility Security (ISPS) requirements, the tanker should provide the terminal with a list of approved visitors, including Agents, Surveyors and Loading Masters. Stores delivery, bunker barges and garbage disposal should be communicated before arrival and agreed at the pre-transfer conference and the details recorded.

21.2.2 Terminal to tanker

The terminal should ensure that the tanker is provided with the facility's TIB and advise the tanker of any defects to terminal equipment. The information that should be contained in the TIB is detailed in the latest edition of OCIMF's *Marine Terminal Information Booklet: Guidelines and Recommendations.*

21.2.3 Tanker to terminal

Whenever possible, the following information should be sent at least 24 hours before arrival:

- Tanker's name, call sign and IMO number.
- Country of registration.
- Length Overall (LOA).
- Beam.
- Arrival draught (fwd, mid and aft).
- Estimated time of arrival.
- Deadweight/displacement.
- If loaded, the type and quantity of cargo and disposition, including any toxic properties.
- Maximum draught expected during cargo handling and when completed.
- Any defects in the hull, machinery or equipment.
- Inert Gas (IG) system, if fitted, is operational and where applicable the tanker's cargo tanks are inert (oxygen content less than 8% volume).
- If an alternative fuel system is used, e.g. Liquefied Natural Gas (LNG), confirmation that the control systems are operational.
- Any need for tank cleaning and/or gas freeing.
- Whether Crude Oil Washing (COW) is to be used and that the pre-arrival checklist has been completed.
- Tanker manifold details, including type, size, number, distance between centres of connections to be presented and the products to be handled at each manifold, numbered from forward.
- Proposed cargo handling, including grades, sequence, quantities and any rate restrictions.
- Quantity and nature of slops and dirty ballast and any contamination by chemical additives. Identification of any toxic components, such as hydrogen sulphide (H_2S) or benzene.
- Quantities and specifications of any bunkers required, including delivery method.
- Ballast on board and individual tank quantities.
- Last calibration certificate of the gas detection system and gas meters, including the IG system.
- Security level currently in effect for the tanker.
- Winterisation procedure, if applicable.
- Contracted Oil Spill Response Organisation (OSRO).
- Any specific additional requirements detailed in the TIB.

21.3 Pre-berthing exchange of information

The pre-arrival exchange of information between the tanker and terminal should cover pre-berthing checks required by the SSSCL (see section 25.4), including the following information detailed below.

21.3.1 Tanker to terminal and/or pilot

On arrival at the designated position and/or pilot station, the Master should establish direct communications with the terminal and/or pilot station. After the Pilot has boarded, the following information should be exchanged:

- Master/Pilot information exchange documentation (see ICS' *Bridge Procedures Guide*).
- Location of the chocks, bollards and strong points that can be used for towing.
- Safe Working Load (SWL) of towing equipment.
- Number and location of areas on the tanker's hull that are strengthened or suitable for pushing, and details of the identification marks.
- Summary of up-to-date critical information for the port call.
- Details of the tanker's mooring system (see OCIMF's *Mooring Equipment Guidelines*).

21.3.2 Terminal and/or pilot to tanker

Before mooring, the Master and Pilot should verify they have received details of the mooring plan, safe access plan, e.g. gangway placement, and the terminal's operating limits. The mooring plan and communications during mooring should be specified. The Master should review these and agree them with the terminal and/or Pilot or Mooring Master.

Any deviation from the agreed mooring plan required by changing weather conditions should be communicated to the Master as soon as possible.

Information should include:

For all types of berth:

- Plan for approaching the berth, including turning locations, environmental limits and maximum speeds.
- The characteristics and number of tugs, mooring boats and other external facilities, including Minimum Breaking Load (MBL) of towlines.
- Any special conditions, e.g. weather, depth of water, tidal currents and marine traffic, that may be expected during the passage.
- Tanker's mooring requirements (number, type, length).
- Safe access arrangements.

For quay and/or jetty berths:

- Information on mooring arrangements.
- Number, SWL and position of bollards or quick release hooks.
- Number and location of jetty manifold connections or Marine Loading Arms (MLAs).
- Limitations of the fendering system and of the maximum displacement, approach velocity and angle of approach for which the berth and fendering system have been designed.
- Details of any berthing aids, such as Doppler radar or laser equipment.
- Any feature of the berth that is considered essential to bring to the prior notice of the Master.

For all offshore terminals, the:

- SWL of the tanker's hose handling equipment.
- Number and flange size of the hoses to be connected and details of any equipment that the tanker should provide to help with hose handling.

For Multi Buoy Moorings (MBMs), (All Buoy Moorings (ABMs) and Conventional Buoy Moorings (CBMs)):

- Minimum number of shackles of cable required on each anchor that may be used during mooring.
- Number and position of mooring lines, shackles and other mooring equipment likely to be needed.

For Single Point Moorings (SPMs):

- Diameter of the chafe chain links used in the mooring.
- Weight of each of the moorings to be lifted on board.
- Length and size of any messenger lines to be used to pick up the moorings.
- Minimum dimension of bow chock or lead required.
- Method to make the SPM fast to the tanker and details of any equipment the tanker should provide.

Further information is in OCIMF's *Guide for Offshore Tanker Operations*, *Guidelines for the Design, Operation and Maintenance of Multi Buoy Moorings* and *Single Point Mooring Maintenance and Operations Guide.*

21.4 Pre-transfer conference

Safe and efficient cargo, ballast and bunkering operations depend on effective cooperation and coordination between all the parties involved. This section covers information that they should exchange before operations begin to ensure completion of the SSSCL, including pre-transfer agreements as per section 25.4.3.

In addition to the pre-transfer conference, the responsible parties from the tanker and the terminal should continue the additional checks required in other relevant parts of the SSSCL.

21.4.1 Tanker to terminal

Before transfer operations start, the Responsible Officer should inform the terminal of the general arrangement of the cargo, ballast and bunker tanks.

Information in preparation for loading cargo and bunkers:

- Details of the last cargo carried, method of tank cleaning (if any) and state of the cargo tanks and lines.
- Grade, volume and tank distribution of any part-cargo on board on arrival.
- Maximum acceptable loading and topping-off rates.
- Maximum acceptable pressure at the cargo manifold.
- Cargo quantities verified and agreed by tanker and terminal.
- Proposed cargo distribution and preferred order of loading.
- Maximum acceptable cargo temperature (where applicable).
- Proposed method of venting.
- Quantities and specifications of bunkers required.
- Quantity, quality and distribution of slops.
- Where applicable, the quality of any IG.
- Communication system for loading control, including the signal for emergency stop.

Information in preparation for cargo discharge:

- Cargo specifications.
- Any toxic components (H_2S, benzene, lead additives or mercaptans).
- Any cargo characteristics requiring special attention, e.g. pour point and True Vapour Pressure (TVP).
- Flashpoint of any relevant products and their temperatures on arrival.
- Distribution of cargo on board by grade and quantity.
- Quantity and distribution of slops.
- Any unaccountable change of ullage in the tanker's tanks since loading.
- Any water dips in cargo tanks.
- Preferred order of discharge.
- Maximum discharge rates and pressures.
- Whether tank cleaning, including COW, is required.
- Approximate start time and duration of ballasting into permanent ballast tanks and cargo tanks.

21.4.2 Terminal to tanker

The following information should be provided to the Responsible Officer.

Information in preparation for loading cargo and bunkers:

- Cargo specifications and the preferred order of loading.
- Any toxic components (H_2S, benzene, lead additives or mercaptans).
- Tank venting requirements.
- Any cargo characteristics requiring special attention, e.g. pour point or high TVP.
- Flashpoints of products and their estimated loading temperatures, particularly when the cargo is non-volatile.
- Bunker specifications.
- 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 tanker/terminal cargo connection.
- Number and sizes of hoses or arms available and manifold connections required for each product or grade of the cargo and any Vapour Emission Control Systems (VECSs).
- Limitations on the movement of hoses or/and arms.
- Communication system for loading control, including the signal for emergency stop.
- Safety Data Sheets (SDSs) for each product to be handled.

Information in preparation for cargo discharge:

- Terminal's acceptable order of discharge.
- Nominated quantities of cargo to be discharged.
- Maximum acceptable discharge rates.
- Maximum pressure acceptable at the cargo manifold.
- Number and sizes of hoses or arms available, the manifold connections required for each product or grade of the cargo and whether these arms are common with each other.
- Any limitations on the movement of hoses and/or arms.
- Any other limitations at the terminal.
- Communication system for discharge control, including the signal for emergency stop.
- Details of any booster pump(s) to be used during discharge.

21.5 Agreed loading plan

On the basis of the information exchanged, the Responsible Officer and Terminal Representative should draw up a written operational agreement that covers:

- Tanker's name, berth, date and time.
- Names of tanker and terminal representatives.
- Cargo distribution on arrival and departure.
- For each product:
  - Quantity.
  - Tanker's tanks to be loaded.
  - Shore tanks to be discharged. Lines to be used tanker/terminal.
  - Cargo transfer rate.
  - Operating pressure.
  - Maximum allowable pressure.
  - Temperature limits.
  - Venting system.
  - Sampling and gauging procedures.
- Any restrictions because of:
  - Electrostatic properties.
  - Emergency Shutdown (ESD) valve closing times.

This agreement should include a loading plan that indicates the expected timing and covers:

- The loading sequence for the tanker's tanks, taking into consideration:
  - De-ballasting operations.
  - Tanker and shore tank change over.
  - Avoiding cargo contamination.
  - Pipeline clearing for loading.
  - Other operations that may affect flow rates.
  - Trim and draught of the tanker.
  - Need to ensure that permitted stresses will not be exceeded.
- The initial and maximum loading rates, topping-off rates and normal stopping times, including:
  - Nature of the cargo to be loaded.
  - Arrangement and capacity of the tanker's cargo lines and gas venting system or vapour return, if applicable.
  - Maximum allowable pressure and flow rate in the tanker/terminal hoses or MLAs.
  - Precautions to avoid static electricity.
  - Any other flow control limitations.
- The method of tank venting to avoid or reduce gas emissions at deck level, accounting for:
  - TVP of the cargo to be loaded.
  - Loading rates.
  - Atmospheric conditions, including wind speed (see section 2.1.3.2) and electrical storms.
- Bunkering or storing operations.
- Emergency stop procedure.

Once the loading plan has been agreed, it should be signed by the Responsible Officer and Terminal Representative.

21.6 Agreed discharge plan

On the basis of the information exchanged, the Responsible Officer and Terminal Representative should draw up a written operational agreement that covers:

- Tanker's name, berth, date and time.
- Names of tanker and terminal representatives.
- Cargo distribution on arrival and departure.
- For each product:
  - Quantity.
  - Shore tanks to be filled.
  - Tanks to be discharged.
  - Lines to be used tanker/terminal.
  - Cargo transfer rate.
  - Maximum allowable pressure.
  - Temperature limits.
  - Venting system.
  - Sampling and gauging procedures.
- Any restrictions because of:
  - Electrostatic properties.
  - ESD valve closing times.

The discharge plan should include the details and expected timings of:

- The discharge sequence for the tanker's tanks, including:
  - Tanker and terminal tank change over.
  - Avoiding cargo contamination.
  - Pipeline clearing for discharge.
  - Any COW or other tank cleaning.
  - Any other movements or operations that may affect flow rates.
  - Trim and freeboard of the tanker.
  - Need to ensure that permitted stresses will not be exceeded.
  - Ballasting operations.
- The initial and maximum discharge rates, accounting for:
  - Specification of the cargo to be discharged.
  - Arrangements and capacity of the tanker's cargo lines, shore pipelines and tanks.
  - Maximum allowable pressure and flow rate in the tanker/terminal hoses or MLAs.
  - Precautions to avoid static electricity.
  - Any other limitations.
- Bunkering or storing operations.
- The ESD procedure.

Once the discharge plan has been agreed it should be signed by the Responsible Officer and the Terminal Representative.

21.7 Agreement to carry out repairs

21.7.1 Repairs on the tanker

The Responsible Officer should seek permission from the Terminal Representative and port authorities for any repair or maintenance work needed on a tanker moored at a berth. Agreement should cover the safety precautions, based on the nature of the work.

21.7.1.1 Immobilisation of the tanker

While a tanker is moored at a terminal its boilers, main engines, steering machinery and other equipment essential for manoeuvring should be kept ready so that the ship can move away from the berth in an emergency.

Repairs and other work that may immobilise the tanker should not be undertaken at a berth without written agreement from the terminal and port authority.

Any unplanned situation that causes the tanker to lose any operational capability, particularly to safety systems, should be immediately communicated to the terminal.

21.7.1.2 Hot work on the tanker

Hot work on the tanker should be prohibited until all applicable regulations and safety requirements have been met and a permit to work has been issued (see chapter 4). This process may involve the Master, operator, chemist, shore contractor, Terminal Representative and port authority.

21.7.2 Repairs on the terminal (communication)

When a terminal is set to build, repair, maintain, modify or dismantle facilities on or next to the berths, any tanker operating at the terminal needs to confirm that it agrees with the work before it starts. A risk assessment should be carried out (see chapter 4) and the risks managed to be As Low As Reasonably Practicable (ALARP).

21.7.3 Using tools while a tanker is alongside a terminal

Hammering, chipping, grit blasting or any power tools should be prohibited outside the engine room or accommodation on a tanker, or on a terminal where a tanker is moored, without the joint agreement of the Responsible Officer and the Terminal Representative and unless a permit to work has been issued.

In all cases, the Responsible Officer and the Terminal Representative should be satisfied that the area is and remains gas free when tools are being used, while observing the precautions in section 4.6.

CHAPTER 22

Mooring and Berthing

22.1 Mooring safety

22.2 Security of moorings

22.3 Preparations for arrival

22.4 Berthing at jetty berths

22.5 Berthing at buoy moorings

This chapter addresses the preparations and procedures necessary to ensure a tanker berths and remains safely moored at a jetty or buoy mooring. Chapter 21 covers communications between the tanker and terminal on mooring arrangements.

For more information on mooring equipment and training, see OCIMF's *Mooring Equipment Guidelines* and *Marine Terminal Operator Competence and Training Guide (MTOCT)*. For descriptions of good operational practice for mooring, see OCIMF's *Effective Mooring*. Particular types of mooring are covered in OCIMF/CDI/ICS/SIGTTO's *Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases* and OCIMF's *Guidelines for the Design, Operation and Maintenance of Multi Buoy Moorings and Guide to Offshore Tanker Operations.*

Tanker, terminal and berth operators are strongly recommended to bring this information to the attention of their workforce to ensure that mooring and berthing are done safely.

22.1 Mooring safety

Mooring, unmooring and maintaining the effectiveness of the mooring arrangements are among the most routine and critical operations undertaken by tanker and marine terminal personnel. They are some of the highest risk activities that personnel perform.

During mooring and unmooring, tanker and terminal personnel are at increased risk. Potential hazards include lines under tension, winches in operation, towing lines and lines handled by mooring boats and tugs.

While the tanker is alongside and undertaking transfer operations the risks are different, but the risk to personnel remains. Ensuring the tanker remains safely moored to the berth is critical. It should be carried out diligently by competent personnel to ensure they remain safe. The security of the tanker, transfer operations and equipment should not be compromised.

It is imperative that there is an effective tanker/terminal interface to ensure that every mooring operation, no matter how frequently undertaken, remains safe. This includes effective communications before arrival, rigorous planning, good procedures, well maintained equipment and trained and competent personnel who are fully aware of the hazards and risks. A failure in this area can cause harm to both tanker and terminal personnel, as well as damage to the tanker, the terminal equipment and to the environment.

22.1.1 Snap-back

There are multiple sources of risk to personnel operating in or around the mooring system. One direct cause of injuries to many tanker and terminal personnel is mooring line failure along with the phenomena of snap-back.

This topic is covered more fully in OCIMF's *Mooring Equipment Guidelines* and *Effective Mooring*. Line failures can occur anytime and the following points should be noted.

As a line comes under tension, it stretches and stores energy. Snap-back is the tendency of the broken ends of a tensioned line to draw back rapidly on failure when that energy is released suddenly.

Snap-back is possible in all types of line, but it is strongest in some synthetic lines that have more inherent elasticity and are less stiff than others. Wires and High Modulus Synthetic Fibre (HMSF) lines, which have low stretch capability, can also suffer snap-back but it may be less pronounced. Wires and HMSF are more likely to experience major snap-back events when they are connected to synthetic tails, which have higher inherent elasticity and stored energy.

The force of the snap-back is as great as the energy stored in the line when it breaks. It presents a significant risk to all personnel working in the mooring area of a tanker, tug or berth. Measures should be put in place to remove these risks or to remove personnel from exposure to these risks. This can be done through ship design and good operating procedures and practices.

Training, proper supervision and good communications are the first means of defence. Other measures to be considered include the following:

- Providing safe access to winch controls.
- Positioning supervisors and tanker and terminal personnel with unobstructed views of the operation.
- Providing operating and personnel management procedures.
- Providing adequate lines of sight for the entire mooring deck workspace.
- Using lines with the most direct leads possible from winch to tanker side fairlead.
- Minimising the crossing of the deck area by lines.
- Minimising the use of pedestal rollers.
- Avoiding sharp angled leads.
- Using personnel trained in mooring operations.
- Briefing tanker and terminal personnel on the planned mooring operation, including;
  - Intended mooring layout.
  - Winches and lines to be used.
  - Shore mooring hooks and bollards to be used.

Due to the confines of the mooring deck, the number of personnel involved in mooring and unmooring and their closeness to mooring lines under tension, snap-back is usually considered a higher risk for tanker personnel. However, shore personnel can also be at risk when lines fail. The above measures should be considered in the design and operation of shore facilities.

Some tankers and terminals mark danger zones where snap-back may be a hazard. This practice is not recommended as it is not possible to accurately determine the whole range of zones in which snap-back is a danger. Also, marking off danger zones may create a false sense of safety outside of these areas.

The entire mooring deck and jetty mooring area should be considered an area of elevated risk. Signage should be used to alert personnel that they are entering a risk area.

22.2 Security of moorings

Any excessive movement of a tanker, or its breaking away from the berth, could cause injury to personnel and damage to the jetty installations and the tanker.

Mooring restraint guidelines for tankers intended for worldwide trade are detailed in OCIMF's *Mooring Equipment Guidelines*. The principle for this guidance is that mooring is considered an integrated system, from mooring hook to winch or bitts, and that all equipment should be operated and maintained so that the tanker remains securely moored according to the design. The condition of mooring lines should be monitored to ensure they are replaced before they can fail. Mooring system design parameters include a well defined hierarchy of failure to protect human life and the assets.

The requirements for tankers above 16,000 tonnes DWT are based on the standard environmental criteria, outlined in OCIMF's *Mooring Equipment Guidelines*, that are used as the basis for the recommendations on mooring systems in this section. These criteria provide the base conditions for restraint in 60 knots of wind and various current directions. They are not adequate for extreme combinations of environmental conditions at every terminal. Most terminals cannot operate in extreme conditions and tankers may, at a minimum, be required to stop operations, e.g. to allow for MLAs to be disconnected, and may also be required to leave the berth based on their Terminal Operating Limits (TOLs). More information on setting environmental operating limits is available in OCIMF's *Mooring Equipment Guidelines*.

At exposed terminals, or those where the criteria are likely to be exceeded, if the tanker is not removed from its berth its moorings should be supplemented with shore based equipment and/or standby tugs.

For tankers below 16,000 tonnes DWT and tankers operating only on a dedicated route and using terminals whose environmental data is available, a risk assessment may be made and the recommended criteria may be changed to suit local conditions or trading patterns.

Tanker and terminal representatives should work closely to ensure that the mooring system is fully functioning and meets design and operating requirements. This assessment should include the tanker mooring equipment and berth mooring facilities, including the fendering. This ensures that the systems are adequate to keep the tanker at the berth and allow for safe transfer operations, while minimising the risk to personnel, facilities, equipment and environment.

Although responsibility for the mooring of a tanker rests with the Master, the terminal should also ensure that tankers are securely and safely moored. Terminal management should have engineering studies and mooring analyses to determine operating parameters for individual berths. This information should be made available in pre-arrival communications. No cargo hoses or MLAs should be connected until both the Terminal Representative and the Master are satisfied that the tanker is safely moored.

This mutual agreement on the tanker's mooring should be achieved before operations begin. It should be among the first duties of the tanker and terminal representatives at the pre-transfer conference (see chapter 21).

22.3 Preparations for arrival

A successful interaction begins before the tanker arrives at the terminal, with an exchange of information between tanker and terminal personnel. It should cover equipment and facilities along with their capabilities and limitations, as described in the TIB.

Only through the rigorous planning, execution and management of the jointly owned tanker/terminal interface will the tanker's mooring, cargo operations and unmooring be safely conducted.

22.3.1 Tanker's mooring equipment

Once a tanker has been nominated to visit a terminal, the tanker operator should provide technical data and information about the mooring equipment to the terminal. Some of this data may be found in the tanker's Ship Inspection Report Programme (SIRE) Programme Vessel Particulars Questionnaire (VPQ). This information may be accessed by tanker and terminal representatives through the tanker owner's direct or (where available) vetting departments. It is, therefore, important this data is kept up to date.

Terminals or charterers may need other information for tanker/berth compatibility studies. This can be provided in industry recognised formats.

Details of the information that should be exchanged are included in chapter 21.

Before arrival at a port or berth, all necessary mooring equipment should be tested and ready for use. Anchors should be ready for use, if required, unless anchoring is prohibited.

The use of emergency tow-off pennants is not recommended by OCIMF. However, some locations require them to satisfy local rules and regulations. More information is available in OCIMF's *Lloyd's Register Risk Assessment of Emergency Tow-off Pennant Systems (ETOPS) Onboard Tank Vessels.*

An adequate number of trained and competent personnel should be available to handle the moorings.

The tanker operator and Master should ask the terminal for the information necessary for a review of ship compatibility and the development of a detailed mooring plan before arrival. Terminal data may come from various sources (see section 21.3.2).

Mooring plans should be discussed with the tanker personnel who will be involved in mooring, to make sure they have a thorough understanding of what is required. A discussion may also be held with the terminal, particularly if any risks or concerns have been identified.

This forward planning will ensure that all required mooring equipment is identified, tested and available. Defective equipment on the tanker or at the terminal may be assessed and risk assessments undertaken to overcome equipment shortcomings in the plan. This may include developing temporary Management of Change (MOC) measures that might affect the safety of the tanker while alongside.

22.3.2 Terminal mooring equipment

Terminals should be designed for the safe mooring and management of the tanker types that may pass through them during their working lives. Once this range of tankers has been identified, studies can be undertaken to assess the requirements for safe operations. Terminal designers should be aware that mooring equipment and physical parameters will vary from tanker to tanker, so berth facilities will need to be flexible to cover the anticipated range. They may need to take some or all of the following items into consideration:

- TOL (see section 16.1).
- Minimum distance needed between moored ships. See the World Association for Waterborne Transport Infrastructure's (PIANC) MarCom WG 153 *Recommendations for the Design and Assessment of Marine Oil and Petrochemical Terminals (2016)* for more information.
- Whether the berth will be affected by passing tankers, narrow channel effects, limited Under Keel Clearance (UKC), tidal bores or other hydrodynamic effects.
- Response times and measures for events such as berth breakouts, including the availability of emergency support services, e.g. tugs.
- Rise and fall of the tide and the impact on mooring restraint of freeboard changes and angles of mooring lines.
- Less than optimal alignment of tankers' mooring equipment to berth facilities and any backup provisions.

This information may be found in sources such as the Marine Terminal Particulars Questionnaire (MTPQ) and the TIB. More details of these are given in chapter 15 and OCIMF's *Marine Terminal Information Booklet: Guidelines and Recommendations*.

While the tanker's Master remains accountable for the safety of the tanker, the terminal operator is in the best position to give advice on the operating environment at its site and its own mooring system. It can advise the Master about operating limits that may affect mooring configurations. The terminal operator should provide this information early in the exchange of information to ensure both parties can agree on a mooring plan ahead of the tanker's arrival. Limits to be considered will include, at least, the following:

- Local operating equipment, e.g. availability, SWL and location of mooring hooks or bollards, fender and gangways and MLA range limits.
- Operational events that may cause a special action, e.g. ESD.
- Environmental conditions, e.g. weather, current, tide, sea and swell.

22.3.3 Use of tugs

The use of tugs in port remains a common occurrence despite increasing numbers of tankers with propulsion machinery that gives them self-sufficiency via controllable pitch propellers, propulsion drives or high-powered bow and stern thrusters.

Every port and terminal should consider its tug capabilities and requirements as part of the port risk assessment. These capabilities should be matched to the projected demands of the port, the maximum local environmental operating conditions of wind, waves and current and possible emergency scenarios. The number and specification of tugs required should be confirmed through mission and suitability studies. These studies should not only consider the routine tasks of assisting in berthing and unberthing, but also the following:

- Tug bollard pull to provide a restraining force when manoeuvring on or off a berth and through the approach channel in passive or active escort modes.
- Additional duties that may have to be performed, e.g. standby, firefighting, anti-pollution, pull back and escort towage.
- Whether duties will extend from the relative calm of harbour waters to open seas.

Details on the development of tug capabilities and uses can be found in PIANC MarCom WG 116 *Aspects Affecting the Berthing Operations of Tankers to Oil and Gas Terminals (2012).*

Before tugs come alongside to assist a tanker, all cargo and ballast tank lids and ullage ports should be closed. This is required no matter what grade of oil is being or has been carried, unless all the cargo tanks have been tested and proven free of hydrocarbon vapour. Tugs and other craft should not be permitted to come alongside before the Master is satisfied that it is safe for them to do so.

Tugs should be adequately fendered to avoid causing damage to the tanker's hull. They should push the tanker at designated push points, which should be clearly marked on the tanker's hull.

When approaching a tanker, tugs should ensure all watertight openings have been secured and should switch off their radar systems without compromising safety of navigation.

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. 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. It should only be undertaken with full agreement of all parties concerned, after a risk assessment has been carried out and under the following conditions:

- Communications should be maintained between tanker and tugboat or mooring launches on agreed channels during the entire period of assistance.
- The agreed tanker/tugboat communication system is working.

- The tugboat is fully functional and ready to operate under its own power in normal conditions, with full power available for immediate use.
- The tugboat's steering gear, rudder and auxiliary manoeuvring systems, e.g. thruster drives, are fully operational.
- All doors and hatches should be kept closed during the assistance period.
- Enough crew are on board to fulfil the requirements of the maritime/port authority to perform all designated tasks and to deal with an emergency.
- The emergency signal to be used by the tanker and tugboat has been well explained and understood.
- The parties have agreed on an ESD (towline release) procedure.

22.3.4 Emergency use of tugs

Severe weather may place excessive strain on moorings, which may increase the risk of mooring line failure and the movement of the tanker on or off the berth. In such circumstances, tugs can be useful in holding the tanker against the berth to reduce strain on the moorings.

It is critical, in these situations, that cargo operations are immediately suspended, hoses or MLAs are disconnected and engines placed on standby.

Tugs helping the tanker to maintain its position should only use the tanker's recognised push points. The tug operators should know the maximum load forces permitted at each push point to ensure no damage is caused to the tanker's hull, to the jetty fendering system or to the berth structure.

22.4 Berthing at jetty berths

Effective tanker mooring management requires knowledge of mooring principles, information about the tanker and terminal mooring equipment, proper maintenance of this equipment and regular tending of mooring lines. All personnel should use OCIMF's *Mooring Equipment Guidelines* and *Effective Mooring* publications for the fullest understanding of the technical, operational and safety considerations involved in berthing. See PIANC MarCom WG 116 *Aspects Affecting the Berthing Operations of Tankers to Oil and Gas Terminals (2012).*

The Master is accountable for the safety of the tanker and its proper mooring. However, the terminal has local knowledge of the operating environment and knows the capabilities of shore equipment, e.g. mooring hooks and fenders, and is responsible for making sure they are available. The terminal operator should advise the Master of the equipment status, mooring line layout and operating limits. See section 22.3.2 for more information.

22.4.1 Fendering

Fendering systems at each berth should be engineered to suit the range of tanker sizes and types that use the berth. They should be capable of withstanding expected loads without causing damage to the tanker or berth. The design should consider the methods of operating the berth, in particular as to whether tugs are used.

The fenders should be spaced on the parallel sides of the tanker to allow the tanker to lie alongside at ballast and loaded draughts and at all expected heights of the tide.

At a jetty, the spacing between outer breasting dolphins should be between 0.25 and 0.40 LOA of the largest ship expected to call. The spacing between the inner breasting dolphins should be approximately 0.25 to 0.40 LOA of the smallest ship expected to call.

For continuous quays, fender spacing should not exceed a maximum of 0.15 LOA of the smallest tanker. More information is available in BS 6349-4: *Maritime works – Code of practice for design of fendering and mooring systems*.

Many different types of fendering systems exist. Studies should be done to help choose the correct system for the various tanker types that will use the berths.

Fendering systems are important in preventing damage to tankers and berth. The system should, therefore, be included in the terminal's inspection and maintenance plans as described in OCIMF/SIGTTO's *Jetty Inspection and Maintenance Guide*. Fenders should be checked as part of berth operator rounds, at a minimum before each tanker berthing. The design should also take into consideration requirements for regular inspection and maintenance (e.g. access) and the anticipated life of the system. More information is available in PIANC MarCom WG 33 *Guidelines for the Design of Fender Systems (2002–2004)* section 5.1.

It is imperative that tankers are not berthed against damaged or inoperable fenders. This may lead to structural damage to the berth or to the tanker's hull. The design should take into consideration the need for repairs and maintenance, so that they may be undertaken in a way that minimises downtime for the berth.

The fendering system should be able to absorb a tanker's berthing energy. The most significant factor is the speed at which the tanker closes with the berth. This should be determined through analysis.

The terminal should tell the tanker's Master, local pilots and berth operating personnel of the maximum permissible closing speed and angle of approach for each berth. This is often difficult to estimate. If the berth has speed of approach equipment, it is strongly recommended that allowable approach speeds for each general size of tanker are included in the operating procedures. Berthing aids can be invaluable in helping the Master and Pilot land the tanker squarely on the fender surface and at a speed that does not damage the tanker or berth.

Unconventional fender systems should be assessed by a qualified marine terminal engineer before use and should be risk assessed, taking into account operational issues, for safe berthing.

More details on the design of fenders can be found in PIANC MarCom WG 33 *Guidelines for the Design of Fender Systems (2002–2004)*.

22.4.2 Type and quality of mooring lines

OCIMF's *Mooring Equipment Guidelines* sets out guidelines and recommendations for an optimum mooring system that can be safely deployed and operated from the tanker.

Mooring lines should, preferably, all be of the same material and construction. Ropes of different stiffnesses, i.e. mixed moorings, should never be used in a single mooring pattern, as low stiffness lines tend to carry almost no load and high stiffness lines tend to be heavily loaded.

The stiffness of lines is important to the type and effectiveness of the mooring system. Mooring lines with high stiffness (or low elastic elongation) are recommended for larger tankers or tankers operating within strict berth movement limits, e.g. where MLAs are connected. This is because they limit the tanker's movement at the berth. Lines with these stiffness properties include winch mounted steel wires or HMSF ropes.

Moorings made entirely of low stiffness lines, e.g. polyester, polypropylene (PP) or polyamide, can absorb higher dynamic loads. For this reason, they are better suited to berths where some movement is expected, such as where there may be swell, waves or passing tanker forces.

Mooring conditions and recommended layouts will differ from port to port. Terminal and port regulations may set their own requirements. It is strongly recommended that tankers and terminals exchange information about mooring equipment and requirements before the tankers' arrivals to make sure they comply with safe mooring expectations.

In some places, swells or the close passing of other ships can cause dynamic (shock) loading on moorings. In such situations, fibre tails on the ends of mooring wires and HMSF mooring ropes can provide enough elasticity to prevent failure. A mooring analysis should be carried out to determine whether tails are required in the system.

Tails are normally provided by the tanker and fitted to the mooring lines before arrival. They can be of various lengths, as specified by the line manufacturer. Shorter, 11m tails can be used on sheltered berths. Longer tails, e.g. 22m, can be used on exposed locations as they can control peak loads more effectively. Longer tails may also cause slightly more tanker movement and they should not be long enough to allow them to come into contact with the tanker's fairlead.

Fibre tails deteriorate faster than the wires or the HMSF ropes to which they are attached. They should, therefore, be at least 25% stronger than the line to which they are attached and receive the same service life tracking as mooring lines. They should be inspected frequently, particularly at the connection point, and replaced if they show signs of damage.

22.4.3 Management of moorings when alongside berth

22.4.3.1 Tending of moorings

Tanker personnel are responsible for the frequent monitoring and tending of the moorings. Qualified terminal personnel should also check the moorings periodically to make sure they are being properly tended. In many terminals, mooring line tension is monitored via remote load cell readouts in a fixed system in the jetty control room.

If moorings become too slack or too taut, the mooring system should be reviewed overall 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. Moorings should not be slackened if the tanker is lying off the fenders.

If tension monitoring is fitted and can make periodic recordings, berth operators should make the readings or recordings available to ship staff so they can use them to support the Mooring System Management Plan (MSMP). Tension monitoring can also help the berth operator make informed decisions. For more information, see PIANC MarCom WG 153 *Recommendations for the Design and Assessment of Marine Oil and Petrochemical Terminals (2016)*. Tension monitoring is, typically, considered in these circumstances:

- For the mooring of larger tankers.
- For places where environmental conditions or passing ships may pose a risk.

During cold weather, precautions should be taken to make sure the winches are always in a state of readiness. The manufacturer's guidance for cold weather operation should be checked. Steam operated winches and windlasses may have to be rotated slowly when not in use to avoid damage due to freezing. Hydraulic winches may have to go through a warm-up sequence using a circulating line.

22.4.3.2 Tension winches

These winches are fitted with automatic rendering and hauling capability and should not be used in automatic mode when the cargo transfer system is connected.

In automatic mode, these winches may render under load, allowing the ship to move out of position. Equipment connected between ship and shore, e.g. cargo connections and gangways, may suffer damage or failure if the movement exceeds safe operating parameters. Movement of the ship on a berth may also cause damage to mooring lines and berth fenders and could compromise separation distance between ships on adjacent berths.

Before arriving at the terminal, ships fitted with automatic tensioning winches should ensure that agreement is reached as to their conditions of use on the berth. This should subsequently be noted in the relevant parts of the SSSCL in the pre-arrival information exchange, checks after mooring and (where partial or full use is allowed) in the agreements section during the pre-transfer conference.

When an agreement between ship and shore is not obtained, the default is that they should always be secured with the winch drum held on the manual brake and with the winch drive disengaged, and remain so until such mutual agreement is achieved and documented.

Automatic mode may be considered appropriate for ships not engaged in cargo transfer operations, e.g. on layby or repair berths, and it may not be possible, at these locations, to obtain the agreement.

In all cases where the use of automatic tensioning winches is considered a viable option, a risk assessment should be undertaken to consider the particulars of the specific berth location and confirm its safe use. This should include ship and berth manning, equipment and facilities, any operating parameters or limitations and include consideration of environmental forces, e.g. wind, tide/current, etc. The outcome of the risk assessment should be documented, along with any associated safe operating conditions. The Responsible Officer should ensure that monitoring of the mooring system and ship's position is rigorously adhered to by the crew at all times.

22.4.3.3 Self-stowing mooring winches

Most tankers are now fitted with mooring winches that enable lines to be self-stowed, especially when either wire or HMSF lines are used. Self-stowing mooring winch drums fall into two categories: undivided (a single drum stores and holds the line) and split drum (it is split into a tension or working drum and a storage drum).

In undivided drums, the weight and size of the mooring lines may cause the outer layers to embed themselves into the lower layers, causing damage. For this reason, many mooring winches are of the split drum type.

Terminal and tanker personnel need to clearly understand certain features of these winches when reviewing mooring arrangements at the terminal. This is to avoid slipping winch brakes, which can cause tankers to break adrift from berths.

The holding power of the brake is specified by the winch manufacturer. It should be consistent with the ship design MBL. Every tanker officer should know the designed brake holding capacity of the tanker's self-stowing mooring winches. Details of the winch design, operation and maintenance should be entered in the tanker's onboard MSMP, as recommended in OCIMF's *Mooring Equipment Guidelines*.

The physical condition of the winch gearing and brake shoe linings or blocks affects the brake holding capacity while the winch is in service. Mooring winch brakes should be tested at regular intervals, at least every 12 months. Records should be kept on the tanker of both regular maintenance and inspections and of tests. More details on winch brake testing requirements and test kits are found in OCIMF's *Mooring Equipment Guidelines*.

Newer self-stowing mooring winches may be fitted with disc brakes. These are less affected by wear, but they are less common in tankers.

Tanker and terminal personnel should be aware that the holding capacity of winch brakes can be reduced if operations are not correctly carried out. Full technical descriptions of these factors can be found in OCIMF's *Mooring Equipment Guidelines*. These include the following:

- Number of layers on the drum.
- Direction of reeling on the drum.
- Condition of the brake linings and drum.
- Application of the brake.

Each of these is discussed in more detail below.

PART 1 General Information
PART 2 Tanker Information
PART 3 Marine Terminal Information
PART 4 Ship/Shore (Tanker/Terminal) Interface

22.4.3.3.1 The number of layers on the drum

The designed holding capacity of the winch brake is usually calculated for the first layer. For each additional layer, the holding capacity is reduced. The reduction can be substantial, with the second layer reduced to 89% of rated holding capacity and further reduction in each additional layer, down to as little as 69% on the fifth 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.

22.4.3.3.2 The direction of reeling on the winch drum

On both single and split drum winches, the holding power of the brake decreases substantially if the mooring line is reeled in the wrong direction. Before arrival at the berth, it is important to confirm that the mooring line's pull direction matches the manufacturer's recommendation and guidance.

Typically, this will be against the fixed end of the brake strap rather than against the pinned end. Reeling in the wrong direction can seriously reduce the brake holding capacity, in some cases by as much as 50%. The correct reeling direction should be permanently marked on the drum. Reelings are to be drawn in accordance with OCIMF's *Mooring Equipment Guidelines*.

Winches fitted with disc brakes do not have this limitation.

22.4.3.3.3 The condition of the brake linings and drum

Oil, moisture or heavy rust on the brake linings or drum can seriously reduce the brake holding capacity. If a brake lining or drum is found to be affected by any of these things, the Responsible Officer should immediately be notified and action should be taken to return the brake to its normal operating condition.

Moisture may be removed by running the winch with the brake lightly applied. This should be done under supervision and care should be taken not to cause excessive wear. Oil cannot be removed, so oil contaminated brake linings should be replaced.

22.4.3.3.4 The application of the brake

Brakes should be tightened as much as is necessary to achieve the required holding capacity (this is usually 60% of the MBL).

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.

22.4.3.4 Shore moorings

At some terminals, shore moorings are added to supplement the tanker's moorings. Shore personnel who handle shore moorings should be fully aware of the hazards of the operation and should use 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 along with the tanker's moorings. If shore based wires with winches are used, shore and tanker personnel should reach an agreement as to who has the responsibility for tending them.

Shore based pulley systems are not commonly used at terminals. However, if one is provided, the tanker should tend the mooring, since both ends of the line are on board.

Before shore based moorings are used on a tanker, the mooring fitting or winch strength capability should be thoroughly reviewed to make sure it does not overload the tanker's equipment. The tanker's management team should do a risk assessment to make sure the risks and hazards of the non-standard equipment are understood by all of the tanker's crew who will be used in the operation.

The Responsible Officer and the Terminal Representative should clearly agree who will take responsibility for tending moorings provided by the terminal.

22.4.3.5 Anchors

Unless otherwise agreed by the terminal, while the tanker is moored at the terminal, anchors not in use should be secured by brake and stopper bars, but should still be available for immediate use. Chains used to secure anchors during sea passages should be removed at every marine terminal, including conventional berths, SPMs and MBMs.

22.5 Berthing at buoy moorings

When berthing at a buoy mooring, tanker personnel should take all the normal precautions for berthing alongside a jetty. Characteristics of the buoy mooring facility should be carefully identified through site-specific studies. Terminal operators at buoy moorings should also review the output from these studies and use risk assessment tools to develop their safety and operations management systems. This should consider, at least, the following factors:

- Mooring and unmooring requirements, including the need to exchange information on berthing and unberthing requirements before a tanker arrives.
- The ability to put a berth in deeper water. This may help serve tankers with larger draughts, but it creates issues with safe access for terminal operations and ancillary support staff.
- The number of tugs necessary to moor and unmoor tankers. Fewer tugs may be needed, but they may also have to operate in exposed open sea conditions with larger swell.
- Weather conditions. Deteriorating conditions may create an increasing sea and swell, which means operations may have to stop earlier and more often. Disconnection from the facility may also have to be done earlier and more often, to allow enough time for unmooring and hose handling. In addition, the operational window for berthing and mooring is usually smaller for offshore facilities.
- Maintenance of terminal equipment. Buoy berth maintenance will almost always require support from specialist contractors, such as divers and support craft for subsea operations.

For detailed guidance on facilities with buoy moorings, see the following OCIMF publications:

- *Guidelines for the Design, Operation and Maintenance of Multi Buoy Moorings.*
- *Single Point Mooring Maintenance and Operations Guide.*
- *Guidelines for Offshore Tanker Operations.*

22.5.1 Mooring Masters

At terminals with buoy moorings for ocean-going tankers, it is recommended that professional advice is obtained on safety issues related to local marine operations. A Mooring Master may be assigned to the terminal, or the terminal may consult with a port or pilotage authority. To further lower risks, Mooring Masters may be required to remain on board tankers throughout their stays, from pre-berthing to unberthing.

Mooring Masters should have the expertise for the full range of duties they will perform, including piloting to and from the berth, manoeuvring and working with tugs and mooring boats during mooring and unmooring and taking part in cargo operations at the buoy berth.

A wide range of skills is required in this critical role. OCIMF's *Competence Assurance Guidelines for Mooring, Loading and Lightering Masters* should be used to provide oversight and guidance for this role, including the following:

- Recommendations for developing and implementing a system to make sure that Mooring Masters are competent.
- Guidance on the competencies required of Mooring Masters.
- Guidance on the knowledge required of Mooring Masters.
- Recommendations on how to assess competence.
- Recommendations on continued verification of competence.
- Advice on record-keeping and documentation for a competence development programme.

22.5.2 Mooring at Multi Buoy Moorings

The two main configurations of MBM are CBM and ABM.

A CBM is an offshore marine berth in which the tanker's bow is held in position by its own anchors and the stern is secured by an array of mooring buoys, typically three to seven of them.

An ABM is an offshore marine berth in which both the tanker's bow and stern are held in position by mooring buoys.

Mooring and unmooring at MBMs is not often carried out by tanker personnel. Given the risks, it is imperative that mooring and unmooring operations are done under a detailed plan developed together with the terminal representatives, e.g. the terminal's Mooring Master. The plan should be communicated to tanker personnel before arrival at the berth.

The tanker's anchors are normally required during the approach. They often are needed in addition to mooring lines as an extra restraint at the berth. For this reason, the plan should consider the extra demands on personnel required for mooring and unmooring stations and the need for supervision, particularly where multiple operations may take place simultaneously.

Mooring personnel should maintain good communication throughout the operation. It is critical that the team handling mooring lines from the poop deck are vigilant to the dangers of mooring lines and mooring boats operating in the water around the tanker's propeller. They should keep these from being caught in the propeller or propeller wash in the event of a sudden engine manoeuvre. Severe loads can develop in mooring lines during mooring. It is essential to use good quality moorings of adequate length and to closely supervise personnel to make sure they remain safe.

At some MBM berths, the tanker's moorings are supplemented by mooring lines provided by the facility, which are run from the buoys or by ground moorings. At some berths these may be wires, which are often heavy. Only experienced personnel should handle them around the warping drum of a winch.

22.5.3 Mooring at Single Point Moorings

Mooring at SPMs presents extra hazards and is not routinely carried out by most tanker personnel. These risks should be managed through planning and the use of tanker and shore personnel. All personnel involved should be trained and competent in operations at this type of terminal.

Mooring and unmooring operations should be done according to a detailed plan developed together with the terminal representatives, e.g. the terminal's Mooring Master. The plan should be communicated to tanker personnel before arrival at the berth.

Mooring personnel should maintain good communication throughout the operation. If any forward mooring winches critical to the operation fail, an abort manoeuvre should immediately be taken until the nature of the winch failure is understood and the equipment is back in working condition.

Complicated and non-standard mooring arrangements at SPMs can lead to dangerous and extended operations. Therefore, both on tankers and on SPMs, the use of standard equipment, fit for purpose and accurately positioned, considerably reduces the risk of injury. The proper fitting of such equipment also provides a more efficient method of securing tankers to SPMs at offshore terminals.

The detailed technical and operational guidance in the relevant operational publications (see section 22.5) is recommended. It should be followed by all SPM terminals and the tankers using them to make sure that tanker and terminal mooring equipment is compatible.

Section 22.1.1 highlights the dangers of snap-back following line failure. These risks are also present in the forward section of the main deck during mooring on SPMs. The loads on pick-up ropes during mooring, and on mooring hawsers when moored, can be significant. For this reason, the mooring deck area should be considered an area of high risk and measures to mitigate these risks should be in place to protect the tanker's crew.

In particular, a storage drum should be used to heave in the SPM pick-up rope before connection of the chafing chain to the stopper. The warping end should never be used for this purpose.

22.5.4 Management of moorings at buoy berths

A large variety and type of buoy mooring facilities and operating environments exists. Conventional tankers and their crews are often unfamiliar with the requirements of a specific buoy berth. The terminal should carry out a risk assessment that covers operations, types of tankers, equipment and resources available, e.g. tugs and other support craft, location of support facilities, likely metocean conditions and potential emergency scenarios. These should be used to develop standard operations procedures.

22.5.4.1 Pre-berthing planning

In pre-planning for berthing at a buoy mooring, the Terminal Representative and tanker Master should have a detailed exchange of information that sets out the technical and operational requirements. It should include the exchange of any required pre-arrival checklists and communications. See information on the pre-berthing/pre-arrival information exchange in chapter 21.

This information should be used to create a pre-berthing plan that considers at least the following factors, to ensure the safety and compatibility of the tanker and facility:

- During the tanker's stay at the buoy mooring, terminal regulations should be closely observed:
  - This includes the maintenance of the tanker's propulsion equipment so that it can leave the berth immediately if required.
  - Engine maintenance should not be done while the tanker is at berth if it will affect the tanker's propulsion system and leave it unready to depart.
- Conventional tanker propulsion systems are not normally used to maintain position once the tanker is securely moored to a buoy system. Except in extraordinary circumstances, tankers have limited capability to run the propulsion astern at low revolutions for long periods of time.
- Where a safe position needs to be maintained, e.g. in relation to the SPM, it is often done with the help of a pull-back tug attached by a towline to the stern of the tanker. If in abnormal conditions a pull-back tug is not able to tow as required, the tanker's main engines may be considered for use.
- All tankers at buoy berths should be ready for manoeuvring and navigation:
  - This may be needed if the tanker's Master, with the advice of a Mooring Master or Pilot, decides that tanker propulsion should be used carefully to help maintain or restore position or to ensure that mooring hawsers and other equipment does not receive excessive dynamic loads.
- A detailed emergency unmooring and contingency plan should be established:
  - It should have clear, safe operating limits that allow enough time for an orderly and safe stop to cargo operations, for disconnection of hoses and for unmooring before conditions become too severe for safe operations by the deck crew or terminal personnel, e.g. mooring boats.

22.5.4.2 Manning at buoy berths

Manning requirements vary according to the tanker capability, facility type and location. Demands on tanker personnel include bridge watches, the continuous monitoring of the mooring from the forecastle and cargo transfer operations. These require a careful management of resources. Human factors should be addressed in the overall operations plan to provide the numbers of personnel required and to make sure enough trained, competent and rested personnel are always available.

The relevant operational publications (see section 22.5) offer further guidance, but as a minimum there should be:

- One Mooring Master on watch at all times to monitor the position of the tanker in relation to the buoy system, mooring loads and weather.
- A bow watchkeeper to report on any issues arising from the tanker position in relation to the buoy system and any abnormal conditions, including mooring hawsers that are excessively tensioned or slack.
- A manifold watch to monitor cargo hoses and report any cargo leaks.
- A qualified and experienced deck officer to oversee cargo operations.

The bow and manifold watchkeeper positions can be combined where facilities, e.g. telemetry, and the use of a Mooring Master makes two persons unnecessary.

Further consideration should be given to the manning of the bridge if additional risk factors are identified. These may include the following:

- Local metocean conditions that could affect the loads placed on the bow mooring equipment or the ability of the tanker to safely maintain position in relation to the buoy system.
- Risks arising from close traffic or navigational hazards, e.g. the distance from the grounding line.
- Potential security threats identified from the use of the *International Ship and Port Facility Security (ISPS) Code* or security risk assessment (see chapter 6).

All terminal marine personnel involved in mooring at buoy berths should take part in the terminal's competency programme. As detailed in section 22.5.1, Mooring Masters should have a programme that follows OCIMF's *Competence Assurance Guidelines for Mooring, Loading and Lightering Masters*.

CHAPTER 23

Tanker and Terminal Precautions for Cargo Operations

23.1 External openings in superstructures

23.2 Central air conditioning and ventilation systems

23.3 Openings in cargo tanks

23.4 Inspecting a tanker's cargo tanks before loading

23.5 Marine cargo inspectors

23.6 Tanker and terminal cargo connections

23.7 Spills and leaks

23.8 Firefighting while the ship is alongside a terminal

23.9 Firefighting while in proximity to other ships

23.10 Notices

23.11 Manning requirements

23.12 Control of vehicles and other equipment

23.13 Helicopter operations

This chapter provides guidance on the safety precautions for tankers and terminals while a tanker is alongside for cargo handling, ballasting, bunkering, tank cleaning, gas freeing and purging operations. The main concern is to eliminate the risk to personnel, equipment and facilities from fires, explosions and health hazards, and of any environmental impact.

23.1 External openings in superstructures

Tanker accommodation and machinery spaces contain equipment that is not suitable for use in flammable atmospheres, so it is important to keep hydrocarbon gas out of these spaces.

All external doors, ports and similar openings should be closed when the tanker, or a tanker at an adjacent berth, is doing any of the following:

- Handling volatile petroleum or non-volatile petroleum that is near or above its flashpoint.
- Loading non-volatile petroleum into tanks containing hydrocarbon vapour.

- COW.
- Ballasting, purging, gas freeing or tank washing after discharging volatile petroleum.

A screen door is not a safe substitute for an external door. Additional doors and ports may have to be closed in special circumstances or because of the structural peculiarities of the tanker.

If external doors have to be opened for access, they should be closed immediately afterwards. Where practical, working access in port should be via a single door. Doors to be kept closed should be clearly marked.

Doors should not normally be locked in port. However, if there are security concerns, the measures to prevent unauthorised access should also ensure that personnel have an escape route. These measures should be agreed by responsible parties from the tanker and terminal, including, where required, Port Facility Security Officer (PFSO) and Ship Security Officer (SSO) and the tanker Master.

23.2 Central air conditioning and ventilation systems

The accommodation should be kept under positive pressure to prevent the entry of hydrocarbon vapours. Bear in mind:

- Intakes for air conditioning units are usually located in a safe area and will not draw in vapours 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 brief entry or exit.
- The system should not be operated with the intakes fully closed, in 100% recirculation mode, as the extraction fans in galley, sanitary spaces and any other relevant spaces (e.g. smoking rooms, laundry facilities, etc.) will reduce the atmospheric pressure in the accommodation to less than the ambient pressure outside.

A gas detection and/or alarm system fitted to the air conditioning intakes will warn if hydrocarbon vapours are present. In this case, the ventilation system should be shut down and cargo transfer suspended until the surrounding atmosphere is free of the vapours.

The same principles of positive pressure and gas detection apply to tankers that have alternative air conditioning systems or additional units.

External air conditioning units, e.g. window or split air conditioning types, should not be operated during any of the operations listed in section 23.1 unless they are in safe areas or certified as safe for use in the presence of flammable vapours.

23.3 Openings in cargo tanks

23.3.1 Cargo tank lids

All cargo tank lids should be closed and secured at all times when handling volatile petroleum, loading non-volatile petroleum into tanks containing hydrocarbon vapour and ballasting after discharging volatile cargo.

Cargo tank lids or coamings should be clearly marked with the number and location of the tank they serve (port, centre or starboard).

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.

23.3.2 Sighting, ullage ports and segregated ballast tank lids

During any of the cargo and ballast handling operations in section 23.1, sighting and ullage ports should be kept closed unless they need to be open for measuring and sampling, or when agreed between the tanker and terminal. If they are opened, the tank pressure should be reduced to the minimum positive pressure and access should be for the shortest time possible to complete the task while taking precautions against possible exposure to hydrocarbons and toxic vapours.

If the system design means sighting or ullage ports are to be opened for venting, the openings should be protected by a flame screen. This may be removed for a short time during ullaging, sighting, sounding and sampling. Any screen should be a good fit, kept clean and in good condition.

Segregated ballast tank lids may be opened before ballast is discharged so that the surface of the ballast can be inspected for contamination. Segregated ballast tank lids should be kept closed when cargo or ballast is being handled because petroleum gas could be drawn into them.

Segregated ballast tank lids should be clearly marked to indicate the tank they serve.

23.3.3 Cargo tank vent outlets

The cargo tank venting system should be set for the operation concerned. High velocity vents should be set in the position to ensure the high exit velocity of vented gas.

When volatile cargo is being loaded into tanks connected to a venting system that also serves tanks that are to be loaded with non-volatile cargo, to prevent flammable gas entering the tanks receiving non-volatile cargo pay close attention to the setting of Pressure/Vacuum (P/V) valves and the associated venting system, including any IG system.

Whenever tanks are isolated to prevent vapour cross-contamination, remember it is possible that pressure variations during the passage could allow oxygen to enter the tank. The inert condition may need to be restored before discharge.

23.3.4 Tank washing openings

During tank cleaning or gas freeing, tank washing cover plates should be removed from only the tanks involved and be replaced immediately when the work is completed. Any openings in the deck should be covered by gratings.

23.4 Inspecting a tanker's cargo tanks before loading

If tank entry is necessary for cargo tank inspections, comply with the requirements in chapter 10.

The inherent risk to personnel means that any tank inspection before loading should be done without entering tanks. This may be achieved through various remote means such as dipping and measuring for heel in the tank, or opening small stripping or educator lines to listen for liquid suction. It may also be possible to sight the tank bottom from a tank lid, ullage port or tank cleaning opening using a powerful torch, although the effectiveness of this method may be impaired due to vapour or haze in the tank atmosphere.

Care should be taken, when using any opening in the tank to sight the bottom, to ensure that the person undertaking the task does not inhale cargo vapours and that any opening is closed immediately after use.

Tanks should be entered for inspection only if absolutely necessary, e.g. the cargo to be loaded has a critical specification and the inspector has no alternative. In these cases only those tanks specifically requiring entry should be entered and the guidance contained in chapter 10 should be followed.

23.5 Marine cargo inspectors

Tankers often use marine cargo inspectors, or expediters/superintendents, to assess the cleanliness of tanks, measure and sample loaded cargo, and issue official documentation such as certificates of quantity and quality on behalf of the charterer, shipper or receiver.

They need to board the tanker at different times during the cargo operation and so need access to working areas of the tank deck and other potentially dangerous spaces, such as cargo tanks and pumprooms.

No matter how familiar cargo inspectors may appear with the terminal or tanker, they should be given a safety induction when arriving at the terminal and when boarding the tanker.

Marine cargo inspectors should be escorted while conducting activities on the tanker. Best practice requires them to complete initial and periodic refresher safety training. Do not assume that the routine presence of a cargo inspector at each port means that they are all trained to the same level of health and safety awareness. The following factors should be taken into consideration.

23.5.1 Independent cargo inspection companies

Cargo inspectors are often appointed to tankers under agreed contracts whose terms and conditions are likely to be unfamiliar to the tanker Master and crew.

It is recommended that cargo inspection companies operate under health and safety policies that specifically govern the safe conduct of their employees while working at terminals and on tankers.

Ideally, the cargo inspection company should be affiliated to recognised industry bodies that operate under a code of practice, e.g. the Testing, Inspection and Certification (TIC) Council, or quality assurance standards, e.g. the International Organization for Standardization (ISO), that include expectations for health and safety performance.

23.5.2 Cargo inspection training and accreditation

Tankers visiting terminals that have appointed cargo inspectors rarely have the opportunity to assess the inspectors' competence and experience before they board the tanker. For this reason, contract owners should verify that all cargo inspectors have been through an industry recognised petroleum inspector certification programme. This programme should ensure the inspector is familiar with not only petroleum inspection guidelines but also:

- Specific health and safety requirements of the terminal and tanker in addition to those of the national, regional or international regulatory bodies that operate at the location.
- Safety recommendations in this publication.
- Has been trained in:
  - Hazard awareness and reporting, including Stop Work Authorities (SWAs).
  - Confined spaces awareness, including tank entry procedures, permits to work and Safety Management Systems (SMSs).
  - Safe working practices in flammable and hazardous environments.
  - Static electricity awareness and precautions.

- Personal Protective Equipment (PPE), including respiratory and other safety apparatus for the specific working environment.
- SDSs.
- Safe handling and transportation of samples.
- Drug/alcohol abuse awareness.

The cargo inspector should also be re-evaluated via periodic audits and recertification, where applicable.

23.5.3 Safe working in terminals and on tankers

23.5.3.1 Duty of care

The safety and welfare of cargo inspectors is, primarily, the responsibility of the cargo inspection company. This responsibility extends to the operator of the site or tanker Master when inspectors are carrying out their duties.

To meet this duty of care, the terminal operator should ensure that cargo inspectors are familiar with the facility and its arrangements for safe movement and working, have had the necessary site safety induction and are authorised to move around the facility. As a minimum, cargo inspectors should report in and out with facility staff at each operating area and it is recommended that they are escorted at all times by facility staff during field operations.

Every tanker has different arrangements and cargo activities that inspectors may not be fully familiar with. When boarding, they should be escorted immediately to the officer in charge of deck operations to undertake a tanker specific safety induction briefing.

23.5.3.2 Safe working on tankers

When working on tankers, inspectors should be accompanied at all times by a responsible crew member and should not operate the tanker's equipment, including tank lids and tank valves.

When measuring and sampling via a vapour lock, coordinated action is needed to deploy the measuring and sampling equipment. A crew member should always stay with the inspector to help with the work and ensure the valve is operated correctly. At the end of the operation, the crew member is also responsible for ensuring the valve is closed securely.

Safe access and movement around tankers and terminals is covered by national and international regulations and by safe working practice standards and guidelines (see section 16.4). Cargo inspectors should comply with these requirements when carrying out their duties, and when boarding and moving around the tanker working areas, so that they do not expose themselves to risks.

Access around deck in general, and sampling and measuring points in particular, can be difficult on ships with above deck transverse stiffeners. In some cases, this will result in having to climb over the stiffeners and cargo pipelines or crawl through lightening holes and under pipelines to facilitate access. These activities can be arduous and unsafe, particularly in wet or inclement weather. Access to and egress from these areas in an emergency could also be challenging.

The minimum lighting requirements during darkness are clearly defined and all personnel, including cargo inspectors, should ensure that they do not enter into areas with inadequate lighting. Further guidance on lighting is in section 17.3.

23.5.3.3 Stop Work Authority

While at a terminal or on a tanker, cargo inspectors should comply with all site safety requirements. If a situation develops that is considered unsafe, they are responsible for their own immediate safety and should alert the responsible people for the terminal or tanker under an SWA (see section 4.3).

If work is stopped, it should not resume until the situation has been fully resolved or an alternate safe solution, with appropriate mitigation, is agreed and implemented.

23.6 Tanker and terminal cargo connections

23.6.1 Flange connections

Terminal cargo connections to tanker manifolds should be in line with OCIMF/CDI's *Recommendations for Oil and Chemical Tanker Manifolds and Associated Equipment.*

The tanker and terminal are jointly responsible for ensuring that presentation flange faces are clean and in good condition. The provider of the transfer equipment (MLAs or hoses) should be responsible for providing new appropriate gaskets before each connection.

Where bolted connections are used they have to be fully secured with all available bolts. Care should be taken as uneven or over-tightened bolts could cause leaks or fractures. Improvised arrangements, with G-clamps or similar devices, should not be used for flange connections.

Where Quick Connect/Disconnect Couplings (QC/DCs) are used to make the flange connection, these can be either automatic (hydraulically actuated) or manual using a camlock-type arrangement. In either case, the terminal and tanker should exchange details of the connection system to ensure the:

- Tanker manifold flange is compatible with the proposed QC/DC system connection.
- System integrity is on the same level as a fully bolted connection.
- Tanker or terminal personnel responsible for the connection and disconnection are clearly defined.

As with all marine terminal equipment, the manufacturer's guidance on installing, operating, inspecting and maintaining the QC/DC coupling should be followed. Documentation should be made available if requested by the tanker.

23.6.2 Removing blank flanges

Each tanker and terminal manifold flange should have a removable blank flange made of steel or other approved material, preferably fitted with handles.

Before removing blanks from tanker and terminal pipelines, MLAs or hoses, ensure that the section between the last valve and blank is drained, depressurised and that appropriate spill protection is in place.

Blank flanges should be capable of withstanding the working pressure of the line or system they are connected to. They should also be as thick as the end flange they are fitted to.

23.6.3 Reducers and spool pieces

Reducers and spools should be made of steel and be fitted with flanges that conform to the American Society of Mechanical Engineers (ASME) Standard B16.5, Class 150 or equivalent (see OCIMF/CDI's *Recommendations for Oil and Chemical Tanker Manifolds and Associated Equipment*).

To ensure compatibility between tanker and terminal, the material of manifold reducers or spool pieces should be confirmed before the tanker arrives, as part of the pre-arrival exchange of information (see section 21.2) and TIB (section 15.2.2).

Manifold pressure gauges should be fitted on the outboard side of the manifold valve to the spool piece or reducer.

All spool pieces and reducers should have lifting lugs fitted close to the centre of balance so that they can be handled more easily. The handles should not interfere with quick acting coupling devices or the bolting of flanges. When in storage, flange faces should be suitably protected.

23.7 Spills and leaks

23.7.1 General

The cargo transfer system should be checked at the start of cargo transfer and at agreed intervals. This should include tanker outboard manifolds, pipelines, MLAs, cargo hoses, unused connections, blanks, valves and waterside checks. At any sign of a leak, cargo transfer should be stopped immediately and resumed only when the situation has been corrected.

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 leaking valves or incorrect operations do not cause overflows.

On double hull tankers, take care not to reduce the Transverse Metacentric Height (GM), which can induce an angle of list or loll when de-ballasting double bottom tanks after some cargo tanks have been topped-off. This could also cause an overflow (see section 12.1.6).

If any released oil or petroleum gas looks like it could enter an engine room or accommodation space intake, take immediate preventive measures. Equipment should be ready to promptly remove any spill on deck. Any oil spill should be reported to the terminal and port authorities. The relevant shore and shipboard oil pollution emergency plans should be activated.

If a tanker has an alternative fuel system that involves the control of gas vapour pressure, the control mechanism should be fully operational to ensure there is no release (see section 12.11).

Harbour authorities, and any nearby ship or shore installations, should be warned of any potential hazard caused by a spill or release.

23.7.2 Checks on quantity during cargo handling

At the pre-transfer conference, the tanker and terminal representatives should agree to regularly check:

- Pressures in the pipeline and cargo transfer system (hose or MLAs).
- Quantity of cargo to be loaded or discharged between the tanker and terminal.
- Tanker calculations for quantities, considering trim and heel corrections.

An unexpected change in pressures, or a marked discrepancy between the tanker and terminal calculations of quantities transferred, could indicate pipeline or hose leaks or blocks, particularly in submarine or long trestle pipelines.

Stop the cargo transfer until the reason for any differences have been identified. The transfer should resume only with the agreement of all parties.

23.7.3 Sea and overboard discharge valves

During cargo, tank cleaning/de-ballasting operations, keep a watch to ensure that no oil is escaping though sea valves.

Sea and overboard discharge valves connected to the cargo and ballast systems should be closed and secured using a Lock-out/Tag-out system (LO/TO), and may be sealed when not in use. In-line blanks should be inserted where provided. When a LO/TO system is not practical as with hydraulic valves, use some suitable marking to indicate clearly that the valves are to remain closed.

More information on this subject is in OCIMF/ICS' *Prevention of Oil Spillages through Cargo Pumproom Sea Valves*.

23.7.4 Scupper plugs

Before cargo handling starts, all deck scuppers and any open drains on the jetty should be effectively plugged to prevent spilled oil escaping into the water around the tanker or terminal. Accumulations of water should be visually checked for oil sheen and periodically drained through absorbent material. The effectiveness of scupper plugs needs to be ensured and they should be replaced immediately after the water has been run off.

Oily water should be transferred to a slop tank or other suitable container. If necessary, the tank pressure should be reduced to help draining.

23.7.5 Spill containment

A permanently fitted spill tank, with suitable means of draining, should be fitted under all tanker/terminal manifold connections. If no permanent spill tank is fitted, portable drip trays should be placed under each connection to catch any leaks. Avoid plastic and other non-metallic containers unless bonding is possible.

23.7.6 Tanker and terminal cargo and bunker pipelines not in use

Valve tightness should not be relied on to stop the escape or seepage of oil. All terminal pipelines, MLAs and hoses not in use at a berth should be securely blanked.

All the tanker's cargo and bunker pipelines not in use should be securely blanked at the manifold. Where fitted, cargo pipelines to stern or bow manifolds should be drained of cargo and isolated from the tanker's main pipeline system. For stern manifolds this will require physical blanking or removal of a spool piece to fully isolate the line forward of the accommodation.

23.7.7 Loading at terminals with Vapour Emission Control Systems

23.7.7.1 General

When tankers are loading at a terminal, the vapours are displaced by the incoming cargo and are then transferred ashore by pipeline for treatment or disposal. However, the operational and safety implications are significant because the tanker and terminal are connected by a common stream of vapours that introduce several additional hazards that have to be controlled.

Detailed guidance on technical issues associated with vapour emission control and treatment systems is available from a number of sources. The IMO has developed international standards for the design, construction and operation of vapour collection systems on tankers and VECSs at terminals. OCIMF has issued guidance on vapour manifold arrangements (see bibliography).

Note that VECSs can serve tankers fitted with IG systems as well as non-inerted tankers.

A summary of the terminal's VECS should be included in the TIB.

23.7.7.2 Misconnection of liquid and vapour lines

To prevent the possible misconnection of the vapour manifold to a liquid loading line, a mechanical keying arrangement should be provided for vapour manifold presentation flanges as follows:

1. The bolt locations should be arranged so that two bolts straddle the 12 o'clock position at the top of the flange face.
2. One cylindrical stud should be permanently attached to each of the presentation flange faces at the 12 o'clock position on the flange bolt circles. This cylindrical stud should project horizontally outboard, perpendicular to the flange face and centred on the same bolt circle, as defined in ASME B16.5. The diameter of the cylindrical stud should be 12.7mm and it should be at least 25.4mm long.

Full details of vapour manifold arrangements, materials and fittings are in OCIMF/CDI's *Recommendations for Oil Tanker Manifolds and Associated Equipment.*

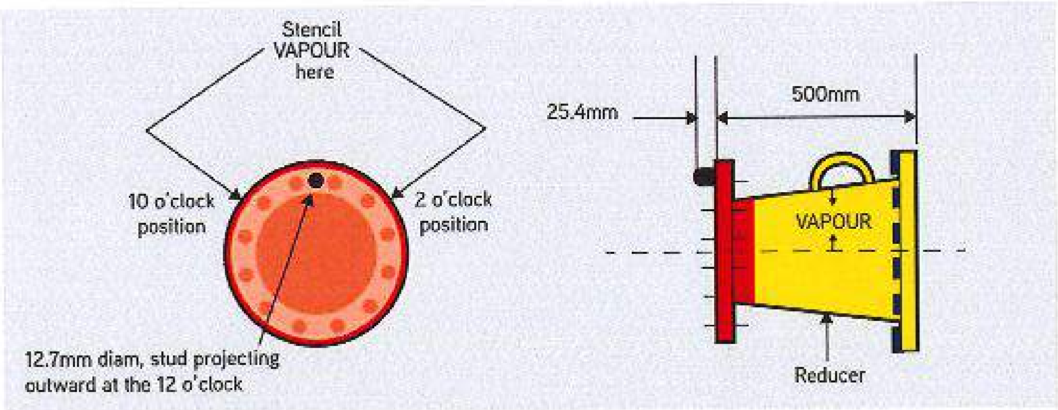


Figure 23.1: Vapour manifold flanges, orientation and labelling

23.7.7.3 Vapour over/under pressure

Although all closed cargo operations require in-tank pressures to be monitored and controlled, the connection to a VECS means that any changes in the terminal's system will directly influence pressures within the tanker's vapour spaces. It is important to ensure that the individual cargo tank P/V protection devices are fully operational and that loading rates do not exceed the maximum allowable rates. Pressures within vapour collection piping systems should be continuously monitored by sensors with high and low pressure alarm functions, connected to audible and visual alarms.

23.7.7.4 Cargo tank overfill

The risk of overfilling a cargo tank when using a VECS is no different from that when loading under normal closed conditions (see section 12.1.6.6).

23.7.7.5 Sampling and gauging

A cargo tank should never be opened to the atmosphere for gauging or sampling while the tanker is connected to the terminal vapour recovery system unless loading to the tank is stopped. The tank should also be isolated from any other tank being loaded and precautions taken to reduce any pressure within the cargo tank vapour space.

On non-inerted tankers, the precautions against static hazards should also be followed (see section 12.8).

23.7.7.6 Fire/explosion/detonation

Connecting the tanker and terminal vapour streams, which may be within the flammable range, introduces significant hazards that are not normally present when loading. Unless adequate protective devices are installed and operational procedures are followed, a fire or explosion in the vapour space of a tanker's cargo tank could transfer rapidly to the terminal and vice versa.

A detonation arrester should be fitted in close proximity to the terminal vapour connection at the jetty head to provide primary protection against a flame spreading from tanker to terminal or terminal to tanker.

The design of the terminal vapour collection and treatment system will determine whether flammable vapours can be safely handled. If they cannot, the system will be able to either inert, enrich or dilute the vapour stream and continuously monitor its composition.

23.7.7.7 Liquid condensate in the vapour line

The vapour line should be fitted with a system to effectively drain and collect any liquid condensate that accumulates in the lines. Any build-up of liquid in the vapour line could impede vapours, which would increase in-line pressures and generate significant electrostatic charges on the surface of the liquid. Drains should be installed at the low points in the vapour piping system and they should be routinely checked to ensure that no liquid is present.

23.7.7.8 Electrostatic discharge

The precautions for initial loading rates in section 12.1.7.3 and for measuring and sampling procedures in section 12.8 should be followed. To prevent the build-up of electrostatic charges within the vapour collection system, all pipework should be electrically bonded to the hull and be electrically continuous. The condition of the bonding arrangements should be inspected regularly. The terminal vapour connections should be electrically insulated from the tanker vapour connection by an insulating flange or a single section of insulating hose.

23.7.7.9 Training

The tanker and terminal personnel involved in the VECS operation should be instructed on the aspects of the system that affect safety at the tanker/terminal interface.

23.7.7.10 Communications

Using a VECS highlights the need for cooperation and communication between the tanker and the terminal. Pre-transfer discussions should provide the tanker and the terminal with a good 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 procedures should be agreed before operations start (see sections 21.4 and 25.4.3).

23.8 Firefighting while the ship is alongside a terminal

When a tanker is alongside a berth, firefighting equipment on the tanker and terminal is to be ready for immediate use.

On board the ship, this is normally achieved by having fire hoses with jet/spray nozzles connected and run out forward and aft of, and adjacent to, the manifold that is in use. In addition, where fire monitors/cannons are fitted for water and/or foam, those immediately forward and aft of the manifold should also be left positioned so as to point towards the manifold area. Having a portable dry chemical powder extinguisher available near the manifold provides additional protection against flash fires.

On the jetty, firefighting equipment should also be ready for immediate use in accordance with guidance in section 19.4.

23.9 Firefighting while in proximity to other ships

23.9.1 Tankers at adjacent berths

Flammable concentrations of petroleum gas may be encountered if another tanker at an adjacent berth is handling cargo or ballast, purging, tank cleaning or gas freeing. In this case, follow the precautions described in section 23.1.

23.9.2 General cargo ships at adjacent berths

General cargo ships are unlikely to comply as fully as tankers with the safety requirements for possible sources of ignition, e.g. smoking, naked lights, cooking and electrical equipment.

When a general cargo ship is at a berth near 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 discharging volatile petroleum, the terminal should evaluate all safety hazards and take precautions additional to those in this chapter, such as those for Simultaneous Operations (SIMOPS).

Such precautions should include a safety briefing with the responsible representatives on the general cargo ship, clearly defining the hazards of the cargoes handled by the tanker and the precautions to be taken on the cargo ship. This is particularly relevant where the ship may have passengers who are less familiar with general ship safety and may be moving around the general cargo berth areas.

23.9.3 Tanker operations at general cargo berths

When tanker operations are conducted at general cargo berths, it is unlikely that personnel on the berths will be familiar with the safety requirements for possible sources of ignition or that cranes or other equipment will comply with the design and installation parameters for electrical equipment in hazardous areas.

As in section 23.9.2, the terminal should take precautions additional to those set out in this chapter. These precautions should include:

- Enhanced security arrangements.
- Restricted vehicle access.
- Removable barriers to control personnel access to the berth.
- Additional firefighting equipment and control of sources of ignition.
- Restrictions on the movement of goods and equipment.
- Lifting of loads by cranes and the coordination of activities.

23.9.4 Tugs and other craft alongside

The number of craft that come alongside under specified conditions, and the duration of their stay, should be agreed between the tanker and the terminal.

If craft are allowed alongside while the tanker is at the terminal, the number of craft and the amount of time alongside the tanker should be kept to a minimum.

Subject to any port authority regulations, only authorised craft with 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 tanker's Responsible Officer should instruct personnel manning the craft that they should observe the regulations on smoking, naked lights and cooking appliances. If there any breaches of the regulations, operations should stop immediately.

Terminals should instruct the operators of authorised craft on the use of engines and other equipment in order to avoid sources of ignition when alongside a tanker or a jetty. Where necessary, this will include providing spark arresters for engine exhausts and instructions on proper fendering. Terminals should also ask the craft to post suitable notices informing personnel 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 the operations should stop.

Before allowing stores and provisions to be supplied to a tanker alongside a terminal during cargo transfer operations, a risk assessment should be completed for SIMOPS (see chapter 4). Additionally, only the craft stores crane (where fitted) should handle stores. The midships cargo handling crane should not be used while cargo operations are underway because of the risk of a suspended load falling onto the pressurised manifold pipelines.

23.10 Notices

23.10.1 Notices on the tanker

On arriving at a terminal, a tanker should display notices at the gangway in appropriate languages stating:

Figure 23.2: Notices on the tanker

Alternative wording containing the same warnings may be used.

Terminal personnel should observe the requirements of these notices when on the tanker.

Photo luminescent notices stating, 'Emergency Escape Route', should be displayed at appropriate locations, together with directional signs.

23.10.2 Notices on the terminal

Permanent notices and signs indicating that smoking and naked lights are prohibited should be displayed clearly 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 clearly displayed.

Emergency escape routes from the tanker berth to safe areas ashore should be clearly indicated.

23.11 Manning requirements

The level of manning should ensure that all operations related to the tanker/terminal interface are carried out safely. It should also ensure that emergency situations and security can be managed at all times during the tanker's stay at a terminal.

Details of manning levels on the tanker and the terminal should be discussed during the pre-transfer conference to ensure all parties involved in the tanker/terminal interface are fully aware of the availability of staff to handle operational and emergency situations. This is particularly relevant if a berth is not continually manned.

23.12 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. Where necessary, barriers or fencing should be provided to prevent unauthorised access.

Only authorised vehicles should be allowed to enter hazardous zones next to the tanker or berth.

23.13 Helicopter operations

Helicopters are not permitted over the tank deck unless all other operations have been suspended and all cargo tank openings are closed. Helicopters should only be operated in line with ICS' *Guide to Helicopter/Ship Operations*.

CHAPTER 24

Bunkering Operations

24.1 General

24.2 Bunkering residual fuel oil or distillates

24.3 Liquefied Natural Gas fuelled ships and Liquefied Natural Gas bunkering

24.4 Ancillary substances

24.5 Alternative fuels

24.6 Bunker checklists

24.7 Liquefied Natural Gas bunkering safety checklists

Spills and leaks during conventional bunkering of residual fuel oil, such as Heavy Fuel Oil (HFO), or distillates such as Marine Diesel Oil (MDO), are a primary source of oil pollution from ships.

Environmental regulations for the sulphur content of conventional fuels and restrictions on air emissions quantity and quality means that fuels face growing control.

Increasing concern over the impact of the maritime transport industry on the environment has seen the industry moving towards alternative fuels, including hydrogen, methanol and LNG, as a prime source of energy for propulsion and electricity generation.

This chapter provides guidance on planning and carrying out conventional bunkering and the bunkering of alternative fuels and ancillary substances. It includes examples of bunker safety checklists. It aims to ensure that conventional and alternative fuelled ships are re-fuelled in line with the highest levels of safety, environmental protection, integrity and reliability.

This chapter provides recommendations and guidance to personnel involved in bunker operations. The recommendations apply to any bunker transfer including from a bunker vessel, tanker, terminal or truck.

24.1 General

Bunkering is a critical operation and requires care to ensure safety and to reduce the risk of pollution.

Bunkering operations should be planned and carried out in line with legislation, standards and best practice guidelines to minimise the risk from the flammability, toxicity, cryogenic nature, volatility or pressure of the fuels being handled.

Vessel operators should manage the risks by ensuring that the crew is familiar with the management procedures for bunker operations and that they have all completed the appropriate training.

The crew designated to bunkering on board should have no other tasks during the operation. This is particularly important when bunkers are being loaded at the same time as cargo. Spills often occur when staff are distracted by other jobs.

24.1.1 Preparation by the bunker supplier, including the bunker vessel operator

Bunker suppliers and bunker receivers should document their bunkering procedures in their management system and for bunker vessel operators, this should be included in their SMS.

These procedures should ensure that the risks have been assessed and that measures are in place to control them. The procedures should also cover every anticipated form of bunker delivery that is likely to be made, the type of fuel involved and its hazardous properties and the emergency steps for unforeseen events, including spills. This will include bunker deliveries that may be carried out:

- Ship to Ship (STS) between a receiving ship and a bunker vessel, including alongside a berth, while at anchor, offshore, etc.
- By road tanker, whether direct to the receiving ship or through a terminal piping system.
- From a shore tank and fixed piping delivery system.
- For LNG fuel, options also exist for:
  - Multiple road tankers, which can be used to simultaneously deliver LNG bunker fuel from a series of road tanks to the receiving ship via a shore delivery system.
  - Increasingly, emerging technology now provides options for LNG fuel to be delivered in containerised Type C tanks (supported within 20 or 40 foot container frames) that are craned on board via either the shore/terminal or from a barge.

When developing procedures, the bunker supplying company should:

- Identify all documents, information analysis, procedures, licences and accreditations required by the authorities.
- All bunkering procedures should be developed based on a bunkering activity risk assessment.
- Develop an emergency and spill response plan based on a risk assessment.
- Consider applicable chapters in this guide, e.g. hose handling.
- Issue bunkering safety instructions.
- Develop bunkering plans and procedures that cover the specific instructions for the receiving ship and bunker supply facility.
- Check that the receiving ship and the bunker supply facility are compatible.
- Check that bunkering equipment is in good condition and appropriate for the service intended.
- Ensure all bunkering personnel are adequately certified and trained.

24.1.2 Bunkering safety management

A bunkering operations risk assessment should be carried out to ensure that the risk to people, the environment and assets have been eliminated or reduced to a level that is ALARP. Establish the required safety control zones around the bunkering operations.

See chapter 4 with regard to safety management.

Operational checks should be carried out to confirm items identified in the pre-bunkering toolbox talk that could have an impact on the safety of the bunkering operation have been actioned, e.g. hot work restrictions in place. These should be in addition to the following specific bunker operational checks that should be carried out before beginning operations.

24.1.3 Bunker procedures

Before the operation starts, hold a pre-bunker conference between competent representatives from the ship and the bunker facility (barge, terminal or truck). Pre-bunker checks should be carried out:

- Designate the fuel tanks to be loaded.
- Confirm there is enough space for the nominated loading volume.
- Establish the maximum loading volume for each of the designated tanks.
- Check that bunker system valves are correctly lined up.
- Determine the rates for the start of loading, bulk loading and topping-off.
- Set out the tank atmosphere control arrangements.
- Establish the internal tank transfer arrangements.
- Verify the operation and accuracy of the gauging system.
- Confirm the alarm settings on overfill alarm units.
- Agree with the bunker supplier, before starting, to establish and record:
  - The loading procedure.
  - How and where to carry out quantity checks.
  - How and where to carry out quality checks, including installing a sampler if used.
- Establish safe access to and from the ship.
- Decide how to monitor the temperature of the bunkers during loading.
- Set out the communication procedure for the operation, including the emergency stop signal and the steps for emergency disconnection and unberthing.
- Decide the personnel requirements to carry out the operation safely.
- Monitor the bunkering operation and that it conforms to the agreed procedure.
- Verify the procedure for changing bunker tanks during loading.
- Confirm the spill response and containment arrangements.
- Define weather operating limitations.

De-bunkering

Various circumstances can create the need for de-bunkering where bunkers already on board have to be pumped to a receiving facility. Existing bunker procedures cannot be used for de-bunkering unless they are carefully reviewed for suitability. De-bunkering always requires a dedicated specific risk assessment and a plan of approach. Local authorities should be informed.

24.2 Bunkering residual fuel oil or distillates

24.2.1 Precautions

Fuel oil, distillates and their vapours contain components that are hazardous to health. Consequently, sampling under closed conditions is recommended, (see section 1.4.6).

If bunker tank lids or sampling points need to be opened, personnel should remain upwind.

Take the following precautions:

- Wear the correct PPE as required by the ship's SMS and the product SDS (see section 4.8.1).
- Wear a personal H_2S monitor (see section 1.4.6).
- Change out of any oil soaked clothing as soon as possible.
- Keep all doors to the accommodation areas closed during bunkering and ensure the accommodation block is kept at positive pressure.
- Restrict the movement of personnel near the bunker vents.

The principles for loading lubricating oil are the same as residual fuel oil or distillates, so the same safety guidance should be followed.

All fuel oils (residual and distillate) must have a flashpoint above 60°C unless exempted from *International Convention for the Safety of Life at Sea (SOLAS)* Chapter II-2 Regulation 4, 2.1.1, but they are often stored at temperatures close to, or above, the flashpoint. High flashpoint fuels sometimes contain residual quantities of light or toxic material that slowly rise to the surface and vaporise after loading, raising the flammability or toxicity of the vapour space. Although the flashpoint of the fuel is above 60°C, care should be taken because the vapour can be flammable and/or toxic.

Never assume that the vapour spaces in bunker tanks or the emissions from them will be safe because the flashpoint is high or the fuel is not labelled as toxic. For the same reason, ullaging, dipping and sampling procedures should follow the recommendations in sections 2.5 and 12.8. Additional safety guidance can be found in sections 23.4 and 23.5.

Do not smoke near fuel tanks, or other locations where there may be fuel vapours. For more on the flammability hazards of residual fuel oils, see section 1.6.

All marine fuels are pollutants and can damage the environment. They are toxic to marine life and the heavier grades are very difficult to clean up after a spill:

- Use the appropriate bunker checklists.
- Know the procedures for preventing and responding to spills.
- Ensure oil spill equipment is ready and available on both the delivering vessel and receiving ship.
- Ensure proper lines of communication.
- Plug all scuppers and drains on the bunker barge and the receiving ship.
- Periodically drain off any accumulation of oil free water.
- Report spills to the authorities.

In addition to the guidance and checks of section 24.1 for general bunkering operations, the following checks should also be made before the bunkering operation begins:

- Special precautions when loading into double bottom tanks.
- Arrangements for bunker tank ventilation or tank atmosphere control.
- Steps to warn or protect personnel working near tank ventilation outlets.
- Methods for managing bunkers that may contain H_2S.
- Testing procedures for hydrocarbon or H_2S vapours.
- Spill containment arrangements and clean-up equipment that is available and ready, in line with the Ship Oil Pollution Emergency Plan and Shipboard Marine Pollution Prevention Emergency Plan (SOPEP/SMPEP).

During bunkering:

- Keep all bunker fuel away from naked flames, sparks or other sources of ignition.
- Keep all bunker fuel away from heated surfaces.
- Do not smoke on deck.
- Supervise bunker operations properly and continuously.
- Check the bunker rate at the intervals agreed by the Responsible Officers for supplier and receiver.
- Ensure that when changing over from one tank to another, excessive back pressure is not put on the hose or bunker lines.
- Decrease the bunker rate when topping-off tanks to avoid spillage.

- Before disconnecting hoses, all hoses and lines should be drained to the tank or, if applicable, back to the bunker facility (barge or terminal) before hose disconnection.
- Blowing lines with air into a receiving ship's bunker tanks introduces a number of safety risks and is not recommended.
- All unused bunker manifolds and hoses connected to the bunker system should be blanked before transfer.

24.3 Liquefied Natural Gas fuelled ships and Liquefied Natural Gas bunkering

The cryogenic nature and volatility of LNG means that its properties, characteristics and behaviour are very different to conventional marine fuels. This means additional precautions are needed, as described below.

The IMO requires new or existing ships over 500 tonnes, that are converted to use or transport LNG and are engaged in international service, to have been approved by their Flag State or competent authority as meeting the *International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)* or the *International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels (IGF Code).*

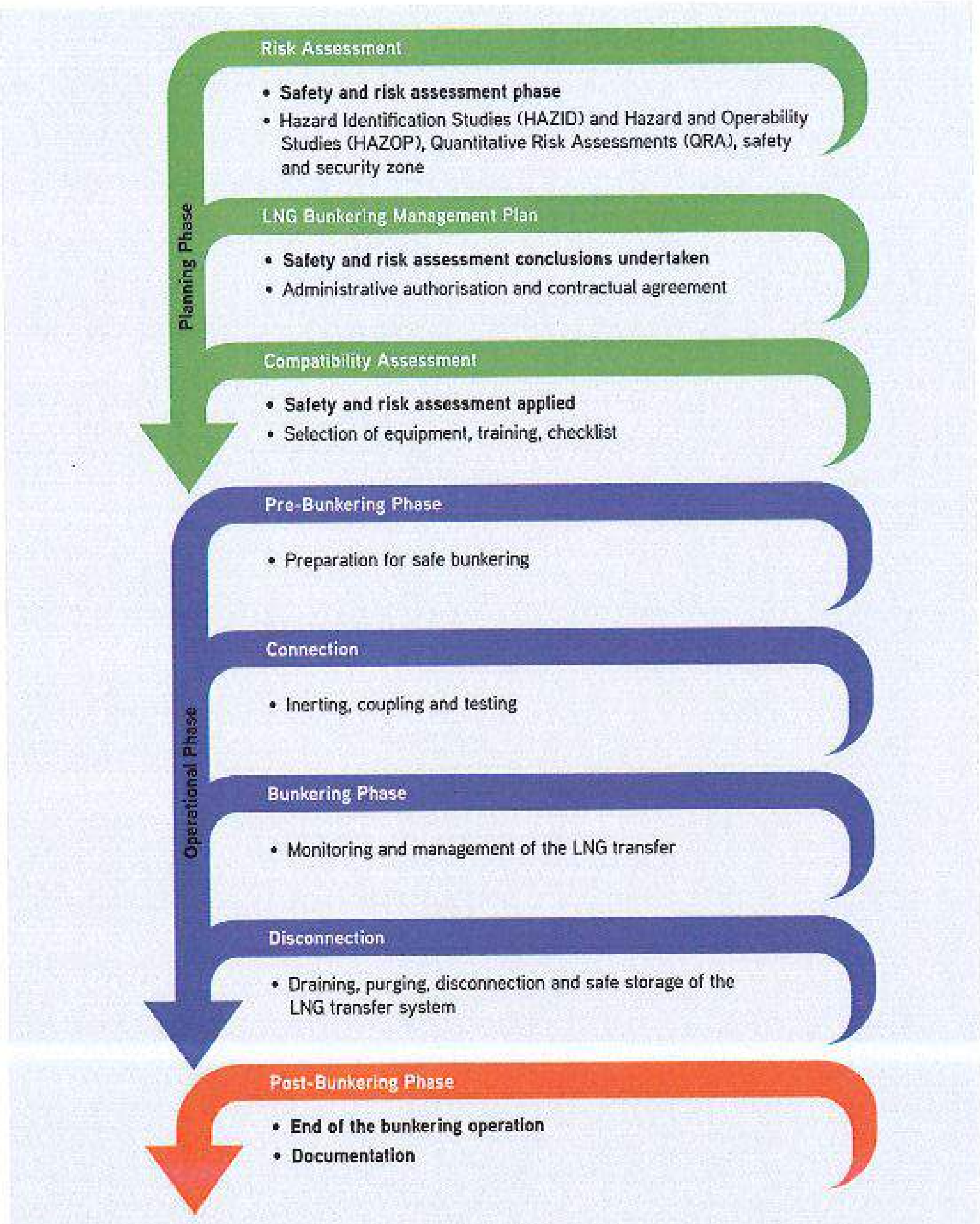
Bunkering facilities and receiving ships should conform to applicable standards.

Mobile facilities, e.g. tank trucks, rail cars and portable tanks, including their tanks, piping, hoses, pumps and valves, should be built to conform to ISO or other recognised standards for handling cryogenic liquids.

The bunkering facility should comply with local codes. If local codes do not address LNG bunkering facilities, the facility operator should obtain a document issued by a competent organisation confirming the facility conforms to the applicable sections of industry standards.

24.3.1 Liquefied Natural Gas bunkering processes and procedures

Figure 24.1 shows the sequence for an LNG bunkering operation carried out between two parties for the first time.



Reference: SGMF 'Gas as a Marine Fuel Safety Guidelines: Bunkering Version 2.0'

Figure 24.1: Typical LNG bunkering operation sequence

24.3.2 Transfer equipment requirements for Liquefied Natural Gas bunkering

Different types of equipment are used to perform LNG bunker transfers: rigid arms, hybrid systems (rigid structure handling flexible lines) and flexible hoses.

All LNG transfer systems should be equipped with an Emergency Release System (ERS) and ESD system connected via a bunkering safety link. The primary function of the bunkering safety link is to connect the supplier's and receiver's ESD systems, ensuring that in an emergency, either one can initiate a shut down of liquid and vapour transfer in a safe, coordinated and controlled manner.

All transfer equipment shall be adequately supported during transfer operations to perform safely under the operating parameters and designed for LNG use.

The bunkering connections must be of dry-disconnect type.

As recommended by the Society for Gas as a Marine Fuel (SGMF), each transfer arm or hose of the transfer system between the receiving ship manifold and the bunker pipeline should have a single insulation (isolation) flange. The installation should not allow shorting out of this insulation. When bunkering from a mobile facility, the vehicle shall be grounded to an earthing point at the quay to prevent static build-up. The earthing point should conform to local electrical codes. Ship to shore bonding cables/straps should not be used.

If national or local regulations require a bonding cable/strap to be used, the circuit continuity should be made via a certified safe switch (such as one housed inside an inherently safe enclosure) and the connection on the ship should be located away from the hazardous area. The switch should always be open when connecting or disconnecting the bonding strap.

24.3.2.1 Liquefied Natural Gas bunkering risk assessments

An LNG bunkering operation risk assessment should be carried out. Factors to be considered in the assessment should be in accordance with the *Guidelines for systems and installations for supply of LNG as fuel to ships* (ISO/TS 18683). The risk assessment should be conducted by or on behalf of the organisation providing the LNG, or the national or local authorities that have jurisdiction over the safety and security where the bunkering operation takes place.

24.3.2.2 Control zones

A critical difference between LNG and other maritime fuels is that, during a spill, a gas cloud could form, extending the hazard to some distance from the LNG installation. Although this is unlikely to happen, controlling the hazard requires an understanding of the extent of the zone that might be affected.

The decision to establish designated LNG bunkering areas belongs to the port or maritime authorities. However, any proposed bunkering location needs to be checked as suitable for LNG operations.

This decision should be made after a risk assessment. While the ship receiving the LNG is not required to assess the bunkering site, the Master or their representative should check that the conditions at the proposed site are within the limits set out in their bunkering operations procedures and that operations can be conducted safely.

In most cases, personnel involved in bunkering operations will not have the legal authority to require other vessels or personnel to remain outside any of the safety zones, monitoring or security areas that are necessary according to the risk assessment. As a result, personnel involved in the transfer should devise procedures to minimise the risks when a safety zone, monitoring or security area in their provisions is breached. If local authorities set up safety or security zones for the bunkering operation, communication should be established so that enforcement personnel can be notified if any restrictions are violated.

Five control zones are defined:

1. Hazardous zone	A flammable atmosphere may be present at any time.
2. Safety zone	Extending beyond the hazardous zone, special precautions are required because of the hazards of natural gas/LNG during bunkering.
3. Marine exclusion zone	Passing marine traffic may affect the safety of the bunkering operation.
4. Monitoring and security area	Activities, e.g. shoreside traffic, should be monitored to ensure they do not encroach on the safety zone.
5. External zone	Where the risks to individuals, particularly the general public, are controlled by local regulations.

24.3.2.3 Liquefied Natural Gas bunkering Simultaneous Operations

SIMOPS during regular operations on board tankers, e.g. repairs, taking in stores or bunkering during loading or unloading, are described in chapter 4.

LNG bunkering SIMOPS require specific guidance. If not covered by the risk assessment, operations on the receiving ship could have an impact on the safety level of the LNG bunker facility and transfer system. A spill of LNG and the dispersion of the gas cloud can have an effect on safety on board the receiving ship.

When it is proposed to carry out LNG bunkering operations at the same time as other operations, a further risk assessment should be carried out to demonstrate that the required level of safety can be maintained. Permission is required from the relevant authority before any SIMOPS are carried out.

24.3.2.4 Boil-Off Gas and pressure control

Boil-Off Gas (BOG) is produced by LNG fuel systems when the storage tanks absorb heat from the environment. Additional BOG may be produced during bunkering operations due to flashing, etc. If this BOG is not managed, it may result in an increase of temperature and pressure in the storage tank. Eventually the pressure relief valves may operate, allowing a release of LNG to the environment.

Vapour control during bunkering operations is critical and can be handled in several different ways, including:

- Vapour Return Line (VRL) allowing the vapour displaced from the receiving tank to be returned to the supplier's tank.
- Pressure accumulation in suitably constructed tanks.
- BOG and LNG conditioning provisions, such as sub-cooler.
- Burning of BOG in an approved consumer, such as a Gas Combustion Unit (GCU) or Dual Fuel Diesel Engine (DFDE).
- Cooling via top spraying/filling in the storage tanks.

Personnel responsible for LNG bunkering operations should be fully familiar with the means fitted to their ship or facility to control BOG and the associated procedures.

The IGF Code states that venting of fuel vapour for the control of the tank pressure is not acceptable except in emergency situations and that LNG fuelled ships must be fitted with means of maintaining tank pressure below the set pressure of the relief valves, with the ship in idle condition, for 15 days.

24.3.3 Additional information for Liquefied Natural Gas as a fuel and Liquefied Natural Gas bunkering

The SGMF provides detailed information, advice and guidance to help seafarers involved in LNG bunkering operations act in compliance with the appropriate regulations and industry best practices.

24.4 Ancillary substances

From time to time, tankers may load substances other than fuel. These include:

- Lubrication oil.
- Hydraulic oil.
- Caustic soda.
- Magnesium oxide.

They may be loaded and stored packaged, i.e. in drums or other containers, or they may be loaded and stored in bulk in dedicated tanks. See chapter 13 for further information on carrying and storing hazardous materials. The bunker station for an ancillary substance should be clearly identified with appropriate safety signage.

If an ancillary substance, e.g. lubricating oil, is to be loaded in a way that presents similar hazards as bulk bunker fuel, the requirements for conventional bunkering should apply (see sections 24.1 and 24.2).

For hazardous ancillary substances a health safety and environmental risk assessment should identify hazards and implement risk mitigation.

Risk mitigation measures should be reflected in an ancillary substance bunkering plan, with the requirements of conventional bunkering (see sections 24.1 and 24.2) and the additional requirements due to the hazardous properties of the substance.

Crews should be trained to handle hazardous ancillary substances, including how to deal with medical emergencies resulting from accidental exposure. The required PPE is dictated in the SDS for the substance.

24.5 Alternative fuels

The characteristics and behaviour of alternative fuels, such as Liquefied Petroleum Gas (LPG), hydrogen (H_2), ammonia (NH_4) and methanol (CH_3OH), are significantly different to conventional marine fuels and LNG. Risks should be mitigated and avoided. Throughout the alternative fuel bunkering chain, each element should be carefully designed and constructed. Dedicated safety, operational and maintenance procedures should be in place to be executed by trained personnel.

Most of the guidelines in section 24.1 apply to all possible alternative fuels. Future risk mitigation, guidelines and regulations will be based on growing industry knowledge, standards already existing for other applications, risk assessments, HAZIDs and HAZOPs and other safety management tools as referred to in chapter 4.

See chapter 8 for guidance on the due diligence requirements for introducing alternative and emerging technologies.

24.6 Bunker checklists

Safe bunker operations depend on good communication between the bunker vessel and the receiving ship, from pre-arrival to post-departure, and on compliance with the agreed safe procedures at all stages. The bunker checklists help to ensure that all the appropriate checks are formally agreed, carried out and recorded.

24.6.1 General

The responsibility for the safe conduct of a bunkering operation is shared between the Master of the receiving ship and the Master or manager of the bunker facility. The effective responsibility is usually delegated to designated Responsible Officers on the receiving ship and the bunker facility. Before the bunkering starts, the Responsible Officers should:

- Agree in writing the transfer procedures, including the maximum transfer rates and volumes.
- Agree in writing the action to be taken in an emergency during transfer operations.
- Complete and sign the bunker checklist sections appropriate to the operations.

Detailed instructions for completing the bunker checklist are provided in section 24.6.5, where the process that uses multiple parts (see figure 24.2) for each stage of the proposed operation is described. Each part contains a number of statements and all relevant statements should be reviewed with the associated responsibility for compliance accepted, either jointly or singly. Each statement provides a reference where guidance on the subject may be found in *ISGOTT Sixth Edition*. This may be shown either as:

1. A complete chapter or technical section with multiple cross references in the sub-paragraphs to the topical issue, e.g. smoking restrictions (4.10).
2. A specific sub-paragraph within a technical section, e.g. fendering (22.4.1).

This guidance is primarily written for tankers at conventional terminals and berths (except where otherwise stated) and, therefore, may not specifically relate to all forms of bunkering operations. However, the guidance is referenced for a general understanding of issues that should be considered, and further aid the preparations for and execution of, a safe operation. For example, references to tanker or terminal in the guidance should be considered in the context of its application to the receiving ship or bunker facility, as appropriate.

Some bunkering operations will involve LNG or other alternative fuels and, where this is the case, guidance on items related to these operations should also be sought from the appropriate industry association e.g. SGMF or the Society of International Gas Tanker and Terminal Operators (SIGTTO).

24.6.2 Bunkering checklist for residual fuel oil and distillates

The bunker checklist is structured for loading bunkers from a bunker vessel, but can be adapted for use when taking bunkers from a jetty or loading bulk lubricating oil or gasoil from a road tanker. These all come under the term 'bunker facility' in this chapter.

The bunker checklist is an official agreement record that helps to ensure the three points in section 24.6.1 are properly facilitated. The compatibility between firefighting or other emergency responses should be checked (see section 9.11) along with the operational parameters (chapter 12).

The bunker checklist may also be seen as a guide for addressing the critical risk management guidelines in chapter 4 and for ensuring other operational safety factors and concerns elsewhere in this publication are considered at the pre-transfer conference. Further guidance is in sections 21.4, 21.5 and 21.6.

The individual sections of the bunker checklist can be used or adapted to supplement any specialised safety checks and procedures that OCIMF, or other appropriate industry guidelines, recommend for any product transfer between a receiving ship and bunker facility.

24.6.3 The principles of the bunker checklist for residual fuel oil and distillates

The bunker checklist uses statements that assign responsibility. Ticking or initialling the appropriate box, and signing the declaration, confirms the acceptance of the appropriate obligations. Once signed it is the minimum basis for safe operations.

The assignment of responsibility and accountability does not mean that the other party is excluded from carrying out checks to confirm compliance. It is intended to clearly identify the party primarily responsible for initial and ongoing compliance checks throughout the transfer.

The Responsible Officers completing the checklist should be the personnel who carry out the bunkering operation or who supervise the nominated crew members doing the work. It is the responsibility of the Master of the receiving ship and the Master or manager of the bunker facility to ensure that only competent people act as their representatives in undertaking the checklist and signing the declaration.

The bunker facility's Responsible Officer should personally check all elements within the responsibility of the bunker facility. Similarly, the receiving ship's Responsible Officer should personally check everything that is within the responsibility of the ship. The Responsible Officers should assure themselves that the standards of safety on both sides of the operation are fully acceptable. They may do this by:

- Sighting appropriate records.
- Joint inspections, where appropriate.

For mutual safety, before the start of operations and then from time to time, the Responsible Officers should inspect the receiving ship to ensure that it is effectively managing its obligations agreed in the bunker checklist. If basic safety requirements are not being met, either party may stop bunker operations (see sections 4.3 and 7.7) until the situation is corrected. See parts H and I of the checklist.

24.6.4 The composition of the bunker checklist for residual fuel oil and distillates

The bunker checklist for residual fuel oil and distillates has five main sections, some of which include sub-sections specifically applicable to each party:

- Pre-arrival.
- Checks after mooring.
- Checks pre-bunkering, including pre-transfer conference.
- Summary of repetitive checks during bunkering.
- Checks after bunkering.

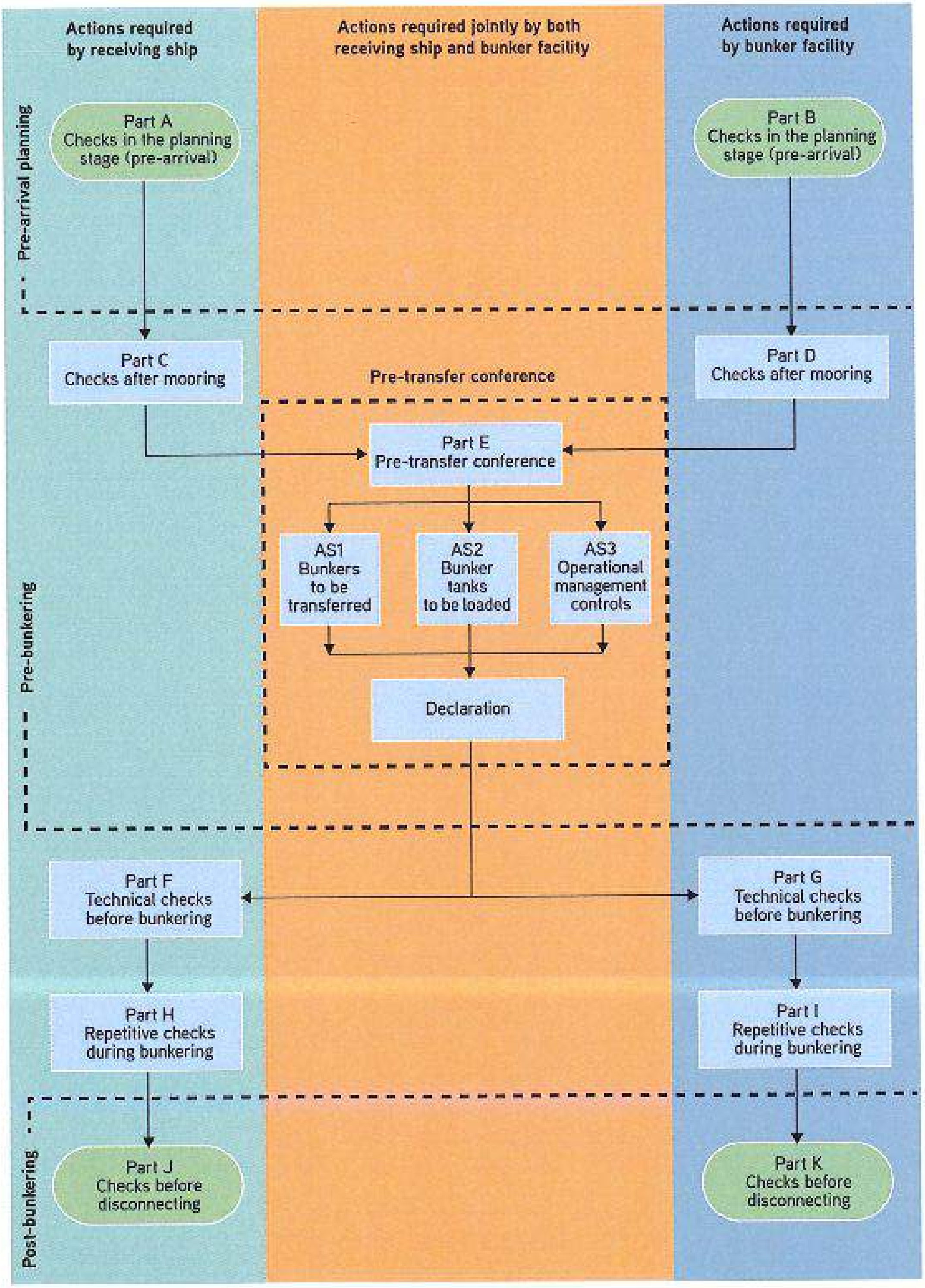


Figure 24.2: Bunker checklist flowchart

The parts of the checklist that apply to a specific process step should be completed before that part of the bunkering process begins.

The receiving ship or bunker facility representatives should keep the original copy of their relevant sub-section (parts) and any declarations, but they should give the other party a copy whenever requested.

Where either the receiving ship or bunker facility is not prepared to accept an assigned responsibility, a comment should be left in the Remarks column. It will then need to be decided whether transfer operations can proceed.

Further, where a particular item is judged not to apply to the receiving ship or bunker facility, or to the planned operation, a note to this effect should be written in the Remarks column.

Any information added to the Remarks column should be clear – any decision about the safety of operations should be based on facts and not assumptions or interpretations.

The safety of operations requires that all relevant statements should be reviewed by each party as appropriate.

Statements should be answered with the Yes box checked, except in the Agreements Parts AS1/AS2/AS3. If that is not possible, an appropriate comment should also be written in the Remarks column. If a 'Yes' answer is not confirmed, it may be appropriate to delay or cancel the transfer operation.

The Agreement Sheets (AS) allow free text to ensure that agreed values and limits are written down and that all parties confirm they understand those values and limits. This should be displayed in the control stations on the receiving ship and the bunker facility, so that all personnel can refer to them.

The joint declaration should be agreed before starting bunkering operations. It should not be signed until all parties have checked and accepted all appropriate checklist sections and their assigned responsibilities and addressed any comments in the Remarks column by formal agreement.

The repetitive checks time period for both parties begins after signing the declaration, regardless of when actual cargo transfer started.

24.6.5 Instructions for completing the bunker checklist

Pre-arrival

The receiving ship should complete part A, then forward it to the bunker facility for review. The bunker facility should complete part B, then forward to the receiving ship for review.

If it is not possible for either party to transmit the completed part A or B then the representative of the receiving ship or the bunker facility (as applicable) should send a message confirming the time and date of completion to the relevant party before arrival. If there are any outstanding issues not marked 'Yes' in the status box, this should be explained in this communication for pre-arrival review by the representatives.

Checks after mooring

The receiving ship should complete part C and give a copy to the bunker facility representative as soon as possible, but no later than at the pre-transfer conference.

The bunker facility should complete part D and give a copy to the receiving ship as soon as possible, but no later than at the pre-transfer conference.

Checks before transfer – the pre-transfer conference

Before the operation starts, a representative of the receiving ship and bunker facility should meet to conduct a pre-transfer conference (see section 24.1.3). The receiving ship and bunker facility should both complete part E as part of the pre-transfer conference, with each party retaining a copy.

During this process, both parties should complete and agree the checklists AS1, AS2 and AS3. These documents summarise the detailed operational factors agreed at the pre-transfer conference. A copy should be displayed at the control stations on the receiving ship and at the bunker facility, so personnel can refer to them.

Pre-bunkering technical checks

On completion of the pre-transfer conference (including agreements), the representatives of both the receiving ship and bunkering facility should undertake final technical checks immediately before the transfer. Checklists part F (receiving ship) and part G (bunker facility) are provided for this purpose. Before beginning the bunker transfer, each party should confirm satisfactory completion to the other party.

Where it is not possible to satisfactorily tick a Yes box, the issue should be brought to the immediate attention of the other party and corrected before beginning. If it is not possible to correct the issue, a further review should be undertaken to confirm whether the transfer operation can safely proceed and whether additional mitigations are required to be agreed. These may require to be risk assessed and additional documentation provided outlining the steps taken to ensure operational safety.

Copies of completed checklists parts F and G, along with any supporting documentation, should be exchanged before signing the declaration.

The declaration

When completed, each separate part of the checklist should be checked off and initialled by personnel from the receiving ship or bunker facility (or both if appropriate) in the relevant boxes on the declaration form. When all parts are completed, and the times for the repetitive checks noted, the details of the two representatives agreeing to start the operation should be added.

Summary of repetitive checks during and after transfer

The receiving ship should complete the repetitive checks in part H at the agreed intervals and have the record available for review by bunker facility personnel.

The bunker facility should complete the repetitive checks noted in part I at the agreed intervals and have the record available for review by receiving ship personnel.

The receiving ship and bunker facility should both provide a final copy of their parts H and I to the other when operations are completed.

Post-bunkering checks before disconnecting

At the end of the operation, both parties should complete the supplemental declaration when they have confirmed their pre-disconnection checklists (parts J and K) are satisfactory. At that point, they may disconnect.

The receiving ship and bunker facility should keep copies of all checklists and the declarations.

24.7 Liquefied Natural Gas bunkering safety checklists

ISO have produced LNG bunker checklists to support the IGF Code. These are contained in *ISO 20519:2017 Ships and marine technology – Specification for bunkering of liquefied natural gas fuelled vessels.*

In addition, the International Association of Ports and Harbors (IAPH) has developed harmonised checklists for known LNG bunkering scenarios: STS, shore to ship and truck to ship. These checklists are available on the lngbunkering.org website and aim to standardise procedures across different ports/countries. ISO 20519 allows alternative checklists to be used as long as they contain at least the same information that is listed in its own checklists.

The checklists developed by IAPH may be used in place of the standard ISO 20519 checklist if:

1. Both parties agree to use the alternative checklists.
2. The competent authorities permit their use.
3. The checklists are used from pre-operations through to the completion of the transfer (no mixing of checklists).

ISGOTT Bunker checklist: pre-arrival

Date and time: ______________________________

Port and berth: ______________________________

Receiving ship: ______________________________

Bunker facility: ______________________________

Part A. Checks at the planning stage for the receiving ship

Item	Check	Status	Remarks
1	Necessary permissions are granted (12.9.1, 21.2.2)	☐ Yes	
2	Local requirements are observed (12.9, 21.2.3, 21.3.1)	☐ Yes	
3	All personnel are aware of operations (23.5.3, 24.1)	☐ Yes	
4	Bunker plan is exchanged (21.2.3, 21.5, 21.6)	☐ Yes	
5	Mooring and fendering arrangement is agreed (22.3.1)	☐ Yes	

Part B. Checks at the planning stage for the bunker facility

Item	Check	Status	Remarks
6	Necessary permissions are granted (21.2.2)	☐ Yes	
7	Local requirements are observed (12.9, 21.2.2, 21.3.2)	☐ Yes	
8	All personnel are aware of operations (23.5.3)	☐ Yes	
9	Bunker plan is exchanged (21.5, 21.6, 24.1.1)	☐ Yes	
10	Mooring and fendering arrangement is agreed (22.3.2)	☐ Yes	

ISGOTT Bunker checklist: checks after mooring

Date and time: ______________________________

Port and berth: ______________________________

Receiving ship: ______________________________

Bunker facility: ______________________________

Part C. Checks after mooring for the receiving ship			
Item	**Check**	**Status**	**Remarks**
11	Fenders are effective (22.4.1)	☐ Yes	
12	Mooring is effective (22.2, 22.4.3)	☐ Yes	
13	Access between ship and facility is safe (16.4)	☐ Yes	

Part D. Checks after mooring for the bunker facility			
Item	**Check**	**Status**	**Remarks**
14	Fenders are effective (22.4.1)	☐ Yes	
15	Mooring is effective (22.2, 22.4.3)	☐ Yes	
16	Access between ship and facility is safe (16.4)	☐ Yes	

ISGOTT Bunker checklist: pre-transfer conference

Date and time: ____________________

Port and berth: ____________________

Receiving ship: ____________________

Bunker facility: ____________________

Part E. Pre-transfer conference

Item	Check	Receiving ship status	Bunker facility status	Remarks
17	Effective communications are established (21.1.1, 21.4, 24.1.3)	☐ Yes	☐ Yes	
18	Bunker watch is established (12.1.6.4, 21.4, 23.11)	☐ Yes	☐ Yes	
19	Smoking restrictions and designated smoking areas are established (4.10, 23.10)	☐ Yes	☐ Yes	
20	Naked light restrictions are established (4.10.1, 24.2.1)	☐ Yes	☐ Yes	
21	Safety data sheets are available (1.4.4, 20.1, 21.4)	☐ Yes	☐ Yes	
22	Hazardous properties of the product to be transferred identified in the safety data sheet are discussed (1.2, 1.4, 24.1.2)	☐ Yes	☐ Yes	

AS1. Agreement sheet part 1

Bunkers to be transferred (21.4, 21.5, 21.6)

Product and grade	Tonnes	Volume (in m³) at loading temperature	Loading temperature	Maximum transfer rate	Maximum line pressure

AS2. Agreement sheet part 2						
Bunker tanks to be loaded (volume in m³) (21.4, 21.5, 21.6)						
Tank number	Product and grade	Capacity of tank (volume in m³)	Volume of oil in the tank before bunkering	Free capacity of tank (volume in m³)	Volume (in m³) to be loaded	Final volume (in m³)

AS3. Agreement sheet part 3				
Operational management controls				
Item ref	Agreement	Details	Receiving ship initials	Bunker facility initials
17	Process for starting transfer	Initial flow rate: Increase of flow to full rate: Quantity transferred check intervals:		
18	Process for completing transfer	Slowdown of flow: Transfer stop:		

ISGOTT Bunker checklist: pre-bunkering

Date and time: ______________________

Port and berth: ______________________

Receiving ship: ______________________

Bunker facility: ______________________

Part F. Receiving ship: technical checks before bunkering			
Item	**Check**	**Status**	**Remarks**
23	Electrical insulation is effective (12.9.5, 17.4.2, 17.4.5, 18.2.14)	☐ Yes	
24	Bunker transfer equipment: (18) • is in good condition • is appropriate • line up is checked • is properly rigged • is secured to manifolds • is fully bolted	☐ Yes	
25	Firefighting equipment is ready for use (5, 23.8)	☐ Yes	
26	Scuppers and savealls are plugged (23.7.4, 23.7.5, 24.2)	☐ Yes	
27	Portable drip trays are correctly positioned and empty (23.7.5)	☐ Yes	
28	Unused bunker connections are blanked and fully bolted (23.7.1, 23.7.6)	☐ Yes	
29	High level and overfill alarm units are operational (12.1.6.6.1, 24.1.3)	☐ Yes	
30	Bunker operation emergency stop is operational (18.5)	☐ Yes	
31	Bunker tank openings are closed (23.3)	☐ Yes	
32	Oil spill clean-up material is available (20.4, 24.2)	☐ Yes	
33	Medium frequency/high frequency radio antennae are isolated (4.11.4, 4.13.2.1)	☐ Yes	
34	Very high frequency and ultra high frequency transceivers are set to low power mode (4.11.6, 4.13.2.2)	☐ Yes	

ISGOTT Bunker checklist: pre-bunkering

Date and time: ______________________

Port and berth: ______________________

Receiving ship: ______________________

Bunker facility: ______________________

Part G. Bunker facility: technical checks before bunkering			
Item	**Check**	**Status**	**Remarks**
35	Electrical insulation is effective (12.9.5, 17.4.2, 17.4.5, 18.2.14)	☐ Yes	
36	Bunker transfer equipment: (18) • is in good condition • is appropriate • line up is checked • is properly rigged • is secured to manifolds • is fully bolted	☐ Yes	
37	Firefighting equipment is ready for use (5, 19.4, 23.8)	☐ Yes	
38	Scuppers and savealls are plugged (23.7.4)	☐ Yes	
39	Portable drip trays are correctly positioned and empty (23.7.5)	☐ Yes	
40	Unused bunker connections are blanked and fully bolted (23.7.1, 23.7.6)	☐ Yes	
41	High level and overfill alarm units are operational (12.1.6.6.1, 24.1.3)	☐ Yes	
42	Bunker operation emergency stop is operational (18.5)	☐ Yes	
43	Bunker tank openings are closed (23.3)	☐ Yes	
44	Oil spill clean-up material is available (20.4, 24.2)	☐ Yes	
45	Medium frequency/high frequency radio antennae are isolated (4.11.4, 4.13.2.1)	☐ Yes	
46	Very high frequency and ultra high frequency transceivers are in low power mode (4.11.6, 4.13.2.2)	☐ Yes	

ISGOTT Bunker checklist: repetitive checks

Date and time: ______________________

Port and berth: ______________________

Receiving ship: ______________________

Bunker facility: ______________________

Part H. Receiving ship: repetitive checks during bunkering								
Item ref	Check	Time	Time	Time	Time	Time	Time	Remarks
Interval time:.................... hrs								
11	Fendering is effective	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
12	Mooring arrangement is effective	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
13	Access between ship and bunker facility is safe	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
17	Communications are effective	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
19	Smoking restrictions and designated smoking areas are complied with	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
20	Naked light restrictions are complied with	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
26	Scuppers and savealls are plugged	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
AS3	Bunker tank contents are monitored	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
Initials								

ISGOTT Bunker checklist: repetitive checks

Date and time: ______________________

Port and berth: ______________________

Receiving ship: ______________________

Bunker facility: ______________________

Part I. Bunker facility: repetitive checks during bunkering								
Item ref	**Check**	**Time**	**Time**	**Time**	**Time**	**Time**	**Time**	**Observation**
Interval time:.................... hrs								
14	Fendering is effective	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
15	Mooring arrangement is effective	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
16	Access between ship and bunker facility is safe	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
17	Communications are effective	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
19	Smoking restrictions and designated smoking areas are complied with	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
20	Naked light restrictions are complied with	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
38	Scuppers and savealls are plugged	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
AS3	Tank contents are monitored	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
Initials								

ISGOTT Bunker checklist: post-bunkering

Date and time: ______________________

Port and berth: ______________________

Receiving ship: ______________________

Bunker facility: ______________________

Part J. Receiving ship: checks before disconnecting			
Item	Check	Status	Remarks
47	Bunker hoses, fixed pipelines and manifolds are drained (12.1.14, 18.4, 24.2)	☐ Yes	
48	Remote and manually controlled valves are closed (12.1.6.17, 12.1.14.3, 23.7.6)	☐ Yes	

Part K. Bunkering facility: checks before disconnecting			
Item	Check	Status	Remarks
49	Bunker hoses, fixed pipelines and manifolds are drained (12.1.14, 18.4, 24.2)	☐ Yes	
50	Remote and manually controlled valves are closed (12.1.6.17, 12.1.14.3, 23.7.6)	☐ Yes	

Declaration

We the undersigned have checked the items in the applicable parts A to G as marked and signed below:

	Receiving ship	Bunker facility
Part A. Checks at the planning stage for the receiving ship	☐	☐
Part B. Checks at the planning stage for the bunker facility	☐	☐
Part C. Checks after mooring for the receiving ship	☐	☐
Part D. Checks after mooring for the bunker facility	☐	☐
Part E. Pre-transfer conference	☐	☐
Part F. Receiving ship: technical checks before bunkering	☐	☐
Part G. Bunker facility: technical checks before bunkering	☐	☐

In accordance with the guidance noted in chapter 24 of *ISGOTT*, we are satisfied that the entries we have made are correct to the best of our knowledge and that the receiving ship and bunker facility are in agreement to undertake the transfer operation.

We have also agreed to carry out the repetitive checks noted in parts H and I of the *ISGOTT* bunker checklist, which should occur at intervals of not more than ____ hours for the receiving ship and not more than ____ hours for the bunker facility.

If, to our knowledge, the status of any item changes, we will immediately inform the other party.

Receiving ship	**Bunker facility**
Name	Name
Rank	Position
Signature	Signature
Date	Date
Time	Time

To be completed after any transfer operation:

	Receiving ship	Bunker facility
Part J. Receiving ship: checks before disconnecting	☐	☐
Part K. Bunkering facility: checks before disconnecting	☐	☐

Receiving ship	**Bunker facility**
Name	Name
Rank	Position
Signature	Signature
Date	Date
Time	Time

CHAPTER 25

The Ship/Shore Safety Checklist

25.1 General

25.2 Composition of the Ship/Shore Safety Checklist

25.3 Example safety letter

25.4 Instructions for completing the Ship/Shore Safety Checklist

Safe transfer operations depend on good communication between the terminal and tanker, from pre-arrival to post-departure, and on complying with agreed safe procedures at all stages. The SSSCL described in this chapter is a means to ensure that all the appropriate checks are formally agreed, carried out and recorded.

25.1 General

The responsibility for the safe conduct of operations while a tanker is at a terminal is shared between the tanker's Master and the Terminal Representative. Before cargo or ballast operations start, the Master (or their representative) and the Terminal Representative should communicate and:

- Agree in writing the transfer procedures and sequences of products, including the maximum loading or unloading rates and initial and topping-off rates (see part 6 of the SSSCL).
- Agree in writing the action to be taken in an emergency while the tanker is at the terminal.
- Complete and sign the SSSCL sections appropriate to the operations.

The communication process (see chapter 21) should start before the ship arrives at the terminal, so that any potential mismatches can be addressed before a problem can occur.

Once at the terminal, matters should be discussed face to face in what is known as the pre-transfer conference. This should be a clear flow of information on all aspects of the proposed operations and should lead to an agreement between both parties. It should not consist of just handing a set of rules over and assuming the other party fully understands. The SSSCL should be seen as the official conference record, helping to facilitate the three points above. The compatibility between the security plans of the tanker and terminal (see chapter 6) should also be discussed and confirmed, along with the joint approaches to firefighting or other emergency responses (see chapters 9 and 20) and the operational parameters (chapters 12 and 23).

The SSSCL may also be seen as an aide-memoire for addressing the critical risk management guidelines (chapter 4) and for ensuring other operational safety factors and concerns elsewhere in this publication are covered in the pre-transfer conference. Further guidance is in sections 21.4, 21.5 and 21.6.

Some specialised operations, e.g. STS transfer and transfers at offshore terminals, require procedures to be followed that use a safety checklist specific to the appropriate industry guidance and the operations involved. The SSSCL can be used or adapted to supplement these other checklists, where appropriate, to ensure consistency of best practice in common operational safety checks.

For more complex transfers, specific arrangements encompassing each tanker involved and the terminal may be needed, with clear agreement on how to use the sections of the SSSCL relevant to each party's operational safety checks.

Terminals should issue an explanatory letter to the Masters of visiting tankers about the shared responsibility for safe operations. An example of suitable text is in section 25.3.

The SSSCL is mainly for cargo handling, but it can also be used when a tanker arrives at a berth for tank cleaning or other cargo related operations. A separate checklist for bunker fuel transfers is in chapter 24.

Instructions for completing the SSSCL are in section 25.4.

The Master, tanker personnel, Terminal Representative and shore personnel should all follow *ISGOTT* guidelines and recommendations throughout the ship's stay at the terminal. Each should cooperate with the other in the mutual interest of safe operations. All parties should agree appropriate actions and record them on the SSSCL.

Responsibility for the statements in the checklist are noted within the document and associated guidance. Either party accepts responsibility by ticking or initialling the appropriate box and finally signing the declarations in the checklist. Once signed, the checklist is the agreed basis for safe operations.

Depending on the phase of the operation, some checklist statements are directly addressed to the tanker, and some are directly addressed to the terminal. Some other statements require the agreement of both parties.

The assignment of responsibility does not mean that the other party is excluded from carrying out checks to confirm compliance. It is intended to clearly identify the party primarily responsible for initial and ongoing compliance checks throughout the ship's stay at the terminal.

The Master is responsible for ensuring that the tanker meets all its responsibilities. Similarly, the Terminal Representative should personally check everything within the terminal's responsibility. In fulfilling these responsibilities they should assure themselves that the standards of safety on both sides of the operation are fully acceptable. They can do this by:

- Confirming that competent people have satisfactorily completed the checklist. If there are any concerns, senior personnel may need to complete the checklist.
- Accessing relevant records.
- Joint inspection, where appropriate.

For mutual safety, before the start of operations, and then from time to time, a Terminal Representative and a Responsible Officer should inspect the ship to ensure that it is effectively managing its obligations agreed in the checklist (see parts 8 and 9 of the SSSCL). Similar checks should be carried out at the terminal. If basic safety requirements are not being met, either party may stop cargo and ballast operations (see sections 4.3 and 7.7) until the situation is corrected.

25.2 Composition of the Ship/Shore Safety Checklist

The checklist has four main sections:

- Pre-arrival.
- Checks after mooring.
- Checks pre-transfer (including agreements).
- Summary of repetitive checks during and after transfer, until the tanker departs.

These are divided into multiple sub-sections, each one for different parts of the proposed operation, for either the tanker or terminal or both, and for differing tanker types; oil tanker (figure 25.1), chemical tanker (figure 25.2) and gas tanker (figure 25.3).

Each party should keep the original copy of their relevant sub-sections and any declarations, but should give the other party a copy.

All relevant statements should be reviewed and the associated responsibility for compliance accepted, either jointly or singly. Each statement provides a primary reference where additional guidance on the subject may be found in *ISGOTT Sixth Edition*. This may be shown either as:

1. A complete chapter or technical section with multiple cross references to the topical issue, e.g. gas measurement (2.4).
2. A specific sub-paragraph within a technical section, e.g. fendering (22.4.1).

Some statements in part 5B (bulk liquid chemical) and part 5C (liquefied gas) have no linked guidance to *ISGOTT Sixth Edition*. Guidance on these technical topics should be sought from the relevant Chemical or Liquefied Gas Safety Guides produced by ICS or SIGTTO.

Where either party is not prepared to accept an assigned responsibility, a comment should be left in the Remarks column. It will then need to be decided whether transfer operations can proceed. Any information added to the Remarks column should be clear – any decision about the safety of operations should be based on facts and not assumptions or interpretations.

Where a particular item is judged not to apply to the tanker, the terminal or to the planned operation, a note to this effect should be written in the Remarks column.

Statements should be answered with the Yes box checked for those in the part 6 (Agreements) table. If that is not possible, an appropriate comment should be written in the Remarks column. If a 'Yes' answer is not confirmed, it may be appropriate to delay or cancel the transfer operation.

The part 6 (Agreements) table allows free text to ensure that agreed values and limits are written down and that all parties confirm they understand those values and limits. This should be displayed in the control stations on the tanker and terminal so that all personnel can refer to it.

The joint declaration should be agreed before starting transfer operations, but neither party should sign until both have checked and accepted all their appropriate checklist parts.

The repetitive checks time period for both parties begins after signing the Declaration, regardless of when actual cargo transfer started.

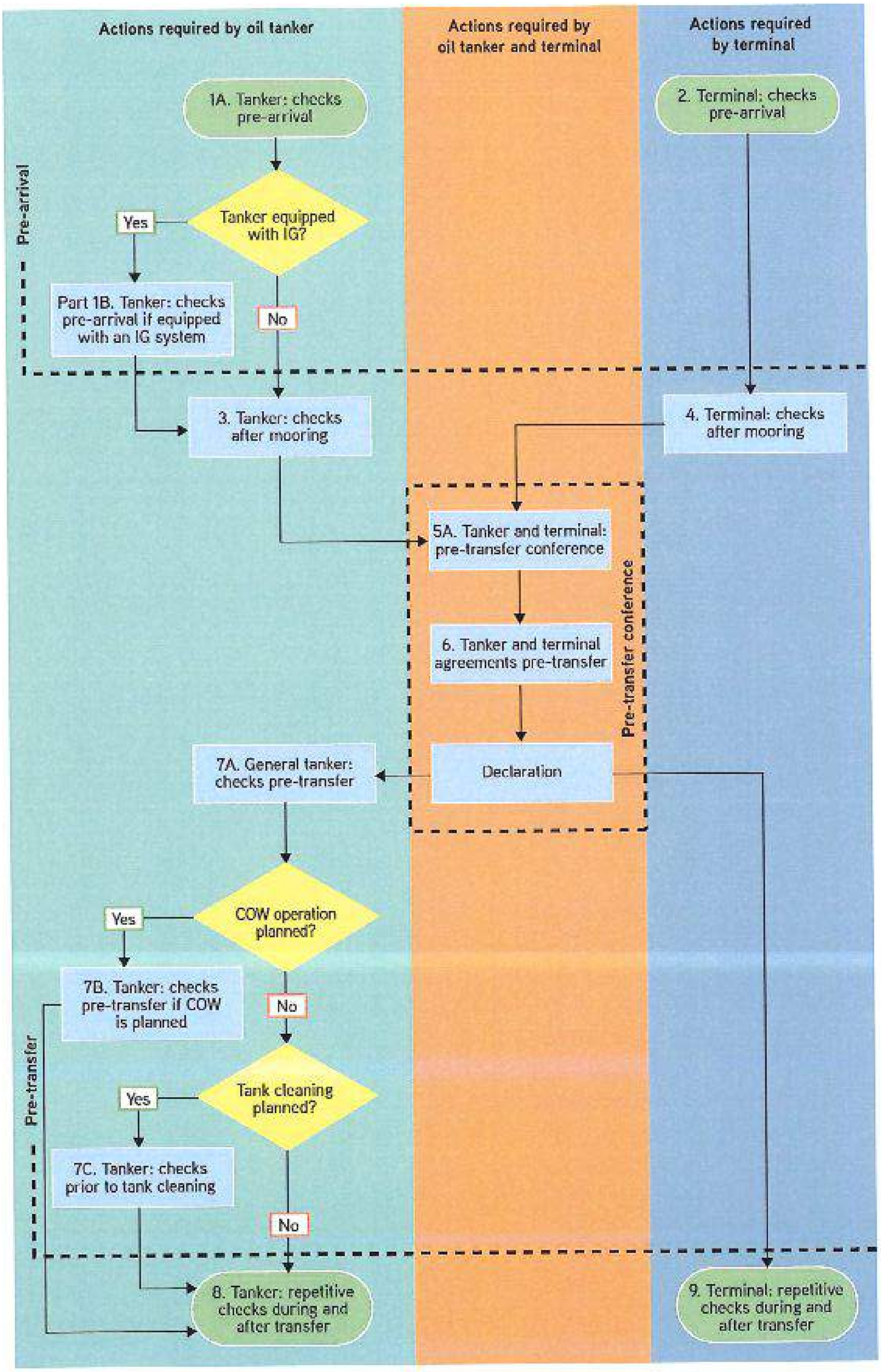


Figure 25.1: Oil tanker flowchart

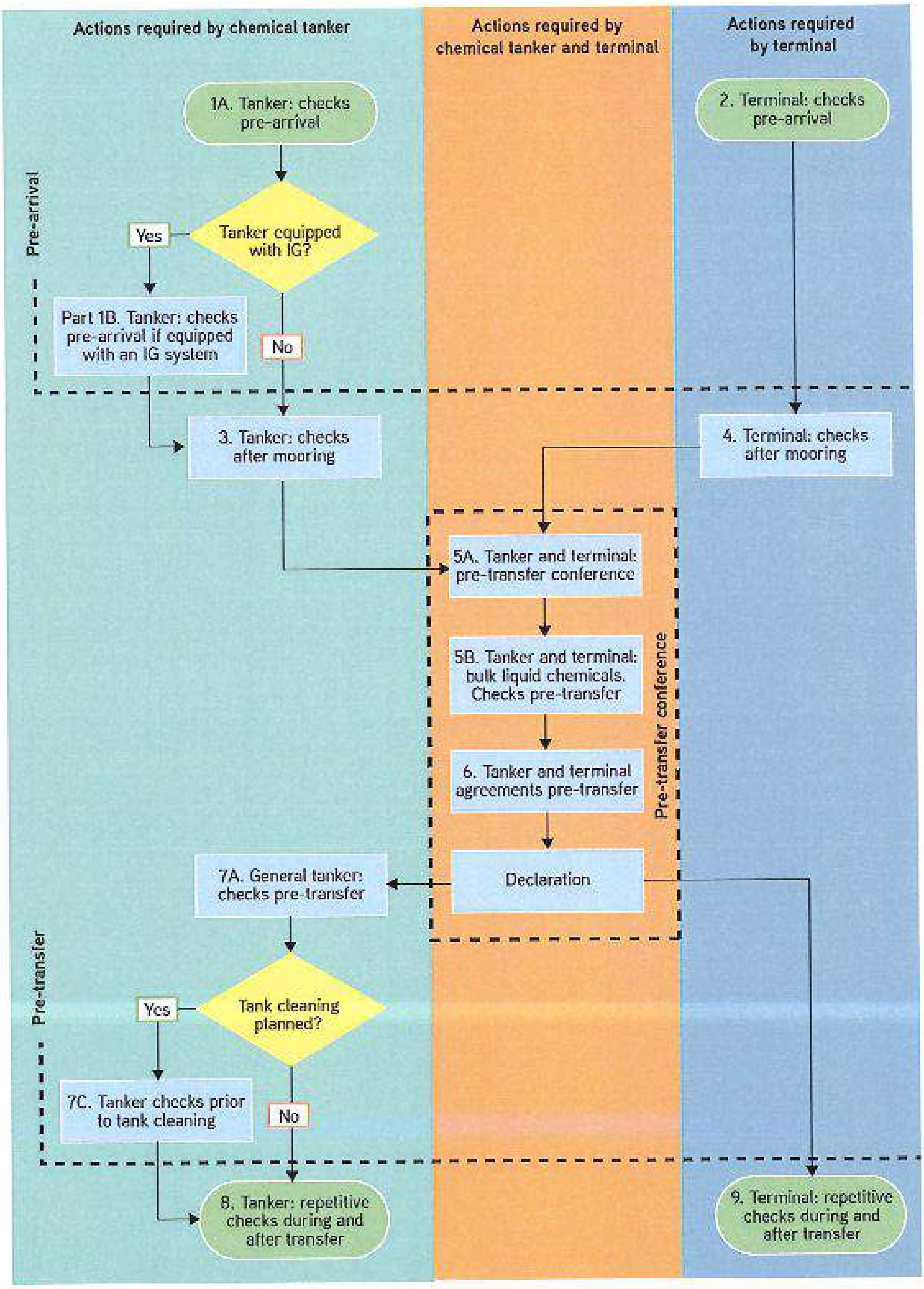


Figure 25.2: Chemical tanker flowchart

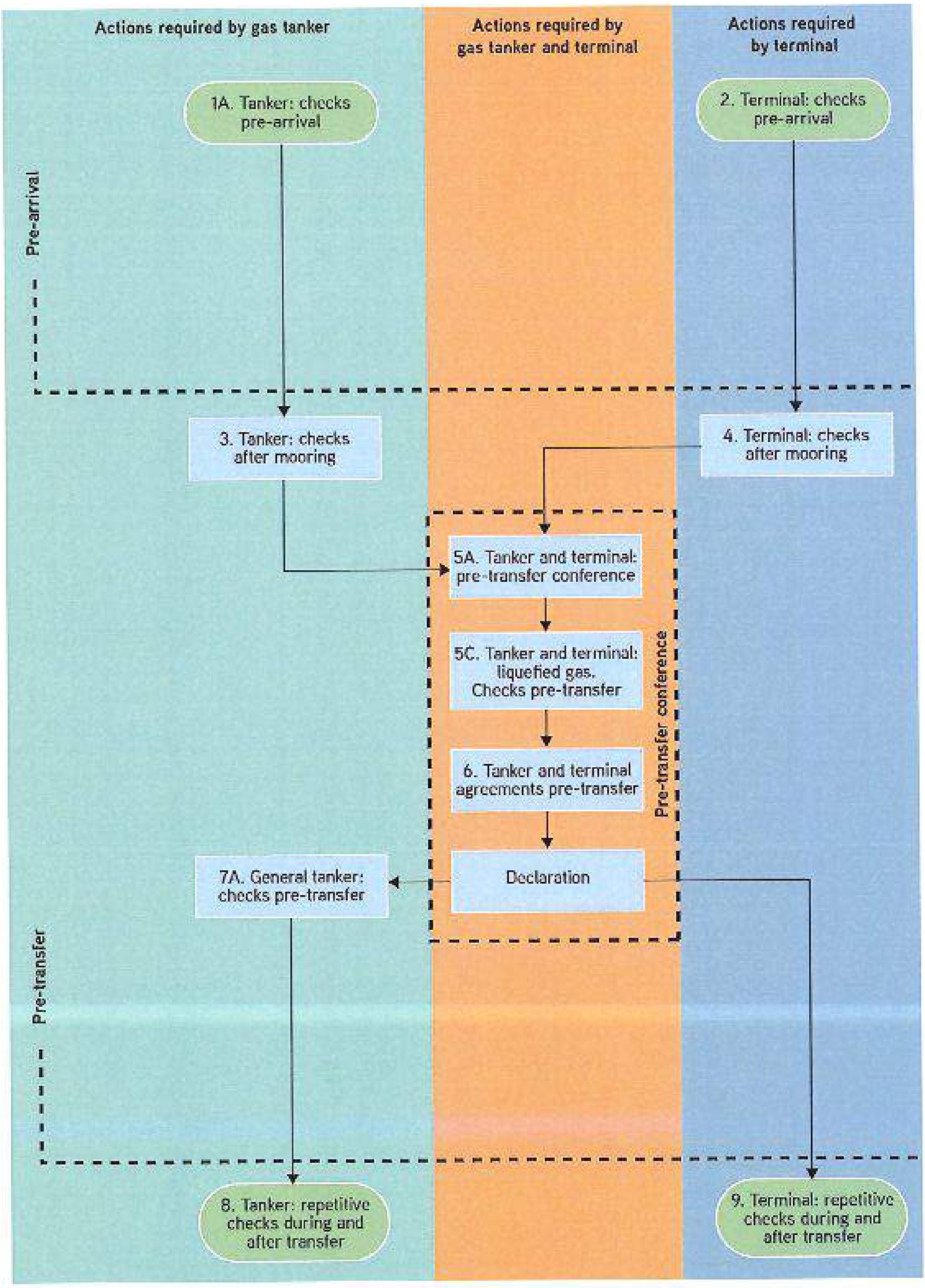


Figure 25.3: Gas tanker flowchart

25.3 Example safety letter

Company ______________________

Terminal ______________________

Date ______________________

The Master SS/MV ______________________

Port ______________________

Dear Captain,

Accountability for the safe conduct of operations while your tanker is at this terminal rests jointly with you, as Master of the tanker, and with the Terminal Representative. Before operations start, your full cooperation and understanding is required to ensure the safety requirements set out in the ship/shore safety checklist are followed. These requirements are based on safe practices that are widely accepted by the oil terminal and tanker industries.

We expect you, and all under your command, to adhere strictly to these requirements throughout your tanker's stay alongside this terminal. We will ensure that our personnel do likewise and will cooperate fully with you in the mutual interest of safe operations.

Before the start of operations, and then from time to time, for our mutual safety, a member of the terminal staff, together with a Responsible Officer where appropriate, will make a routine inspection of your tanker.

Where corrective action is needed we will not agree to operations starting. If they have started, we may require them to be stopped immediately. Similarly, if you consider that safety is being endangered by any action on the part of our terminal staff or by any equipment under our control, you should request operations to be stopped immediately.

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 ______________________

25.4 Instructions for completing the Ship/Shore Safety Checklist

Before completing the SSSCL, tanker and terminal representatives should read and understand the following instructions to ensure satisfactory completion.

An effective application of the SSSCL will provide a basis for safe operations while the tanker is at the terminal. It is important that each applicable part is completed as required to ensure this.

25.4.1 Pre-arrival

The tanker should complete part 1A (and 1B if using an IG system) and then forward a copy to the terminal for review before arrival. The terminal should complete part 2 and then similarly forward a copy to the tanker for review before arrival.

On completion of the pre-arrival parts, if it is not possible to send a copy of the completed part to the tanker and/or terminal, then a message should be sent confirming the time and date of completion to the relevant party before arrival. If there are any outstanding issues not marked 'Yes' in the status box, this should be explained in this communication.

25.4.2 Checks after mooring

The tanker should complete part 3 and give a copy to the Terminal Representative as soon as possible, but no later than at the pre-transfer conference.

The terminal should complete part 4 and give a copy to the tanker as soon as possible, but no later than at the pre-transfer conference.

25.4.3 Checks before transfer – the pre-transfer conference

Tanker and terminal personnel should both complete part 5A as part of the pre-transfer conference. Each party should retain a copy. This requires completion by ALL tankers.

If bulk chemicals are to be transferred, the tanker and terminal personnel should also complete the additional part 5B as part of the pre-transfer conference, and each should retain a copy (for further information, see ICS' *Tanker Safety Guide: Chemicals*).

If bulk gases are to be transferred, the tanker and terminal personnel should also complete the additional part 5C as part of the pre-transfer conference, and each party should retain a copy (for further information, see ICS' *Tanker Safety Guide: Liquefied Gas*).

The tanker and terminal personnel should discuss and agree the content of part 6 (Agreements), which summarises the detailed operational factors agreed at the pre-transfer conference. A reference copy for personnel on the tanker and in the terminal should be displayed at the relevant control stations.

Tanker personnel should also complete the additional pre-transfer checks for all tankers in part 7A immediately before beginning transfer operations.

If COW is planned, they should also complete part 7B.

All tankers planning on tank cleaning and/or gas freeing alongside should discuss the intention during the pre-transfer conference and, once agreement is reached, provide a copy of part 7C to the terminal before beginning operations.

25.4.4 The declaration

When completed, each separate checklist part should be checked off and initialled by tanker personnel, terminal personnel, or both, in the relevant boxes on the declaration form.

When all parts are addressed, tanker and terminal representatives should agree the intervals at which they will undertake repetitive checks of items applicable to their responsibility from the SSSCL, and that could impact on the safety of the operation if not monitored. This interval should be noted in the declaration, after which the two representatives may agree to start operations and add their details.

The tanker and terminal should retain a copy of all checklist parts and the declarations for their files in accordance with the operator's document retention period.

25.4.5 Summary of repetitive checks during and after transfer

Repetitive checks to be undertaken at intervals agreed in the pre-transfer conference by the tanker and terminal representatives are provided to:

- Act as an aide memoire for tanker and terminal personnel to monitor key operational items during the period of operations.
- Provide a basis for status checks at watch or shift handovers.
- Enable decision making in the event that conditions change during the course of operations.

Where an item reviewed during the repetitive checks is no longer in compliance with the original status agreed during the pre-transfer conference, the tanker or terminal representative should take immediate steps to remedy the issue or cease operations until the status agreed at the pre-transfer conference can be reinstated.

If cessation is necessary, the tanker and terminal representatives should meet to agree the course of action taken to resolve the issue and agree that a resumption is acceptable.

The tanker personnel should complete the repetitive checks in part 8 at the agreed intervals. The record should be available for terminal personnel to review.

The terminal personnel should complete the repetitive checks noted in part 9 at the agreed intervals. The record should be available for tanker personnel to review.

The tanker and terminal personnel should provide a final copy of their parts 8 and 9 to the other when operations are completed. This will provide a basis for review of the operation and verification of checks undertaken.

ISGOTT Checks pre-arrival Ship/Shore Safety Checklist

Date and time: ______________________________

Port and berth: ______________________________

Tanker: ______________________________

Terminal: ______________________________

Product to be transferred: ______________________________

Part 1A. Tanker: checks pre-arrival			
Item	**Check**	**Status**	**Remarks**
1	Pre-arrival information is exchanged (6.5, 21.2)	☐ Yes	
2	International shore fire connection is available (5.5, 19.4.3.1)	☐ Yes	
3	Transfer hoses are of suitable construction (18.2)	☐ Yes	
4	Terminal information booklet reviewed (15.2.2)	☐ Yes	
5	Pre-berthing information is exchanged (21.3, 22.3)	☐ Yes	
6	Pressure/vacuum valves and/or high velocity vents are operational (11.1.8)	☐ Yes	
7	Fixed and portable oxygen analysers are operational (2.4)	☐ Yes	

Part 1B. Tanker: checks pre-arrival if using an inert gas system			
Item	**Check**	**Status**	**Remarks**
8	Inert gas system pressure and oxygen recorders are operational (11.1.5.2, 11.1.11)	☐ Yes	
9	Inert gas system and associated equipment are operational (11.1.5.2, 11.1.11)	☐ Yes	
10	Cargo tank atmospheres' oxygen content is less than 8% (11.1.3)	☐ Yes	
11	Cargo tank atmospheres are at positive pressure (11.1.3)	☐ Yes	

Part 2. Terminal: checks pre-arrival			
Item	**Check**	**Status**	**Remarks**
12	Pre-arrival information is exchanged (6.5, 21.2)	☐ Yes	
13	International shore fire connection is available (5.5, 19.4.3.1, 19.4.3.5)	☐ Yes	
14	Transfer equipment is of suitable construction (18.1, 18.2)	☐ Yes	
15	Terminal information booklet transmitted to tanker (15.2.2)	☐ Yes	
16	Pre-berthing information is exchanged (21.3, 22.3)	☐ Yes	

ISGOTT Checks after mooring Ship/Shore Safety Checklist

Part 3. Tanker: checks after mooring			
Item	**Check**	**Status**	**Remarks**
17	Fendering is effective (22.4.1)	☐ Yes	
18	Mooring arrangement is effective (22.2, 22.4.3)	☐ Yes	
19	Access to and from the tanker is safe (16.4)	☐ Yes	
20	Scuppers and savealls are plugged (23.7.4, 23.7.5)	☐ Yes	
21	Cargo system sea connections and overboard discharges are secured (23.7.3)	☐ Yes	
22	Very high frequency and ultra high frequency transceivers are set to low power mode (4.11.6, 4.13.2.2)	☐ Yes	
23	External openings in superstructures are controlled (23.1)	☐ Yes	
24	Pumproom ventilation is effective (10.12.2)	☐ Yes	
25	Medium frequency/high frequency radio antennae are isolated (4.11.4, 4.13.2.1)	☐ Yes	
26	Accommodation spaces are at positive pressure (23.2)	☐ Yes	
27	Fire control plans are readily available (9.11.2.5)	☐ Yes	

Part 4. Terminal: checks after mooring			
Item	**Check**	**Status**	**Remarks**
28	Fendering is effective (22.4.1)	☐ Yes	
29	Tanker is moored according to the terminal mooring plan (22.2, 22.4.3)	☐ Yes	
30	Access to and from the terminal is safe (16.4)	☐ Yes	
31	Spill containment and sumps are secure (18.4.2, 18.4.3, 23.7.4, 23.7.5)	☐ Yes	

ISGOTT Checks pre-transfer Ship/Shore Safety Checklist

Date and time: ____________________

Port and berth: ____________________

Tanker: ____________________

Terminal: ____________________

Product to be transferred: ____________________

Part 5A. Tanker and terminal: pre-transfer conference				
Item	**Check**	**Tanker status**	**Terminal status**	**Remarks**
32	Tanker is ready to move at agreed notice period (9.11, 21.7.1.1, 22.5.4)	☐ Yes	☐ Yes	
33	Effective tanker and terminal communications are established (21.1.1, 21.1.2)	☐ Yes	☐ Yes	
34	Transfer equipment is in safe condition (isolated, drained and de-pressurised) (18.4.1)	☐ Yes	☐ Yes	
35	Operation supervision and watchkeeping is adequate (7.9, 23.11)	☐ Yes	☐ Yes	
36	There are sufficient personnel to deal with an emergency (9.11.2.2, 23.11)	☐ Yes	☐ Yes	
37	Smoking restrictions and designated smoking areas are established (4.10, 23.10)	☐ Yes	☐ Yes	
38	Naked light restrictions are established (4.10.1)	☐ Yes	☐ Yes	
39	Control of electrical and electronic devices is agreed (4.11, 4.12)	☐ Yes	☐ Yes	
40	Means of emergency escape from both tanker and terminal are established (20.5)	☐ Yes	☐ Yes	
41	Firefighting equipment is ready for use (5, 19.4, 23.8)	☐ Yes	☐ Yes	
42	Oil spill clean-up material is available (20.4)	☐ Yes	☐ Yes	
43	Manifolds are properly connected (23.6.1)	☐ Yes	☐ Yes	
44	Sampling and gauging protocols are agreed (23.5.3.2, 23.7.7.5)	☐ Yes	☐ Yes	
45	Procedures for cargo, bunkers and ballast handling operations are agreed (21.4, 21.5, 21.6)	☐ Yes	☐ Yes	
46	Cargo transfer management controls are agreed (12.1)	☐ Yes	☐ Yes	
47	Cargo tank cleaning requirements, including crude oil washing, are agreed (12.3, 12.5, 21.4.1)	☐ Yes	☐ Yes	See also parts 7B/7C as applicable

Part 5A. Tanker and terminal: pre-transfer conference (cont.)				
Item	**Check**	**Tanker status**	**Terminal status**	**Remarks**
48	Cargo tank gas freeing arrangements agreed (12.4)	☐ Yes	☐ Yes	See also part 7C
49	Cargo and bunker slop handling requirements agreed (12.1, 21.2, 21.4)	☐ Yes	☐ Yes	See also part 7C
50	Routine for regular checks on cargo transferred are agreed (23.7.2)	☐ Yes	☐ Yes	
51	Emergency signals and shutdown procedures are agreed (12.1.6.3, 18.5, 21.1.2)	☐ Yes	☐ Yes	
52	Safety data sheets are available (1.4.4, 20.1, 21.4)	☐ Yes	☐ Yes	
53	Hazardous properties of the products to be transferred are discussed (1.2, 1.4)	☐ Yes	☐ Yes	
54	Electrical insulation of the tanker/terminal interface is effective (12.9.5, 17.4, 18.2.14)	☐ Yes	☐ Yes	
55	Tank venting system and closed operation procedures are agreed (11.3.3.1, 21.4, 21.5, 23.3.3)	☐ Yes	☐ Yes	
56	Vapour return line operational parameters are agreed (11.5, 18.3, 23.7.7)	☐ Yes	☐ Yes	
57	Measures to avoid back-filling are agreed (12.1.13.7)	☐ Yes	☐ Yes	
58	Status of unused cargo and bunker connections is satisfactory (23.7.1, 23.7.6)	☐ Yes	☐ Yes	
59	Portable very high frequency and ultra high frequency radios are intrinsically safe (4.12.4, 21.1.1)	☐ Yes	☐ Yes	
60	Procedures for receiving nitrogen from terminal to cargo tank are agreed (12.1.14.8)	☐ Yes	☐ Yes	

Additional for chemical tankers **Checks pre-transfer**

Part 5B. Tanker and terminal: bulk liquid chemicals. Checks pre-transfer				
Item	**Check**	**Tanker status**	**Terminal status**	**Remarks**
61	Inhibition certificate received (if required) from manufacturer	☐ Yes	☐ Yes	
62	Appropriate personal protective equipment identified and available (4.8.1)	☐ Yes	☐ Yes	
63	Countermeasures against personal contact with cargo are agreed (1.4)	☐ Yes	☐ Yes	
64	Cargo handling rate and relationship with valve closure times and automatic shutdown systems is agreed (16.8, 21.4, 21.5, 21.6)	☐ Yes	☐ Yes	
65	Cargo system gauge operation and alarm set points are confirmed (12.1.6.6.1)	☐ Yes	☐ Yes	

Part 5B. Tanker and terminal: bulk liquid chemicals. Checks pre-transfer (cont.)				
Item	**Check**	**Tanker status**	**Terminal status**	**Remarks**
66	Adequate portable vapour detection instruments are in use (2.4)	☐ Yes	☐ Yes	
67	Information on firefighting media and procedures is exchanged (5, 19)	☐ Yes	☐ Yes	
68	Transfer hoses confirmed suitable for the product being handled (18.2)	☐ Yes	☐ Yes	
69	Confirm cargo handling is only by a permanent installed pipeline system	☐ Yes	☐ Yes	
70	Procedures are in place to receive nitrogen from the terminal for inerting or purging (12.1.14.8)	☐ Yes	☐ Yes	

Additional for gas tankers Checks pre-transfer

Part 5C. Tanker and terminal: liquefied gas. Checks pre-transfer				
Item	**Check**	**Tanker status**	**Terminal status**	**Remarks**
71	Inhibition certificate received (if required) from manufacturer	☐ Yes	☐ Yes	
72	Water spray system is operational (5.3.1, 19.4.3)	☐ Yes	☐ Yes	
73	Appropriate personal protective equipment is identified and available (4.8.1)	☐ Yes	☐ Yes	
74	Remote control valves are operational	☐ Yes	☐ Yes	
75	Cargo pumps and compressors are operational	☐ Yes	☐ Yes	
76	Maximum working pressures are agreed between tanker and terminal (21.4, 21.5, 21.6)	☐ Yes	☐ Yes	
77	Reliquefaction or boil-off control equipment is operational	☐ Yes	☐ Yes	
78	Gas detection equipment is appropriately set for the cargo (2.4)	☐ Yes	☐ Yes	
79	Cargo system gauge operation and alarm set points are confirmed (12.1.6.6.1)	☐ Yes	☐ Yes	
80	Emergency shutdown systems are tested and operational (18.5)	☐ Yes	☐ Yes	
81	Cargo handling rate and relationship with valve closure times and automatic shutdown systems is agreed (16.8, 21.4, 21.5, 21.6)	☐ Yes	☐ Yes	
82	Maximum/minimum temperatures/pressures of the cargo to be transferred are agreed (21.4, 21.5, 21.6)	☐ Yes	☐ Yes	
83	Cargo tank relief valve settings are confirmed (12.11, 21.2, 21.4)	☐ Yes	☐ Yes	

Part 6. Tanker and terminal: agreements pre-transfer				
Part 5 item	**Agreement**	**Details**	**Tanker initials**	**Terminal initials**
32	Tanker manoeuvring readiness	Notice period (maximum) for full readiness to manoeuvre: Period of disablement (if permitted):		
33	Security protocols	Security level: Local requirements:		
33	Effective tanker/terminal communications	Primary system: Backup system:		
35	Operational supervision and watchkeeping	Tanker: Terminal:		
37 38	Dedicated smoking areas and naked lights restrictions	Tanker: Terminal:		
45	Maximum wind, current and sea/swell criteria or other environmental factors	Stop cargo transfer: Disconnect: Unberth:		
45 46	Limits for cargo, bunkers and ballast handling	Maximum transfer rates: Topping-off rates: Maximum manifold pressure: Cargo temperature: Other limitations:		

Part 6. Tanker and terminal: agreements pre-transfer (cont.)				
Part 5 item	**Agreement**	**Details**	**Tanker initials**	**Terminal initials**
45 46	Pressure surge control	Minimum number of cargo tanks open: Tank switching protocols: Minimum number of cargo tanks open: Tank switching protocols: Full load rate: Topping-off rate: Closing time of automatic valves:		
46	Cargo transfer management procedures	Action notice periods: Transfer stop protocols:		
50	Routine for regular checks on cargo transferred are agreed	Routine transferred quantity checks:		
51	Emergency signals	Tanker: Terminal:		
55	Tank venting system	Procedure:		
55	Closed operations	Requirements:		
56	Vapour return line	Operational parameters: Maximum flow rate:		
60	Nitrogen supply from terminal	Procedures to receive: Maximum pressure: Flow rate:		

Part 6. Tanker and terminal: agreements pre-transfer (cont.)				
Part 5 item ref	**Agreement**	**Details**	**Tanker initials**	**Terminal initials**
83	For gas tanker only: cargo tank relief valve settings	Tank 1: Tank 2: Tank 3: Tank 4: Tank 5: Tank 6: Tank 7: Tank 8: Tank 9: Tank 10:		
XX	Exceptions and additions	Special issues that both parties should be aware of:		

Date and time: ______________________

Port and berth: ______________________

Tanker: ______________________

Terminal: ______________________

Product to be transferred: ______________________

Part 7A. General tanker: checks pre-transfer			
Item	**Check**	**Status**	**Remarks**
84	Portable drip trays are correctly positioned and empty (23.7.5)	☐ Yes	
85	Individual cargo tank inert gas supply valves are secured for cargo plan (12.1.13.4)	☐ Yes	
86	Inert gas system delivering inert gas with oxygen content not more than 5% (11.1.3)	☐ Yes	
87	Cargo tank high level alarms are operational (12.1.6.6.1)	☐ Yes	
88	All cargo, ballast and bunker tanks openings are secured (23.3)	☐ Yes	

Part 7B. Tanker: checks pre-transfer if crude oil washing is planned			
Item	**Check**	**Status**	**Remarks**
89	The completed pre-arrival crude oil washing checklist, as contained in the approved crude oil washing manual, is copied to terminal (12.5.2, 21.2.3)	☐ Yes	
90	Crude oil washing checklists for use before, during and after crude oil washing are in place ready to complete, as contained in the approved crude oil washing manual (12.5.2, 21.6)	☐ Yes	

ISGOTT Checks after pre-transfer conference Ship/Shore Safety Checklist

For tankers that will perform tank cleaning and/or gas freeing alongside

Part 7C. Tanker: checks prior to tank cleaning and/or gas freeing			
Item	**Check**	**Status**	**Remarks**
91	Permission for tank cleaning operations is confirmed (21.2.3, 21.4, 25.4.3)	☐ Yes	
92	Permission for gas freeing operations is confirmed (12.4.3)	☐ Yes	
93	Tank cleaning procedures are agreed (12.3.2, 21.4, 21.6)	☐ Yes	
94	If cargo tank entry is required, procedures for entry have been agreed with the terminal (10.5)	☐ Yes	
95	Slop reception facilities and requirements are confirmed (12.1, 21.2, 21.4)	☐ Yes	

Declaration

We the undersigned have checked the items in the applicable parts 1 to 7 as marked and signed below:

	Tanker	Terminal
Part 1A. Tanker: checks pre-arrival	☐	☐
Part 1B. Tanker: checks pre-arrival if using an inert gas system	☐	☐
Part 2. Terminal: checks pre-arrival	☐	☐
Part 3. Tanker: checks after mooring	☐	☐
Part 4. Terminal: checks after mooring	☐	☐
Part 5A. Tanker and terminal: pre-transfer conference	☐	☐
Part 5B. Tanker and terminal: bulk liquid chemicals. Checks pre-transfer	☐	☐
Part 5C. Tanker and terminal: liquefied gas. Checks pre-transfer	☐	☐
Part 6. Tanker and terminal: agreements pre-transfer	☐	☐
Part 7A. General tanker: checks pre-transfer	☐	☐
Part 7B. Tanker: checks pre-transfer if crude oil washing is planned	☐	☐
Part 7C. Tanker: checks prior to tank cleaning and/or gas freeing	☐	☐

In accordance with the guidance in chapter 25 of *ISGOTT*, we have satisfied ourselves that the entries we have made are correct to the best of our knowledge and that the tanker and terminal are in agreement to undertake the transfer operation.

We have also agreed to carry out the repetitive checks noted in parts 9 and 10 of the *ISGOTT* SSSCL, which should occur at intervals of not more than ____ hours for the tanker and not more than ____ hours for the terminal.

If, to our knowledge, the status of any item changes, we will immediately inform the other party.

Tanker	**Terminal**
Name	Name
Rank	Position
Signature	Signature
Date	Date
Time	Time

ISGOTT Checks during transfer Ship/Shore Safety Checklist

Repetitive checks

Part 8. Tanker: repetitive checks during and after transfer								
Item ref	**Check**	**Time**	**Time**	**Time**	**Time**	**Time**	**Time**	**Remarks**
Interval time:.................... hrs								
8	Inert gas system pressure and oxygen recording operational	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
9	Inert gas system and all associated equipment are operational	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
11	Cargo tank atmospheres are at positive pressure	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
18	Mooring arrangement is effective	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
19	Access to and from the tanker is safe	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
20	Scuppers and savealls are plugged	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
23	External openings in superstructures are controlled	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
24	Pumproom ventilation is effective	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
28	Tanker is ready to move at agreed notice period	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
29	Fendering is effective	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
33	Communications are effective	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
35	Supervision and watchkeeping is adequate	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
36	Sufficient personnel are available to deal with an emergency	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
37	Smoking restrictions and designated smoking areas are complied with	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
38	Naked light restrictions are complied with	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	

Part 8. Tanker: repetitive checks during and after transfer (cont.)								
39	Control of electrical devices and equipment in hazardous zones is complied with	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
40 41 42 51	Emergency response preparedness is satisfactory	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
54	Electrical insulation of the tanker/terminal interface is effective	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
55	Tank venting system and closed operation procedures are as agreed	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
85	Individual cargo tank inert gas valves settings are as agreed	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
86	Inert gas delivery maintained at not more than 5% oxygen	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
87	Cargo tank high level alarms are operational	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
Initials								

Part 9. Terminal: repetitive checks during and after transfer								
Item ref	Check	Time	Time	Time	Time	Time	Time	Remarks
Interval time:.................. hrs								
18	Mooring arrangement is effective	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
19	Access to and from the terminal is safe	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
29	Fendering is effective	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
32	Spill containment and sumps are secure	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
33	Communications are effective	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
35	Supervision and watchkeeping is adequate	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
36	Sufficient personnel are available to deal with an emergency	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
37	Smoking restrictions and designated smoking areas are complied with	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
38	Naked light restrictions are complied with	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
39	Control of electrical devices and equipment in hazardous zones is complied with	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
40 41 47 51	Emergency response preparedness is satisfactory	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
54	Electrical insulation of the tanker/terminal interface is effective	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
55	Tank venting system and closed operation procedures are as agreed	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	☐ Yes	
Initials								