ISGINTT
International Safety Guide for Inland Navigation Tank-barges and Terminals

(Second edition 2023)

CCNR
CENTRAL COMMISSION FOR THE NAVIGATION OF THE RHINE

OCIMF

Issued by the

Central Commission for the Navigation of the Rhine (CCNR)
Palais du Rhin
2, Place de la République – CS10023
67082 Strasbourg Cedex
France
+33 (0)3 88 52 20 10
ccnr@ccr-zkr.org
www.ccr-zkr.org

Oil Companies International Marine Forum
29 Queen Anne's Gate
London SW1H 9BU
United Kingdom
Telephone: +44 (0)20 7654 1200
Email: enquiries@ocimf.org
www.ocimf.org

Second edition 2023

Central Commission for the Navigation of the Rhine (CCNR)
The Central Commission for the Navigation of the Rhine (CCNR) is an international organisation that exercises an essential regulatory role in the navigation of the Rhine. It is active in the technical, legal, economic and environmental fields. In all its areas of action, its work is guided by the efficiency of transport on the Rhine, safety, social considerations, and respect for the environment. Many of the CCNR's activities now reach beyond the Rhine and are directly concerned with European navigable waterways more generally. The CCNR works closely with the European Commission as well as with the other river commissions and international organisations.

The Oil Companies International Marine Forum (OCIMF)
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.

Contents

Foreword

The Oil Companies International Marine Forum (OCIMF) and the Central Commission for the Navigation of the Rhine (CCNR) have worked, together with other European organisations, to produce this latest revision of the *International Safety Guide for Inland Navigation Tank-barges and Terminals (ISGINTT)*. Despite their individual roles in inland barging, all organisations recognise safety and environmental improvements cannot be made by regulation alone; it is testimony to the good practices adopted and constantly refined by the industry, and the dedication of the people it employs, to continuously improve.

One of the main functions of the international associations that have prepared this publication is to represent the industry's interests at regulatory bodies such as the International Maritime Organization (IMO) and the Central Commission for the Navigation of the Rhine (CCNR). The European Chemical Industry Council (CEFIC), the European Barge Union (EBU), FuelsEurope, the Federation of European Tank Storage (FETSA), the Oil Companies International Marine Forum (OCIMF), the European Inland Waterways Transport Platform (IWT) and the European Federation of Inland Ports all contribute to various extents to the work of these regulatory bodies.

This commitment to continuous improvement is demonstrated by the industry's efforts to develop the *International Safety Guide for Inland Navigation Tank-barges and Terminals* – or *ISGINTT,* as it is known within the industry.

It therefore gives us great pleasure to introduce this second edition of the guide. OCIMF and CCNR recognise *ISGINTT* as the principal industry reference manual on the safe operation of inland tankers and the terminals that serve them.

This guide provides updated safety practices on the operation of tank-barges and terminals and continues to embrace a risk-based control philosophy. By enhancing risk awareness, *ISGINTT* seeks to foster an environment where the uncertainties associated with some shipboard operations are reduced not solely by prescription, but also by encouraging barge and terminal crew, as well as their employers, to identify the risks in everything they are doing and to then implement fit-for-purpose risk reduction measures. This puts the focus on people and is, therefore, entirely consistent with a strategy related to the human element which has had increased focus in recent years.

We are confident that *ISGINTT* will not only contribute to the further improvement of the industry's excellent safety record but will also bring us closer to the goal of zero accidents to which we all aspire. We, therefore, commend it to all interested parties.

Lucia Luijten
Secretary-General
Central Commission for the Navigation of the Rhine

Karen Davis
Managing Director
Oil Companies International Marine Forum (OCIMF)

Introduction

Safety is critical to the tank barging industry. The authors of the *International Safety Guide for Inland Tank-barges and Terminals (ISGINTT*) hope that this revised guide will become the standard reference work on the safe operation of inland tank-barges and the terminals they serve. To do so, the guide must keep abreast of changes in tanker design and operating practice and reflect the latest technology and legislation. This has been the purpose for developing and introducing the revision to the industry.

The safety check-lists contained in the guide cover ship/shore as well ship/barge (and vice versa) transhipment of cargo and slops. The authors hope that these check-lists comprehensively reflect the individual and joint responsibilities of the tank-barge and the terminal and that the check-lists will be adopted universally by ports and terminals.

The guide has been kept to the original structure for ease of use. It is divided into five sections: “General Information”; “Tanker Information”; “Terminal Information”, the “Management of the Tanker and Terminal Interface” and “Additional Information for the Handling of Liquefied Gases”.

All intellectual property rights, including copyright, in *ISGINTT* are protected (see the copyright notice on page 2 of this document). Sections of the OCIMF and ICS *International Safety Guide for Oil Tankers and Terminals 6th Edition (ISGOTT6)* and the SIGTTO *Liquefied Gas Handling Principles on Ships and In Terminals* were used in the production of this document as recognised industry best practice and to avoid any inconsistency of guidance at the ship/barge interface. Use of OCIMF, ICS and SIGTTO publications in this document does not constitute a waiver of any of the intellectual property rights in those OCIMF, ICS and SIGTTO publications.

The authors believe that *ISGINTT* will continue to provide the best technical guidance on inland tank-barge and terminal operations. All operators are urged to ensure that the recommendations in this guide are not only read and fully understood, but also followed.

OCIMF and CCNR established the Secretariat to support the development of the *ISGINTT* revision and to ensure it is regularly updated in the future. The Secretariat encourages the users of *ISGINTT* to transmit comments and suggestions for improvement for possible inclusion in future editions. The *ISGINTT* website not only provides the latest information on *ISGINTT*, but serves also as the communication link between users of *ISGINTT* and the experts and organisations that participated in its development.

The *ISGINTT* website can be found at www.isgintt.org, the ISGINTT Secretariat can be reached by email at secretariat@isgintt.org.

Central Commission for the Navigation of the Rhine (CCNR)
Palais du Rhin
2, place de la République – CS10023
67082 Strasbourg Cedex
France
www.ccr-zkr.org

Oil Companies International Marine Forum (OCIMF)
29 Queen Anne’s Gate
London SW1H 9BU
United Kingdom
www.ocimf.org

The European Chemical Industry Council (CEFIC)
Rue Belliard, 40
1040 Brussels
Belgium
www.cefic.org

European Barge Union (EBU)
Handelsplein 92
3071 PR Rotterdam
The Netherlands
www.ebu-uenf.org

FuelsEurope
Boulevard du Souverain 165 – 3rd Floor
1160 Brussels
Belgium
www.fuelseurope.eu

Federation of European Tank Storage (FETSA)
Boulevard Auguste Reyers, 80
1030 Brussels
Belgium
www.fetsa.eu

European Inland Waterways Transport Platform (European IWT Platform)
Avenue des Arts, 56
B-1000 Brussels
Belgium
www.inlandwaterwaytransport.eu

European Federation of Inland Ports (EFIP)
Treurenberg, 6
1000 Brussels
Belgium
www.inlandports.eu

Purpose and scope

The purpose of this guide is to improve safety of transport of dangerous goods at the interface of inland tank-barge with other vessels or shore facilities (terminals). The guide is not intended to create, to replace or to amend current legal requirements, but to provide additional guidelines that should not be part of legal requirements.

The safety guide is recommended for implementation by the participating industry organisations CEFIC, EBU, ESO, ESPO, EUROPIA, FETSA, IAPH, OCIMF, ICS and SIGTTO with the necessary political and legal support of CCNR. This guide references the 2021 edition of the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN). Users should always refer to the latest edition of this agreement.

This guide makes recommendations for inland tanker and terminal personnel on the safe carriage and handling of such products that are normally carried in petroleum, chemicals or liquefied gas inland tankers and terminals handling those inland tankers.

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

When adopting alternative procedures, operators should follow a risk-based management process that incorporates systems for identifying and assessing the risks and for demonstrating how they are managed. This should be accompanied by a robust management of change process. For shipboard operations, this course of action must satisfy the requirements of relevant legislation.

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

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

Certain subjects are dealt with in greater detail in other publications issued by CCNR, OCIMF, ICS or SIGTTO or by other inland navigation or maritime intergovernmental organisations or 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 inland tankers. Information on these matters may be obtained from intergovernmental organisations, national authorities and from authorised bodies such as classification societies active in the field of inland navigation. Similarly, the guide does not attempt to deal with certain other safety related matters, e.g. navigation and shipyard safety, although some aspects are inevitably touched upon.

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

Bibliography

The following publications are referred to within this guide or represent a source of good industry information and should be consulted as appropriate for additional information.

BS Circular Flanges for Pipes, Valves and Fittings (Class Designated). Steel, Cast Iron and Copper Alloy Flanges. Specification for Steel Flanges (BS EN 1759-1 2004)

CEN Classification of Fires (EN 2)

IMO Code for Existing Ships Carrying Liquefied Gases in Bulk

IMO Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk

IMO Crude Oil Washing Systems

EU Directive of the European Parliament and of the Council of 12 December 2006 laying down technical requirements for inland waterway vessels and repealing Council Directive 82/714/EEC (2006/87/EC)

EU Directive 2008/68/EC of the European Parliament and of the Council of 24 September 2008 on the inland transport of dangerous goods

ICS Drug Trafficking and Drug Abuse: Guidelines for Owners and Masters on Prevention, Detection and Recognition

CEN Explosive Atmospheres – Part 10-1: Classification of Areas Explosive Gas Atmospheres (EN 60079-10-1)

CDNI Convention on the collection, deposit and reception of waste generated during navigation on the Rhine and other Inland Waterways

EU Corrugated Metal Hoses and Hose Assemblies (EN ISO 10380)

IEC Electrical Installations in Ships – Part 502: Tankers – Special Features (IEC 60092502)

CENELEC Electrostatics – Code of Practice for the Avoidance of Hazards Due to Static Electricity (Technical Report CLC/TR 50404)

IMO Emergency Procedures for Ships Carrying Dangerous Goods – Group Emergency Schedules

UNECE European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN)

UNECE European Globally Harmonized System of Classification and Labelling of Chemicals (GHS)

CESNI European Standard – Technical Requirement Inland Navigation (ES-TRIN)

IMO Guidelines on Fatigue

IMO Guidelines for Maintenance and Monitoring of Onboard Materials Containing Asbestos (MSC/Circ.1045, 28 May 2002)

OCIMF Guidelines for the Control of Drugs and Alcohol Onboard Ship

IMO Guidelines on Maintenance and Inspection of Fire Protection Systems and Appliances (MSC.1/Circ.1432)

Energy Institute HM 50. Guidelines for the Cleaning of Tanks and Lines for Marine Tank Vessels Carrying Petroleum and Refined Products

IMO IBC Code – The International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk

IMO IGC Code – The International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk

IMO IMDG Code – the International Maritime Dangerous Goods Code

CEN	Inland navigation vessels – Installation of berths and loading areas (EN 14329)
OCIMF	International Safety Guide for Oil Tankers and Terminals (ISGOTT)
IMO	International Safety Management (ISM) Code
IMO	ISPS – International Ship and Port Facility Security Code
SIGTTO/ OCIMF	Jetty Maintenance and Inspection Guide
SIGTTO	Liquefied Gas Handling Principles on Ships and in Terminals
OCIMF	Marine Terminal Baseline Criteria and Assessment Questionnaire
OCIMF	Marine Terminal Training and Competence Assessment Guidelines for Oil and Petroleum Product Terminals
IMO	MARPOL 73/78 – International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978
EFOA	MTBE/ETBE Transport over Inland Waterway Guidelines
ICS	Model Ship Security Plan
IMO	Provisional categorization of liquid substances in accordance with Marpol Annex II and the IBC Code (MEPC.2/Circ.xx)
IMO	Recommendations for Material Safety Data Sheets (MSDS) for MARPOL Annex I Oil Cargo and Oil Fuel (MSC Res. 286(86))
IMO	Recommendations on the Safe Transport of Dangerous Cargoes and Related Activities in Port Areas
CCNR	Rhine Vessel Inspection Regulation
EU	Rubber Hose Assemblies for Oil Suction and Discharge Services (EN 1765)
EU	Rubber and Thermoplastics Hoses and Hose Assemblies (EN 12115)
CDI/OCIMF/ SIGTTO	Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases
IMO	SOLAS 74/88 – International Convention for the Safety of Life at Sea, 1974 and 1988 Protocol, as amended
IMO	Standards for Vapour Emission Control Systems (MSC/Circ.585, 16 April 1992)
EU	Thermoplastic Multilayer (Non-vulcanized) Hoses and Hose Assemblies (EN 13765)
CEN	Transport Quality Management System – Road, Rail and Inland navigation transport – Quality management system requirements to supplement EN ISO 9001 for the transport of dangerous goods with regard to safety (EN 12798)

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

CDI	www.cdi.org.uk
CDIT	www.cdit.nl
CDNI	www.cdni-iwt.org
CEFIC	www.cefic.org
CCNR	www.ccr-zkr.org
DC	www.danubecommission.org
EFOA	www.efoa.org
EIGA	www.eiga.org
IAPH	www.iaphworldports.org
ICS	www.marisec.org
IMO	www.imo.org
IVR	www.ivr.nl
OCIMF	www.ocimf.org
SIGTTO	www.sigtto.org
UNECE	www.unece.org

Definitions

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

Adiabatic Describes an ideal process undergone by a gas in which no gain or loss of heat occurs.

Administration Means the government of the state whose flag the inland tanker is entitled to fly.

ALARP As low as reasonably practicable.

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

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

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

Barge See 'inland tanker.'

Boil-off Boil-off is the vapour produced above the surface of a boiling cargo due to evaporation. It is caused by heat ingress or a drop in pressure.

Boiling point The temperature at which the vapour pressure of a liquid is equal to the pressure on its surface (the boiling point varies with pressure).

Bonding The connecting together of metal parts to ensure electrical continuity.

Booster pump A pump used to increase the discharge pressure from another pump (such as a cargo pump).

Bulk cargo Cargo carried as a liquid in cargo tanks and not shipped in drums, containers or packages.

Carbamates A white powdery substance produced by the reaction of ammonia with carbon dioxide.

Carcinogen A substance capable of causing cancer.

Cargo area That part of the inland tanker which contains the cargo containment system, cargo pumps and compressor rooms, and includes the deck area above the cargo containment system, cofferdams, ballast tanks and void spaces at the after end of the aftermost hold space or the forward end of the forward.

Cargo Containment Systems The arrangement for containment of cargo including, where fitted, primary and secondary barriers, associated insulations, interbarrier spaces and the structure required for the support of these elements (refer to the Gas Codes for a more detailed definition).

Cascade Reliquefaction Cycle A process in which vapour boil-off from cargo tanks is condensed in a cargo condenser in which the coolant is a refrigerant gas such as R22 or equivalent. The refrigerant gas is then compressed and passed through a conventional sea water-cooled condenser.

Cathodic protection The prevention of corrosion by electrochemical techniques. On inland 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.

Cavitation A process occurring within the impeller of a centrifugal pump when pressure at the inlet to the impeller falls below that of the vapour pressure of the liquid being pumped. The bubbles of vapour which are formed collapse with impulsive force in the higher pressure regions of the impeller. This effect can cause significant damage to the impeller surfaces and, furthermore, pumps may lose suction.

Certificate of Fitness A certificate issued by a flag administration confirming that the structure, equipment, fittings, arrangements and materials used in the construction of a gas carrier comply with the relevant Gas Code or applicable legal requirements. Such certification may be issued on behalf of the administration by an approved classification society.

Certified Gas Free A tank or compartment is certified to be gas-free when its atmosphere has been tested with an approved instrument and found in a suitable condition by an independent chemist. This means it is not deficient in oxygen and sufficiently free of toxic or flammable gas for a specified purpose.

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. The aim of closed operations is to avoid any escape of vapours to the atmosphere. During closed operations, seagoing and inland tankers will require the means to enable closed monitoring of tank contents, either by a fixed gauging system or by using portable equipment passed through a vapour lock.

CMR substance A substance that is carcinogenic, mutagenic or reprotoxic.

Cold work Work that cannot create a source of ignition.

Combustible (also referred to as 'flammable') Capable of being ignited and of burning. For the purposes of this guide, the terms 'combustible' and 'flammable' are synonymous.

Condensate Reliquefied gases which collect in the condenser and are then returned to the cargo tanks.

Craft Any vessel for auxiliary services such as a tug, mooring boat, work boat, supply vessel, fire-fighting boat, rescue craft.

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

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

Critical pressure The pressure at which a substance exists in the liquid state at its critical temperature. (In other words, it is the saturation pressure at the critical temperature.)

Critical temperature The temperature above which a gas cannot be liquefied by pressure alone.

Cryogenics The study of the behaviour of matter at very low temperatures.

Dangerous area An area on an inland tanker which, for the purposes of the installation and use of electrical equipment, is regarded as dangerous. For terminal, see 'hazardous area'.

Dangerous goods Hazardous/dangerous cargoes are defined according to the flowchart in ADN 3.2.3.3.

Deepwell pump A type of centrifugal cargo pump. The prime mover is usually an electric or hydraulic motor. The motor is usually mounted on top of the cargo tank and drives, via a long transmission shaft, through a double seal arrangement, the pump assembly located in the bottom of the tank. The cargo discharge pipeline surrounds the drive shaft and the shaft bearings are cooled and lubricated by the liquid being pumped.

Degassing An operation with the aim of lowering the concentration of dangerous gases and vapours in empty or unloaded cargo tanks by emitting them to the atmosphere or to reception facilities.

Density The mass per unit volume of a substance at specified conditions of temperature and pressure (see section 1.3).

Dew point The temperature at which condensation will take place within a gas if further cooling occurs.

Dry chemical powder A flame inhibiting powder used in fire-fighting.

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

Enclosed space A space that has limited openings for entry and exit, unfavourable natural ventilation, and that is not designed for continuous worker occupancy. This includes cargo spaces, double bottoms, fuel tanks, ballast tanks, pump rooms, cofferdams, void spaces, duct keels, inter-barrier spaces, engine crankcases and sewage tanks.

Endothermic A process which is accompanied by the absorption of heat.

Enthalpy Enthalpy is a thermodynamic measure of the total heat content of a liquid or vapour at a given temperature and is expressed in energy per unit mass (kJoules per 1kg) from absolute zero. Therefore, for a liquid/vapour mixture, it will be seen that it is the sum of the enthalpy of the liquid plus the latent heat of vaporisation.

Entropy Entropy of a liquid/gas system remains constant if no heat enters or leaves while it alters its volume or does work, but increases or decreases should a small amount of heat enter or leave. Its value is determined by dividing the intrinsic energy of the material by its absolute temperature. The intrinsic energy is the product of specific heat at constant volume multiplied by a change in temperature. Entropy is expressed in heat content per mass per unit of temperature. In the Sl system its units are therefore Joule/kg/K. It should be noted that in a reversible process in which there is no heat rejection or absorption, the change of entropy is zero.

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

Explosimeter See 'combustible gas indicator'.

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

Explosive range See 'flammable range'.

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

Flame-proof See 'explosion-proof'.

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

Flammable (also referred to as 'combustible') Capable of being ignited and of burning. For the purposes of this guide, the terms 'flammable' and 'combustible' are synonymous.

Flammable gas monitors (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).

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

Flashlight See 'torch'.

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

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

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

Foam concentrate (also referred to as 'foam compound') The full strength liquid received from the supplier, which is diluted and processed to produce foam.

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

Free fall The unrestricted fall of liquid into a tank.

From the top, or overall See 'loading over the top'.

Gas-Dangerous Space or Zone A space or zone (defined by the Gas Codes) within an inland tanker's cargo area which is designated as likely to contain flammable vapour and which is not equipped with approved arrangements to ensure that its atmosphere is maintained in a safe condition at all times (refer to the Gas Codes for a more detailed definition).

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

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

Gas-freeing The removal of toxic, and/or flammable gas from a tank or enclosed space.

Gassing-up Gassing-up means replacing an inert atmosphere in a tank with the vapour from the next cargo to a suitable level to allow cooling down and loading.

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

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

Hazardous task A task other than hot work which presents a hazard to the inland tanker, terminal or personnel, the performance of which needs to be controlled by a risk assessment process such as a permit to work system or a controlled procedure.

Hazardous zone See 'hazardous area'.

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

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

Hydrocarbon gas A gas composed entirely of hydrocarbons.

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

Inert gas A gas or a mixture of gases (most typically nitrogen gas) containing insufficient oxygen to support the combustion of hydrocarbons.

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

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

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

Inhibitor A substance (additive) used to prevent or retard cargo deterioration or a potentially hazardous chemical self-reaction, e.g. polymerisation.

Inland tanker (barge) Any cargo vessel for the transport of bulk liquid cargoes for inland and port navigation. This includes: self-propelled inland tanker, tank barge without propulsion operated by tug boats (push or towing).

Inland tanker Master/crew Either the Master/crew of the self-propelled inland tanker or the captain/crew of the tug boat when operating tank barges.

Insulating flange A flanged joint incorporating an insulating gasket, sleeves and washers to prevent electrical continuity between inland tanker and shore.

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

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

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

Isothermal Descriptive of a process undergone by an ideal gas when it passes through pressure or volume variations without a change of temperature.

Latent heat The heat required to cause a change in state of a substance from solid to liquid (latent heat of fusion) or from liquid to vapour (latent heat of vaporisation). These phase changes occur without change of temperature at the melting point and boiling point, respectively.

Latent heat of vaporisation Quantity of heat to change the state of a substance from liquid to vapour (or vice versa) without change of temperature.

Liquefied gas A liquid which has a saturated vapour pressure exceeding 2.8 bar absolute at 37.8°C and certain other substances specified in the Gas Codes.

LNG This is the abbreviation for Liquefied Natural Gas, the principal constituent of which is methane.

Loading over the top (also referred to as 'loading overall') The loading of cargo or ballast through an open-ended pipe or by means of an open-ended hose entering a tank through a deck opening, resulting in the free fall of liquid.

Loading rate The volumetric measure of liquid loaded within a given period, usually expressed as cubic metres per hour (m^3/h) or barrels per hour (bbls/h).

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 the Lower Explosive Limit (LEL).

LPG This is the abbreviation for Liquefied Petroleum Gas. This group of products includes propane and butane which can be shipped separately or as a mixture. LPGs may be refinery by-products or may be produced in conjunction with crude oil or natural gas.

MOC – Management of Change To establish procedures for evaluating and managing changes to operations, procedures, equipment or personnel to ensure that all risks are identified and mitigated prior to implementing change.

MARVS Maximum Allowable Relief Valve Setting on an inland tanker cargo tank – as stated on the inland tanker's Certificate of Fitness or equivalent.

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

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

Non-standard operation (non-routine operation) A non-standard operation is one that is not covered by standard company procedures and therefore the risks involved in carrying out the task have not been comprehensively assessed and addressed.

Non-volatile cargo Cargoes having a flashpoint of 60°C or above, as determined by the closed cup method of test.

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

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.

Occupational health Occupational health deals with all aspects of health and safety in the workplace and has a strong focus on primary prevention of hazards. The health of the workers has several determinants, including risk factors at the workplace leading to cancers, accidents, musculoskeletal diseases, respiratory diseases, hearing loss, circulatory diseases, stress related disorders and communicable diseases and others. (World Health Organisation).

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

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

Permit (to work) A document issued by a Responsible Person which allows work to be performed in compliance with the inland tanker's Safety Management System.

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

Petroleum Crude oil and liquid hydrocarbon products derived from it.

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

Phases 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.

Polymerisation The chemical union of two or more molecules of the same compound to form a larger molecule of a new compound called a polymer. By this mechanism, the reaction can become self-propagating causing liquids to become more viscous and the end result may even be a solid.

Pour point The lowest temperature at which a product will remain fluid.

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

Pressure/vacuum relief valve (P/V valve) A device that provides for the flow of the small volumes of vapour, air or inert gas mixtures caused by thermal variations in a cargo tank.

Pump purging The operation of clearing liquid from submerged pumps.

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

Receiver The consignee according to the contract for carriage. If the consignee designates a third party in accordance with the provisions applicable to the contract for carriage, this person shall be deemed to be the consignee. If the transport operation takes place without a contract for carriage, the enterprise which takes charge of the dangerous goods on arrival shall be deemed to be the consignee.

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

Relative liquid density The mass of a liquid at a given temperature compared with the mass of an equal volume of fresh water at the same temperature or at a different given temperature.

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 for loading or unloading) A person appointed by the company or the Master of the inland tanker and empowered to take all decisions relating to a specific task, and having the necessary qualifications, knowledge and experience for that purpose.

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

Rollover The phenomenon where the stability of two stratified layers of liquid of differing relative density is disturbed resulting in a spontaneous rapid mixing of the layers accompanied in the case of liquefied gases, by violent vapour evolution.

Safety Data Sheet (SDS) A document identifying a substance and all its constituents. It provides the recipient with all necessary information to manage the substance safely. Guidance on the format and content of an SDS are given in the European Globally Harmonized System of Classification and Labelling of Chemicals (GHS).

Safety Management System (SMS) A formal, documented system required by the ISM Code, compliance with which should ensure that all operations and activities on board an inland tanker are carried out in a safe manner.

Seagoing tanker-to-inland tanker transfers Transfer of cargo from/to a seagoing tanker to/from and inland tanker.

Secondary barrier The liquid-resisting outer element of a cargo containment system designed to provide temporary containment of a leakage of liquid cargo through the primary barrier and to prevent the lowering of the temperature of the inland tanker structure to an unsafe level.

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

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

Slops A mixture of cargo residues and washing water, rust or sludge which is either suitable or not suitable for pumping.

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

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

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

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

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

Static accumulator liquid cargo A liquid cargo with an electrical conductivity of less than 50 picoSiemens/metre (pS/m), so that it is capable of retaining a significant electrostatic charge.

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

Static non-accumulator oil A liquid cargo with an electrical conductivity greater than 50 picoSiemens/metre (pS/m), so that it is incapable of retaining a significant electrostatic charge.

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

Submerged Pump See 'deepwell pump'.

Supplier (as in consignor or sender) The enterprise which consigns dangerous goods either on its own behalf or for a third party. If the transport operation is carried out under a contract for carriage, consignor means the consignor according to the contract for carriage. In the case of a tank vessel, when the cargo tanks are empty or have just been unloaded, the boat master is considered to be the consignor for the purpose of the transport document.

Surge pressure A phenomenon generated in a pipeline system when there is a change in the rate of flow of liquid in the line. Surge pressures can be dangerously high if the change of flow rate is too rapid and the resultant shock waves can damage pumping equipment and cause rupture of pipelines and associated equipment.

Tank cleaning The process of removing last cargo residues and vapours from cargo tanks. Usually carried out so that tanks can be entered for inspection or hot work or to avoid contamination between grades.

Tanker (general) A ship or inland tanker designed to carry liquid petroleum, chemical or gas cargo in bulk.

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

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

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

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

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

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

Torch (also referred to as 'flashlight') A battery operated hand lamp. An approved torch is one that is approved by a competent authority for use in a flammable atmosphere.

Toxicity The degree to which a substance or mixture of substances can harm humans, animals or the aquatic environment.

- **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.

Toxic cargo Cargos classified as toxic are listed in the relevant publication (for example ADN, IBC Code, IGC Code).

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

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

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

Vapour Gas suspended in air (a mixture of gas from the cargo and the atmosphere).

Vapour Emission Control System (VECS) An arrangement of piping and equipment used to control vapour emissions during inland tanker operations, including inland tanker 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.

Void space An enclosed space in the cargo area external to a cargo containment system, other than a hold space, ballast space, fuel oil tank, cargo pump or compressor room or any space in normal use by personnel.

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

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

Water spray A spray of water divided into coarse drops by delivery through a special nozzle for use in firefighting.

PART 1:
GENERAL INFORMATION

1 Basic properties of bulk liquids

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

1.1 Vapour pressure

1.1.1 True Vapour Pressure

All crude oils, petroleum products and chemical products are essentially mixtures of a wide range of different compounds. The boiling points of these compounds range from -162°C (methane) to well in excess of +400°C. The volatility (i.e. the tendency to produce gas) of any particular mixture of compounds depends primarily on the quantities of the more volatile constituents (i.e. those with a lower boiling point).

The volatility is characterised by the vapour pressure. When a product is transferred to a gas-free tank or container, it starts to vaporise, liberating gas into the space above it.

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

The vapour pressure of a pure compound depends only upon its temperature. The vapour pressure of a mixture depends not only on its temperature, but also on its constituents and the volume of the gas space in which vaporisation occurs – i.e. it depends upon the ratio of gas to liquid by volume.

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

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

The TVP of a product provides a good indication of its ability to give rise to gas. Unfortunately, this is a property that is difficult to measure, although it can be calculated from a detailed knowledge of the composition of the liquid. 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, generally used method for measuring the volatility of bulk liquids. It is conducted with standard apparatus and in a closely defined way.

A sample of the liquid is introduced into the test container at atmospheric pressure, so that the volume of the liquid is one fifth of the total internal volume of the container. The container is sealed and immersed in a water bath where it is heated to 37.8°C. After the container has been shaken to bring about equilibrium conditions, the rise in pressure due to vaporisation is read on an attached pressure gauge. This reading gives a close approximation to the vapour pressure, in bars, of the liquid at 37.8°C.

RVP is useful for comparing the volatilities of a wide range of products in a general way. However, it is of little value in itself as a means of estimating the likely gas evolution in specific situations, mainly because the measurement is made at the standard temperature of 37.8°C and at a fixed gas/liquid ratio, but instead TVP is much more useful for this.

1.2 Flammability

1.2.1 General

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

1.2.2 Flammable limits

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

The flammable limits vary for different hydrocarbon gases and for gas mixtures derived from different petroleum liquids. For practical purposes, the gas mixtures from 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 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 Effect of inert gas on flammability

When an inert gas (IG) – for example, nitrogen – is added to a product gas/air mixture, the oxygen content is reduced and the result is to increase the LFL concentration and to decrease the UFL concentration. These effects are shown in figure 1.1.

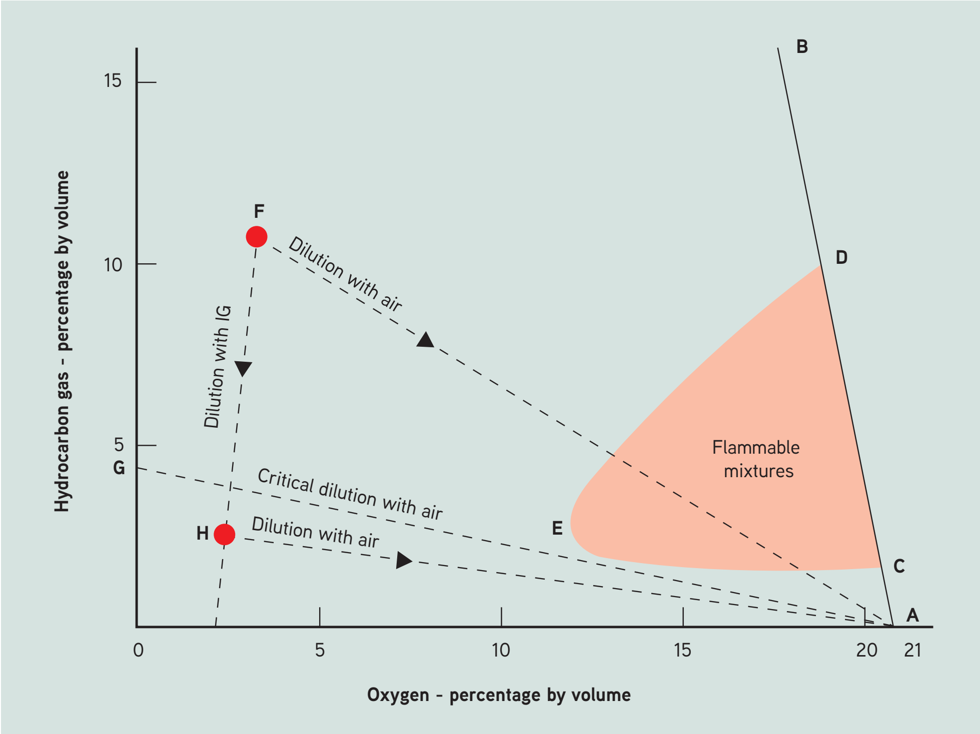


Figure 1.1: *Flammability composition diagram for a hydrocarbon gas/air/inert gas mixture*

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

Instead, the oil industry makes use of two standard methods. One is the RVP test (see section 1.1.2) and the other is the flashpoint test (see section 1.2.5), which measures flammability directly. However, it has been shown with some residual fuel oils that the flashpoint test will not always provide a direct indication of flammability (see section 2.7.3).

1.2.5 Flashpoint

In this test, a sample of the liquid is gradually heated in a special pot and a small flame is repeatedly and momentarily applied to the surface of the liquid. The flashpoint is the lowest liquid temperature at which the small flame initiates a flash of flame across the surface of the liquid, thereby indicating the presence of a flammable gas/air mixture above the liquid.

For all oils, except some residual fuel oils, this gas/air mixture corresponds closely to the LFL mixture.

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

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

1.2.6 Flammability classification

There are many schemes for dividing the complete range of bulk 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.

Generally, in this guide it has been sufficient to group bulk liquids into two categories, non-volatile and volatile, defined in terms of flashpoint:

Non-volatile
Flashpoint of 60°C or above, as determined by the closed cup method of 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
Flashpoint below 60°C, as determined by the closed cup method of testing. A few petroleum liquids in this category are capable of producing an equilibrium gas/air mixture within the flammable range when in some part of the normal ambient temperature range, while the rest give equilibrium gas/air mixtures above the UFL at all normal ambient temperatures.

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

1.3 Density of hydrocarbon gases

It is important to know if the density of a gas is greater or less than the density of air. If the gas density is higher than the density of air, the gas will spread over the bottom of a compartment or, in a terminal, stay close to the ground. In cargo-handling operations, layering effects can be encountered and may give rise to hazardous situations.

Table 1.2 gives the gas densities relative to air for a few products.

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

High densities, higher than air, and the layering effects that result from them, are only significant while the gas remains concentrated. As it is diluted with air, the density of the gas/air mixture from all three types of cargo approaches that of air. At the LFL, is indistinguishable from air.

1.4 Corrosiveness

Tanks, pipelines, hoses and associated equipment, such as pumps, gaskets, instruments and fittings, must be made of materials which have either a:

- Good mechanical and chemical resistance against the product.
- Suitable coating to protect against the properties of the product.

2 Hazards of bulk liquids

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

Specific issues, including the handling of high vapour pressure cargoes and the particular hazards associated with the handling, storage and carriage of residual fuel oils, are also discussed.

The chapter also describes the principles, uses and limitations of gas-detection equipment and addresses issues relating to gas evolution and dispersion.

2.1 Flammability

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

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

For detailed information on flammability, see section 1.2.

2.2 Density

The gases from bulk liquids can be heavier than air and handling of cargoes should take account of the hazard that this presents.

Information on the density of these gases is given in section 1.3.

2.3 Toxicity

2.3.1 Introduction

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

Toxic substances can harm humans in three main ways: by being swallowed (ingestion), through skin contact (absorption), and through the lungs (inhalation). Toxic substances can have local effects, such as skin or eye irritation, but can also affect other, more distant parts of the body (systemic effects).

The purpose of this section is to describe the adverse effects associated with toxic substances to which personnel engaged in tanker operations are most likely to be exposed, to indicate the concentrations at which those adverse effects are expected to occur in humans through a single or repeated exposure, and to describe procedures for reducing the risks of such exposure. Although not strictly a matter of toxicity, the effects of oxygen deficiency are also described.

Products and product vapours can have various effects. They can be carcinogenic (causing cancer), reprotoxic (effecting reproduction), and can cause chemical burns, eczema, asthma, damage to organs, etc. These effects will be described in the Safety Data Sheet (SDS) for the product.

2.3.2 Bulk liquids

2.3.2.1 Ingestion

The oral toxicity of chemical products varies widely, and the SDS should be checked for the specific information on the product and for the measures that have to be taken when a person swallows it. The SDS will also describe the required Personal Protective Equipment (PPE).

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

2.3.2.2 Absorption

For chemical products the effect of absorption can vary considerably. Products can have acute effects (unconsciousness, dizziness, chemical burns, organ failure, death) or chronic effects (cancer, organ damage, reprotoxic).

The SDS should be checked for the specific information on the product and for the measures that have to be taken when a person has skin contact with it.

When many petroleum products, especially the more volatile ones, come into contact with the skin they can cause irritation and remove essential oils, possibly leading to dermatitis. They can also cause irritation to the eyes. Certain heavier oils can cause serious skin disorders on repeated and prolonged contact. Direct contact with petroleum should always be avoided by wearing the appropriate protective equipment, especially impermeable gloves and goggles.

The SDS should be consulted for information on the appropriate PPE to be worn.

2.3.3 Product vapours

2.3.3.1 Inhalation

The effects of inhaling product gases can vary considerably. Gases can have acute (unconsciousness, dizziness, chemical burns, organ failure) or chronic (cancer, organ damage, reprotoxic) effects. Of importance is the risk of pulmonary oedema. Liquid in the lungs can cause serious shortness of breath and often occurs hours after the inhalation.

The SDS should be checked for the specific information and for the measures that have to be taken when a person has inhaled the product vapour. The SDS will also describe the required PPE.

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

In general, the danger of the product increases when the vapour pressure is high and the Occupational Exposure Limits (OELs) is low.

Comparatively small quantities of product gas, when inhaled, can cause symptoms of diminished responsibility and dizziness similar to intoxication, with headache and irritation of the eyes. The inhalation of an excessive quantity can be fatal. This depends mainly on the product, for which information should be sought from the SDS.

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

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

2.3.3.2 Exposure limits

The exposure limits are always described in the SDS.

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

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

Best practice is to maintain concentrations of all atmospheric contaminants as low as reasonably practicable (ALARP).

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

To avoid the damage to health, exposure peaks have to be limited (see SDS or similar).

2.3.3.3 Effects

The effects of exposure to vapours can vary depending on the type of product and information should be obtained from SDS for the product.

2.3.4 Safety Data Sheets

To help ship's crews prepare for toxic cargoes, the International Maritime Organization (IMO) has urged governments to ensure that ships are supplied with, and carry, SDS for significant cargoes. The SDS should indicate the type and probable concentrations of hazardous or toxic components in the cargo to be loaded, particularly hydrogen sulphide and benzene. The SDS should be United Nations Globally Harmonized System of Classification and Labelling of Chemicals (UN GHS) compliant.

The supplier should provide the relevant SDS to a tanker before it starts loading the products. The tanker should provide 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.

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

UNECE and EU regulations do not require that tankers carry SDS. Instead, tankers need to be issued with 'Instructions in Writing'. However, as these instructions contain fewer and more general information, it is strongly recommended that UN GHS compliant SDS are available for all products carried on board as they will be of help during cargo-related emergencies.

2.3.5 Benzene, other carcinogenic, mutagenic and reprotoxic products, and other aromatic hydrocarbons

2.3.5.1 Aromatic hydrocarbons

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

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

2.3.5.2 Benzene and other carcinogenic, mutagenic and reprotoxic products

---

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

Exposure limits

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

Personal Protective Equipment

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

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

Tank entry

Before entering a tank that has recently carried products containing benzene and/or other carcinogenic, mutagenic and reprotoxic products, the tank should be tested for these concentrations. This is in addition to the requirements for enclosed space entry detailed in chapter 10.

2.3.6 Hydrogen sulphide

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

2.3.6.1 Sources of hydrogen sulphide

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

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

Cargo and bunker fuels (as cargo) should not be treated as free of hydrogen sulphide until after they have been loaded and the absence of hydrogen sulphide has been confirmed by the results of monitoring and the relevant SDS information.

2.3.6.2 Expected concentrations

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

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

During transit, the concentration of hydrogen sulphide vapours may increase significantly and therefore has to be monitored.

Attention should be given to the possibility of previous cargoes containing hydrogen sulphide with respect to the release of contaminated vapours during loading, particularly when heated cargoes are being loaded.

Attention should be also be given to the potential deviation of hydrogen sulphide analysers which may be in the order of 0-3ppm by weight.

Precautions against high hydrogen sulphide concentrations are normally considered necessary if the hydrogen sulphide content in the vapour phase is 5ppm by volume or above. However, national and international legislation may be more stringent than this level.

The effects of hydrogen sulphide at various increasing concentrations in air are shown in table 2.1.

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

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

2.3.6.3 Exposure limits

For many countries, the OEL-TWA for hydrogen sulphide is 5ppm over a period of eight hours. However, national and international legislation may be more stringent. Working procedures should aim at ensuring that the lowest possible gas concentrations are achieved in work locations.

2.3.6.4 Procedures for handling cargo and bunkers containing hydrogen sulphide

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

Hydrogen sulphide (H_2S) concentration (ppm by volume in air)	Physiological effects
0.1-0.5ppm	First detectable by smell
10ppm	May cause some nausea, minimal eye irritation
25ppm	Eye and respiratory tract irritation. Strong odour.
50-100ppm	Sense of smell starts to break down. Prolonged exposure to concentrations at 100ppm induces a gradual increase in the severity of these symptoms and death may occur after 4-48 hours' exposure
150ppm	Loss of sense of smell in 2-5 minutes
350ppm	Could be fatal after 30 minutes' inhalation
700ppm	Rapidly induces unconsciousness (few minutes) and death. Causes seizures, loss of control of bowel and bladder. Breathing will stop and death will result if not rescued promptly.
700+ ppm	Immediately fatal
Note:	• Anybody over-exposed to H_2S vapour should be removed to clean air as soon as possible. • The adverse effects of H_2S can be reversed and the probability of saving the person's life improved if prompt action is taken.

Table 2.1: *Typical effects of exposure to hydrogen sulphide*

Vapour monitoring

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

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

The use of personal hydrogen sulphide 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 a hydrogen sulphide reading and an alarm. It is further recommended that the alarms be set at a value of the maximum OEL-TWA. Personnel should always carry personal monitors when working in enclosed spaces, gauging, sampling, entering a pumproom, connecting and disconnecting loading lines, cleaning filters, draining to open containments and mopping up spills if hydrogen sulphide concentrations could exceed the OEL-TWA.

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

Personal Protective Equipment

Procedures should be defined for the use of respiratory protective equipment when concentrations of vapour may be expected to exceed the OEL-TWA.

Consideration should be given to providing emergency-escape breathing devices to personnel working in hazardous areas. These are very portable and can be donned quickly should gas be detected.

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

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

Company and terminal procedures
The tanker's Safety Management System (SMS) and the terminal's operations manual should contain instructions and procedures to ensure safe operations when handling cargoes that are likely to contain hydrogen sulphide. The functional requirements should include, but not be limited to, the following:

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

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

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

To prevent exposure to high concentrations of hydrogen sulphide, crew members on deck should wear a personal hydrogen sulphide alarm meter. When this gives an alarm the following actions, as a minimum, should be taken immediately:

- Stop cargo operations.
- Inform other crew members.
- Inform jetty personnel.
- Inform other adjacent tankers (especially those at leeward side).
- Inform the tanker's operator.
- Ask the terminal to perform a measurement.
- Discuss, in close cooperation with the terminal and operator, how to proceed with the transfer operation.

Try to stay at windward side and do not stay on deck unnecessarily.

2.3.6.6 Corrosion

Hydrogen sulphide is very corrosive, so enhanced inspection and maintenance regimes should be put in place if it is likely to be present in high concentrations.

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

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

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

2.3.6.7 General nuisances

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

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

2.3.7 Mercaptans

Mercaptans are colourless, odorous gases generated naturally by the degradation of natural organisms. Their smell has been likened to rotting cabbage. They can also be found in water treatment plants and ballast treatment facilities.

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

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

2.3.8 N/A

2.3.9 Inert gas

2.3.9.1 General

Inert gas is principally used to control cargo tank atmospheres, and so prevent the formation of flammable mixtures. The primary requirement for an inert gas is low oxygen content. Its composition can, however, be variable.

2.3.9.2 Toxic constituents

The main hazard associated with inert gas is its low oxygen content. However, some inert gases might contain trace amounts of various toxic gases that may increase the hazard to personnel exposed to them.

Precautions prior to tank entry do not include requirements for the direct measurement of the concentration of the trace constituents of inert gas. This is because the gas-freeing activity required for tank entry is sufficient to reduce these toxic constituents to below their OEL-TWA.

2.3.9.3 N/A

2.3.9.4 N/A

2.3.9.5 N/A

2.3.10 Oxygen deficiency

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

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

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

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

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

2.3.11 Fatty acid methyl ester

Fatty acid methyl ester is used as a bio component to blend in middle distillate bio fuels. The molecules are primarily obtained from vegetable oils by transesterification (the process of exchanging the alcohol group of an ester compound with another alcohol). When shipped, care needs to be taken to avoid contamination with noxious materials that could affect the safety of the final product and effect the processing of the oleochemical itself. Methyl esters in the range C8-C18 are practically non-toxic.

The resistance of cargo tank coatings and synthetic or rubber parts of cargo equipment to methyl esters should be considered.

2.3.12 Methyl tertiary butyl ether and ethyl tertiary butyl ether

These (MTBE and ETBE) are highly flammable liquids with a distinctive disagreeable odour. They are made from blending chemicals such as isobutylene and methanol, and have been used as an oxygenate gasoline additive in the production of gasoline. MTBE/ETBE quickly evaporates and small amounts may dissolve in water. MTBE/ETBE may stick to particles in water, which will cause it to eventually settle to the bottom sediment.

Consideration should be given to the environmental hazards associated with mixtures of water and MTBE/ETBE in cargo and slop tanks. It is recommended that MTBE/ETBE is only carried in tankers that have a segregated ballast system.

It is recommended that tankers carrying MTBE/ETBE are fitted with low-emission sampling points.

ETBE is commonly used as an oxygenate gasoline additive. MTBE/ETBE vapours are heavier than air so will naturally drift towards the river water surface. Thus, in transit, ideally vapours should not be vented.

Ballasting should always be restricted to dedicated ballast tanks. Any cleaning of cargo tanks, as well as the disposal of any product residues and wash waters, must be done in a controlled manner at authorised disposal facilities and according to the applicable local law.

2.3.13 Ethanol

Ethanol (ethyl alcohol, grain alcohol) denatured is a clear, colourless liquid with a characteristic, agreeable odour and is used as a blend component in bio fuels.

Ethanol is denatured to prevent its use as a beverage. Denatured ethanol can contain small amounts, 1-2% each, of several different unpleasant or poisonous substances.

Consideration should be given to mixtures of water and ethanol in cargo and slop tanks and related flammability. A separate ballast cargo tank system, as well as vapour-return and efficient stripping facilities is preferred. Attention should be given to the wide flammable range (3.4-19% by volume in air) of product vapours, and ballasting should always be restricted to dedicated ballast tanks. Any cleaning of cargo tanks, as well as the disposal of any product residues and wash waters, must be done in a controlled manner at authorised disposal facilities and according to the applicable local law.

2.4 Gas measurement

2.4.1 Introduction

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

It is essential that any instrument used is:

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

2.4.2 Measurement of product concentration

There are a number of different portable instruments available to detect product concentrations and hazardous atmospheres, toxic gases and oxygen. In the light of the differences in instrument sensitivity and limitations, reference should be made to guidance contained in manufacturer's literature and SDSs when selecting an instrument for a particular task.

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

1. **The measurement of hydrocarbon gas in air at concentrations below the LFL.**
   This is to detect the presence of flammable (and potentially explosive) vapours and to detect concentrations of hydrocarbon vapour that may be harmful to personnel. These readings are expressed as a percentage of the LFL and are usually recorded as % LFL. The instruments used to measure % LFL are catalytic filament combustible gas indicators, which are usually referred to as flammable gas monitors or explosimeters. Such an indicator should not be used for measuring hydrocarbon gas in inert atmospheres.
2. **The measurement of hydrocarbon gas as a percentage by volume of the total atmosphere being measured.**
   On board a tanker, this is usually carried out to measure the percentage of hydrocarbon vapour in an oxygen deficient (inerted) atmosphere. Instruments used to measure hydrocarbon vapours in an inert gas atmosphere are specially developed for this purpose. The readings obtained are expressed as the percentage of hydrocarbon vapour by volume and are recorded as % volume.

   The instruments used to measure percentage hydrocarbon vapours in inert gas are the non-catalytic heated filament gas indicators (usually referred to as tankscopes) and refractive index meters. Modern developments in gas detection technology have resulted in the introduction of electronic instruments using infrared sensors that can perform the same function as the tankscope.

2.4.3 Flammable gas monitors

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

2.4.3.1 Operating principle

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

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

A gas sample may be taken in several ways:

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

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

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

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

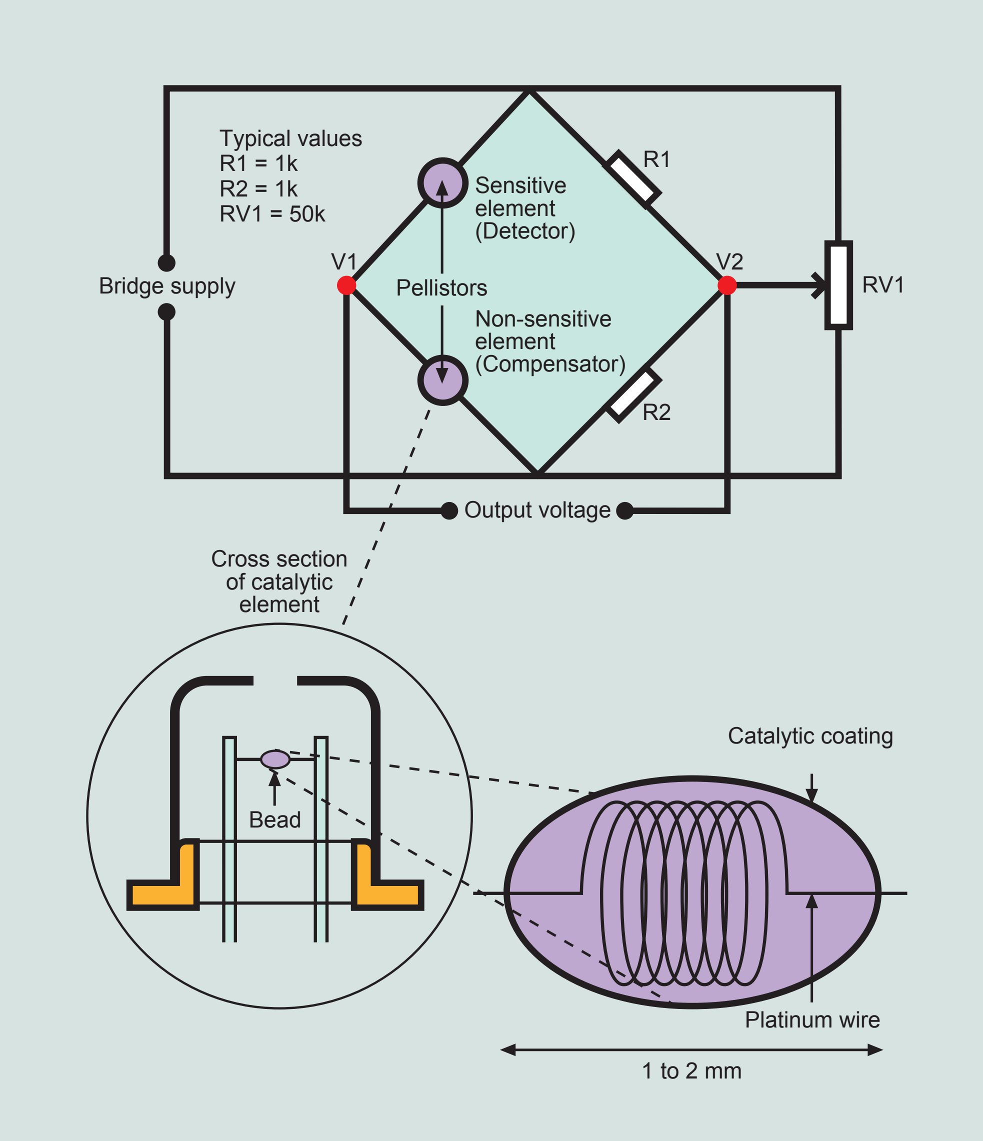


Figure 2.1: *Simplified diagram of a flammable gas monitor incorporating a pellistor*

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

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

2.4.3.2 Cautions

Poisons and inhibitors

Some compounds can reduce the sensitivity of the pellistor:

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

Pressure

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

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

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

The above is also relevant when using multi-gas instruments. For example, when an infrared sensor is being used to take a % volume gas reading, any pellistor sensor in the instrument may suffer damage if the inlet gas stream into the instrument is at a pressure or has a high velocity.

Condensation

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

Combustible mists

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

2.4.3.3 Instrument calibration and check procedures

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

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

2.4.3.4 Precision of measurement

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

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

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

2.4.3.5 Operational features

Older instruments are fitted with flashback arresters in the inlet and outlet of the detector filament chamber. The arresters are essential to prevent the possibility of flame propagation from the combustible chamber, and a check should always be made to ensure that they are in place and fitted properly. Modern pellistor type instruments have sintered filters usually built into the pellistor body.

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

2.4.4 Non-catalytic heated filament gas indicators (tankscopes)

2.4.4.1 Operating principle

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

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

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

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

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

2.4.4.2 Instrument check procedures

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

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

2.4.4.3 Precision of measurement

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

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

2.4.4.4 Instruments with infrared sensors

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

2.4.5 Inferometer (refractive index meter)

2.4.5.1 Operating principle

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

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

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

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

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

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

The measurement of the concentration of hydrocarbon gas in an inerted atmosphere is affected by the carbon dioxide present when flue gas is used for inerting. In this case, the use of soda lime as an absorbent for carbon dioxide is recommended, provided the reading is corrected appropriately.

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

2.4.5.2 Instrument check procedures

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

2.4.6 Infrared instruments

2.4.6.1 Operating principle

The infrared sensor is a transducer for the measurement of the concentration of hydrocarbons in the atmosphere, by the absorption of infrared radiation.

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

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

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

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

2.4.6.2 Instrument check procedures

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

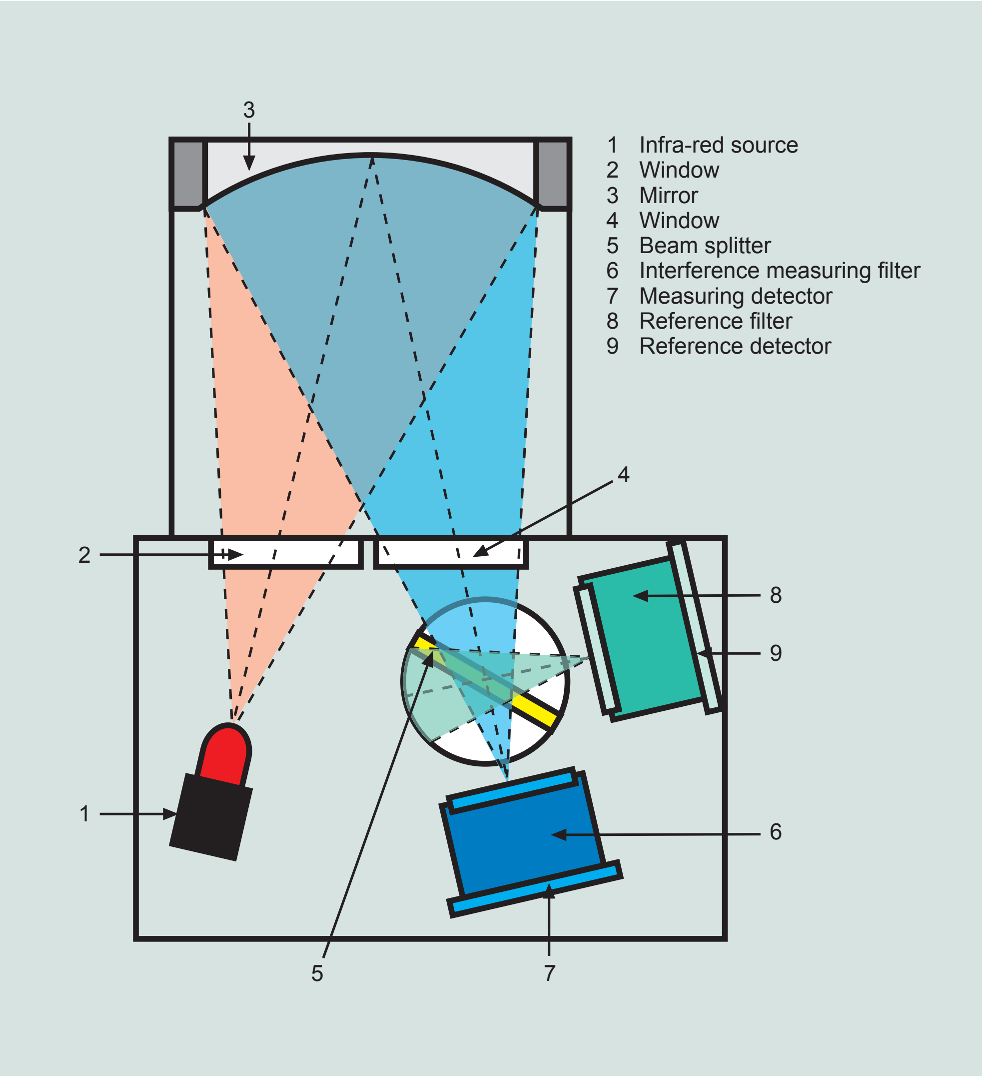


Figure 2.2: *Infrared sensor*

2.4.7 Measurement of low concentrations of toxic gases

2.4.7.1 Chemical indicator tubes

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

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

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

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

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

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

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

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

2.4.7.2 Electrochemical sensors

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

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

Electrochemical sensors can be used in standalone instruments, which may provide a warning at a predetermined concentration of vapour, or they can be fitted in a multi-sensor instrument to provide a reading of the concentration of the vapour, usually in ppm.

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

2.4.8 Fixed gas-detection installations

Fixed gas-detection installations are used on some tankers to monitor the flammability of the atmosphere in spaces such as double-hull spaces, pumprooms, double bottoms, engine rooms, boiler rooms, wheel house and accommodation.

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

- Sensing devices distributed throughout the spaces to be monitored. Signals are taken sequentially from each sensor by a central control.
- A gas-measurement system installed in the central control panel.

- Infrared sensors located in the space being monitored, and the electronics necessary for processing the signals located in a safe location.

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

2.4.9 Measurement of oxygen concentrations

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

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

- Paramagnetic sensors.
- Electrochemical sensors.

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

2.4.10 Use of oxygen analysers

2.4.10.1 Paramagnetic sensors

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

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

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

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

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

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

2.4.10.2 Electrochemical sensors

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

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

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

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

2.4.10.3 Maintenance, calibration and test procedures

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

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

Testing is simple on all analysers using atmospheric air to test the reference point (21% oxygen) and an inert gas to test the 0% oxygen reference point (nitrogen or carbon dioxide) (also see sections 8.2.6 and 8.2.7).

2.4.11 Multi-gas instruments

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

- Hydrocarbon vapour as a % LFL (explosimeter function using a pellistor sensor).
- Hydrocarbon vapour in inert gas as a % volume (tankscope function using an infrared sensor).
- Oxygen (using an electrochemical sensor).
- Hydrogen sulphide (using an electrochemical sensor).

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

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

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

2.4.12 Personal gas monitors

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

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

2.4.13 Gas sample lines and sampling procedures

2.4.13.1 Gas sample lines

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

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

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

Sample tubing should be resistant to hot wash water.

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

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

2.4.13.2 Sampling procedures

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

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

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

2.4.13.3 Filters in sample lines

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

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

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

2.5 Product gas evolution and dispersion

2.5.1 Introduction

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

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

If gases are denser than air, this has an important bearing on how they behave, both inside and outside the tanks (see section 1.3).

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

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

2.5.2 Gas evolution and venting

2.5.2.1 Evolution during loading

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

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

- TVP of the cargo.
- Amount of splashing as the product enters the tank.
- Time required to load the tank.
- Occurrence of a partial vacuum in the loading line.

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

When considering dispersion of gases outside cargo tanks, only high gas concentrations in the vented gas are relevant. Therefore, 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. It should be remembered that product gas will be detectable at heights above the liquid surface several times the layer depth defined in this way.

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

2.5.2.2 Venting during the loading of cargo

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

Concentrations in the range 30-50% by volume of product gas are quite usual in the vented gas towards the end of loading, although the very high concentration immediately above the liquid surface remains in the final ullage space on completion of loading.

Subsequently, evaporation continues until an equilibrium hydrocarbon gas concentration is established throughout the ullage space. This gas is only vented by breathing of the tank, and thus only intermittently. When the product is discharged, a 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 product gas concentration in the vented gas during loading depends upon the previous history of the tank. Before loading with a different product, the compatibility with the previous products must be checked to prevent any hazardous reactions.

The following provides examples of typical gas concentrations:

- Shortly after the discharge of a motor or aviation gasoline cargo, there is a layer at the bottom of the tank where concentrations of 30-40% by volume of hydrocarbons have been measured. If loaded at this stage, the gas enters the venting system immediately ahead of the concentrated layer formed by the next cargo.
- In motor or aviation gasoline tanks that have been battened down after discharge and not gas freed, uniform hydrocarbon gas concentrations as high as 40% by volume have been measured throughout the tanks. This concentration is expelled to the vent system throughout the next loading until the concentrated layer above the liquid surface approaches the top of the tank.

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

2.5.2.3 Ballasting into a cargo tank

The atmosphere in cargo tanks before ballasting will be similar to that before the loading of the cargo, given a similar tank history. The gas concentration expected to enter the venting system during ballasting will therefore be comparable to that in the examples given above.

2.5.2.4 Inert gas purging

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

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

2.5.2.5 Gas freeing

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

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

In specific cases, gas-freeing operations are regulated by legislation and require permits by competent authorities.

2.5.3 Gas dispersion

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

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

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

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

- Accommodation blocks into which the gas can enter through doors, ports or ventilation intakes.
- The cargo deck, which, although usually regarded as free of sources of ignition, is a work area and thoroughfare.
- An adjacent jetty, which, although usually regarded as free of sources of ignition, is a work area and thoroughfare.
- Adjacent vessels.

2.5.4 Variables affecting dispersion

2.5.4.1 The dispersion process

A mixture of product gas and air (or inert gas) issuing vertically from an outlet rises under its own momentum as a plume above the outlet. If there is no wind, the plume remains vertical, but otherwise it is bent over in the downwind direction. The rise of the plume due to its momentum is opposed by a tendency to sink if 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 but decreases as air is drawn into the plume. This air decreases the product gas concentration and hence the gas density in the plume. The progressive decreases in velocity, product concentration and density, together with the wind speed and other meteorological factors, determine the final shape of the plume and hence of the flammable zone.

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

- A high velocity vent installed at a minimum height of 2m 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 6m above the deck.

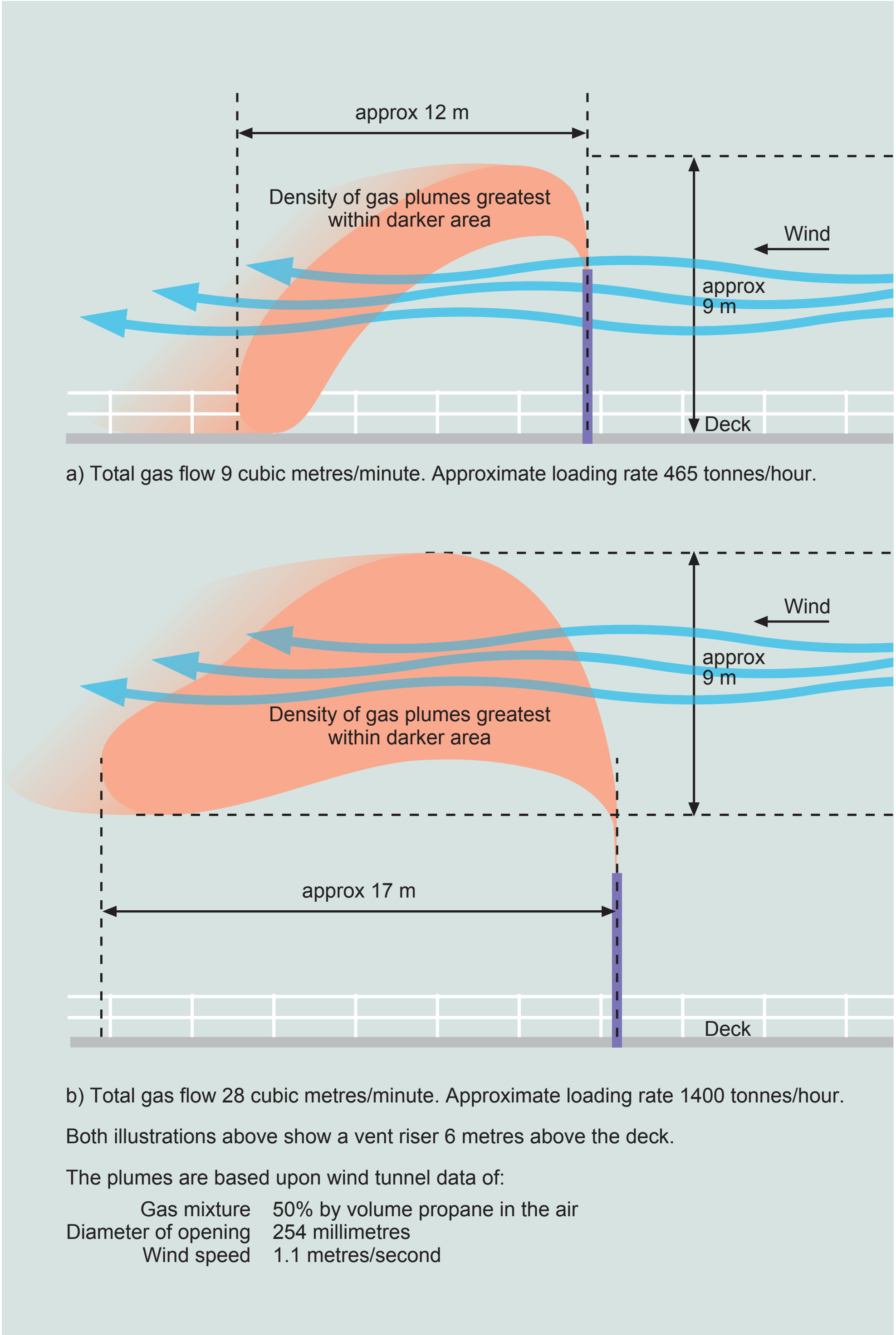
These high-velocity vents and risers may not be placed closer than 10m to any accommodation house vent, to ensure that cargo vapours will be safely dispersed before they reach these locations.

2.5.4.2 Wind speed

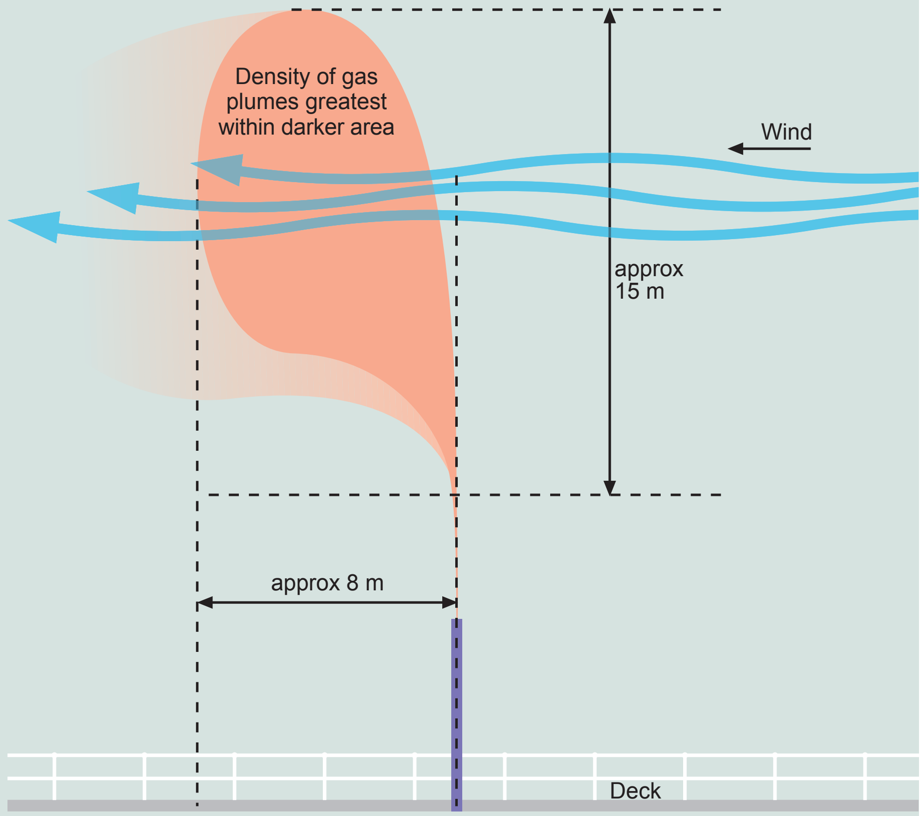
For many years, it has been recognised that the dispersion of product gas/air mixtures is inhibited by low wind speeds. This recognition is based upon experience on tankers, and little experimental work has been done to obtain quantitative information on the effect of wind speed. Much depends upon the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

2.5.4.3 Rate of flow of gas

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



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



c) Total gas flow 46 cubic metres/minute. Approximate loading rate 2300 tonnes/hour.

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

The plumes are based upon wind tunnel data of:

Gas mixture	50% by volume propane in the air
Diameter of opening	254 millimetres
Wind speed	1.1 metres/second

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

In addition, at low rates of total gas flow, the initial momentum of the plume may not be enough to counteract the tendency of the plume to sink if it has a high density.

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

2.5.4.4 Concentration of product gas

With a constant total rate of flow of gas, changes in product concentration have two effects. The rate of emission of hydrocarbon gas increases in proportion to the concentration so that, other things being equal, the extent of the flammable zone increases. Also, the initial density of the gas mixture as it issues from the opening becomes greater so that there is a greater tendency for the plume to sink.

At low concentrations, therefore, a flammable zone similar in outline to that shown in figure 2.3 (c) is to be expected, but it is likely to be small because of the relatively small amount of hydrocarbon gas. As the concentration increases, the flammable zone tends to assume such shapes as depicted in figures 2.3 (b) and 2.3 (a) as the increasing density exerts its influence.

In addition, the overall size of the zone becomes greater due to the greater rate of emission of hydrocarbon gas.

2.5.4.5 Cross-sectional area of the opening

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

2.5.4.6 The design of the vent outlet

The design and position of a vent outlet must comply with current applicable national and international legislation.

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

2.5.4.7 Position of the vent outlet

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

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

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

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

Figure 2.5 (b) illustrates the effect of an additional opening that doubles the amount of gas 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.

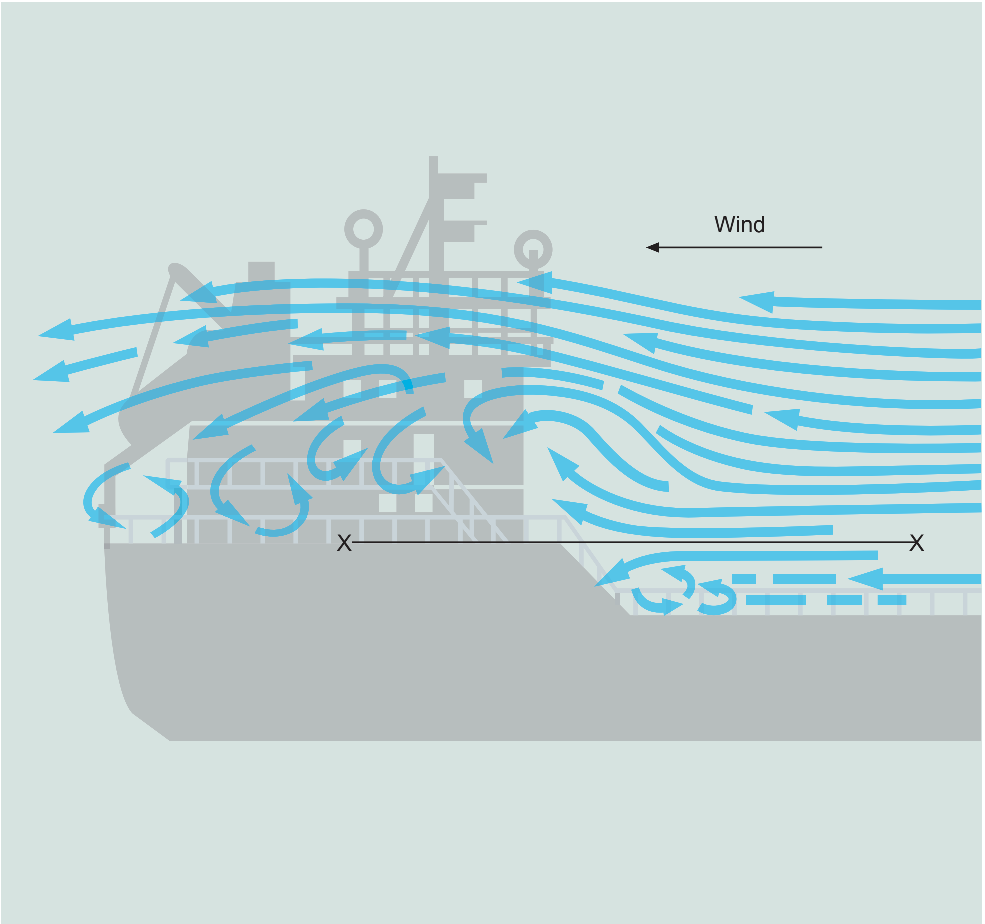


Figure 2.4: *Typical pattern of airflow around an accommodation block*

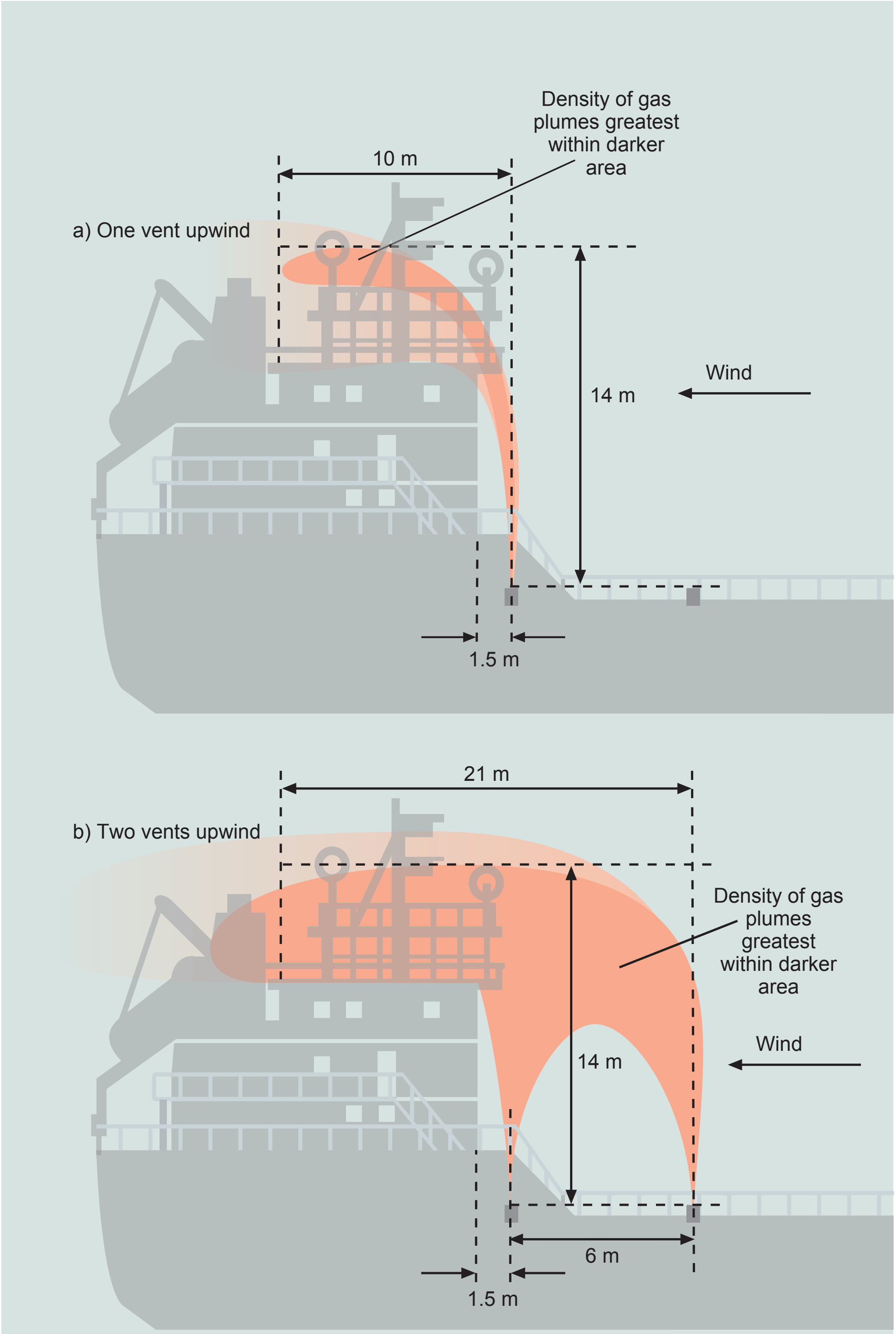
2.5.5 Minimising hazards from vented gas

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

The following conditions should be taken into account for any operation where flammable mixtures are displaced to the atmosphere or where mixtures are displaced which could become flammable on dilution with air, such as on inerted tankers:

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

When using a vent outlet of fixed diameter, usually designed for 125% of the maximum cargo loading rate, the efflux velocity will drop at lower loading rates. Vent outlets with automatically variable areas (high velocity vent valves) may be fitted to maintain a high efflux velocity under all loading conditions.



Both illustrations above are based upon wind tunnel data of:

Gas mixture	50% by volume propane in air
Diameter of openings	152 millimetres
Wind speed	1.1 metres/sec
Total gas flow per opening	1220 cubic metres/hour

Figure 2.5: *Flammable zone from apertures near an accommodation block*

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

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

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

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

2.5.6 N/A

2.6 N/A

2.7 The hazards associated with handling, storing and carrying residual fuel oil products

2.7.1 General

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

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

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

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

2.7.2 Nature of hazard

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

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

2.7.3 Flashpoint and headspace flammability measurement

2.7.3.1 Flashpoint

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

2.7.3.2 Headspace flammability

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

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

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

2.7.4 Precautionary measures

2.7.4.1 Storage and handling temperatures

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

2.7.4.2 Filling and venting

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

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

2.7.4.3 Headspace classification

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

2.7.4.4 Hazard reduction

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

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

When residual fuel oil is carried as cargo on board tankers fitted with inert gas, it is recommended that the inert gas is used and that the headspace is maintained in an inert condition.

2.7.4.5 Ullaging and sampling

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

2.7.5 Hydrogen sulphide hazard in residual fuel oils

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

Before loading bunkers, the tanker should communicate with the supplier to ascertain whether the fuel to be loaded is likely to have any hydrogen sulphide 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 hydrogen sulphide 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 hydrogen sulphide should be continued until the bunker tank is refilled with a fuel oil not containing hydrogen sulphide.

3 Static electricity

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

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

3.1 Principles of electrostatics

3.1.1 Summary

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

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

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

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

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

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

3.1.2 Charge separation

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

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

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

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

- The flow of liquid product through pipes.
- Flow through fine filters (less than 150 microns) that have the ability to charge products to a very high level, as a result of all the product being brought into intimate contact with the filter surface where charge separation occurs.
- Contaminants, such as water droplets, rust or other particles, moving relative to the product as a result of turbulence in the product as it flows through pipes.

- The settling of a solid or an immiscible liquid through a liquid (e.g. water, rust or other particles through the product). This process may continue for up to 30 minutes after completion of loading into a tank.
- Gas bubbles rising up through a liquid (e.g. air, inert gas introduced into a tank by the blowing of cargo lines or vapour from the liquid itself, released when pressure is dropped). This process may also continue for up to 30 minutes after completion of loading.
- Turbulence and splashing in the early stages of loading product into an empty tank. This is a problem in the liquid and in the mist that can form above the liquid.
- The ejection of particles or droplets from a nozzle (e.g. during steaming operations or injection of inert gas).
- The splashing or agitation of a liquid against a solid surface (e.g. water washing operations or the initial stages of filling a tank with product).
- The vigorous rubbing together and subsequent separation of certain synthetic polymers (e.g. the sliding of a polypropylene rope through gloved hands).

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

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

If an uncharged conductor is present in an electrostatic field, it has approximately the same voltage as the region it occupies. Furthermore, the field causes a movement of charge within the conductor; a charge of one sign is attracted by the field to one end of the conductor and an equal charge of the opposite sign is left at the opposite end. Charges separated in this way are known as ‘induced charges’ and, as long as they are kept separate by the presence of the field, they are capable of contributing to an electrostatic discharge.

3.1.3 Charge accumulation

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

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

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

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 a sudden flow recombination that generates intense local heating (e.g. a spark) that can be a source of ignition in a flammable atmosphere. Although all insulating media can be affected by breakdowns and electrostatic discharges, the main concern for tanker operations is to prevent discharges in air or vapour and so 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 occur. A discharge may occur between a protrusion and an insulated conductor or solely between a conductive protrusion and the space in its vicinity, without reaching another object.

3.1.4.1 Types of discharge

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

A corona is a diffuse discharge from a single sharp conductor that slowly releases some of the available energy. A corona on its own is incapable of igniting a gas.

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

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

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

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

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

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

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

The short circuit can be achieved:

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

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

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

3.1.4.2 Conductivity

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

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

Liquids are considered to be non-conductors when they have conductivities less than 50pS/m (pico Siemens/metre). Such liquids are often referred to as static accumulators. Refer to a product's SDS to ascertain its conductivity.

The solid non-conductors include plastics, such as polypropylene, PVC, nylon and many types of rubber. They can become more conductive if their surfaces are contaminated with dirt or moisture (the precautions to be taken when loading static accumulator oils are covered in section 11.1.7).

Semi-conductive materials (or dissipative materials or intermediate conductors)
The liquids in this intermediate category have conductivities exceeding 50pS/m and, along with conductive liquids, are often known as static non-accumulators. 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 low enough to bring them into the non-conductive range.

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

For materials with intermediate conductivities, the risk of electrostatic discharge is small, particularly if the practices in this guide are adhered to, and their chance of being incendive is even smaller. However, caution should still be exercised when dealing with intermediate conductors because their conductivities are dependent upon many factors, so their actual conductivity is not known.

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

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

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, which has important implications for mists and particulate suspensions in air and other gases. Charged mists are formed during the ejection of liquid from a nozzle, for example:

- Products entering an empty tank at high velocity.
- Wet steam condensing.
- Water from tank washing machines.

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

3.2 General precautions against electrostatic hazards

3.2.1 Overview

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

- The bonding of metal objects to the metal structure of the tanker to eliminate the risk of spark discharges between metal objects that might be electrically insulated. This includes metallic components of any equipment used for dipping, ullaging and sampling.
- The removal from tanks or other hazardous areas of any loose conductive objects that cannot be bonded.
- Restricting the linear velocity of the cargo to a maximum of 1m/sec at the individual tank inlets during the initial stages of loading, i.e. until:
  a. The filling pipe and any other structure on the base of the tank has been submerged to twice the filling pipe diameter so that all splashing and surface turbulence has ceased.
  b. Any water collected in the pipeline has been cleared. It is necessary to load at this restricted rate for 30 minutes or until two pipeline volumes (i.e. from shore tank to ship's tank) have been loaded into the tank, whichever is the lesser.

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

Table 3.2: *Loading rates equivalent to flow velocity of 1m/sec (initial stage of loading)*
Also see sections 7.3.3.2 and 11.1.7.3

- Continuing 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 within this context is one that contains less than 0.5% by volume of free water or other immiscible liquid and less than 10mg/ℓ of suspended solids.[1]
- Avoiding splash filling by employing bottom entry using a fill pipe terminating close to the bottom of the tank.

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

- Banning the use of all metallic equipment for dipping, ullaging and sampling during loading and for 30 minutes after completion of loading. After the 30-minute wait, metallic equipment

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

may be used but it must be effectively bonded and securely earthed to the structure of the tanker before it is introduced into the tank, and must remain earthed until after removal.

- Banning the use of all non-metallic containers of more than 1ℓ capacity for dipping, ullaging and sampling during loading and for 30 minutes after completion of loading.

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

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

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

3.2.2 Bonding

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

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

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

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

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

3.2.3 Avoiding loose conductive objects

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

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

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

3.3 Other sources of electrostatic hazards

3.3.1 Filters

Three classifications of filter may be used:

Coarse (greater than or equal to 150 microns)
These do not generate a significant amount of charge and require no additional precautions provided that they are kept clean.

Fine (less than 150 microns, greater than 30 microns)
These can generate a significant amount of charge and so require enough time for the charge to relax before the liquid reaches the tank. It is essential that the liquid spends a minimum of 30 seconds (residence time) in the piping downstream of the filter. Flow velocity should be controlled to ensure that this residence time is met.

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.

3.3.2 Fixed equipment in cargo tanks

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

Metal probes of the type described above can be avoided by installing the equipment adjacent to a bulkhead or other tank structure to reduce the electrostatic field at the probe tip. Alternatively, a support can be added running from the lower end of the probe downward to the tank structure below, so that the rising liquid meets the support at earth potential rather than the insulated tip of a probe. In some cases another possible solution is to construct the probe-like device entirely of a non-conductive material. These measures are not necessary if the tanker is limited to conductive products or if the tanks are inerted.

3.3.3 Free fall in tanks

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

3.3.4 Water mists

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

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

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

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

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

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

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

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

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

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

3.3.5 Inert gas

Small particulate matter carried in inert gas can be electrostatically charged. The charge separation originates in the combustion process and the charged particles are capable of being carried through the scrubber, fan and distribution pipes into the cargo tanks. The electrostatic charge carried by the inert gas is usually small, but levels of charge have been observed well above those encountered with the water mists formed during washing. Because the tanks are normally in an inert condition, the possibility of an electrostatic ignition has to be considered only if it is necessary to inert a tank 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 11.8.3).

3.3.6 Discharge of carbon dioxide

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

3.3.7 Clothing and footwear

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

3.3.8 Synthetic materials

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

4 General hazards for inland tanker and terminal

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

4.1 General principles

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

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

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

Air intakes must be set to ensure that the atmospheric pressure inside the accommodation is greater than that of the external atmosphere. In engine and boiler rooms, ignition sources such as those arising from boiler operations and electrical equipment cannot be avoided (see section 4.2.4). It is essential therefore to prevent the entry of flammable gases into such compartments. Fuels may present a flammability hazard (see section 2.7) and the routine checking of bunker spaces for flammability by inland tanker and terminal personnel is to be encouraged.

It is possible, by good design and operational practice, for both flammable gases and ignition sources to be safely controlled in workshops, store rooms, etc. However, the means for such control must be rigorously maintained and may be subjected to local regulation.

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

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

4.2 Control of potential ignition sources

4.2.1 Naked lights

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

4.2.2 Smoking

Smoking presents significant risks on board inland tankers and therefore requires careful management. While the text of this section refers explicitly to smoking, the controls should also be applied to the burning of other products, e.g. incense and joss sticks, electric cigarettes and other smoking devices. As with tobacco products, smouldering smoke-producing products should never be left unattended or allowed near bedding or other combustible materials.

4.2.2.1 Smoking while an inland tanker is under way

While an inland tanker is under way, smoking should be permitted only at times and in places specified by the inland tanker's Master. Personnel on board inland tankers should only smoke in the dedicated smoking room, if one is available. Smoking should be prohibited on the tank 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 4.2.2.3.

4.2.2.2 Smoking in port and controlled smoking

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

Smoking should be prohibited in the restricted area around all tankers and berths and onboard any tanker while at a berth, except in designated places. Smoking onboard barges and other small craft should be prohibited while they are alongside the tanker or terminal. Attention should be given to local (port) regulations.

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

Some conventional vessels, typically smaller barges and inland watercraft are similarly at risk through their inability to maintain positive pressure in the accommodation block and other spaces. In such cases, the inherent difficulty in maintaining a gas-free environment either within, immediately outside or below such an accommodation block or lesser structure makes the provision of a safe smoking area impossible. Smoking on board such craft should be strictly prohibited while they remain alongside the terminal or facility.

4.2.2.3 Location of designated smoking places

The designated smoking places on shore should be agreed in writing between the Responsible Person and the Terminal Representative before operations start. The Responsible Person should ensure that all the people on board the inland tanker are informed of the selected places for smoking.

Criteria for designating smoking places on shore include:

- Smoking places should be confined to locations within the buildings.[2]
- Smoking places should not have doors or windows that open directly onto open spaces.
- Account should be taken of conditions that may suggest danger, such as an indication of unusually high petroleum gas concentrations, particularly in the absence of wind, and when there are operations on adjacent inland tankers or on the jetty berth.

While the inland tanker is moored at the terminal, even when no operations are in progress, smoking can only be permitted in designated smoking places and after prior agreement in writing between the Responsible Person and the Terminal Representative, in any other closed accommodation, subject to local (port) regulations.

4.2.2.4 Matches and cigarette lighters

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

All matches used on board inland tankers should be of the safety type. The use of matches and cigarette lighters outside the accommodation should be prohibited. Matches and cigarette lighters 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 inland tankers.

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

[2] Local legislation may prohibit having a smoking location within buildings. A formal risk assessment should be in place to ensure an acceptable safety standard.

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

4.2.2.5 Notices

Portable and permanent notices prohibiting smoking and the use of naked lights should be displayed conspicuously on the inland tanker and at the exits from the accommodation area. Within the accommodation area, instructions concerning smoking should be displayed conspicuously.

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

4.2.3 Galley stoves and cooking appliances

The use of galley stoves and other cooking appliances that employ naked flames should be prohibited while an inland tanker is at the terminal.

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

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

The crew should be trained in handling fire emergencies and appropriate responses. Appropriate fire extinguishers and fire blankets should be readily available, regularly inspected and maintained.

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

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

4.2.4 Engine and boiler rooms

4.2.4.1 Combustion equipment

As a precaution against funnel fires and sparks, burners, tubes, uptakes, exhaust manifolds and spark arresters should be kept in good working condition. If there is a funnel fire or sparks are emitted from the funnel when sailing, the inland tanker should take measures as soon as possible to avoid sparks falling on the tank deck. Any cargo, ballasting or tank-cleaning operations in progress must be stopped and all tank openings closed.

4.2.4.2 N/A

4.3 Portable electrical equipment

4.3.1 General

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

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 4.3.7).

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.

ISGINTT2 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).

4.3.2 Lamps and other electrical equipment on flexible cables (wandering leads)

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

- Compartments within which, or over which, the equipment and the leads are to be used are safe for hot work (see section 9.4).
- All the equipment, including wandering leads, is intrinsically safe.
- Or the equipment is contained within an approved explosion-proof housing. Any flexible cables should be approved for extra-hard usage, have an earth conductor, and be permanently attached to the explosion-proof housing in an approved manner.

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

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

4.3.3 Air-driven lamps

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

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

Permanently installed units should be earthed.

4.3.4 Torches (flashlights), lamps and portable battery power

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

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

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.

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

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

4.3.5 Cameras

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

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

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

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

4.3.6 Other portable electrical equipment

For guidance on the use of mobile telephones and pagers, see sections 4.8.6 and 4.8.7.

Any other electrical or electronic equipment of non-approved type, whether mains or battery powered, must not be active, switched on or used within hazardous areas. This includes, but is not limited to, radios, calculators, games consoles, photographic equipment, laptop computers, handheld computers, smart watches, fitness wristbands, E-cigarettes, remote controlled devices e.g. drones, CD and DVD players, tape recorders and digital music players and any other portable equipment or wearable technology that is electrically powered but not approved for operation in hazardous areas.

In view of the ready availability and widespread use of such equipment, appropriate measures should be taken to prevent its use within hazardous areas. Personnel must be advised of the prohibition of non-approved equipment, and terminals should have a policy for informing visitors of the potential dangers associated with the use of portable electrical equipment.

Terminals should also reserve the right to require any non-approved items of equipment to be deposited at the entrance to the port area or other appropriate boundary within the terminal.

4.3.7 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.

4.4 Management of electrical equipment and installations in dangerous areas

4.4.1 General

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

4.4.2 Dangerous and hazardous areas

4.4.2.1 Dangerous areas on an Inland tanker

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

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

4.4.2.2 Hazardous areas at a terminal

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

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

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

4.4.2.3 Application of hazardous area classifications to an inland tanker at a berth

When an inland tanker is at a berth, it is possible that an area in the tanker that is regarded as safe may fall within one of the hazardous zones of the terminal. If such a situation arises and, if the area in question contains unapproved electrical equipment, then such equipment may have to be isolated while the tanker is at the berth. During cargo, bunkering, ballasting, tank-cleaning, gas-freeing, purging or inerting operations, all unapproved electrical equipment should be isolated.

4.4.3 Electrical equipment

4.4.3.1 Fixed electrical equipment

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

4.4.3.2 Closed circuit television

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

4.4.3.3 Electrical equipment and installations on board an inland tanker

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

4.4.3.4 Electrical equipment and installations at terminals

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

4.4.4 Inspection and maintenance of electrical equipment

4.4.4.1 General

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

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

4.4.4.2 Inspections and checks

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

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

4.4.4.3 Maintenance of electrical equipment

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

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

To assist with routine servicing and repair, inland tankers should be provided with detailed maintenance procedures and/or manuals for the specific systems and arrangements fitted on board. 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*.

4.4.4.4 Insulation testing

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

4.4.4.5 Alterations to the terminal's or inland tanker's equipment, systems and installations

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

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

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

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

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

4.4.4.6 Periodic mechanical inspections

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

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

4.4.5 Electrical repairs, maintenance and test work at terminals

4.4.5.1 General

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

The use of mechanical LO/TO devices and safety tags is strongly recommended.

4.4.5.2 Cold work

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

4.4.5.3 Hot work

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

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

Before undertaking any hot work, refer to section 9.4.

4.5 Use of tools

4.5.1 Grit blasting and mechanically powered tools

It should be noted that grit blasting and the use of mechanically powered tools are not normally considered to fall within the definition of hot work in the shipping industry. However, these activities have a significant potential for producing sparks and should be carried out under the control of a permit-to-work system or of the inland tanker's SMS.

The following precautions should be observed:

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

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

There is a risk of perforation of pipelines when grit blasting or chipping, so great care must be taken when planning such work. Before starting work on cargo lines on deck, they should be flushed. Cargo line valves should be closed and filled with water or inerted. The atmosphere inside the section to be worked on should be confirmed as either inerted to less than 5% oxygen by volume or gas-free to not more than 1% LFL. Similar precautions should be adopted for efficient stripping, vapour return, inert gas and crude oil washing lines or tank washing lines, as appropriate.

4.5.2 Hand tools

The use of hand tools such as chipping hammers, scrapers and scouring equipment for steel preparation, maintenance and painting may be permitted without a hot work permit. However, they must be restricted to deck areas and fittings not connected to the cargo system.

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

Non-ferrous, so-called non-sparking, tools are only marginally less likely to give rise to an incendive spark and, because of their comparative softness, are not as efficient as their ferrous equivalents. Particles of concrete, sand or other rock-like substances are likely to become embedded in the working face or edge of such tools and can then cause incendive sparks on impact with ferrous or other hard metals. The use of non-ferrous tools is therefore not recommended. Chrome vanadium tools may provide an acceptable alternative.

4.6 Equipment made of aluminium

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

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

4.7 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.

4.8 Communications equipment

4.8.1 General

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

4.8.2 An inland tanker's radio equipment

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

4.8.2.1 N/A

4.8.2.2 VHF/UHF equipment

The use of permanently and correctly installed VHF and UHF equipment during cargo, bunkering, ballasting, tank-cleaning, gas-freeing, purging or inerting operations is considered safe. However, it is recommended that the transmission power be set to low power (one watt or less) when used in port operations.

Only portable VHF/UHF radios that are certified and maintained to intrinsically safe or explosion-proof standards and have a power output of one watt or less should be used on board and within the terminal.

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

4.8.2.3 Satellite communications equipment

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

4.8.3 An inland tanker's radar equipment

Marine radar systems operate in the high radio frequency 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 inland tanker's deck or jetty.

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

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

Radar scanner motors are not rated for use in dangerous/hazardous areas. On smaller vessels they may be situated within shore hazardous zones. Caution should therefore be exercised should radars require testing alongside a terminal. The radar should be switched off or placed on standby and the terminal should be consulted before testing radar equipment during cargo operations.

4.8.4 Automatic Identification Systems

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

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

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

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

The use of AIS equipment may affect the security of the inland tanker or the terminal where it is berthed. In such circumstances, the use of AIS may be determined by the port authority depending on the security level.

4.8.5 Telephones

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

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

4.8.6 Mobile telephones

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

Although transmission power levels of non-intrinsically safe mobile telephones are not enough to cause problems with sparking from induced voltages, the batteries can have enough power to create an incendive spark if damaged or short circuited. If switched on, equipment such as mobile telephones and radio pagers can be activated remotely and a hazard generated by the alerting or calling mechanism and, in the case of telephones, by the natural response to answer the call. When taken through a terminal, or on or off an inland tanker, they should be switched off and should only be re-commissioned once they are in a non-hazardous area, such as inside the inland tanker's accommodation or clear of the terminal.

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

4.8.7 Pagers

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

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

4.9 Spontaneous combustion

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

Cotton waste, rags, canvas, bedding, jute sacking, sawdust or any similar absorbent material should therefore not be stowed in the same compartment as oil, paint, etc and should not be left lying on the jetty, on decks, on equipment or next to pipelines, etc. If such materials become damp, they should be dried before being stowed away. If soaked with oil, they should be cleaned or destroyed.

Certain chemicals used for boiler treatment are also oxidising agents. Although carried in diluted form, they are capable of spontaneous combustion if allowed to evaporate.

4.10 Auto-ignition

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

4.11 Asbestos

The disturbance or removal of asbestos should be carried out by specialist contractors if possible. In cases where crew members are involved in urgent repair work, measures should be in place to ensure they are adequately protected from asbestos exposure. IMO MSC Circular 1045 provides the necessary guidance on how to handle asbestos safely on vessels and barges.

5 Fire-fighting

This chapter describes the types of fire that may be encountered on an inland tanker or at a terminal, and the means of extinguishing them. Descriptions of fire-fighting equipment to be found on inland tankers and in terminals are provided in chapters 8 and 19.

5.1 Theory of fire-fighting

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

They are extinguished by removing the heat, fuel or air, or by interrupting the chemical reaction of combustion. The main objective of fire-fighting is to reduce the temperature, remove the fuel, exclude the supply of air or interfere chemically with the combustion 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).*

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 Extinguishing agents

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

5.3.1 Cooling agents

5.3.1.1 Water

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

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

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

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

Water jets should not be directed at energised electrical equipment as this could provide a path for electricity from the equipment, creating a danger of electric shock to fire-fighting personnel. When using water in large quantities or for extended periods of time for firefighting, cooling or personnel protection, vessel stability should be monitored. Large amounts of water, in a damaged vessel, can reduce stability. De-watering of the vessel must be a consideration.

5.3.1.2 Foam

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

5.3.2 Smothering agents

5.3.2.1 Foam

The primary extinguishing action of foam is smothering. Foam is an aggregation of small bubbles, lower in specific gravity than oil or water, that flows across the surface of a burning liquid and forms a coherent smothering blanket. A good foam blanket seals against flammable vapour loss, provides some cooling of the fuel surface by the absorption of heat, isolates the fuel surface from the oxygen supply, and separates the flammable vapour layer from other ignition sources (e.g. flames or extremely hot metal surfaces), thereby eliminating combustion. A good foam blanket will resist disruption due to wind and draught, or heat and flame, and will reseal when its surface is broken or disturbed. Foam is an electrical conductor and should not be applied to energised electrical equipment.

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.

AR-AFFF creates a physical, polymer-membrane barrier between the foam blanket and the fuel surface. AR-AFFF suppresses Class B hydrocarbon fires (diesel, gasoline, kerosene, etc.) and polar solvent/water-miscible fuel fires (alcohol, e.g. methanol, ethanol; ketones and ethers, e.g. MTBE/ETBE products). In addition, AR-AFFF suppresses the hazardous vapours emitted from fires or spills of these materials.

High-expansion foam, made from hydrocarbon surfactant concentrates, is available in expansion ratios from about 200:1 to 1,000:1. A foam generator, which may be fixed or mobile, sprays foam solution onto a fine mesh net 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 to extinguish a fire by displacing free air in the compartment. High-expansion foam is generally unsuitable for use outside as it cannot readily be directed onto a hot unconfined spill fire and is quickly dispersed in light winds.

High-expansion foam systems are being enhanced with the introduction of a new development called ‘hot foam’, which is now being increasingly used on inland tankers as a replacement for halon. These 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 air.

Medium-expansion foam has an expansion ratio from about 20:1 to 250:1. It is made from the same concentrates as high-expansion foam, but its aeration does not require a fan. Portable applicators can be used to deliver considerable quantities of foam onto spill fires, but they have limited throw and the foam is liable to be dispersed in moderate winds.

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

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

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

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

Check the compatibility of foam compounds when considering joint operations with other fire-fighters.

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

5.3.2.2 Carbon dioxide

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

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

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

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

5.3.2.3 Steam

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

5.3.2.4 Sand

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

5.3.3 Flame inhibiting agents

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

5.3.3.1 Dry chemical

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

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

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

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

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

5.3.3.2 Vaporising liquids

Vaporising liquids, in the same way as dry chemical powder, have a flame inhibiting and slight smothering effect.

5.3.3.3 New fire-fighting technologies

New fire-fighting technology is regularly introduced for use on board vessels and at terminals. Companies should look at their local, regional or international fire prevention services for new technology that has been approved for use on board or at terminal. Crew members and terminal personnel should be trained to guarantee safe and correct use.

5.4 Fire detection systems

Fixed fire detection systems in combination with an alarm station are recommended and should be tested on a regular basis. Also see chapter 8 and chapter 19.

5.5 General precautions

For the use of fixed fire gas extinguishing systems, the following precautions are recommended:

- All personnel have to be evacuated from the space where the fire is.
- Before activating the system, ventilators must be stopped.
- All ventilation inlets must be closed.

Any fixed fire gas extinguishing system can be used only once.

Take time before opening any space after the fire is extinguished. Once air has been re-introduced into the space, re-ignition of the fire is possible.

After the use of fixed fire gas extinguishing systems, the following precautions are recommended:

- Ensure sufficient ventilation before entering the space.
- Oxygen concentration should be tested.
- Any significant presence of toxic gases should be tested.
- Procedures for entry into enclosed spaces must be followed.

Inland tanker crews should be familiar and trained in the use of fixed fire gas extinguishing systems and the system should be subject to periodical testing. The system should be periodically examined by a competent and certified company.

6 Security

Inland tankers and barges often load or unload at facilities where seagoing tankers are being handled and so the International Ship and Port Facility Security Code is applicable. This chapter provides a summary of the major provisions of the Code.

6.1 General

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

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

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

Legislation may require inland tankers and terminals to apply specific security measures. It is recommended that when inland tanker barges visit terminals and facilities where the ISPS Code is mandatory, or where legislation regulates security measures, these measures harmonise with the requirements of the ISPS Code to avoid gaps in security.

6.2 Security assessments

The security assessment for terminals and inland tankers should include a risk analysis of all aspects of the tanker's and terminal's operations in order to determine which parts of them are more susceptible and/or more likely to have a security incident. The risk is a function of the threat of a security incident, coupled with the vulnerability of the target and the consequences of the incident. As a minimum, the security assessment should examine:

- Existing security measures, procedures and operations on board the tanker or at the terminal.
- Key assets and infrastructure it is important to protect.
- Perceived threats to the tanker or terminal facility and their likely occurrence.
- Potential vulnerabilities and consequences of potential incidents to tankers, terminals, berths and tankers at the berths.
- Any weaknesses (including human factors) in the infrastructure, policies and procedures.

6.3 Responsibilities under the ISPS Code

For a terminal, responsibility for the security plan rests with the terminal management and they must appoint a designated Port Facility Security Officer (PFSO) who has the skills and training to ensure full implementation of the security measures at the terminal.

For inland tankers and barges, the carrier, consignor and other participants engaged in the carriage of dangerous goods shall adopt, implement and comply with a security plan that addresses at least the elements such as specified in the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN) 1.10.3.2.2.

6.4 Security plans in compliance with SOLAS and the ISPS Code

Security plans will vary from terminal to terminal and from tanker to tanker depending on the particular circumstances identified by the security assessment, requirements for compliance with SOLAS and the ISPS Code, and local and national security considerations. The plan should describe:

- Who is responsible for carrying out security measures.
- The security organisation on board the inland tanker or at the terminal and port.
- Security training and drills.
- Basic security measures for normal operation and additional measures that will allow the inland tanker and terminal to progress, without delay, to increased or lowered security levels as the threat changes.
- Additional measures that will allow the inland tanker and terminal to respond quickly to changes in threats, e.g. by reducing or increasing the level of security.
- Procedures for interfacing the security activities of seagoing tankers and terminals with those of local port authorities, other tankers, terminals and dock 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 upon experience or changing circumstances.
- Measures designed to prevent unauthorised access to the inland tanker and terminal, in particular measures to restrict access to vulnerable areas of a terminal and to restrict access to tankers when moored at the terminal, including the identification of tanker and terminal personnel (e.g. by identity documents or identification badges).
- Measures designed to prevent unauthorised weapons, dangerous substances or devices intended for use against people, tankers or terminals from being taken on board the tanker or introduced to the terminal.
- Procedures for responding to security threats or breaches of security, which may include evacuation.

6.5 Security plans for inland tankers

When carrying high consequence dangerous goods, carriers, consignors and other participants shall adopt, implement and comply with a security plan based on ADN section 1.10.3.2.

6.6 Declaration of Security (DoS)

Based on ISPS legislation, a Declaration of Security may be completed by the seagoing tanker and the inland tanker. The declaration describes detailed information about mutually agreed security measures taken. The following is an example of the content of a DoS:

Declaration of Security **Between a ship and other ship it interfaces with**	
Name of ship	Name of other ship
Port of registry	Port of registry
IMO Number	IMO Number

This declaration of security is valid from .... until ....
for the following activities ....
.... under the following security levels

Security level(s) for the ship	
Security level(s) for the other ship	

The ship and the other ship agree to the following security measures and responsibilities (as applicable) to ensure compliance with the requirements of Part A of the International Code for the Security of Ships and of Port facilities.

	The affixing of the initials of the master or SSO under these columns indicates that the activity will be done, in accordance with the relevant approved plan, by:	
Activity	**The ship**	**The other ship**
Ensuring the performance of all security duties		
Monitoring restricted areas to ensure that only authorised personnel have access		
Controlling access to the ship		
Controlling access to the other ship		
Monitoring of the areas surrounding the ship		
Monitoring of the areas surrounding the other ship		
Handling of cargo		
Delivery of ship's stores		
Handling of unaccompanied baggage		
Controlling the embarkation of persons and their effects		
Ensuring that security communication is readily available between the ships		

The signatories to this agreement certify that security measures and arrangements for both ships during the specified activities meet the provisions of chapter XI-2 and part A of the Code that will be implemented in accordance with the provisions already stipulated in their approved plan or the specific arrangements agreed to and set out in the attached annex.

Dated at .... on the ....

Signed for and on behalf of	
The ship	The other ship
(Signature of master or ship security officer)	*(Signature of master or ship security officer)*

Name and title of person who signed	
Name	Name
Title	Title

Contact details	
Master	Master
Ship security officer	Ship security officer
Company	Company
Company security officer	Company security officer
Telephone number	Telephone number
Radio channels	Radio channels

PART 2:
TANKER INFORMATION

7 Shipboard systems

This chapter describes the principal tanker systems that are used during cargo and ballast operations in port.

7.1 Fixed inert gas systems

This section describes in general terms the operation of a fixed inert gas system that is used to maintain a safe atmosphere within a ship's cargo tanks. It also covers the precautions to be taken to avoid hazards to health resulting from the risks associated with operating inert gas plants. It should be noted that nitrogen is normally used on inland tankers as an inert gas.

Refer to the tanker's operations manual and the manufacturer's instructions and installation drawings for details on the operation of a particular system.

7.1.1 General

Flammable gases in inland tankers cannot burn in an atmosphere containing less than approximately 11% oxygen by volume. Accordingly, one way to provide protection against fire or explosion in the vapour space of cargo tanks is to keep the oxygen level below that figure. This can be achieved by adding inert gas to each cargo tank in order to reduce the air content, and hence the oxygen content, and render the tank atmosphere non-flammable.

See section 1.2.3 (and figure 1.1) for detailed information on IG and flammability.

7.1.2 Sources of inert gas

Typical sources of inert gas on inland tankers are:

- An independent inert gas (nitrogen) generator.
- Inert gas (nitrogen) supplied at terminal facilities.
- Inert gas (nitrogen) stored on board.

7.1.3 Composition and quality of inert gas

Inert gas systems should be capable of delivering inert gas with an oxygen content in the inert gas main of not more than 5% by volume at any required rate of flow. Systems should also be able to maintain a positive pressure in the cargo tanks at all times with an atmosphere having an oxygen content of not more than 8% by volume except when it is necessary for the tank to be gas-free.

When an independent inert gas generator is fitted, the oxygen content can be automatically controlled within finer limits, usually within the range 1.5-2.5% by volume.

In certain ports, the maximum oxygen content of inert gas in the cargo tanks may be set at 5% to meet particular safety requirements, such as the operation of a vapour emission control system.

7.1.4 Methods of replacing tank atmospheres

If the entire tank atmosphere could be replaced by an equal volume of inert gas, the resulting tank atmosphere would have the same oxygen level as the incoming inert gas. In practice, this is impossible to achieve and a volume of inert gas equal to several tank volumes must be introduced into the tank before the desired result can be achieved.

The replacement of a tank atmosphere by inert gas can be achieved by inerting or purging. In either of these methods, one of two distinct processes, dilution or displacement, will dominate.

Dilution takes place when the incoming inert gas mixes with the original tank atmosphere to form a homogeneous mixture throughout the tank so that, as the process continues, the concentration of the original gas decreases progressively. It is important that the incoming inert gas has enough entry velocity to penetrate to the bottom of the tank. To ensure this, a limit must be placed on the number of tanks that can be inerted simultaneously. Where this limit is not clearly stipulated in the operations manual, only one tank should be inerted or purged at a time when using the dilution method.

Displacement depends on the fact that inert gas is slightly lighter than hydrocarbon gas, so while the inert gas enters at the top of the tank, the heavier hydrocarbon gas escapes from the bottom through suitable piping. When using this method, it is important that the inert gas has a very low velocity to enable a stable horizontal interface to be developed between the incoming and escaping gas. In practice, some dilution inevitably takes place owing to the turbulence caused in the inert gas flow. Displacement generally allows several tanks to be inerted or purged simultaneously.

Whichever method is used, and whether inerting or purging, it is vital that oxygen or gas measurements are taken at several heights and horizontal positions within the tank to check the efficiency of the operation. A mixture of inert gas and flammable gas, when vented and mixed with air, can become flammable. The normal safety precautions taken when flammable gas is vented from a tank should not be relaxed.

7.1.5 Cargo tank atmosphere control

7.1.5.1 Inert gas operations

Inland tankers using an inert gas system should maintain their cargo tanks in a non-flammable condition at all times. It follows that:

- Tanks should be kept in an inert condition at all times, except when it is necessary for them to be gas-free for inspection or work, i.e. the oxygen content should be not more than 8% by volume and the atmosphere should be maintained at a positive pressure.
- The atmosphere within the tank should make the transition from the inert condition to the gas-free condition without passing through the flammable condition.

7.1.5.2 Inert gas system maintenance

It is emphasised that the protection provided by an inert gas system depends on the proper operation and maintenance of the entire system.

It is particularly important to ensure that non-return barriers function correctly, especially block and bleed valves, so that there is no possibility of product gases or liquids passing back to the machinery spaces.

To demonstrate that the inert gas plant is fully operational and in good working order, a record of inspection of the inert gas plant, including defects and their rectification, should be maintained on board.

7.1.5.3 Degradation of inert gas quality

Tanker personnel should be alert to the possible degradation of inert gas quality within tanks as a result of inappropriate operation of the inert gas systems. For instance:

- Not topping up the inert gas promptly if the pressure in the system falls due to temperature changes at night.
- Prolonged opening of tank apertures for tank gauging, sampling and dipping.

7.1.6 Application to cargo tank operations

Before the inert gas system is put into service, the tests required by the operations manual or manufacturer's instructions should be carried out. The fixed oxygen analyser and recorder should be tested and proved to be in good order. Portable oxygen and hydrocarbon meters should also be prepared and tested.

7.1.6.1 Inerting of empty tanks

When inerting empty tanks that are gas-free, e.g. following a dry docking or tank entry, inert gas should be introduced through the distribution system while venting the air in the tank to the atmosphere. This operation should continue until the oxygen content throughout the tank is not more than 8% by volume. The oxygen level will not then increase if a positive pressure is maintained by using the inert gas system to introduce additional inert gas when necessary.

If the tank is not gas-free, the precautions against static electricity given in section 7.1.6.8 should be taken until the oxygen content of the tank has been reduced to 8% by volume.

When all tanks have been inerted, they should be kept common with the inert gas main and the system pressurised with a minimum positive pressure. If individual tanks have to be segregated from a common line (e.g. for product integrity), the segregated tanks should be provided with an alternative means of maintaining an inert gas blanket.

7.1.6.2 Loading cargo or ballast into tanks in an inert condition

When loading cargo or ballast, the inert gas plant, if applicable, should be shut down and the tanks vented through the appropriate venting system. On completion of loading or ballasting, and when all cargo measurements are completed, the tanks should be closed, then the inert gas system restarted and re-pressurised. The system should then be shut down and all safety isolating valves secured.

Local regulations may prohibit venting after unloading.

7.1.6.3 Simultaneous cargo and/or ballast operations

In the case of simultaneous loading and discharge operations involving cargo and/or ballast, venting to the atmosphere should be minimised or possibly avoided. Depending on the relative pumping rates, pressure in the tanks may be increased or a vacuum drawn, and so it may be necessary to adjust the inert gas flow to maintain tank pressures within normal limits.

Particular attention should be paid to the potential impact of free surface effects when undertaking ballast operations during loading or unloading (see section 11.2.2).

7.1.6.4 Vapour balancing

Vapour balancing is used to avoid the release of any gases to the atmosphere through vents and to minimise the use of the inert gas systems when transferring cargo from tanker-to-tanker. As a minimum, follow these recommendations:

Before starting the cargo transfer:

- Equipment should be provided on at least one of the tankers to enable the oxygen content of the vapour stream to be monitored.
- The oxygen content of the vapour space of each tank should be checked and confirmed to be less than 8% by volume.

During the cargo transfer:

- The inert gas system on the discharging tanker, if applicable, should be kept operational and on standby.
- Cargo tank pressure on both tankers should be monitored and each tanker advised of the other’s pressure on a regular basis.
- No air should be allowed to enter the cargo tanks of the discharging tanker.
- Transfer operations should be suspended if the oxygen content of the vapour stream exceeds 8% by volume and should only be resumed once the oxygen content has been reduced to 8% or less by volume.
- The cargo transfer rate must not exceed the design rate for the vapour balancing system.

7.1.6.5 Loaded passage

A positive pressure of inert gas should be maintained in the ullage space at all times during the loaded passage in order to prevent the possible ingress of air (see section 7.1.5.3). If the pressure falls below the established low-pressure level or alarm level, it will be necessary to start the supply of inert gas to restore an adequate pressure in the system.

Loss of pressure is normally associated with leaks from tank openings and falling air and water temperatures. In the latter cases, it is all the more important to ensure that the tanks are gas tight. Gas leaks are usually easily detected by their noise and every effort must be made to eliminate leaks at tank hatches, ullage lids, tank washing machine openings, valves, etc.

Leaks that cannot be eliminated should be marked and recorded, based on the toxicity or hazards created, for sealing during the next ballast passage or at another suitable opportunity.

Certain oil products, principally aviation turbine kerosene and diesel oil, can absorb oxygen during the refining and storage process. This oxygen can later be liberated into an oxygen deficient atmosphere such as the ullage space of an inerted cargo tank. Although the recorded incidence of oxygen liberation is low, cargo tank oxygen levels should be monitored so that any necessary precautionary measures can be taken before starting the discharge.

7.1.6.6 Discharge of cargo from tanks in an inert condition

The inert gas supply must be maintained throughout cargo discharge operations to prevent air entering the tanks. If a satisfactory positive inert gas pressure can be safely maintained without a continuous supply of inert gas, then it is acceptable to re-circulate or stop the supply of inert gas provided that the inert gas plant is kept ready for immediate operation.

Throughout the discharge of cargo, the oxygen content of the inert gas supply must be carefully monitored. Additionally, both the oxygen content and pressure of the inert gas main should be monitored during discharge. For action to be taken in the event of failure of the inert gas plant during discharge from inerted tanks, see section 7.1.12.

If hand dipping of a tank is necessary, the pressure may be reduced while dipping ports are open but take care 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. Stop the discharge immediately if there is a danger of the tanks coming under vacuum.

7.1.6.7 Ballast passage

During a ballast passage, cargo tanks other than those required to be gas-free should remain in the inert condition and under positive pressure to prevent ingress of air. Whenever pressure falls to the low-pressure alarm level, restart the inert gas plant to restore the pressure, and pay attention to the oxygen content of the inert gas delivered.

7.1.6.8 Static electricity precautions

In normal operations, the presence of inert gas prevents the existence of flammable gas mixtures inside cargo tanks. However, hazards due to static electricity may arise, mainly in the case of a failure of the inert gas system. To avoid these hazards, the following procedures are recommended:

- If the inert gas plant breaks down during discharge, suspend operations (see section 7.1.12). If air has entered the tank, no dipping, ullaging, sampling or other equipment should be introduced into the tank until at least 30 minutes after the injection of inert gas ceased. After this period, equipment may be introduced provided that all metallic components are securely earthed. This requirement for earthing should be applied for at least five hours after the injection of inert gas ceased.
- During any necessary re-inerting of a tank following a failure and repair of the inert gas system, or during initial inerting of a non-gas-free tank, no dipping, ullaging, sampling or other equipment should be inserted until the tank is in an inert condition, as established by monitoring the gas vented from the tank being inerted. However, should it be necessary to introduce a gas sampling system into the tank to establish its condition, leave at least 30 minutes after stopping the injection of inert gas before inserting the sampling system. Metallic components of the sampling system should be electrically continuous and securely earthed (see chapter 3 and section 11.8).

7.1.6.9 Tank washing

Before each tank is washed, the oxygen content must be determined, at a point one metre below the deck and at the middle level of the ullage space. At neither of these locations should the oxygen content exceed 8% by volume. Monitor the oxygen content and pressure of the inert gas being delivered during the washing process.

If, during washing, the oxygen content in the tank exceeds 8% by volume or the pressure of the atmosphere in the tanks is no longer positive, stop washing until satisfactory conditions are restored (see section 7.1.12).

7.1.6.10 Purging

When a tank needs to be gas-free after washing, it should first be purged with inert gas to reduce the hydrocarbon content to 2% or less by volume. This is to ensure that during the subsequent gas-freeing operation no portion of the tank atmosphere is brought within the flammable range.

The hydrocarbon content must be measured with an appropriate meter designed to measure the percentage of flammable gas in an oxygen-deficient atmosphere. The usual flammable gas indicator is not suitable for this purpose (see section 2.4).

If the dilution method of purging is used, it should be carried out with the inert gas system set for maximum capacity to give maximum turbulence within the tank. If the displacement method is used, the gas inlet velocity should be lower to prevent undue turbulence (see section 7.1.4).

7.1.6.11 Gas-freeing

Before starting to gas-free, isolate the tank from other tanks. When fixed fans connected to the cargo pipeline system are used to introduce air into the tank, isolate the inert gas inlet. If the inert gas system fan is employed to draw air into the tank, isolate both the line back to the inert gas source and the inert gas inlet into each tank that is being kept inerted.

7.1.6.12 Preparation for tank entry

For general advice on entry into enclosed spaces see chapter 10.

7.1.7 Precautions to be taken to avoid health hazards

7.1.7.1 Inert gas on deck

Certain wind conditions may bring vented gases back down onto the deck, even from specially designed vent outlets. Also, if gases are vented at low level from cargo hatches, ullage ports or other tank apertures, the surrounding areas can contain levels of gases in harmful concentrations and may be oxygen deficient. In these conditions, stop all non-essential work. Only essential personnel should remain on deck, taking all appropriate precautions.

When the last cargo carried contained hydrogen sulphide, tests should be made for the gas. If these detect a level in excess of 5ppm, no personnel should be allowed to work on deck unless they are wearing suitable respiratory protection (see sections 2.3.6 and 11.1.9). Note that national and international legislation may be more stringent with regard to the level detected and actions to take.

7.1.7.2 Ullaging and inspecting tanks from cargo hatches

The low oxygen content of inert gas can cause rapid asphyxiation. Therefore, take care to avoid standing in the path of vented gas (see section 11.8.3).

7.1.7.3 Entry into cargo tanks

Entry into cargo tanks should be permitted only after they have been gas-freed, as described in sections 7.1.6.10 and 7.1.6.11. Observe the safety precautions set out in chapter 10 and consider using personal oxygen deficiency alarms. If the hydrocarbon and oxygen levels specified in section 10.3 cannot be achieved, permit entry only in exceptional circumstances and when there is no practicable alternative. Carry out a thorough risk assessment and put in place appropriate risk mitigation measures. As a minimum, personnel must wear breathing apparatus under such circumstances (see section 10.7).

Cargo and ballast tanks under inert gas should be identified with warning signs placed next to tank hatches. Examples of warning signs:

Figure 7.1: *Examples of warning signs*

7.1.7.4 N/A

7.1.8 Cargo tank protection against over/under-pressure

Serious incidents have occurred on oil tankers due to cargo tanks being subjected to extremes of over or under-pressure. It is essential that venting systems are thoroughly checked to ensure that they are correctly set for the intended operation. Once operations have started, make further checks for any abnormalities, such as unusual noises of vapour escaping under pressure or pressure/vacuum valves lifting (see section 7.2.2 for detailed information on the likely causes of tank over-pressurisation and under-pressurisation and the precautions to avoid them).

The tanker's personnel should be provided with clear, unambiguous operating procedures for the proper management and control of the venting system and should fully understand its capabilities.

7.1.8.1 N/A

7.1.8.2 Pressure/vacuum valves

These are designed to provide for the flow of the small volumes of tank atmosphere, caused by thermal variations, in a cargo tank. The pressure/vacuum valves should be kept in good working order by regular inspection and cleaning.

7.1.8.3 Full flow pressure/vacuum venting arrangements

In inert gas systems fitted with tank isolating valves, secondary protection from over and under-pressurisation of the cargo tanks may be provided by using high-velocity vent and vacuum valves as the full flow protection device. Where this is the case, pay particular attention to ensuring that the valves operate at the required pressure and vacuum settings. Planned maintenance procedures should be established to maintain and test these safety devices. See section 7.2.1 for details.

7.1.8.4 Individual tank pressure monitoring and alarm systems

In inert gas systems fitted with tank isolating valves, indication of the possible over and under-pressurisation of the cargo tank is provided by using individual tank pressure sensors connected to an alarm system. Where such systems are used, planned maintenance procedures should be established to maintain and test these sensors and to confirm that they are providing accurate readings.

7.1.9 N/A

7.1.10 N/A

7.1.11 Cold weather precautions for inert gas systems

The inert gas system may be subject to operational faults when operating in extreme cold weather conditions.

7.1.11.1 Condensation in inert gas piping

The piping system should be designed to prevent accumulation of cargo or water in the pipeline under all normal conditions. However, in extreme cold weather, residual water in the inert gas may freeze in the inert gas main. Operators should be aware of this and should therefore operate the system to minimise residual water and closely monitor the system's operation.

7.1.11.2 Control air

Air-operated control valves fitted to the inert gas system outside the engine room may not operate correctly when exposed to extremely low ambient temperatures and the control air has a high water vapour content.

Water separators in control air systems should be drained frequently and the control air dryers should be checked regularly for efficient operation.

7.1.11.3 Safety devices

In extremely cold weather, ice may prevent the pressure/vacuum valves from operating and may block the flame screens on the pressure/vacuum valves and mast risers.

7.1.11.4 N/A

7.1.12 Inert gas system failure

Each tanker fitted with an inert gas system should be provided with detailed instruction manuals. These should cover operations, safety and maintenance requirements, and the occupational health hazards relevant to the installed system and its application to the cargo tank system. The manual must include guidance on procedures for dealing with a fault or failure of the inert gas system.

7.1.12.1 Action to be taken on failure of the inert gas system

If the inert gas system fails to deliver the required quality and quantity of inert gas, or to maintain a positive pressure in the cargo tanks, take immediate action to prevent any air being drawn into the tanks. Stop all cargo or ballast discharge from inerted tanks, close the inert gas deck isolating valve, open the vent valve between it and the gas pressure regulating valve (if provided), and repair the inert gas system immediately.

National and local regulations may require the failure of an inert gas system to be reported to the harbour authority, terminal operator and to the port and Flag State administrations.

Section 11.1.7 gives guidance on special precautions to be taken should the inert gas system fail while loading static accumulator oils into inerted cargo tanks.

7.1.12.2 N/A

7.1.12.3 Follow-up action on tankers with coated cargo tanks

The cargo tanks of tankers usually have coatings that inhibit the formation of pyrophors. If it is considered totally impracticable to repair the inert gas system, discharge may therefore be resumed with the written agreement of all interested parties, provided that an external source of inert gas is provided, or detailed procedures are established to ensure the safety of operations. The following precautions should be taken:

- The manual referred to in section 7.1.12 above should be consulted.
- Devices to prevent the passage of flame, or flame screens (as appropriate), should be in place and checked to ensure that they are in a satisfactory condition.
- Special attention should be given to ensuring that the amount of supplied inert gas is in balance with the discharge rate. In any case, a positive pressure inside the cargo tanks should be carefully regulated and monitored to prevent the potential opening of P/V valve(s) due to over or under pressure.
- No free fall of water or slops is permitted.
- No dipping, ullaging, sampling or other equipment is introduced into the tank unless essential for the safety of the operation. If it is necessary for such equipment to be introduced into the tank, it should be done at least 30 minutes after the injection of inert gas has stopped (see section 7.1.6.8 for static electricity precautions relating to inert gas and section 11.8 for static electricity precautions when dipping, ullaging and sampling).
- All metal components of any equipment to be introduced into the tank should be securely earthed. This restriction should be applied for at least five hours after the injection of inert gas has stopped.

7.1.13 Inert gas plant repairs

As inert gas causes asphyxiation take great care to avoid the escape of inert gas into any enclosed or partly enclosed space.

Before opening the IG system, it should, if possible, be gas-freed and any enclosed space in which the system is opened up should be ventilated to avoid any risk of oxygen deficiency.

Continuous positive ventilation must be maintained before and during the work.

7.2 Venting systems

7.2.1 General

It is important that venting systems are operated to meet their design intent and are properly maintained.

To help dilute the flammable vapours into the atmosphere and clear of the tanker's deck, venting systems allow vapours to be released either:

- At a low velocity, high above the deck from a vent riser, if present.
- At high velocity from a high-velocity valve closer to the deck.

Vents are sited in selected locations to prevent the accumulation of a flammable atmosphere on the tank deck or around any accommodation or engine room housings (see section 2.5.4).

The tanker's personnel should be fully conversant with the operation and maintenance of all components of the venting system and should be aware of its limitations in order to prevent over or under-pressurisation of the tank(s) the system is serving (see section 7.2.2 below).

7.2.2 Tank over-pressurisation and under-pressurisation

7.2.2.1 General

Over-pressurisation of cargo and ballast tanks is due to compression of the ullage space by the inadequate release of vapour or the overfilling of the tank. Under-pressurisation can be caused by not allowing inert gas vapour or air into the tank when liquid is being discharged. The resulting over or under-pressure in the tank may result in serious deformation or catastrophic failure of the tank structure and its peripheral bulkheads. This can seriously affect the structural integrity of the tanker and could lead to fire, explosion and pollution (see section 7.1.8).

To guard against over and under-pressurisation of tanks, owners/operators should give serious consideration to the fitting of protection devices as follows:

- Individual pressure sensors with an alarm for each tank.
- Individual full flow pressure/vacuum release devices for each tank.

7.2.2.2 Tank over-pressurisation – causes

Over-pressurisation usually occurs during ballasting, loading or internally transferring cargo or ballast. It can be caused by one of the following:

- Overfilling the tank with liquid.
- Incorrect setting of the tank's vapour or inert gas isolating valve to the vapour line or inert gas line.
- Failure of an isolating valve to the vapour line or inert gas line.
- Failure or seizure of the venting valve or high-velocity valve.
- A choked flame arrester or screen.
- Loading or ballasting the tank at a rate which exceeds the maximum venting capacity (see section 7.3.3.1).
- Ice forming on the vents, the pressure/vacuum or high-velocity valves freezing, or ice on the surface of the ballast (see section 7.1.11.3).
- Restriction in the vapour lines caused by wax, residues or scale.

7.2.2.3 Tank over-pressurisation – precautions and corrective actions

The major safeguard against tank over-pressurisation are good operating procedures. These should include:

- On tankers without an inert gas system, a procedure to control the setting of the isolating valves on the vapour lines. This should include methods to record the current position of the isolating valves and to prevent them being incorrectly or casually operated.
- On tankers with inert gas systems where isolating valves are fitted to the branch line to each tank, it is recommended these valves be "provided with locking arrangements which shall be under the control of the responsible officer". This statement should be taken to mean that the

valves must be locked to prevent the possibility of any change in the valve setting, and only the Responsible Person can provide the means of releasing the locking system on the valve.

- A method to record the status of all valves in the cargo system and to prevent them being incorrectly or casually operated.
- A system for setting the valves in the correct position for the operation and monitoring that they remain correctly set.
- Restricting the operation of the valves to authorised personnel only.
- A process of regular maintenance, pre-operational testing and operator awareness of isolating valves, pressure/vacuum valves or high-velocity vents can guard against failure during operation.

To protect against over-pressurisation through filling tanks too quickly, all tankers should have maximum filling rates for each individual tank, which should be available for reference by all personnel (see also section 7.3.3). Tank vents should be checked to ensure that they are clear when the operation starts. During freezing weather conditions, they should be inspected regularly throughout the operation.

Where over-pressurisation of a tank or tanks is suspected, the situation requires appropriate corrective action. Stop loading liquid immediately.

7.2.2.4 Tank under-pressurisation – causes

The causes of under-pressurisation are similar to those of over-pressurisation:

- Incorrect setting of the tank's isolating valve to the vapour line or inert gas line.
- Failure of an isolating valve on the vapour line or inert gas line.
- Failure in one of the inert gas supply valves.
- A choked flame screen on the vapour inlet line.
- Ice forming on the vents of ballast tanks during cold weather.
- Unloading or deballasting the tank at a rate that exceeds the maximum venting capacity (see section 7.3.3.1).

7.2.2.5 Tank under-pressurisation – precautions and corrective actions

The precautions to guard against under-pressurisation are the same as those relating to over-pressurisation (see section 7.2.2.3).

Where under-pressurisation of a tank or tanks is suspected, the situation requires corrective action. Stop discharging liquid immediately.

The methods of reducing a partial vacuum in a tank are either to raise the liquid level in the tank by running or pumping cargo or ballast into the affected tank from another tank, or to admit inert gas or air into the tank ullage space.

Cautions

On a tanker with an inert gas system, the quality of the inert gas may be compromised by air leaking past the seals in the tank access locations.

Admitting inert gas at a high velocity to return the tank to a positive pressure could cause an electrostatic hazard.

The precautions set out in section 11.8.3 should be observed when measuring and sampling.

On tankers without an inert gas system, so it is not possible to reduce the partial vacuum by raising the liquid level, take care to ensure that the rush of air does not draw into the tank foreign objects that pose an ignition risk, e.g. rust.

7.3 Cargo and ballast systems

This section describes the pipelines and pumps used for loading and discharging cargo and ballast. For the purposes of this guide, the cargo heating system, where fitted, is considered part of the cargo system.

The cargo system is one of the prime locations where breaching a cargo containment may occur, so take care not to over-pressurise sections of the system or to subject it to shock loads.

Operation of the cargo and ballast systems should only be carried out by personnel who are familiar with the correct operation of the pumps and associated systems, as described in the operation manual.

7.3.1 Operation manual

The tanker's personnel should have access to up-to-date drawings and information on the cargo and ballast systems, and be given an operation manual describing how the systems should be operated.

7.3.2 Cargo and ballast system integrity

The cargo and ballast systems are subjected to many conditions that may ultimately lead to failure, resulting in loss of containment. These include the following:

- Turbulence in the flow caused by poor pipeline design or excessive flow rates, and abrasion caused by solid particulates in the cargo or ballast, can result in local erosion and pitting in the pipelines.
- The main fore and aft pipeline runs are usually located at the bottom of the tanks and on the main deck where the effects of hogging, sagging and the cyclical motions of a tanker in a seaway are most pronounced. These movements may result in damage to pipeline connections and bulkhead penetrations, and to local external damage at pipeline supports.
- Handling cargoes for which the system has not been designed. Particular care should be taken to prevent damage to cargo valve seals and pump seals that are not suited to aggressive cargoes.
- Corrosion caused by oxidation (rusting) when pipe systems are used for both water and oil service.

Preferential corrosion is found where internal coatings have failed, with the corrosion concentrated in a small area. This localised corrosion may be accelerated when water is allowed to lie in the bottom of pipelines, along with sulphurous products from cargo, or if electrolytic corrosion cells are set up when pipeline connections are not securely bonded.

The presence of any latent defect in the cargo system will usually reveal itself when the system is pressurised during the discharge operation. It is good practice to pressure test cargo lines periodically, depending on the trade of the tanker. Although these pressure tests may provide an indication of the system's condition at the time of the test, they should not be considered a substitute for regular external inspection of the pipeline system and periodic internal inspections, particularly at known failure points, such as pump discharge bends and stub pipe connections.

The presence of any latent defect in the ballast system will usually reveal itself when the system is being used during the de-ballasting operation. The inability to fully discharge or drain ballast tanks may result in stability problems on double bottom or double hull tankers and could in some instances result in the tanker being overloaded. Where a single ballast pump is fitted, company procedures should address use of alternative means of ballasting/de-ballasting.

7.3.3 Loading rates

Tanker Masters should be provided with information on maximum permissible loading rates for each cargo and ballast tank and, where tanks have a combined venting system, for each group of cargo or ballast tanks. This requirement is aimed at ensuring that tanks are not over or under-pressurised by exceeding the capacity of the venting system, including any installed secondary venting arrangements.

Other considerations also need to be taken into account when determining maximum loading rates for oil tankers. Precautions against static electricity hazards and pipeline erosion are described in section 7.3.3.2.

7.3.3.1 Venting arrangements

Venting capacity is based on the maximum volume of cargo entering a tank plus an approximate 25% margin to account for gas evolution (vapour growth).

When loading cargoes have a very high vapour pressure, gas evolution may be excessive and the allowance of 25% may prove insufficient. Actions to consider to ensure the capacity of the venting system is not exceeded include closely monitoring that vapour line pressures on inerted tankers and limiting the loading rates on non-inerted tankers throughout the loading period. Note that the vapour growth increases when the liquid levels in the tank are above 80%. On inerted tankers, closely monitor inert gas system pressures, particularly when topping-off during loading 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.

7.3.3.2 Flow rates in loading lines

Depending upon the trade of the tanker, a number of loading rates need to be determined for each cargo tank. These loading rates will 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 rate for static accumulator cargoes into non-inerted tanks.
- A loading rate based on a linear velocity of 7m/sec for bulk loading 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 provided for guidance only and is generally considered a rate above which pipeline erosion may occur at pipe joints and bends.

Where a number of tanks are loaded through a common manifold, the maximum loading rate may be determined by the flow rate through the manifold or drop lines. For this reason, it is important that a constant check is kept on the number of cargo tank valves that are open simultaneously and that a suitable loading rate is determined for the particular loading operation.

7.3.3.3 Rate of rise of liquid in the cargo tank

Small tanks may have larger filling or suction valves than their size normally requires in order to accommodate certain operations. 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 necessary to consider the rate of rise of the liquid in the tank if overfilling is to be avoided.

To exercise control over the rate of liquid rise in any cargo tank, it may be appropriate to set the loading rate to limit the rate of rise of liquid in a cargo tank.

7.3.3.4 Loading rates for ballast tanks

Loading rates for ballast tanks should be determined in the same manner as cargo tanks, taking into account the size of vent outlets using a vent velocity of 36m/sec. Liquid filling rates can be calculated using a pipeline flow rate of 12m/sec, and a similar rate of rise as in section 7.3.3.3 should also be considered where practical.

7.3.4 Monitoring void and ballast spaces

Void and ballast spaces within the cargo tank block should be routinely monitored to check that no leak has occurred from adjacent tanks. Monitoring should include regular atmosphere checks for flammable content and regular sounding/ullaging of the empty spaces (see sections 11.7 and 11.8).

7.4 Power and propulsion systems

While a tanker is berthed at a terminal, its main engines, steering machinery and other equipment essential for manoeuvring should normally be kept ready so the tanker can move away from the berth in the event of an emergency. See section 22.7.1.1 for advice about planned immobilisation.

A terminal may allow some degree of immobilisation of the propulsion plant while the tanker is alongside. However, the tanker must obtain permission from the Terminal Representative or local authority before taking any action affecting the readiness of the tanker to move under its own power.

Any unplanned condition that results in the loss of operational capability, particularly to any safety system, should be immediately communicated to the terminal.

7.5 N/A

7.6 N/A

8 Ship's equipment

This chapter describes equipment that is provided on board tankers for fire-fighting purposes, for gas measurement and for lifting operations. Reference is also made to the need for testing and maintenance procedures for this equipment.

8.1 Shipboard fire-fighting equipment

8.1.1 General

The requirements for tankers' fire-fighting equipment are laid down by the regulations of the particular country where the tanker is registered.

The theory of fire-fighting and the types of fire that may be encountered are discussed in chapter 5.

8.1.2 Tanker fixed fire-fighting installations – cooling

All tankers are provided with a water fire-fighting system consisting of pumps with a permanent underwater connection, a fire-main with hydrant points, fire hoses and couplings, and jet nozzles (or preferably jet/spray nozzles). Enough hydrants are provided and located to ensure that two jets of water can reach any part of the tanker.

In cold weather, prevent the freezing of fire-mains and hydrants 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.

8.1.3 Tanker fixed fire-fighting installations – smothering

One or more of the different smothering systems listed below may be installed on board tankers (also see section 5.3).

8.1.3.1 Carbon dioxide flooding system

This system is designed to fight fires in the engine room, boiler room and pumproom. The system normally consists of a battery of large carbon dioxide cylinders. The carbon dioxide is piped from the cylinder manifold to suitable points with diffusing nozzles. An alarm should be activated in the compartment before the carbon dioxide is released to give personnel time to evacuate.

8.1.3.2 Foam systems

Foam systems are used for fighting fire in the cargo spaces, on the cargo deck, in the pumproom or in the engine spaces. A foam system has storage tanks containing foam concentrate. Water from the fire pumps picks up the correct proportion of foam concentrate from the tank through a proportioner. The foam solution is then conveyed through permanent supply lines to offtake points, fixed foam monitors or, in the case of engine room installations, to fixed dispersal nozzles.

8.1.3.3 Water fog

A water fog system consists of high-pressure water lines and special fog nozzles. A ring of nozzles around the inside of the tank opening effectively blankets a cargo tank hatch fire. Some tankers are also fitted with fixed pressurised water fog systems for protecting specific parts of the engine room, such as oil fuel treatment spaces, boiler firing platforms, small machinery spaces and pumprooms.

8.1.3.4 Water curtain

Some tankers have a fixed system to give a protective water curtain between the cargo deck and the superstructure.

8.1.3.5 Inert gas system

The purpose of an inert gas system is to prevent cargo tank fires or explosions. It is not a fixed fire-fighting installation, but in the event of a fire the system may be useful in controlling the fire and preventing explosions.

8.1.4 Portable fire extinguishers

All tankers are provided with a range of portable fire extinguishers to meet the requirements of the respective legislation.

All fire extinguishers should be in permanent good order and available for immediate use. As a minimum, all fire extinguishers should be formally checked every year for proper location, charging pressure and condition.

Consider providing portable extinguishers, suitable for use on Class A fires (see table 5.1) and dedicated to deployment at the tanker's manifold when in port.

8.1.4.1 Types of portable fire extinguisher

In addition to fire hose reels for water extinguishing of Class A fires involving combustible materials such as wood, paper and fabrics, all tankers are provided with a range of portable fire extinguishers. Table 8.1 gives an overview of the types of extinguisher likely to be found on a tanker and their uses. Class D fires are included mainly for completeness (see section 5.2 Types of fire and appropriate extinguishing agents).

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 8.1: *Portable fire extinguishing media and their uses*

8.2 Gas testing equipment

8.2.1 Introduction

This section provides operational guidance on the use of the gas-measuring instruments described in section 2.4.

The safe management of operations on tankers often depends on the crew's ability to determine the composition of the ambient atmosphere or the atmosphere in an enclosed space.

Tanker personnel need to measure the oxygen, flammable and toxic gas concentrations in an atmosphere. This will enable them to detect the presence of any explosive mixtures, toxic vapours or oxygen deficiency that may present a risk of explosion or hazard.

Tankers fitted with an inert gas system have the additional need to measure the oxygen content of inert gas as part of the safe management of cargo tank atmospheres.

8.2.2 Summary of gas testing tasks

8.2.2.1 Atmosphere monitoring

The external atmosphere should be monitored for:

- Flammable vapour when undertaking hot work (see 9.4 for important restrictions on performing hot work). This is achieved by using a flammable gas indicator, capable of measuring gas to the LFL and with the scale graduated as a percentage of this limit.
- Toxic vapours when loading cargoes containing toxic components and when undertaking gas-freeing operations following the carriage of such cargoes. This is achieved by using an instrument capable of measuring concentrations of toxic gases in the human toxicity range, usually calibrated in ppm.

8.2.2.2 Enclosed space monitoring

Before permitting entry into an enclosed space, measurements must be taken to detect the presence of hydrocarbon gas, to confirm normal oxygen levels and to detect the presence of any toxic vapours (for a full description of the required tests, see section 10.3).

Measurement to ensure that the atmosphere is free of harmful hydrocarbon vapour is undertaken using a flammable gas indicator capable of measuring gas to the LFL and with the scale graduated as a percentage of this limit (% LFL). For tank entry this reading should be below 1% of the LFL.

An oxygen analyser is used to determine that the normal level of oxygen in air of 21% by volume is present.

Where toxic vapour may be present in the space to be entered, the atmosphere should be tested with an instrument capable of measuring concentrations of toxic gases in the human toxicity range, usually calibrated in ppm. The level of any toxic vapours and gases should not be more than 50% of the OEL.

8.2.2.3 Inert gas atmosphere management

Tankers fitted with an inert gas system should be equipped with an oxygen analyser for determining the quality of the inert gas and for measuring the levels of oxygen in the cargo tanks. See section 7.1 for further information on inert gas management.

A gas indicator capable of measuring the percentage of flammable gas by volume in an inerted atmosphere is also required for safe management of operations that include the purging and gas-freeing of cargo tanks.

8.2.3 The provision of gas measuring instruments

It is recommended that a tanker carrying cargoes that are likely to emit a toxic or flammable gas, or to deplete the oxygen in a cargo space, should carry an appropriate instrument for measuring the concentration of gas or oxygen in the air, together with detailed instructions for its use.

Implicit in this recommendation is the requirement that the tanker operator provides the correct instrument for each gas test required. Note that the different gas-testing functions can be incorporated into a multi-function gas measuring instrument.

The gas measurement instrumentation on a tanker should form a comprehensive and integrated system that addresses all the necessary applications identified by the operator. The instruments should be fit for the task to which they are applied, and users should be made aware of the particular applications and limitations of each instrument.

Users of gas measuring instruments should be trained in the proper use of the equipment, to a level suited to their work duties.

8.2.4 Alarm functions on gas measuring instruments

Alarms should only be fitted to instruments that are to be used where an audible warning is necessary, such as a personal gas alarm monitor. Analytical instruments that are used to provide numerical values for gases and vapours for dangerous space entry certification do not need to have an alarm function.

Instruments with an alarm capability should be designed so that the alarm-inhibit and activate function cannot be changed by the operator. This is to avoid the possibility of inappropriate or accidental inhibition of the function.

The use of different instruments for testing atmospheres for entry certification, and for monitoring atmospheres with a personal monitor during the entry operation, reduces the probability of an accident caused by an instrument malfunction. It is therefore recommended that the testing instrument is not used as the personal alarm during the entry operation.

8.2.5 Sampling lines

If fitted, sampling lines should be suitable for the intended service and be impervious to the gases present in the atmospheres being monitored. They should also resist the effects of hot wash water. They should be regularly inspected and cleaned.

8.2.6 Calibration

Calibration should not be confused with operational testing (see section 8.2.7).

The accuracy of measurement equipment should be in accordance with the manufacturer's stated standards. On initial supply, equipment should have a calibration certificate, traceable where possible to internationally recognised standards. Thereafter, procedures for management of the calibration certification process should form part of the SMS. These procedures may include on board calibration in line with the manufacturer's guidelines and/or equipment being periodically landed to a recognised testing facility for calibration, either on a timed basis, or during the tanker's refit, or when the accuracy of the equipment is considered to be outside the manufacturer's stated standards.

Calibration certificates, showing the instrument's serial number, the calibration date and the calibration gas or the method of calibration, together with reference to applicable standards, should be retained on board.

Instruments are typically calibrated using a calibration gas consistent with the use of the instrument, such as propane or butane. The calibration gas used should be marked on the instrument.

The use of an inappropriate gas for calibration could result in erroneous readings during operation, even though the instrument appears to be operating correctly.

Instruments should only be dismantled by people qualified and certified to carry out such work.

8.2.7 Operational testing and inspection

Gas measuring instruments should be tested in accordance with the manufacturer's instructions before starting operations that require their use. Such tests are designed only to ensure that the instrument is working properly. They should not be confused with calibration (see section 8.2.6 above).

Instruments should only be used if the tests indicate that the instrument is giving accurate readings, and that alarms, if fitted, are operating at the pre-determined set points.

Physical checks should include (if applicable):

- Hand pump.
- Extension tubes.
- Tightness of connections.
- Batteries.
- Housing and case.

Instruments not passing these operational tests should be re-calibrated before they are returned to operational use. If this is not possible, they should be removed from service and clearly labelled to say that they are not to be used.

During operations, occasionally check the instrument and sample lines for leaks, since the ingress of air will dilute the sample and give false readings. Leak testing may be carried out by pinching the end of the sample line and squeezing the aspirator bulb. The bulb should not expand as long as the sample line is pinched.

During extended operations, the tanker operator should determine the frequency at which operational checks should be made. The results of the tests and inspections should be recorded.

These procedures should be documented in the SMS (see section 9.1).

8.2.8 Disposable personal gas monitors

Disposable personal gas monitors should be periodically tested in accordance with the manufacturer's recommendations to confirm that they are operating correctly.

Disposable gas detection monitors, which cannot be re-calibrated, should be safely disposed of when the calibration expiry date is reached. For this reason, it is important to record the date when disposable instruments are first commissioned in order to establish their expiry date.

8.3 Lifting equipment

8.3.1 Inspection and maintenance

All shipboard lifting equipment, such as that used to handle cargo transfer equipment and/or gangways, should be examined at intervals not exceeding one 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.
- Strops, slings, chains and other ancillary equipment.

All equipment should be tested by suitably qualified individuals or authorities and be clearly marked with its safe working load, serial number and test date.

All maintenance of lifting equipment should be carried out in accordance with manufacturer's guidelines. Routine checks should be included with the tanker's planned maintenance system.

All records of tests and inspections should be recorded in the lifting equipment register. These records should be available for inspection by Terminal Representatives when their personnel are involved in lifting operations using tanker's equipment.

8.3.2 Training

Lifting equipment should only be operated by personnel who are trained and proven to be competent in its operation.

9 Management of safety and emergencies

Carrying dangerous goods requires measures appropriate to the nature and extent of foreseeable dangers in order to avoid damage or injury and, if necessary, to minimise their effects. To control the health and safety aspects associated with handling dangerous goods, it is recommended that a Safety Management System (SMS) is in place aimed at minimising the risks. When transporting dangerous goods by inland waterways, the ISM Code for seagoing vessels may be used should no equivalent code be available.

This chapter provides guidance on SMSs and introduces a risk-based approach to planning and carrying out hazardous work.

It also provides guidance on risk-assessment and risk-management processes and provides information on the practical application of these processes when managing hot work and other hazardous tasks on board.

Safety on board inland tankers extends to the work of contractors and repair teams. This chapter also addresses the safe management of contractors and repair work outside a shipyard.

Finally, it provides advice on effective management structures and organisation during shipboard emergencies.

9.1 Safety Management Systems

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

The SMS enables the operator's health, safety and environmental protection policy to be implemented effectively. The SMS is regularly audited to verify its suitability and to confirm that it is effective and that stated procedures are being followed.

Although ISGINTT specifies a range of safety management topics, the operator should develop the content and form of its SMS. The SMS must demonstrate that acceptable levels of safety management are in place to protect the inland tanker, 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 tanker and the possible situations that could affect the safety of the tanker or its operation.

These activities and situations will involve varying degrees of hazard to the tanker, its personnel and the environment. Careful assessment of these hazards, and the probability of their occurrence, will determine the severity of the risks. Risk management tools are then applied to accomplish safe completion of the work, ensure compliance with the SMS and provide the objective evidence needed for verification, such as:

- Documented policies, procedures and instructions.
- Documentation of the verification carried out by the Responsible Person of day-to-day operation, when relevant to ensure compliance.

The result of an effective SMS is a safe system of work.

9.2 Risk Management

9.2.1 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.

9.2.2 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 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.

Unintended changes in conditions during a previously assessed event (e.g. worsening weather, loss of a person due to work limits or illness, course changes that increase the vessel's motion) can trigger the need for reassessment. This is more important for lengthy projects or work tasks.

9.2.3 Hierarchy of controls

Table 9.1 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 9.1: *Risk assessment hierarchy of controls*

9.2.4 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.

9.2.5 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.

9.3 Permit to work systems

9.3.1 General

While operators will develop their own procedures for managing all aspects of operations and tasks undertaken, to manage hazardous tasks many choose to include a permit to work system in their SMS.

A permit to work system is a formal written system that is used to control certain types of work. It delivers a risk-based approach to safety management and requires personnel to undertake and record risk assessments in the development of a safe system of work.

Guidance for establishing a permit to work system is contained in a number of publications issued by industry organisations and national safety bodies.

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

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

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

9.3.2 Permit to work systems: structure

The structure of the system and the processes employed have an important role in ensuring that the system delivers the necessary level of safety and operational integrity.

The permit to work system should define:

- Company responsibility.
- Responsibilities for all personnel operating the system.
- Training in the use of the system.
- A measure of the competency of personnel.
- Types of permit and their application.
- Levels of authority.
- Isolation processes.
- Permit issuing procedures.
- Permit cancelling procedures.
- Emergency actions.
- Record keeping.
- Auditing.
- System updating.

The system will determine the appropriate controls to manage the risk associated with each task, and the appropriate management tool to manage the task, as in section 9.3.1 above.

The system need not require that all tasks are carried out 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 and that the process is effective in identifying and managing the risks.

9.3.3 Permit to work systems: principles of operation

A permit to work system should comprise the following steps:

- Identify the task and location.
- Identify the hazards and assess the risks.
- Ensure appropriate competency of personnel who will carry out the work.
- Define the risk control measures – state the precautions and PPE needed.
- Determine communication procedures.
- Identify a procedure and initiate a permit to work.
- Obtain formal approval to perform the work.
- Carry out a pre-work briefing.
- Prepare the work.
- Carry out the work to completion.

- Return the work site to a safe condition.
- Complete the process, keeping records for audit purposes.

9.3.4 Permit to work forms

The permit to work form leads the operator through an appropriate process in a logical, detailed and responsible manner. The permit is produced jointly by those authorising the work and those performing the work. The permit should ensure that all safety concerns are fully addressed.

The structure and content of permit to work forms will be determined by the specific individual requirement of an inland tanker's SMS, but are typically:

- Type of permit.
- Number of permits.
- Supporting documents, e.g. details of isolations, gas test results.
- Location of work.
- Description of work.
- Hazard identification.
- Precautions necessary.
- Protective equipment to be used.
- Period of validity.
- Authorisation for the work including duration, endorsement by the Master or department head.
- Acceptance by those performing the work.
- Management of changes to workforce or conditions.
- Declaration of completion.
- Cancellation.

The issue of a permit does not by itself make a job safe.

Adhering to the requirements of the permit and identifying any deviations from the specified controls or expected conditions, are essential to completing the task safely. The system should also identify any conflicts between tasks being carried out simultaneously on board.

9.3.5 Work planning meetings

Work planning meetings should be held to ensure that operation 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.
- Interference with other tasks.
- 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 SMS and will be determined by the inland tanker's activities.

It may be appropriate to have two levels of meetings: one on a management level and one that addresses the practical issues associated with carrying out specific tasks.

9.3.6 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 Person in Charge (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.
- Stop Work Authority (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, dentify the hazards at the worksite, then move somewhere quieter to finish the toolbox talk.

9.3.7 Stop Work Authority

It is recommended that inland tanker and terminal SMS's 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 13.7).

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.

9.4 Hot work

Warning! The following sections on hot work do not replace any legal obligations to perform hot work under the supervision and/or official approval of a competent authority. Authorities may mandate on-site gas-free inspections before any hot work is undertaken by an authority accredited surveyor. It is best practise to use an authority accredited surveyor for on-site gas-free inspections before any hot work is performed.

A number of fires and explosions have been caused by hot work in, on, or near cargo tanks or other spaces that contain, or have previously contained, flammable substances or substances that emit flammable vapours.

9.4.1 Control of hot work

The SMS should include adequate guidance on the control of hot work and should be robust enough to ensure compliance (see figure 9.2). Absence of guidance should be regarded as prohibition rather than approval.

9.4.2 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 and 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 complete.

For hot work such as electric arc welding (see section 9.5) or gas cutting, establish a safe boundary inside the designated space to prevent arc flash and contain sparks. This area should be bounded 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 operators 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 9.4.4.1).

9.4.3 Hot work outside a designated space

9.4.3.1 General

Hot work should be controlled under the SMS with a permit to work system.

The Master should decide whether the use of hot work is justified and whether it can be done safely. The Master or Responsible Person must approve the completed permit before any hot work can begin.

The usual resource limitations on board an inland tanker mean that only one hot work operation should normally be performed at a time. A separate permit should be approved for each intended task and location.

A risk assessment should be carried out to identify the hazards and assess the risks involved. This will result in a number of risk-reduction measures that will need to be taken to allow the task to be carried out safely.

The risk assessment should identify hazards associated with the risks to fire watch personnel and their means of evacuation in an emergency. The risk assessment should also include the additional PPE required to ensure risk levels are acceptable.

A written plan for undertaking the work should be completed, discussed and agreed by all who have responsibilities in connection with the work.

This plan should define the preparations needed before work starts, the procedures for actually carrying out the work, and the related safety precautions. The plan should also indicate the person authorising the work and the people responsible for carrying out the specified work, including contractors if appropriate (see section 9.7).

A Responsible Person not directly involved in the hot work should be designated to ensure that the plan is followed.

The hot work permit should be issued immediately before the work is to be performed. In the event of a delay to the start of the work, all safety measures should be re-checked and recorded before work actually starts.

Permits are issued under specific conditions. If those conditions change, hot work must stop immediately. The permit should be withdrawn or cancelled until all conditions and safety precautions have been checked and reinstated to allow the permit to be reissued or re-approved.

The work area should be carefully prepared and isolated before hot work starts.

Fire safety precautions and fire extinguishing measures should be reviewed. Adequate fire-fighting equipment must be prepared, laid out and be ready for immediate use.

Fire watch procedures must be established for the area of hot work and for adjacent spaces where the transfer of heat or accidental damage might create a hazard, e.g. damage to hydraulic lines, electrical cables, thermal oil lines, etc. The fire watch should monitor the work and take action in case of ignition of residues or paint coatings. Effective means to contain and extinguish welding sparks and molten slag must be established.

The atmosphere of the area should be tested and be less than 1% LFL.

The work area must be adequately and continuously ventilated and the frequency of atmosphere monitoring must be established. Times of atmosphere monitoring and results should be recorded on the hot work permit.

If it is necessary to carry out hot work in a dangerous or hazardous area the guidance in section 9.4.4 should also be followed.

When alongside a terminal, hot work should only be permitted in line with prevailing national or international regulations, port and terminal requirements, and after all necessary approvals have been obtained.

Isolation of the work area and fire safety precautions should be continued until the risk of fire no longer exists.

Personnel carrying out the work should be adequately trained and have the competency required to carry it out safely and effectively.

A flow chart for guidance is in figure 9.1. The flow chart assumes the work is considered essential for safety or the immediate operational capability of the tanker, and that it cannot be deferred until the next planned visit to a repair yard.

Figure 9.2 depicts how guidance for hot work on an inerted tanker may be presented within the SMS. This is provided as an example for operators to tailor to their own requirement.

9.4.3.2 Hot work in a gas safe area

(intentionally left blank)

9.4.3.3 Hot work inside the machinery space

Hot work inside the main machinery space, when associated with fuel tanks and fuel pipelines, must take into account the possible presence of hydrocarbon vapours in the atmosphere and the existence of potential ignition sources.

No hot work should be carried out on bulkheads of bunker tanks, or within 500mm of such bulkheads, unless that tank is cleaned to hot work standard.

9.4.4 Hot work in dangerous or hazardous areas

9.4.4.1 General

Dangerous or hazardous areas are locations on board or within the terminal where an explosive atmosphere could be present, as defined in section 4.4.2. For inland tankers, this effectively means an area slightly larger than the cargo tank deck, which includes cargo tanks and pumprooms, and the atmospheric space around and above them. No hot work should be undertaken in a dangerous or hazardous area until it has been made safe, and has been proved to be safe, and all appropriate approvals have been obtained.

Any hot work in a dangerous or hazardous area should be subject to a full risk assessment. The guidance in section 9.4.3 should also be followed. Account must be taken of the possible presence of hydrocarbon vapours in the atmosphere and the existence of potential ignition sources.

Hot work in dangerous or hazardous areas should only be carried out when the tanker is in ballast. Hot work should be prohibited during cargo or ballast operations, and when tank cleaning, gas-freeing, purging or inerting. If hot work needs to be interrupted to carry out any of these operations, the permit should be withdrawn or cancelled. On completion of the operation, all safety checks should be carried out once more and the permit re-approved or a new procedure developed.

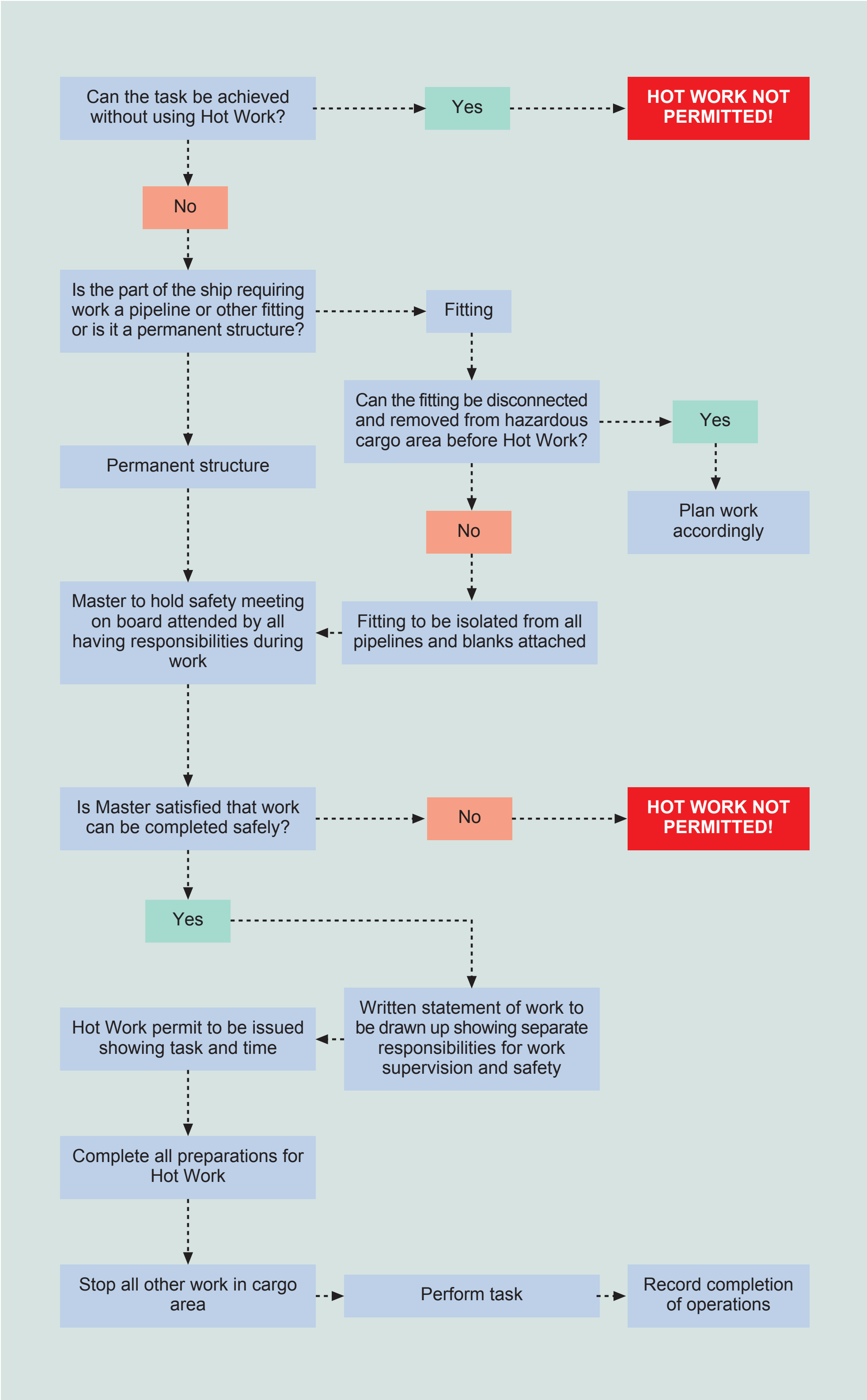


Figure 9.1: *Hot work flow chart*

Work Location Minimum Requirements	Engine room workshop	Other parts of non-hazardous area	Open deck aft of accommodation	Enclosed spaces (other than pumprooms)	Main deck (deck plating)	Work on fixtures/fittings in the main deck area	Work on any cargo-related pipelines incl. heating coils in a cargo tank	Cargo pumprooms	Cargo or ballast tanks
Work planning meeting to be held and risk assessment completed	✓	✓	✓	✓	✓	✓	✓	✓	✓
Work in designated space with shield or curtain erected	✓								
Adequate ventilation	✓	✓		✓			✓	✓	✓
Confirmation from Master or designate that work is OK to proceed	✓								
Tank atmosphere checks carried out and entry permit issued				✓			✓		✓
Tank to be washed and gas freed					✓		✓		✓
Cargo tanks to be purged and inerted to not more than 8% O_2 and not more than 2% HC					✓	✓	✓	✓	✓
Work to be carried out further than 500 mm from the tank deck or bulkheads				✓		✓		✓	
Work to be carried out more than 500 mm from a fuel oil tank deck or bulkheads			✓	✓		✓		✓	
Local cleaning to be carried out as per requirements				✓			✓	✓	✓
All interconnecting pipelines flushed and drained							✓	✓	✓
Tank valves isolated							✓	✓	✓
Hot Work permit to be issued on board		✓							
Hot Work permit issued in agreement with Company			✓	✓	✓	✓	✓	✓	✓
Hot Work permit approved by Master or Responsible Officer		✓	✓	✓	✓	✓	✓	✓	✓

Figure 9.2: *Example of SMS guidance for hot work on an inerted inland tanker*

Where hot work involves entry into an enclosed space, the procedures outlined in chapter 10 for enclosed space entry should be followed. A compartment in which hot work is to be undertaken should be cleaned and ventilated. Particular attention should also be given to the condition of any adjacent spaces.

Adjacent fuel oil bunker tanks may be considered safe if tests give readings of less than 1% LFL in the vapour space of the bunker tank. No hot work should be carried out on bulkheads of bunker tanks, or within 500mm from such bulkheads, unless that tank has been cleaned for hot work.

Adjacent ballast tanks and compartments, other than cargo tanks, should be checked to ensure they are gas-free and safe for hot work. If adjacent ballast tanks and compartments are found to contain hydrocarbon liquid or vapours, they should be cleaned and gas-freed or inerted.

9.4.4.2 Hot work in cargo tanks

To clean the work area, all sludge, cargo-impregnated scale, sediment or other material likely to give off flammable vapour should be removed. The extent of the cleaned area should be established following a risk assessment of the particular work to be carried out. Special attention must be given to the reverse side of frames and bulkheads. Other areas that may be affected by the hot work, such as the area immediately below the work location, should also be cleaned.

Table 9.2 provides guidance on the safe distance for areas to be cleaned and represents minimum requirements that may need to be extended, based on the output of the risk assessment. Cleaning distances are based on the type of work being carried out and the height above the tank bottom.

Consideration should be given to using fire resistant blankets or putting a water bottom in the tank to prevent sparks from falling on to paint coatings.

All interconnecting pipelines to other compartments should be flushed through with water, drained, vented and isolated from the compartment where hot work will take place. Cargo lines may be subsequently inerted or completely filled with water, if considered necessary.

Height of work area	Operator's side			Opposite side		
	Gas cut	Welding	Gouging	Gas cut	Welding	Gouging
0-5 metres	1.5m	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 9.2: *Radius of areas to be cleaned in preparation for hot work in tanks*

Heating coils should be flushed or blown through with steam and proved clear of hydrocarbons.

An adjacent fuel oil bunker tank may be considered safe if tests give a reading of less than 1% LFL in the vapour space of the bunker tank, and the hot work will cause no heat transfer through the bulkhead of the bunker tank.

Non-inerted inland tankers

The compartment where the hot work is to be carried out should be cleaned, gas-freed to hot work standard and be continuously ventilated and monitored.

Adjacent cargo tanks, including diagonally positioned cargo tanks, should either have been cleaned and gas-freed to hot work standard or completely filled with water.

All slops should be either removed from the inland tanker or securely isolated in a closed and non-adjacent tank at least 30 metres from the hot work location. For this purpose, tanks located diagonally should be regarded as adjacent tanks. A non-adjacent slop tank should be kept closed, securely isolated from the inert gas main and isolated from the piping system for the duration of the hot work.

Vapour or vent lines to the compartment should also be ventilated to not more than 1% LFL and isolated.

The possibility of using an external source of inert gas should be considered.

Inerted inland tankers

The compartment where the hot work is to be carried out should be cleaned, gas-freed to hot work standard and be continuously ventilated and monitored.

Adjacent cargo tanks, including diagonally positioned cargo tanks, should either be:

- Cleaned and gas-freed, with hydrocarbon vapour content reduced to not more than 1% LFL and maintained at that level.
- 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, then the space on the other side should also be cleaned to hot work standard.

Consideration should be given to reducing the inert gas pressure for the duration of the hot work to prevent uncontrolled venting.

Inert gas lines to the compartment should be purged with inert gas to not more than 2% hydrocarbon by volume and isolated.

All slops should be either removed from the inland tanker or securely isolated in a non-adjacent tank at least 30 metres from the hot work location. For this purpose, tanks located diagonally should be regarded as adjacent tanks. A non-adjacent slop tank should be kept closed, securely isolated from the inert gas main and isolated from the piping system for the duration of the hot work.

9.4.4.3 Hot work within the cargo tank deck area

On the tank deck

If hot work is to be undertaken on the tank deck or at a height of less than 500mm above the tank deck, it should be classed as hot work within that tank and the appropriate measures complied with (see 9.4.4.2).

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 (where applicable) for the duration of the hot work to prevent controlled 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 either be removed from the ship or securely isolated in a non-adjacent tank at least 30 metres from the hot work location.

Above the tank deck

If hot work is to be undertaken above the tank deck (higher than 500mm), any cargo and slop tanks within a radius of at least 30 metres around the working area should either be:

- Cleaned and gas-freed, with the 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 must be inerted with openings closed.

All slops should be either removed from the inland tanker or isolated in a tank as far as practicable from the hot work location.

Alternatively on non-inerted inland tankers without an inert gas system

All cargo tanks within 30 metres of the work location, including diagonally positioned cargo tanks, should either have been cleaned and gas-freed to hot work standard or completely filled with water.

All slops should be either removed from the inland tanker or securely isolated in the tank furthest (and at least 30 metres) from the hot work location. Vapour or vent lines to the compartment should also be ventilated to not more than 1% LFL and isolated.

The possibility of using an external source of inert gas should be considered.

9.4.4.4 Hot work in the vicinity of bunker tanks

Hot work in the vicinity of bunker fuel tanks should, in general, be treated in the same manner as hot work over the tank deck. No hot work should be carried out on the deck, or within 500mm of such a deck, unless the tank has been cleaned to hot work standard.

Bunker fuel tanks should be clearly identified to avoid any misunderstanding as to their location and extent.

9.4.4.5 Hot work on pipelines

Wherever possible, sections of pipelines and related items, such as strainers and valves, should be removed from the system and repaired in the designated space (see section 9.4.2). Any breaking of lines should comply with the permit to work system for control of hazardous energy.

Where hot work on pipelines and valves needs to be carried out with the equipment in place, the item requiring hot work must be disconnected by cold work, and the remaining pipework blanked off. The item to be worked on should be cleaned and gas-freed to a safe hot work standard, regardless of whether it is removed from the hazardous cargo area.

If the location where the hot work is to be carried out is not in the immediate vicinity of the disconnected pipeline, consideration should be given to continuous ventilation of the pipeline with fresh air and monitoring the exhaust air for hydrocarbon vapour.

Heating coils should be flushed or blown through with steam and proved clear of hydrocarbons.

9.5 Welding and burning equipment

Welding and other equipment used for hot work should be carefully inspected before each use to ensure that it is in good condition. Where required, it must be correctly earthed. When using electric arc equipment, special attention must be paid to ensure that:

- Electrical supply connections are made in a gas-free space.
- Existing supply wiring is adequate to carry the electrical current demand without overloading and causing heating.
- Insulation of flexible electric cables is in good condition.
- The cable route to the work site is the safest possible, only passing over gas-free or inerted spaces.
- The earthing connection is adjacent to the work site and the earth return cable leads directly back to the welding machine. The inland tanker's structure should not be used as an earth return.

9.6 Other hazardous tasks

A hazardous task is defined as a task, other than hot work, which presents a hazard to the inland tanker, terminal or personnel, the performance of which needs to be controlled by a risk assessment process, such as a permit to work system.

It follows that, for each hazardous task, a work permit or controlled procedure should be developed and approved. The permit or controlled procedure should follow the process outlined in section 9.3 and should be discussed with the personnel who are performing the task.

The procedure, approval and record of compliance should be retained within the SMS records.

Hazardous tasks should only be carried out alongside a terminal with prior agreement of the terminal representative.

Examples of such tasks are:

- Enclosed space entry.
- Tank inspections.
- Diving operations.
- Blanking sea chests.
- Extended work aloft or over the side.
- Heavy or unusual lifting operations.
- Work on or adjacent to a pressurised system.
- Testing and launching of lifeboats.
- Work on critical equipment and systems.
- Electrical work.

9.7 Management of contractors

The Master should satisfy himself that whenever contractors or work gangs are employed, arrangements are made to ensure their understanding of, and compliance with, all relevant safe working practices. This is particularly important when they are to be involved in hot work or hazardous tasks. Contractors should be effectively supervised and controlled by a designated Responsible Person.

The contractor should take part in relevant safety meetings to discuss the arrangements for work. Where applicable, the contractor should sign the formal approval relevant to work being undertaken, thereby verifying awareness of the hazards and safety precautions required to reduce the risks to an acceptable level.

9.8 Repairs at a facility other than a shipyard

9.8.1 Introduction

This section deals with repairs that are to be carried out on board an inland tanker that is at a facility other than a shipyard. The guidance in this section supplements, does not replace, the guidance given elsewhere in this publication.

9.8.2 General

When an inland tanker is operational, under way or in port, the inland tanker's personnel carry out their duties in accordance with the tanker's SMS. When a tanker is at a shipyard, the tanker is not operational, and the work is primarily carried out and managed by the shipyard. While it may be monitored and checked by the tanker's personnel, the safety of the tanker and anyone on board generally depends on the shipyard's SMS. There will be occasions when a tanker that is operational is required to carry out repairs using shore labour outside a shipyard or dry dock facility. In these cases, the safety of all on board will depend on the tanker's SMS and all activities should therefore be carried out in line with the SMS.

Repairs may be undertaken while the tanker is:

- At anchor.
- Alongside at a lay-by berth, not normally used for cargo operations.
- Alongside a commercial jetty.
- Under way.

Such repair work is only carried out on an exceptional basis and attention will need to be paid to ensure that the scope of the tanker's SMS fully embraces the planned activities and the exposures to the shore labour employed.

9.8.3 Supervision and control

The Master, Company Superintendent or other specifically appointed person should maintain full control of the repair work, ensuring that the inland tanker is maintained in a safe condition at all times and that all work is carried out in a safe and proper manner.

Specific procedures will be required when the tanker is to be repaired in a 'dead' condition or when there are limitations on the electrical power available.

9.8.4 Pre-arrival planning

Prior to arrival at the repair berth, anchorage or other facility, the initial planning should consider the:

- Type and location of the berth or anchorage.
- Moorings – numbers, type.
- Condition of the tanker – gas-free or inert.
- Safe access – by launch, gangway or other means.
- Number of personnel involved, including contractors.

- Location of work to be undertaken – engine room, cargo spaces, above deck, accommodation, etc.
- Facilities for disposal of slops or sludge.
- Arrangements for permits and certification.
- Port or terminal requirements.
- Availability of main power or main engine(s).
- Emergency procedures on board and ashore.
- Availability of assistance – firefighting, medical facilities, etc.
- Connection to shore side services – water, power, etc.
- Weather.
- Draught and trim limitations (to avoid unnecessary ballast handling).
- Restrictions on smoking and other naked lights.
- Port and ship security arrangements, including ship and port security level.

9.8.5 Mooring arrangements

When moored to a repair berth, the number and size of mooring lines used should be adequate for all likely weather and tidal conditions.

Whenever practicable, an alternative power source should be provided for the deck machinery so that moorings can be adjusted if main power is not available.

On repair berths, the mooring pattern may be restricted due to crane movements or other activity on the dock side. Such restrictions should be taken into account when planning the berthing of the tanker.

Moorings should be clear of hot work areas or other locations where the lines may be damaged by the repair work in progress.

When at anchor, it may be necessary to use extra cable, particularly if the main engine(s) will not be available at any time.

9.8.6 Shore facilities

Whenever practicable, the inland tanker should be physically isolated from regular terminal facilities or berths where other tankers are being worked.

If any repairs are to be carried out at the same time as cargo handling operations, specific permission should be granted by the terminal operators.

The Master should establish whether any significant operations are to take place involving other vessels in the vicinity of the berth at which repairs are being undertaken, i.e. departure/arrival of other vessels, bunkering, fuel oil transfer, etc.

The Master should be familiar with any specific safety requirements of the facility and/or harbour authorities.

There should be safe means of access at all times with guard rails and safety nets as appropriate. The number of access points should be sufficient to allow quick evacuation of all personnel on board. The gangway should be monitored at all times and a gangway watch – or an equivalent technical solution – should be posted to control access to the vessel (see chapter 6).

On a lay-by berth where the tanker is not gas-free, a sign should be placed at the foot of the gangway worded: “No unauthorised access. This tanker is not gas-free.”

Port security plans should be implemented and followed as appropriate.

It is advised to document the status of the crew and guests and specify if the person is on board or ashore. This is especially true during long duration repairs or port-stays making the tracking of personnel on board the tanker difficult during an emergency. Contractors should advise the Master of the number and movement of workers on board each day during the repair period.

Procedures for the use of cranes or other lifting equipment should be determined upon arrival.

Garbage disposal procedures should be agreed between the tanker and the facility, with regular disposal of accumulated garbage being arranged.

Emergency alarm signals should be agreed and, whenever practicable, a drill held before repair work starts. Further drills should be arranged when repairs are to be carried out over an extended period.

Any restrictions on activities such as bunkering, storing or taking lube oils are to be agreed.

9.8.7 Pre-work safety meeting

Work planning meetings should be held before any work starts and on each subsequent work day.

Work planning meetings will normally include representatives from the tanker and all the contractors involved.

The prime function of these meetings is to ensure that all personnel involved are aware of the daily schedule, the interrelation between contractors, particular areas of concern and special precautions to be taken, etc.

9.8.8 Work permits

Permits should be issued for the relevant repair work jobs, including any repairs being carried out by inland tanker staff. In particular, permits 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. Copies should also be retained by the person in charge (PIC) of the operation.

All personnel involved should be made fully aware of the requirements for, and benefits of, the work permit system, and should be advised of restrictions on starting any 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.

9.8.9 Tank condition

Whether the inland tanker is gas-free will depend on the work being undertaken and the specific port or facility regulations.

A certified chemist should test all cargo/ballast spaces for oxygen and hydrocarbon content. The conditions of all tanks and void spaces should be included on the chemist's certificate.

As a minimum, gas-free certificates should be issued daily.

If cargo tanks are not required to be gas-free and the tanker is inert, positive inert gas pressure should be maintained within the tanks at all times.

9.8.10 Cargo lines

All cargo lines on deck, in the tanks and in the pumproom, including those lines and pumps that may not have been used for recent cargo or tank cleaning operations, should be thoroughly washed and drained. This includes any dead ends in the system.

The automatic valve system should be isolated in a way to prevent unintentional operation of cargo valves during the work process. Appropriate notices should be posted and the people in charge of the relevant repair team(s) should be advised.

9.8.11 Fire-fighting precautions

9.8.11.1 Fire water

Fire-mains should be continuously pressurised, either by the inland tanker's pumps or from a shore supply.

There should be an agreed pressure for the fire-mains, which should be maintained at all times.

9.8.11.2 Fire patrols

There should be an agreed procedure for fire patrols on board.

Fire patrols can be provided either by the inland tanker's crew or by shore contractors.

Each member of the fire patrol should be fully aware of the procedure for raising the alarm and the action to take in an emergency.

All areas where hot work is being carried out should be monitored by fire patrols at all times.

9.8.12 Dedicated Safety Responsible Person

A dedicated Safety Responsible Person should be appointed to co-ordinate the permit and certification processes associated with the repair period.

The dedicated Safety Responsible Person should be fully aware of all their duties and responsibilities.

9.8.13 Hot work

The following supplements and does not replace the guidance given in section 9.4, which should also be followed for any repair activities involving hot work.

Hot work should be prohibited within or on the boundaries of cargo tanks, ballast tanks, slop tanks, bunker tanks, pumprooms and forward cofferdams, including the deck and inland tanker's shell plating, except when special preparations have been made before entering the berth or facility and the necessary special conditions have been met.

Use of electrical welding equipment should be controlled and correct grounding cables should be used. Welding current should not be returned to the transformer via the tanker's hull.

Hot work should not be carried out within 30 metres of any non-gas free spaces and always subject to local authority regulations.

Notices should be posted at the tank access, at minimum, to indicate the current state of any tank or void space, e.g. stating whether it is gas-free and suitable for hot work or only safe for entry.

Hot work should be suspended immediately if any of the specific safety requirements cannot be complied with.

Any hot work on or above the weather decks should be stopped if the inert gas pressure reaches the relieving pressure of the pressure/vacuum valves. If it is necessary to release tank pressure to atmosphere, all work should be suspended until the operation has been completed. Consideration may need to be given to clearing the deck area of personnel during venting, especially when there is the possibility of toxic gas (e.g. H_2S) being present. A new permit should be issued before resuming work.

9.9 Shipboard emergency management

9.9.1 General

The SMS should require that the operator establishes procedures to identify, describe and respond to potential emergency shipboard situations. This section provides guidance on meeting this responsibility by addressing those aspects covered by the scope of this guide.

9.9.2 Inland tanker emergency plan

9.9.2.1 Preparation

Planning and preparation are essential if personnel are to deal successfully with emergencies on board inland tankers. The Master and crew should consider what they would do in the event of various types of emergency, such as fire in cargo tanks, the engine room or accommodation, a person collapsing in a tank, the tanker breaking adrift from her berth, and the emergency release of a tanker from her berth.

They will not be able to foresee in detail what might occur in emergencies, but good advance planning will result in quicker and better decisions and a well-organised reaction to the situation.

The following information should be readily available:

- Type of cargo, amount and disposition.
- Location of other hazardous substances.
- General arrangement plan.
- Stability information.
- Fire-fighting equipment plans.

9.9.2.2 Emergency organisation

An emergency organisation should be set up for mobilisation in an emergency. The purpose of this organisation will be to raise the alarm, locate and assess the incident and possible dangers, and to organise manpower and equipment. Reference should be made to the SMS.

9.9.2.3 Preliminary action

The person who discovers the emergency must raise the alarm and follow the procedures in the SMS.

9.9.2.4 Inland tanker'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 ship's whistle, between four and six seconds each, or by some other locally required signal.

9.9.2.5 Fire control plans

Fire control plans must be permanently displayed in prominent positions showing clearly, for each deck, the location and particulars of all fire-fighting equipment, dampers, controls, etc. When the inland tanker is in port, these plans could also be displayed, or be readily available, outside the accommodation block to help shore-based fire-fighting personnel.

9.9.2.6 Inspection and maintenance

Fire-fighting equipment should always be ready for immediate use and should be checked frequently. The dates and details of such checks should be recorded and indicated on the appliance. The inspection of all fire-fighting and other emergency equipment should be carried out by a Responsible Person and any necessary maintenance work completed without delay.

9.9.2.7 Training and drills

Inland tanker personnel should be familiar with the theory of firefighting outlined in chapter 5 and should receive instruction in the use of fire-fighting and emergency equipment. Practices and drills should be arranged at intervals to ensure that personnel remain familiar with the equipment.

If an opportunity arises for a combined fire practice or 'table-top' drill with shore personnel at a terminal (see section 20.2.8), the Master should make an officer available to show the shore personnel the location of portable and fixed fire-fighting equipment on board and also to instruct them on any design features of the tanker that may require special attention in case of fire.

9.9.3 Actions in an emergency

9.9.3.1 Fire on an inland tanker at anchor or under way

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 5.2). 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.

9.9.3.2 Emergencies in port

Emergencies either on board or adjacent to the inland tanker when it is in a port are addressed in section 26.5, as action taken will be the joint responsibility of the Master and the port or terminal authority.

9.9.3.3 Jettison of cargo

Jettisoning cargo is an extreme measure justified only for the purpose of securing the safety of the ship or saving life at sea. A decision to jettison cargo 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.
- Maintain records in relevant logbooks.

9.9.3.4 Follow-up

As soon as possible after an incident, there should be a thorough check of all the equipment used. Portable extinguishers should be re-filled or replaced with spares from stock and breathing apparatus bottles should be recharged. Foam systems should be flushed through with water.

Post-incident discussion should address what lessons can be learned and how contingency plans can be further developed.

10 Enclosed spaces

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 13).

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 inland 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 13).

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.

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.

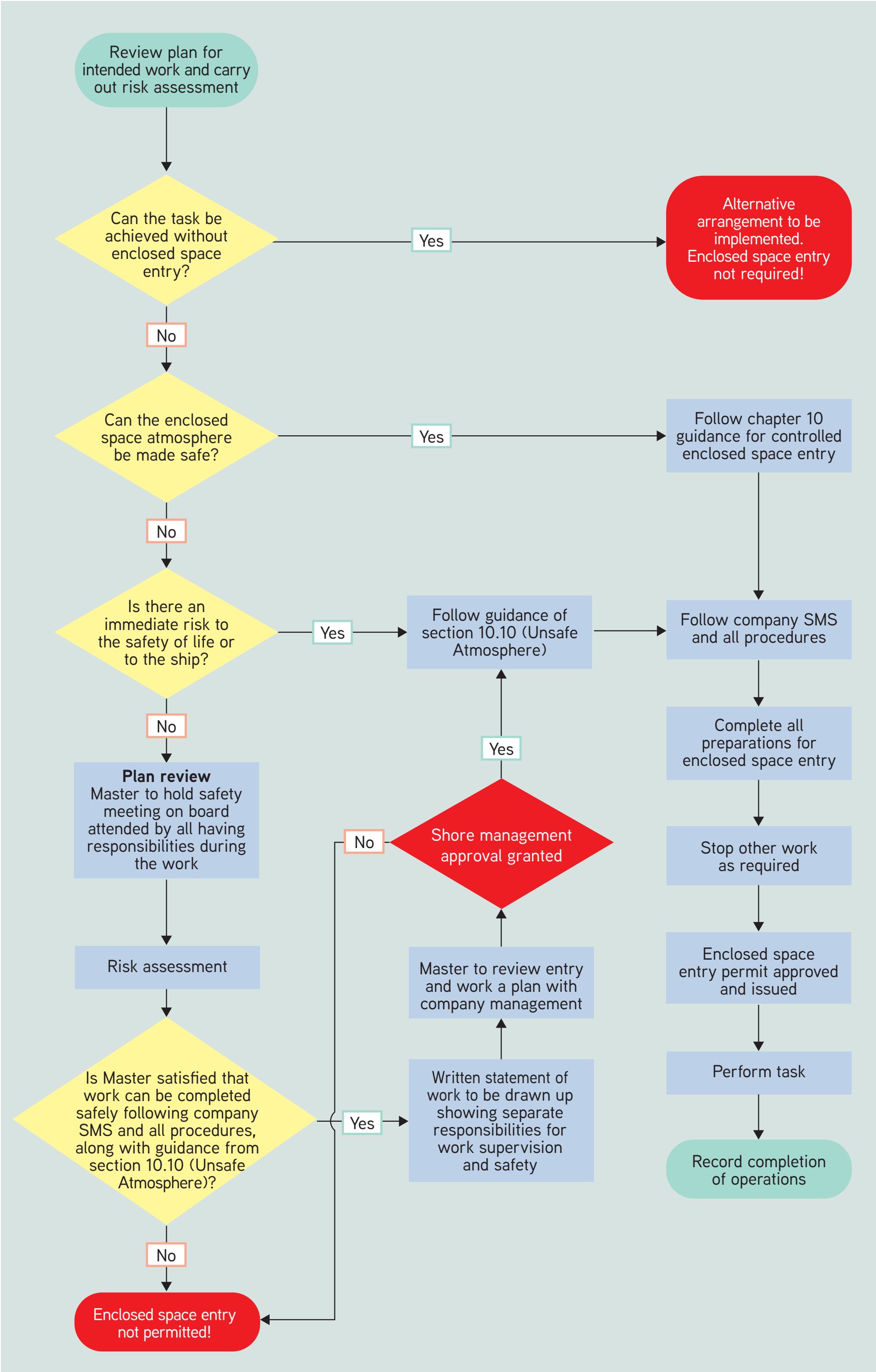


Figure 10.1: *Enclosed space entry decision flowchart*

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 (see section 9.3.6) 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 9.2.3) 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	Sludge and other tanks
Fuel tanks	Aft and Fore Peak tanks	Boilers
Ballast tanks	Cofferdams	Engine crank cases
Cargo pumprooms	Void spaces	Engine scavenge spaces
Sewage tanks	Lube oil tanks	Thruster spaces
Bunker boom foundations	Hydraulic wheelhouse riser	

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
	Gas bottle storage lockers	Carbon dioxide (CO_2) rooms
Lockers within the cargo area e.g. Sample Lockers	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 20.8% 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.

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.

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.

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 simultaneous operations (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 9.2.2 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 lock-out/tag-out (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

N/A

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 requirements of all local regulations MUST be followed, with 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.

10.11.3 Cargo pumproom entry precautions

Where cargo pumprooms are fitted, the requirements of all local regulations MUST be followed. 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.

10.11.4 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.

10.11.5 Cargo pumproom ventilation

Given the potential presence of hydrocarbon gas in the pumproom, mechanical ventilation by extraction is required in a safe atmosphere.

Ships 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. The ventilation system must be capable of providing the minimum number of changes of air required by the inland tankers regulatory or local requirements. This capacity must be based upon the total volume of the service space.

10.12 Respiratory Protective Equipment

Several different types of RPE are available on tankers.

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.

10.12.1 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, noting that when entering enclosed spaces using this equipment it can be very noisy, making it harder to hear the alarm.

- 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.

10.12.2 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.

10.12.3 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.

10.12.4 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.

10.12.5 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.

10.12.6 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.

11 Shipboard operations

This chapter provides information on the full range of shipboard operations, including loading and discharging of cargo, hose clearing, tank cleaning and gas-freeing, ballasting, tanker-to-tanker transfers and mooring.

The chapter also includes information on the safe handling of particular cargoes, such as static accumulator oils, those having a high vapour pressure and those containing hydrogen sulphide.

Other operations that are addressed include the use of vapour emission control systems and efficient stripping.

11.1 Cargo operations

11.1.1 General

All cargo operations should be carefully planned and documented well in advance of their execution. The details of the plans should be discussed with all personnel on the tanker and at the terminal. Plans may need to be modified following consultation with the terminal and changing circumstances, either on board or ashore. Any changes should be formally recorded and brought to the attention of all personnel involved with the operation. Chapter 22 contains details of cargo plans and communications regarding them.

11.1.2 Setting of lines and valves

Before starting any loading or discharging operation, the tanker's cargo pipelines and valves should be set as per the required loading or discharging plan by a Responsible Person, and independently checked by other personnel.

11.1.3 Valve operation

To avoid pressure surges, valves at the downstream end of a pipeline system should not be closed against the flow of liquid, except in an emergency. This should be stressed to all personnel responsible for cargo handling operations, both on the tanker and at the terminal (see section 11.1.4 below).

In general, where pumps are used for cargo transfer, all valves in the transfer system (both tanker and shore) should be open before pumping begins, although the discharge valve of a centrifugal pump may be kept closed until the pump is up to speed and the valve then opened slowly. In the case of tankers loading by gravity, the final valve to be opened should be that at the shore tank end of the system.

If the flow is to be diverted from one tank to another, either the valve on the second tank should be opened before the valve on the first tank is closed, or pumping should be stopped while the change is made. Valves that control liquid flow should be closed slowly. The time taken for power-operated valves to move from open to closed, and from closed to open, should be checked regularly at their normal operating temperatures.

11.1.4 Pressure surges

The incorrect operation of pumps and valves can produce pressure surges in a pipeline system.

These surges may be severe enough to damage the pipeline, hoses or metal arms. One of the most vulnerable parts of the system is the tanker-to-shore connection. Pressure surges are produced upstream of a closing valve and may become excessive if the valve is closed too quickly. They are more likely to be severe where long pipelines and high flow rates are involved.

Where the risk of pressure surges exists, information should be exchanged between the tanker and the terminal, and written agreement reached concerning the control of flow rates, the rate of valve closure, and pump speeds. This should include the closure period of remotely controlled and automatic-shutdown valves. The agreement should be included in the operational plan (see section 16.8).

11.1.5 Butterfly and non-return (check) valves

Butterfly and pinned-back non-return valves in tanker and shore cargo systems have been known to slam shut when cargo is flowing through them at high rates, setting up large surge pressures which can cause line, hose or metal arm failures and even structural damage to jetties. These failures are usually a result of the valve disc not being completely parallel to, or fully withdrawn from, the flow when in the open position. This can create a closing force that may shear either the valve spindle (in the case of butterfly valves) or the hold open pin (in the case of pinned-back non-return valves). It is important to check that all such valves are fully open when they are passing cargo.

11.1.6 Loading Procedures

11.1.6.1 General

The responsibility for safe cargo-handling operations is shared between the tanker and the terminal, and rests jointly with the tanker's Master and the Terminal Representative. The manner in which the responsibility is shared should be agreed between them and ensure that all aspects of the operations are covered.

11.1.6.2 Joint agreement on readiness to load

Before starting to load cargo, the Responsible Person and the Terminal Representative should formally agree that both the tanker and the terminal are ready to do so safely.

11.1.6.3 Emergency shutdown system

An emergency shutdown procedure and alarm should be agreed between the tanker and the terminal, and then recorded on an appropriate form.

The agreement should designate those circumstances in which operations must be stopped immediately.

Due regard should be given to the dangers of a pressure surge associated with any emergency shutdown procedure (see section 16.8).

Tankers can be equipped with following emergency shut down systems:

During loading

If provided with a shutdown system, cargo tank high-level sensors are installed in each cargo tank. When activated, they should give a visual and audible alarm on board and at the same time activate an electrical contact in the form of a binary signal that interrupts the electric current loop provided by the shore facility and initiates measures at the shore to prevent overflowing during loading.

The signal should be transmitted to the shore facility via a watertight two-pin plug of a connector device in accordance with (e.g.) standard EN 60309-2: 1999 for direct current of 40-50V, identification colour white, position of the nose 10h.

The plug should be permanently fitted to the tanker, close to the manifold position.

The high-level sensor should also have the capability of shutting down the tanker's pumps when discharging.

It is recommended that the high-level sensor is independent of the level alarm device.

During discharging

During discharging by means of the onboard pump, a shutdown system will make it possible for the shore facility to stop the tanker's pumps. For this purpose, an independent, intrinsically safe circuit, fed by the vessel, is switched off by the shore facility via an electrical contact.

It should be possible for the binary signal of the shore facility to be transmitted via a watertight two-pole socket or a connector device in accordance with (e.g.) standard EN 60309-2: 1999, for direct current of 40-50V, identification colour white, position of the nose 10h.

This socket should be permanently fitted to the vessel, close to the shore connections of the transfer system.

11.1.6.4 Supervision

The following safeguards should be maintained throughout loading:

- A Responsible Person should be on watch and enough crew be on board to deal with the operation and security of the tanker. A continuous watch of the tank deck should be maintained.
- The agreed tanker-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 Person and the Terminal Representative should each confirm that the communications system for the control of operations is understood by them and by the personnel on watch and on duty.
- The standby requirements for the normal stopping of pumps on completion of cargo transfer, and the emergency stop system for both the tanker and terminal, should be fully understood by all personnel concerned.

11.1.6.5 Inert gas procedures

Before loading starts, the inert gas plant, if installed and applicable, should be closed down. The inert gas pressure in the tanks to be loaded should also be reduced.

11.1.6.6 Loading

A. Closed loading

For effective closed loading, cargo should be loaded with the ullage, sounding and sighting ports securely closed.

For most volatile products, local, national or international legislation may prohibit the venting of cargo vapours to the atmosphere. If this is the case, closed loading has to be used in conjunction with vapour balancing with the loading terminal. In this case, the terminal must ensure that the maximum vapour pressure inside the cargo tank of the tanker will not reach the setting of the high-pressure velocity valve at any stage of the operation.

If the cargo vapours displaced by the incoming cargo cannot be balanced to the terminal, and as for a safety measurement, it must be possible to vent these vapours to the atmosphere through high-velocity valves to ensure these gases are taken clear of the cargo deck. Devices fitted to vent stacks to prevent the passage of flames should be regularly checked to confirm they are clean, in good condition and correctly installed.

To undertake closed loading, the vessel should be equipped with ullaging equipment that allows the tank contents to be monitored without opening tank apertures (see section 11.8.1).

There is a risk of overfilling a cargo tank when loading under normal closed conditions. Due to the reliance placed on closed gauging systems, they should be fully operational, and a backup provided in the form of an independent overfill alarm arrangement. The alarm should provide audible and visual indication and be set at a level that will enable operations to be stopped before the tank is overfilled. Under normal operations, the cargo tank should never be filled higher than the level set for the overfill alarm.

Individual overfill alarms should be tested at the tank before loading starts to ensure they are operating properly, unless the system is provided with an electronic self-testing capability that monitors the condition of the alarm circuitry and sensor, and confirms the instrument set point.

After testing the overfill alarms, if it appears the overfill alarm is not working properly loading should not start.

On vessels without inert gas systems, this equipment should comply with the precautions highlighted in section 11.8.2.

B. Open loading

For some products, local, national or international legislation may allow displaced gas to be vented through cargo tank sighting ports, provided they are protected with a flame screen that is a good fit, clean and in good condition. In all cases the gases must be taken clear of the cargo deck.

If it is expected that flammable cargo vapours are accumulating on the cargo deck, loading must stop immediately.

11.1.6.7 Starting to load alongside a terminal
When all necessary terminal and tanker valves in the loading system are open, and the tanker has signified its readiness, loading can start. The initial flow should be at a slow rate, whenever possible by gravity and to a single tank. The shore pumps should not start until the system has been checked and the tanker advises that cargo is being received in the correct tank(s). When the pumps have been started, the tanker/shore connections should be checked for tightness until the agreed flow rate or pressure is reached.

11.1.6.8 N/A
11.1.6.9 N/A
11.1.6.10 N/A
11.1.6.11 Loading through pumproom lines
The increased risk of leaks in the pumproom means it is not good practice to load cargo via pumproom lines. Whenever possible, cargo should be loaded through drop lines within the cargo tank area, with all pumproom valves closed.

11.1.6.12 Cargo sampling when loading starts
Where facilities exist, a sample of the cargo should be taken as soon as possible after loading has started. This will allow the product's visual quality to be checked to ensure the correct grade is being loaded. This should be done before opening up subsequent tanks for loading (see appendix 7).

On non-inerted tankers loading static accumulator cargoes, precautions against static electricity hazards should be observed when taking the sample (see section 11.1.7).

11.1.6.13 Periodic checks during loading
Throughout loading, the tanker should monitor and regularly check all full and empty tanks to confirm that cargo is only entering the designated cargo tanks and that there is no escape of cargo into pumprooms or cofferdams.

The tanker should check tank ullages/innages at least hourly and calculate a loading rate. Cargo figures and rates should be compared with shore figures to identify any discrepancy.

On tankers where stress considerations may be critical, hourly checks should include, where possible, the observation and recording of the shear forces, bending moments, draught and trim and any other relevant stability requirements particular to the tanker. This information should be checked against the required loading plan to confirm that all safe limits are heeded and that the loading sequence can be followed, or amended, as necessary. Any discrepancies should be reported immediately to the Responsible Person.

Any unexplained drop in pressures, or any marked discrepancy between tanker and terminal estimates of quantities transferred, could indicate pipeline or hose leaks, in which case cargo operations should be stopped until investigations have been made.

The tanker should carry out frequent inspections of the cargo deck and pumproom to check for any leaks. Overside areas should likewise be checked regularly.

11.1.6.14 Fluctuation of loading rate
The loading rate should not be substantially changed without informing the tanker.

11.1.6.15 Pumping from the terminal stops
Many terminals require a standby period for stopping pumps and this should be understood and noted as discussed under item 24 of the guidelines for completing the tanker/shore safety checklist before loading starts (see section 26.4).

11.1.6.16 Topping-off on the tanker
The tanker should advise the terminal when tanks are to be topped-off and give the terminal enough time to reduce the loading rate to permit effective control of the flow on the tanker. After topping-off individual tanks, master valves should be closed, where possible, to provide two-valve segregation of loaded tanks. The ullages/innages of topped-off tanks should be

checked from time to time to ensure that overflows do not occur as a result of leaking valves or incorrect operations. In general, the tanker should give the terminal notice when the last cargo tank will be loaded.

The number of valves to be closed during the topping-off period should be reduced to a minimum.

The tanker should not close all its valves against the flow of product.

Where possible, loading should be completed by gravity. If pumps have to be used to the end, their delivery rate during the standby time should be regulated so that shore control valves can be closed as soon as the tanker asks. Shore control valves should be closed before the tanker's valves.

11.1.6.17 Checks after loading

After loading is completed, a Responsible Person should check that all the required valves in the cargo system are closed, all appropriate tank openings are closed and that pressure/vacuum (P/V) relief valves are set correctly.

11.1.7 Loading static accumulator oils

11.1.7.1 General

Petroleum distillates often have electrical conductivities of less than 50pS/m and thus fall into the category of static accumulators.

Since the conductivities of distillates are not normally known, they should all be treated as static accumulators unless they contain an antistatic additive that raises the conductivity of the product above 50pS/m (see section 11.1.7.9). A static accumulator may carry enough charge to constitute an incendive ignition hazard during loading into the tank, and for up to 30 minutes after loading is completed.

Bonding (see section 3.2.2) is an essential precaution for preventing electrostatic charge accumulation and its importance cannot be over-emphasised. However, while bonding assists relaxation, it does not prevent accumulation and the production of hazardous voltages. Bonding therefore should not be seen as a universal remedy for eliminating electrostatic hazards.
This section describes methods for controlling electrostatic generation by preventing charge separation, which is another essential precaution (see section 3.1.2).

11.1.7.2 Controlling electrostatic generation

Electrostatic discharge is a hazard associated with the handling of flammable products.

FAILURE TO FOLLOW THE GUIDANCE GIVEN IN THIS SECTION WILL LEAD TO THE HAZARDOUS CONDITIONS REQUIRED FOR ELECTROSTATIC IGNITION ACCIDENTS TO OCCUR.

When a tank is known to be in an inert condition, no antistatic precautions are necessary.

If a flammable atmosphere is possible within the tank, then specific precautions will be required for maximum flow rates and for safe ullaging/innaging, sampling and gauging procedures when handling static accumulator products.

Mixtures of oil and water constitute a potent source of static electricity. Extra care should therefore be taken to prevent excess water and unnecessary mixing.

11.1.7.3 During initial filling of a tank

The generally accepted way to control electrostatic generation in the initial stages of loading is to restrict the velocity of oil entering the tank to 1m/sec until the tank inlet is well covered and all splashing and surface turbulence has stopped.

The 1m/sec limit applies in the branch line to each individual cargo tank and should be determined at the smallest cross-sectional area, including valves or other piping restrictions in the last section before the tank's loading inlet.

Minimum diameter of piping* (mm)	Approx. flow rate (m^3/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

* Note that the diameters given are nominal diameters, which are not necessarily the same as the actual internal diameters.

Table 11.1: *Rates corresponding to 1m/sec*

Table 11.1 shows approximate volumetric flow rates that correspond to a linear velocity of 1m/sec in piping of various diameters.

The reasons for such a low linear velocity as 1m/sec are:

1. At the beginning of filling, there is the greatest likelihood of water being mixed with the oil entering the tank. Mixtures of oil and water are a highly 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 the dispersal of any water present, so that it quickly settles to the bottom of the tank where it can lie relatively undisturbed when the loading rate is subsequently increased.
3. A low product-velocity at the tank inlet minimises the formation of mists that may accumulate a charge, even if the oil is not considered to be a static accumulator. This is because the mist droplets are separated by air, which is an insulator. A mist can result in a flammable atmosphere even if the liquid has a high flashpoint and is not normally capable of producing a flammable atmosphere.

Figure 11.1 is a flow chart to help in deciding the precautions that need to be taken when loading static accumulator cargoes.

11.1.7.4 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.

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 11.1.7.3).

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.

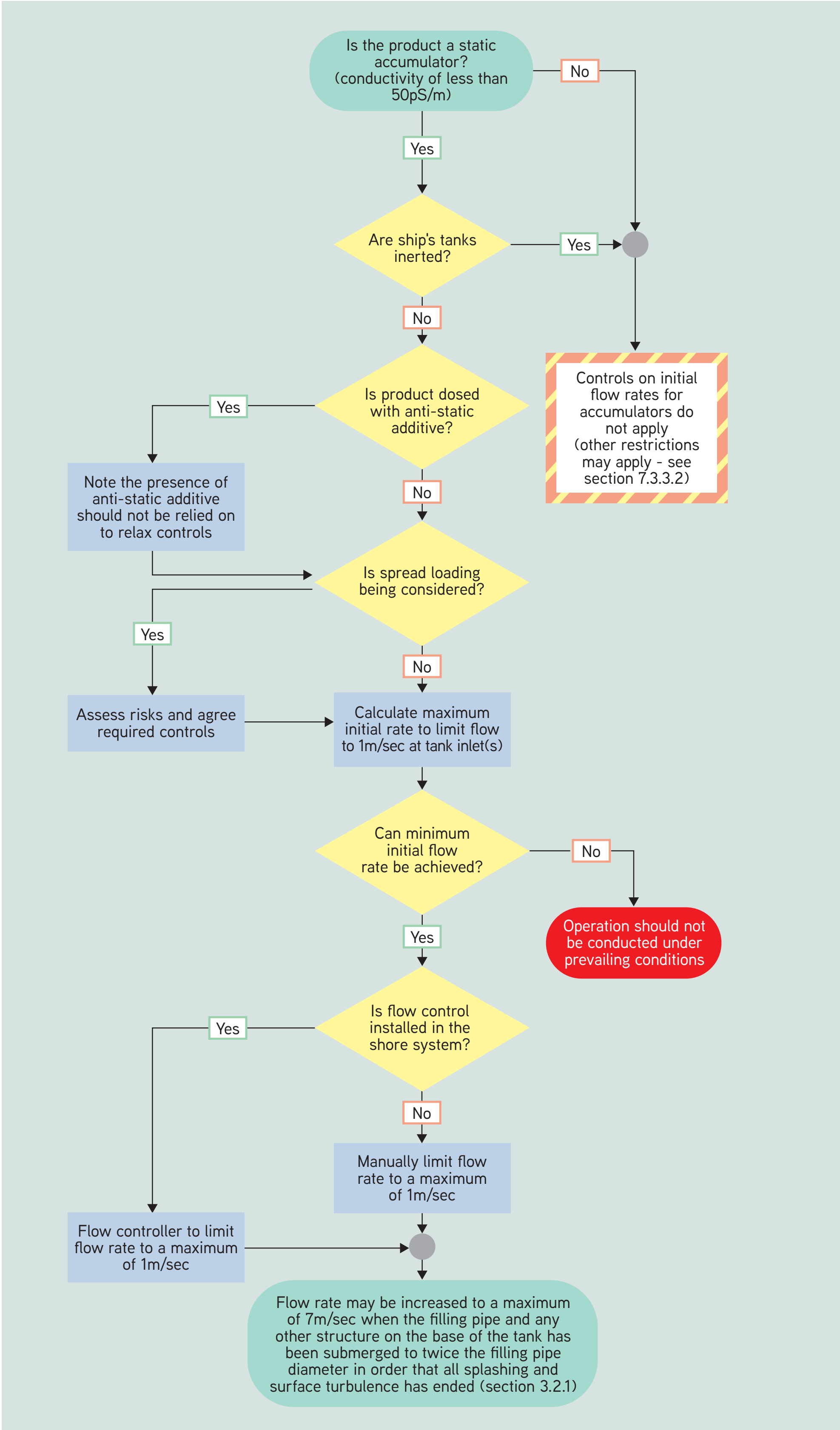


Figure 11.1: *The control hazards associated with the initial loading of static accumulator cargoes*

11.1.7.5 Examples

Initial loading phase

Figure 11.2 shows the pipeline arrangements for a vessel loading a static accumulator product at a berth. The table defines the pipeline sizes and the volumetric flow rates at a velocity of 1m/sec. For initial loading to two cargo tanks, the limitation will allow a loading rate of 366m^3/hr to be requested in the example given (see also table 3.2).

11.1.7.6 Practical considerations

In practice, not all terminals are equipped with flow control devices to regulate the loading rate and therefore may not be able to establish a loading rate to one cargo tank equivalent to a velocity of 1m/sec. Some terminals achieve, or try to achieve, a low loading rate by starting to load by gravity flow alone.

11.1.7.7 Spread loading

Spread loading is the practice of starting to load via a single shore line to several of the tanker's cargo tanks simultaneously where it is necessary to mitigate a terminal's lack of flow control. The aim of this practice is to achieve a loading rate that will give a maximum velocity at each tank inlet of 1m per second.

Spread loading presents a number of potentially significant static-generation risks that should be assessed and properly managed if this practice is to be used safely. For example:

- Uneven flow in the tanker's cargo lines can create a backflow of vapour (gas or air) from other open tanks to the tank that is receiving product. This eductor effect will create a two-phase mixture of product and vapour that will result in increased turbulence and mist formation within the tank.
- The possibility of exceeding 1m/sec product velocity at one tank inlet due to uneven distribution of product between the open tanks.

The following precautions should be taken to manage the risks associated with the spread loading of static accumulator cargoes:

- The overall loading rate should be selected 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 made to ensure an equal flow distribution between cargo tanks.
- Not more than four cargo tanks should be loaded at any one time.
- Tank inlet valves should not be used to control cargo flow in the initial loading phase. Their use will reduce the cross-sectional area of the inlet, resulting in increased tank inlet velocity, greater turbulence and mist formation. If it is necessary to throttle valves to control flow rate, this should be done upstream of the tank valves.
- Managing the risks inherent in spread loading will require a risk assessment process to be followed. The risk assessment should consider:
  - The terminal's piping configuration, including flow control capability.
  - The tanker's piping configuration.
  - The tanker's cargo tank condition, e.g. previous cargo, tank atmosphere and physical condition (such as the integrity of heating coils).
  - The product to be loaded and the potential for generating a flammable atmosphere.

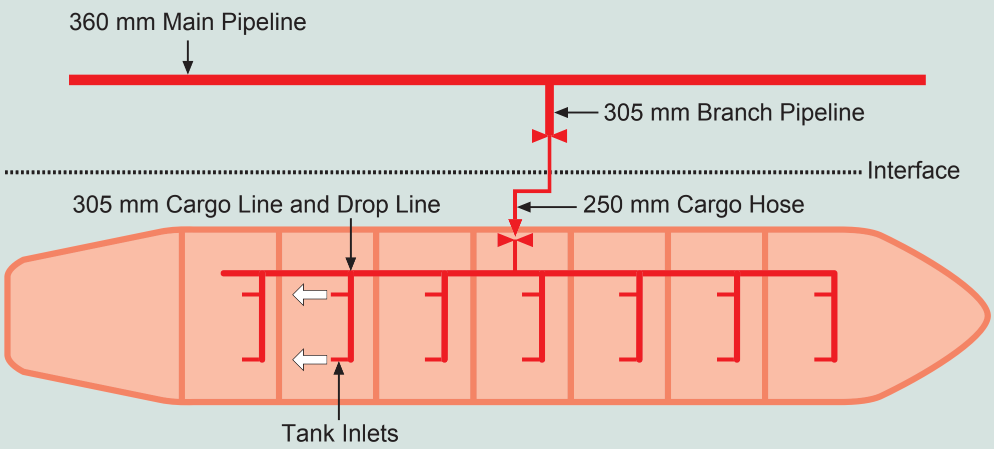
Spread loading should only be carried out when the tanker and the terminal are both satisfied that the risks have been identified and that appropriate risk-response measures have been taken to minimise, avoid or eliminate them.

11.1.7.8 Limitation of product velocity (loading rates) after the initial filling period (bulk loading)

After the initial filling period, electrostatic-generating processes such as mist formation and stirring up tank bottoms by turbulence are suppressed by the rising liquid level, and the concern changes to ensuring that excessive charge does not accumulate on the bulk liquid. This is also done by controlling the flow rate, but the maximum acceptable velocity is higher than for the initial filling period, provided the product is ‘clean’ as defined in section 3.2.1.

When the tank bottom is covered and all splashing and surface turbulence has stopped, the rate can be increased to the lesser of the tanker or shore pipeline and pumping system maximum flow rates consistent with proper control of the system. Practice and experience indicate that hazards do not arise if the product velocity is less than 7m/sec. Some national codes of practice also suggest 7m/sec as a maximum value. However, a number of 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 empirical relationships for safe loading have come from experiments limited to a maximum flow of 7m/sec.)

Only where well-documented experience indicates that higher velocities can be safely used should be limit of 7m/sec be replaced by an appropriate higher value.



Determining the Initial Loading Rate

Line	Diameter	Flow Rate (m^3/hr) at 1 m/sec Flow
Main Shore Pipeline	360	320
Shore Branch Line	305	362
Hose	250	183
Ship’s Cargo and Drop Line	305	262
Tank Inlets	250	183 x 2 = 366

Therefore, an initial loading rate of not more than 366 m^3/hr should be requested for loading to two tanks simultaneously. This will result in the shore line flowing at more than 1 metre/sec which would clear any water lying in the line whilst the velocity at the tank inlets is 1 metre/sec.

Determining the Maximum Bulk Loading Rate

The smallest pipeline in the loading system is the cargo hose with a diameter of 250 mm. A maximum linear flow velocity at 7 metres/sec gives a maximum volumetric rate of 1281 m^3/hr.

Figure 11.2: *Determining loading rates for static accumulator cargoes*

Operators should be aware that the maximum velocity might not occur at the minimum diameter of the pipeline when the pipeline feeds multiple branch lines. Such configurations would be where a pipeline feeds multiple loading arms or hoses or, on a tanker, 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, not in the branch lines.

Figure 11.2 also shows that the smallest diameter section of piping in the system is the cargo hose, which is 250mm. If a loading velocity of 7m/sec is acceptable to the tanker and shore, a maximum loading rate of 1,281m^3/hour should be requested.[3]

11.1.7.9 Antistatic additives

If the oil product contains an effective antistatic additive, it is no longer a static accumulator. Although in theory this means that the precautions applicable to a static accumulator can be relaxed, it is still advisable to comply with them in practice. The effectiveness of antistatic additives depends on how long since the additive was introduced to the product, satisfactory product mixing, other contamination and the ambient temperature. It can never be certain that the product's conductivity is above 50pS/m, unless it is continuously measured.

11.1.7.10 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, it is important to reduce charge generation by avoiding splash loading and other charge-generating mechanisms such as filters in the pipeline. The flow rate should be restricted as per sections 11.1.7.3 and 11.1.7.8 during the initial and bulk loading periods.

Product specification and quality requirements normally mean that switch loading does not arise on tankers handling finished products. However, this situation may be encountered when handling cargo slops or off-grade product for which no tank preparation may be required as the grades can be mixed without a risk of product contamination. In this situation, the precautions outlined for switch loading described above should be implemented.

11.1.8 Loading very high-vapour pressure cargoes

To prevent gassing-up of cargo pumps, the expected TVP of the cargo at the discharge port should be taken into consideration.

11.1.9 Loading cargoes containing hydrogen sulphide

11.1.9.1 General

Increasing numbers of cargoes contain significant and increasing quantities of hydrogen sulphide. Guidance on hydrogen sulphide toxicity is to be found in section 2.3.6 and guidelines on gas measurement and gas testing are to be found in sections 2.4 and 8.2.

This section provides practical guidance on operational measures that can be taken to minimise the risks associated with loading cargoes containing hydrogen sulphide, commonly referred to as 'sour' cargoes.

11.1.9.2 Precautions when loading cargoes containing hydrogen sulphide

Before loading, the tanker's crew (Responsible Person/tanker Master) should be advised by the terminal (verbally and in writing) if any cargo to be loaded is suspected to contain hydrogen sulphide.

It also considered to be best practice to load cargoes suspected of containing hydrogen sulphide under fully closed conditions, preferably in combination with vapour balancing.

---

[3] With regard to the requested maximum loading rate, it is also important to check the maximum venting capacity of the tanker. This maximum venting capacity may be calculated by the classification society. See also 7.3.3.1.

The precautions to consider when preparing to load sour cargoes are:

- Before arriving at the loading port, ensure the cargo system is free of leaks from the cargo piping, tank fittings and the venting system.
- Check that all doors and ports can be securely closed to prevent any small gas ingress.

When loading a cargo containing hydrogen sulphide:

- A safety plan should be produced for the loading operation. This should include guidance on the venting procedure, monitoring for vapour, PPE to be used, accommodation and engine room ventilation arrangements, and emergency measures that have been put in place.
- The closed loading procedures described in section 11.1.6.6 should be used.
- Venting to the atmosphere at a relatively low tank pressure should be avoided, particularly in calm wind conditions.
- If the cargo is loaded without any means of vapour return connected to the terminal, loading should be stopped if there is no wind to disperse the vapours or if the wind direction takes vapours towards the accommodation.
- Only personnel actively engaged in tanker security and cargo handling should be permitted on open decks. Regular maintenance on deck should be limited or postponed until after the end of cargo operations. Visitors should be escorted to and from the accommodation spaces and briefed on the hazards of the cargo and emergency procedures.
- Hydrogen sulphide is very corrosive and mechanical gauges are therefore more likely to fail than usual. Their operational condition should be checked frequently. In the event of a gauge failure, repairs should not be undertaken unless an appropriate permit has been issued and all necessary precautions observed.
- Hydrogen sulphide is heavier than air, so in tanker-to-tanker transfers particular attention should be given to the difference in freeboards of the tankers and the possibility of vapour not being dispersed freely. Vent velocities should be kept high on the receiving tanker and the tankers should be turned so as to allow the wind to carry vapours away from the accommodation spaces.

11.1.10 Loading cargoes containing benzene

Guidance on benzene toxicity is in section 2.3.5. Cargoes containing benzene should be loaded using the closed operation procedures described in section 11.1.6.6 as this will significantly reduce exposure to benzene vapour. Where a vapour emission control system is available ashore, it should be used (see section 11.1.13).

Operators should adopt procedures to verify the effectiveness of the closed loading system in reducing the concentrations of benzene vapours around the working deck. This will involve surveys to determine the potential for exposing personnel to benzene vapour during all operations such as loading, discharging, sampling, hose-handling, tank-cleaning, gas-freeing and gauging of cargoes containing benzene. These surveys should also be carried out to ascertain vapour concentrations when cleaning, venting or ballasting tanks whose previous cargo contained benzene.

Spot checks on vapour concentrations, using detector tubes and pumps, toxic analysers or an electronic detector tube, should be carried out by tanker's personnel to ascertain if TLVTWAs are being exceeded and therefore whether PPE should be worn.

The precautions described in section 11.8.4 should also be taken to minimise exposure when measuring and sampling cargoes containing benzene.

11.1.11 Loading heated products

Unless the tanker is specially designed for carrying very hot cargoes, such as a bitumen carrier, cargo heated to a high temperature can damage a tanker's structure, the cargo tank coatings, and equipment such as valves, pumps and gaskets.

Some classification societies have rules regarding the maximum temperature at which cargo may be loaded. Tanker Masters should consult the tanker operator whenever the cargo to be loaded has a temperature over 60°C.

The following precautions may help to alleviate the effects of loading a hot cargo:

- Spreading the cargo throughout the tanker as evenly as possible to dissipate excess heat and to avoid local heat stress.
- Adjusting the loading rate in an attempt to achieve a more reasonable temperature.
- Taking great care to ensure that tanks and pipelines are completely free of water before receiving any cargo that has a temperature above the boiling point of water.

11.1.12 N/A

11.1.13 Loading at terminals that have vapour emission control systems

11.1.13.1 General

The fundamental concept of a vapour emission control system is relatively simple. When tankers are loading at a terminal, the vapours are collected as they are displaced by the incoming cargo or ballast and 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, so introducing into the operation a number of extra hazards that have to be effectively controlled.

A summary of the terminal's vapour emission control system should be included in the terminal information booklet.

11.1.13.2 Misconnection of liquid and vapour lines

To guard against misconnecting the tanker's vapour manifold to a terminal liquid-loading line, the vapour connection should be clearly identified. Pipes for loading and unloading shall be clearly distinguishable from other piping, e.g. by colour marking.

11.1.13.3 Vapour over and under-pressure

Although all closed cargo operations require in-tank pressures to be effectively monitored and controlled, the connection to a vapour emission control system results in pressures within the tanker's vapour spaces being directly influenced by any changes within the terminal's system. Given this, it is important to ensure that the individual cargo tank pressure/vacuum protection devices are fully operational and that loading rates do not exceed maximum allowable rates.

11.1.13.4 Tank overfill

The risk of overfilling a cargo tank when using a vapour emission control system is no different than when loading under normal closed conditions. However, owing to the reliance on closed gauging systems, it is important that they are fully operational and that an independent overfill alarm arrangement provides backup. The alarm should be audible and visual, and be set at a level that will enable operations to be shut down before the tank is overfilled. Under normal operations, the cargo tank may never be filled higher than the level at which the overfill alarm is set.

Individual overfill alarms should be tested at the tank before loading to ensure they are working properly, unless the system is capable of electronic self-testing, which monitors the condition of the alarm circuitry and sensor, and confirms the instrument set point.

11.1.13.5 Sampling and gauging

A cargo tank should never be opened to the atmosphere for gauging or sampling purposes while the tanker is connected to the shore vapour recovery system unless loading to the tank is stopped, the tank is isolated from any other tank being loaded, and precautions are taken to reduce any pressure within the cargo tank vapour space.

On non-inerted tankers, precautions against static hazards should also be followed (see section 11.8).

11.1.13.6 Fire/explosion/detonation

The interconnection of tanker and shore vapour streams, which may or may not be within the flammable range, introduces further hazards that are not normally present when loading. Unless adequate protective devices are installed and operational procedures observed, a fire or explosion in the vapour space of a cargo tank on board could transfer rapidly to the terminal and vice versa.

A detonation arrestor should be fitted close to the terminal vapour connection at the jetty head in order to provide primary protection against the transfer or propagation of a flame from tanker to shore or shore to tanker.

The design of the terminal vapour collection and treatment system will determine whether flammable vapours can be safely handled. If they cannot, it will also include provisions for inerting, enriching or diluting the vapour stream and continuously monitoring its composition.

11.1.13.7 Liquid condensate in the vapour line

The tanker's systems should be able to effectively drain and collect any liquid condensate that may accumulate within vapour pipelines. Any build-up of liquid in the vapour line could impede the passage of vapours and so increase in-line pressures and could also generate significant electrostatic charges on the surface of the liquid. It is important that drains are installed at the low points in the tanker's vapour piping system and that they are routinely checked to ensure that no liquid is present.

11.1.13.8 Electrostatic discharge

The precautions in section 11.1.7.3 for initial loading rates, and in section 11.8 for measuring and sampling procedures, should be followed. Also, 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 bonding arrangements should be inspected periodically to check their condition. The terminal vapour connections should be electrically insulated from the tanker vapour connection by an insulating flange or a single section of insulating hose.

11.1.13.9 Training

It is important that the Responsible Person has received instruction on the particular vapour emission control system installed on the tanker.

11.1.13.10 Communications

The introduction of vapour emission control reinforces the importance of good co-operation and communications between the tanker and shore. Pre-transfer discussions should give them an understanding of each other's operating parameters. Details such as maximum transfer rates, maximum allowable pressure drops in the vapour collection system, and alarm and shutdown conditions and procedures must be agreed before operations start (see section 26.3).

11.1.14 Discharging procedures

11.1.14.1 Joint agreement on readiness to discharge

Before starting to discharge cargo, the Responsible Person and the Terminal Representative must formally agree that both the tanker and the terminal are ready to do so safely.

11.1.14.2 Operation of pumps and valves

Throughout pumping operations, no abrupt changes in the rate of flow should be made.

Reciprocating main cargo pumps can set up excessive vibration in metal loading/discharging arms which, in turn, can cause leaks in couplers and swivel joints, and even mechanical damage to the support structure. Where possible, such pumps should not be used. If they are, take care to select the least critical pump speed or, if more than one pump is used, a combination of pump speeds to achieve an acceptable level of vibration. A close watch should be kept on the vibration level throughout the cargo discharge.

Centrifugal pumps should be operated at speeds that do not cause cavitation, which can damage the pump and other equipment on the tanker or at the terminal.

11.1.14.3 Closed discharging

On tankers, discharging, gauging and sampling should normally be carried out with all ullage, sounding and sighting ports closed. Air should be admitted to the tanks by the dedicated venting system or via the vapour return lines

If, for any reason, the air admitted via the normal venting system is not at a sufficient rate, air may be admitted via a sighting or ullage port that is fitted with a permanent flame screen. In this situation, the tanker is no longer considered to be closed discharging.

11.1.14.4 N/A

11.1.14.5 N/A

11.1.14.6 N/A

11.1.14.7 Start of discharge

Shore valves must be fully open to receiving tanks before the tanker's manifold valves are opened. The elevation of the shore tanks above the level of the tanker's manifold means it is possible that pressure might exist in the shore line and no non-return (check) valves are fitted in the shore line. In this case, the tanker must be informed, and its manifold valves should not be opened until the pumps have developed adequate pressure.

Discharge should start at a slow rate and only be increased to the agreed rate once both parties are satisfied that the flow of oil to and from designated tanks is confirmed.

11.1.14.8 N/A

11.1.14.9 N/A

11.1.14.10 Periodic checks during discharge

Throughout discharging, the tanker should monitor and regularly check all full and empty tanks to confirm that cargo is only leaving the designated cargo tanks and that there is no escape of cargo into pumprooms (if applicable).

The tanker should check tank ullages/innages at least hourly and calculate a discharge rate. Cargo figures and rates should be compared with shore figures to identify any discrepancy. Where possible, these checks should include observations and recordings of shear forces, bending moments, draught and trim and any other relevant stability requirements particular to the tanker. This information should be checked 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. Any discrepancies should be immediately reported to the Responsible Person.

Any drop in pressure or marked discrepancy between tanker and terminal estimates of quantities could indicate pipeline or hose leaks, and require cargo operations to stop until investigations have been made.

The tanker should frequently inspect the cargo deck and pumproom (if applicable) to check for any leaks. Overside areas should also be checked regularly. During darkness, where safe and practical, the water around the tanker should be illuminated.

11.1.14.11 Fluctuations in discharge rate

During discharge, the flow of cargo should be controlled by the tanker according to the agreement with the terminal.

The discharge rate should not be substantially changed without informing the terminal.

11.1.14.12 Simultaneous ballast and cargo handling

Ballasting must be planned and programmed around the cargo operations in order to avoid exceeding specified draught, trim or list requirements, while at the same time keeping shear force, bending moments and metacentric height within prescribed limits.

11.1.14.13 N/A

11.1.14.14 Stripping and draining of cargo tanks

In general, all cargo loaded should be completely discharged at the unloading terminal.

A terminal should be able to receive drainings and should cooperate in this matter.

Arrangements for draining the tanker's tanks can consist of:

- Suction by a terminal's pump.
- Discharge by a tanker's pump (stripping pump).
- Purged by inert gas or air through a stripping line.[4]

---

[4] Air and/or gas bubbles in a liquid can generate static electricity. Also see chapter 3.

For these purposes, the recommended interface system on the tanker side are:

- EN 14 420-6 DN 50 (male connection).
- EN 14 420-7 DN 50 (male connection).

It is recommended that terminals are equipped with the equivalent female connections.

If a terminal has self-sealing couplings, it should provide appropriate connectors for the male connectors.

When engaged in efficient stripping, the tanker must be able to provide a liquid pressure of at least 300kPa (3 bar). The back pressure required to achieve product flow ashore should not exceed 300kPa (3 bar).

11.1.15 Pipeline and hose clearing following cargo operations

11.1.15.1 General

The procedure for clearing the pipelines, hoses or marine arms between the shore valve and tanker's manifold will depend on the facilities available and whether these include a slop tank or other receptacle. The relative heights of the tanker and shore manifolds may also influence procedures.

In general, line clearing should preferably be done with inert compressed gas. Compressed air is not a preferred medium, especially if flammable products with a flashpoint below 60°C are being handled. If compressed air is used for line clearing to shore, the precautions in section 11.1.15.4 should be taken.

11.1.15.2 N/A

11.1.15.3 Line draining

On completion of loading, the tanker's cargo deck lines should be drained into appropriate cargo tanks to ensure that thermal expansion of the contents of the lines cannot cause leaks or distortion. The hoses or marine arms, and perhaps a part of the pipeline system between the shore valve and the tanker's manifold, are also usually drained into the tanker's tanks. Enough ullage must be left in the final tanks to accept the cargo product drained from hoses, marine arms and tanker or shore lines.

On completion of discharge, the tanker's cargo deck lines should be drained into an appropriate tank and then discharged ashore.

When draining is complete, and before hoses or marine arms are disconnected, the tanker's manifold valves and shore valves should be closed and the drain cocks at the tanker's manifold opened to drain into fixed drain tanks or portable drip trays. Cargo manifolds and marine arms or hoses should be securely blanked after being disconnected. The contents of portable or fixed drip trays should be transferred to a slop tank or other safe receptacle ashore.

11.1.15.4 Clearing hoses and loading arms to the terminal

If hoses or marine arms have to be cleared to the terminal using compressed air or inert gas, the following precautions should be strictly observed in order to avoid hazardous static electrical charge or mechanical damage to tanks and equipment:

- The procedure to be adopted must be agreed between tanker and terminal.
- There must be adequate ullage in the reception tank.
- To ensure that the amount of compressed air or inert gas is kept to a minimum, the operation must be stopped when the line has been cleared.
- The inlet to the receiving tank should be located well above any water in the bottom of the tank.
- To avoid generating a static charge, the inlet to the receiving tank should be at least 30cm below the liquid surface level. See also 11.1.15.7.
- The line clearing operation must be continuously supervised by a Responsible Person (both tanker and terminal).

11.1.15.5 Clearing hoses and marine arms to the tanker

Do not use compressed air to clear hoses and marine arms to the tanker due to the risks of:

- Static charge generation.
- Compromising inert gas quality (if applicable).
- Over-pressurisation of tanks, pipelines, filter boxes, pump seals or pipeline fittings.
- Oil mists emanating from tank vents.

11.1.15.6 Clearing tanker's cargo pipelines

When compressed air or inert gas is used to clear tanker's pipelines, e.g. when evacuating the liquid column above a submerged pump, sometimes referred to as 'purging', similar hazards to those above may arise and similar precautions must be taken. Line clearing must be undertaken according to the operating procedures previously established for the particular tanker.

11.1.15.7 Gas release in the bottom of tanks

A strong electrostatic field can be generated by blowing air or inert gas into the bottom of a tank containing a static accumulator oil. If water or particulate matter is present in the cargo, the effect is made worse, as the rising gas bubbles will disturb the particulates and water droplets. The settling contaminants will generate a static charge within the cargo. A settling period of 30 minutes should be observed after any blowing of lines into a non-inerted tank or a tank that could contain a flammable atmosphere.

Precautions should be taken to minimise the amount of air or inert gas entering tanks containing static accumulator oils. However, it is best to avoid blowing lines back to tanks containing such cargo.

Whenever possible, cargo lines should be drained by gravity. Attention should be given to gas bubbles into the product when using compressed air or nitrogen, which can lead to overflow of the receiving tank or miscalculation of quantities.

11.1.15.8 Receiving nitrogen from shore

Personnel should be aware of the hazards associated with nitrogen and, in particular, those related to entering enclosed spaces or areas such as 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 anybody entering the area could asphyxiate. Nitrogen cannot be detected by human senses, so personnel may not be able to recognise the physical or mental symptoms of overexposure in time for them to take preventive measures.

If there is a requirement to use shore-supplied nitrogen, e.g. to purge tanks, padding cargo or clearing lines, the tanker should be aware that this may be at high pressure (up to 10 bar) and at a high flow rate. This is potentially hazardous because of the risk of over-pressurisation of the cargo tanks, pipelines, filter boxes, pump seals or pipeline fittings.

A risk assessment should be carried out and the operation should only proceed if appropriate risk responses are in place. As a minimum, the precautions detailed in section 7.2.2 must be observed.

One method of reducing the risk of over-pressure is to ensure the tank has vents with a greater flow rate capacity than the inlet, so that the tank cannot be over-pressurised. Where vapour control and emission regulations require closed operation, the incoming flow of nitrogen must be restricted to a rate equal to, or less than, the maximum flow of vapour possible through the vapour return line. Positive measures to ensure this should be agreed. A small hose or reducer before the manifold can be used to restrict the flow rate, but pressure must be controlled by the terminal. A gauge will permit the tanker to monitor the pressure.

It is not appropriate to attempt throttling a gas flow by using a tanker's manifold valve that is designed to control liquid flow. However, the manifold can, and should, be used as a rapid safety stop in an emergency. Note that the effect of a pressure surge in a gas is not as violent as in a liquid.

Sensitive cargoes, e.g. some highly specialised lubricating oils, may have to be carried under a pad or blanket of nitrogen supplied from ashore. In this case, it is preferable to purge the entire cargo tank before loading. After purging, loading the cargo in a closed condition will create the required pad within the tank. This significantly reduces the risk of over-pressurisation when padding with shore-supplied nitrogen as a separate procedure on completion of loading.

11.1.15.9 Pigging

Pigging is a form of line clearing where an object, most often 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, usually be propelled by water or compressed gas, or to follow a previous grade to ensure the pipeline remains as free of product as possible, in which case it is likely to be propelled by the next grade.

A common arrangement for catching the pig is for the shore terminal to provide a pig receiver, which is mounted outboard of the tanker’s manifold. Here, the pig may be removed.

A pressure of about 2.7 bar (40psi) is the minimum necessary to drive the pig, but pressures of up to 7 bar (100psi) may be used.

Before any pigging operation, the Responsible Person and the Terminal Representative should agree the procedures and associated safeguards to be put in place. Items that should be discussed and agreed are 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.

During the pigging operation, the terminal should monitor the pressure upstream of the pig to ensure that it is not stuck in the line. Failure of the pig to arrive within the expected time will also indicate that its free movement has been restricted.

Care should be taken after the pig lands in the pig receiver, as the nitrogen or air that follows directly after the pig through the shore cargo line to the tanker may enter at the bottom of a cargo tank. The nitrogen or air will form a bubble that will expand in the tank. This could lead to turbulence in the liquid – the ‘bubble effect’ – that can cause problems on tankers operating closed, potentially damaging the cargo tank, pipelines, filter boxes, pipeline fittings and in-tank equipment.

To avoid turbulence effects, it is recommended that once the pig has been received the pressure in the line is released ashore. The opening of the valve of the appropriate cargo tank and/or manifold should be set to a minimum.

When the pigging operation is completed, the terminal should verify that the pig has arrived. Any residual pressure in the shore line must then be bled-off before opening the pig trap or disconnecting cargo arms or hoses.

Personnel at the receiving end should be aware that there may be sediment in the pig receiver unit and there should be means to deal with this, e.g. rags, absorbent material and drums.

11.2 Stability, stress, trim and sloshing considerations

11.2.1 General

Single hull oil tankers with a centreline bulkhead usually have such a high metacentric height in all conditions that they remain inherently stable. While tanker personnel have always had to take account of longitudinal bending moments and vertical shear forces during cargo and ballast operations, the actual stability of the tanker has seldom been a prime concern. However, this changed with the introduction of double hulls.

11.2.2 Free surface effects

The main problem likely to be encountered is the effect on the transverse metacentric height of liquid-free surface in the cargo and double-hull ballast tanks.

Depending on the design, type and number of these tanks, the free surface effect and the specific density of the cargo could significantly reduce the transverse metacentric height. This will be most severe with a combination of wide cargo tanks with no centreline bulkhead and ballast tanks also having no centreline bulkhead (‘U’ tanks).

The most critical stages of any operation will be while filling the double-bottom ballast tanks during cargo discharge, and emptying the tanks during cargo loading. If enough cargo tanks and ballast tanks are slack simultaneously, the overall free-surface effect could well reduce the transverse metacentric height to a point where the transverse stability of the tanker may be threatened. This could cause the tanker to develop a sudden and severe list or angle of loll. A large free-surface area is especially likely to threaten stability at greater soundings (innages), with an associated high vertical centre of gravity.

Double hull tankers need a damage stability plan and a stability calculation. From these plans it should be clear which cargo and ballast situations are in accordance with the plans and which are not.

It is imperative that tanker and terminal personnel involved in cargo and ballast operations are aware of this potential problem, and that all cargo and ballast operations are conducted strictly in accordance with the tanker's loading manual, if applicable.

Where fitted, interlock devices to prevent too many cargo and ballast tanks from being operated simultaneously and causing an excessive free-surface effect, should always be maintained in full operational order, and should never be overridden.

11.2.3 Sloshing

It is imperative that tanker Masters are aware that partially loading a cargo tank may present a 'sloshing' problem. The combination of free surface and the flat tank bottom can result in wave energy that is powerful enough to severely damage the internal structure and pipelines.

11.2.4 Loading and discharge planning

Ballasting and deballasting must be planned and programmed around the cargo operations in order to avoid exceeding specified draught, trim or list requirements, while at the same time keeping shear force, bending moments and metacentric height within prescribed limits.

11.3 Tank cleaning

11.3.1 General

This section deals with procedures and safety precautions for cleaning cargo tanks after the discharge of volatile or non-volatile products carried in non-gas free, non-inert or inert tanks.

11.3.2 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, and appropriate preventive measures put in place to reduce the risk to as low as reasonably practicable.

The prime risk during tank-washing operations is fire or explosion arising from a flammable atmosphere and a source of ignition. The focus should be to eliminate one or more of the hazards that contribute to that risk: the sides of the fire triangle – air/oxygen, ignition source and fuel (i.e. flammable vapours).

Inert tanks

The method with the lowest risk is washing the tank in an inert atmosphere. The inert condition provides for no ambiguity: to be deemed inert, the tank must by definition have an oxygen content in the atmosphere at a level that cannot support combustion.

If direct measurements fail to prove that the tank is inert, the tank must be considered to be in a non-inert condition.

Non-inert tanks

On tankers with no access to inert gas, via either onboard facilities (e.g. IGS plant) or a supply from shore, it is only possible to address the fuel and sources of ignition (and not the air/oxygen). In a non-inert condition, there are no physical barriers to ensure elimination of these two hazards individually. So the safety of tank washing in a non-inert condition depends on the integrity of equipment and strict procedures to ensure these two hazards are effectively controlled.

Non-inert cargo tank washing should only be undertaken when two sides of the fire triangle are addressed by a combination of measures to control the flammability of the tank atmosphere AND sources of ignition.

All tankers that operate in the non-inert mode should have within their design and equipment the ability to mechanically ventilate cargo tanks concurrently with tank washing in order to control tank atmospheres.

11.3.3 Supervision and preparation

11.3.3.1 Supervision

A Responsible Person must supervise all tank-washing operations.

All crew involved in the operation should be fully briefed by the Responsible Person on the tank washing plans, and their roles and responsibilities before starting.

All other personnel on board should be notified that tank washing is about to begin. This must be include those not involved directly in the tank washing but whose own concurrent tasks may have an impact on the safety of the tank washing.

11.3.3.2 Preparation

Before and during tank washing, the Responsible Person should be satisfied that all the appropriate precautions set out in chapter 4 are being observed.

Before starting to tank wash alongside a terminal, the following additional measures should be taken:

- The relevant precautions described in chapter 24 should be observed.
- The appropriate personnel ashore should be consulted to confirm that conditions on the jetty do not present a hazard, and to obtain agreement that operations can start.
- The method of tank washing used on a tanker depends on how the atmospheres in the cargo tanks are managed and what equipment is fitted to the vessel.

11.3.4 Tank atmospheres

Tank atmospheres can be either of the following:

11.3.4.1 Inert

This is a condition where the tank atmosphere is at its lowest risk of explosion. This is because the atmosphere is kept non-flammable with the introduction of inert gas, so the reduction of the overall oxygen content in any part of any cargo tank does not exceed 8% by volume while under a positive pressure (see section 7.1.5.1).

The maintenance of an inert atmosphere and the precautions to be observed during washing are set out in section 7.1.6.9. These provide the most certain level of control of an atmosphere during tank washing operations.

This method physically removes and controls the oxygen side of the fire triangle.

11.3.4.2 Non-inert

For the purposes of this chapter, a non-inert atmosphere is one in which the oxygen content has not been confirmed to be less than 8% by volume.

Tank-washing and gas-freeing operations in non-inert atmospheres present increased risk, so additional control measures are required to reduce the risk of operations to as low as reasonably practicable. These control measures must address the fuel and sources of ignition sides of the fire triangle.

11.3.5 Tank washing

11.3.5.1 Washing in an inert atmosphere

The control measures for washing in inert atmospheres are in section 7.1.6.9.

During tank washing, measures must be taken to verify that the atmosphere in the tank remains non-flammable (oxygen content not to exceed 8% by volume) and at a positive pressure.

11.3.5.2 Washing in a non-inert atmosphere

Non-inert cargo tank washing should only be undertaken when the source of ignition and the flammability of the tank atmosphere are controlled. To achieve this, the following precautions to control 'sources of ignition' and 'fuel' must be taken:

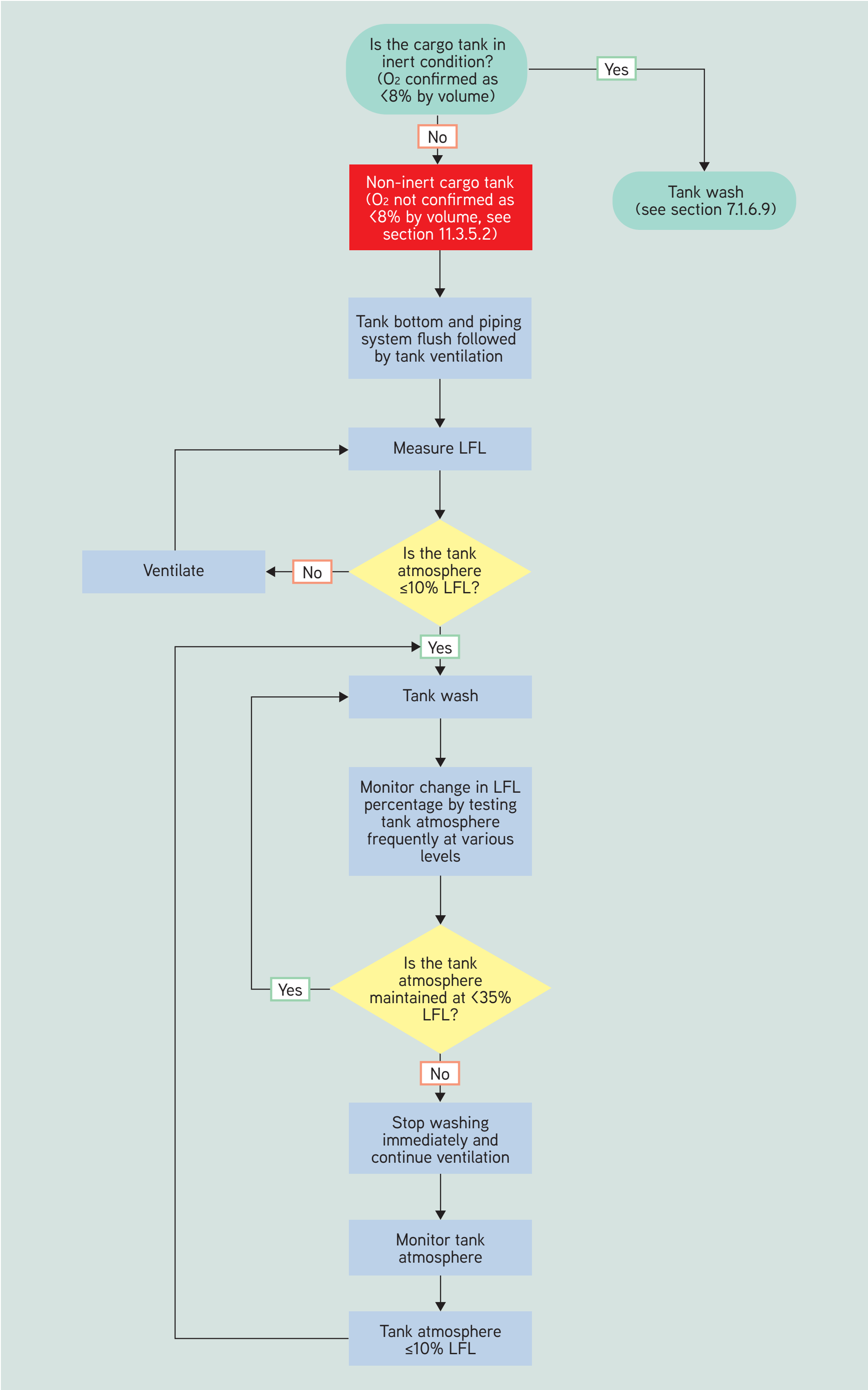


Figure 11.3: *Steps to control the fuel (flammable vapours) while tank washing in a non-inert tank atmosphere flowchart.*

Controlling the 'fuel' in the tank atmosphere
(See figure 11.3).

Before tank washing:

- Determined whether the product to be cleaned holds a flash point of less than 60°C or 60°C and higher.
- Depending on the flash point of the product, different procedures must be followed.
- More than just the last cargo product should be taking into consideration. It is best practice to check the flash point of at least the last three cargoes.

If the tank to be cleaned contained a product with a flashpoint of less than 60°C:

- Check if the tank is under inert conditions, i.e. less than 8% oxygen by volume.
- If a tank is not under inert conditions, follow the steps in point 1 ('Before washing').
- If a tank is under inert conditions, follow the steps in point 2 ('During washing with heated water').

If the tank to be cleaned contained a product with a flashpoint of 60°C and higher:

- Follow the steps in point 2 ('During washing with heated water').

1. Before washing:

- The tank bottom should be flushed with water, so that all parts are covered, and then stripped. This flush should be undertaken using the main cargo pumps and lines. Alternatively, permanent pipework extending the full depth of the tank can be used. This flush should not use the tank washing machines.
- The piping system, including cargo pumps, crossovers and discharge lines, should also be flushed with water. The flushing water should be drained to the tank designed or designated to receive slops.
- The tank should be ventilated to reduce the gas concentration of the atmosphere to 10% or less of the LFL, or a pre-wash with cold water might be considered. Gas tests must be made at various levels and due consideration given to the possible existence of pockets of flammable gas, particularly near potential sources of ignition such as mechanical equipment that might generate hot spots, e.g. moving parts, such as those in in-tank (submerged) cargo pump impellors.
- Tank washing with heated wash water may only start once the tank atmosphere reaches 10% or lower of the LFL.

2. During washing with heated wash water:

- Atmosphere testing should be frequent and taken at various levels inside the tank during washing to monitor the change in LFL percentage.
- Consideration should be given to the possible effect of water on the efficiency of the gas-measuring equipment and to suspend washing to take readings.
- Whenever possible, mechanical ventilation should be continued during washing, providing a free flow of air from one end of the tank to the other.
- The ability to mechanically ventilate concurrent with tank washing is recommended, but where mechanical ventilation is not possible, the monitoring of the tank atmosphere should be more frequent as the likelihood of rapid gas build-up is increased.
- The tank atmosphere should be maintained at not more than 35% LFL. Should the gas level reach 35% LFL at any measured location within a tank, tank washing operations in that individual tank MUST stop immediately.
- Washing may be resumed when continued ventilation or a cold pre-wash has reduced the gas concentration to 10% or lower of the LFL and is maintaining it at that level.
- If the tank has a venting system that is common to other tanks, the tank must be isolated to prevent ingress of gas from other tanks.

Controlling the 'sources of ignition' in the tank

- Individual tank washing machines should not have a throughput greater than $60m^3/h$.
- The total water throughput per cargo tank should be kept as low as practicable and must not exceed $180m^3/h$.
- Different washing methods give rise to different risks and the following should be followed for tank washing in non-inert conditions:
  - Recirculated wash water MUST NOT be used.
  - Heated wash water may be used but should stop if the gas concentration reaches 35% of the LFL. A hot wash for a low flashpoint product should ONLY take place following a full (i.e. top to bottom) cold wash cycle.
  - If the hot wash water temperature is above 60°C, monitoring the gas concentration level more frequently.
  - Chemical additives may only be considered if the temperature of the wash water DOES NOT exceed 60°C.
  - Steam must never be injected into the tank when tank washing in non-inert conditions and MUST NOT be considered until the tank has been verified as gas-free (see section 3.1.2 and Definitions).
- The tank should be kept drained during washing. Washing should be stopped to clear any build-up of wash water.
- At all times, the discharge into a wash water reception/slop tank should be below the liquid level in that tank.
- If portable washing machines are used, all the hose connections should be made up and tested for electrical continuity before the washing machine is brought into the tank.
- Portable washing machines should not be introduced into the tank until the LFL level is 10% or lower.
- Connections should not be broken until after the machine has been removed from the tank. To drain the hose, a coupling may be partially opened (but not broken) and then re-tightened before the machine is removed.
- Introduce sounding rods and other equipment into the tank using a full-depth sounding pipe. If a full-depth sounding pipe is not fitted, any metallic components of the sounding rod or other equipment must be bonded and securely earthed to the tanker before going into the tank, and remain earthed until removed. This precaution should be observed during washing and for five hours afterwards to allow time for any mist carrying a static charge to dissipate. This can be reduced to one hour if the tank is continuously mechanically ventilated after washing. During this period:
  - A metallic interface detector may be used if earthed to the tanker by a clamp or bolted metal connection.
  - A metal rod may be used on the end of a metal tape if earthed to the tanker by a clamp or bolted metal connection.
  - A metal sounding rod suspended on a fibre rope should NOT be used, even if the end at deck level is fastened to the tanker because the rope cannot be relied on to provide an earthing path.
  - In general, equipment made entirely of non-metallic materials may be used without earthing, e.g. a wooden sounding rod suspended on a natural fibre rope.
  - Ropes made of synthetic polymers should NOT be used for lowering equipment into cargo tanks.
- Measures should be taken to guard against ignition from mechanical defects in machinery, e.g. in-tank (submerged) cargo pumps, tank washing machines, tank gauging equipment, etc.
- Precautions should be taken to eliminate the risk of mechanical sparks from metallic objects being dropped into the tank: e.g. hand tools, sounding rods, sample buckets, etc.
- The use of non-intrinsically safe equipment – e.g. torches and inspection lamps, mobile phones, communications radios, handheld computers and organisers, etc – should NOT be allowed.

11.3.6 Precautions for tank washing

11.3.6.1 Portable tank washing machines and hoses

The outer casing of portable machines should be of a material that will not cause an incendive spark on contact with the internal structure of a cargo tank.

The coupling arrangement for the hose should establish 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 means of a suitable connection or external bonding wire.

When suspended within a cargo tank, machines should be supported by a natural fibre rope and not the water supply hose.

11.3.6.2 Portable hoses for use with 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 between them.

Hoses should be indelibly marked for identification. A record should be kept showing the date and the result of electrical continuity testing.

11.3.6.3 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.

11.3.6.4 Tank cleaning concurrently with cargo handling

As a general rule, tank cleaning and gas-freeing should not take place concurrently with cargo handling. If for any reason this is necessary, there should be close consultation with, and agreement from, the Terminal Representative and the port authority.

11.3.6.5 Free fall

It is essential to avoid the free fall of water or slops into a tank. The liquid level should always cover the discharge inlets in the slop tank to a depth of at least one metre to avoid splashing. However, this is not necessary when the slop and cargo tanks are fully inerted.

11.3.6.6 Spraying 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 by water settling. Tanks that contain static accumulator oil should always be pumped out before they are washed with water, unless the tank is kept in an inert condition (see section 3.3.4).

11.3.6.7 N/A

11.3.6.8 Special tank cleaning procedures

After carrying certain products, tanks can only be adequately cleaned by steaming or by adding tank cleaning chemicals or additives to the wash water.

Steaming tanks

Because of the hazard from static electricity, steam should not be used in cargo tanks where 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 from such clouds are similar to those for the mists created by water washing, but levels of charging are much higher. The time it takes to reach maximum charge levels is also much less. Also, although a tank may be almost free of flammable gas at the start of steaming, the heat and disturbance will often release gases, and pockets of flammability may build-up.

Steaming may only be carried out in tanks that have been either inerted or water washed and gas-freed. The concentration of flammable gas should not exceed 10% of the LFL before steaming. Precautions should be taken to avoid the build-up of steam pressure within the tank.

Strict observance of the static electricity precautions in chapter 3 is essential.

Using chemicals in tank cleaning wash water
Constraints on the use of chemicals in tank cleaning wash water will depend on the type of tank atmosphere (see section 11.3.5.2).

If tank cleaning chemicals are to be used, it is important to recognise that certain products may introduce a toxic or flammable hazard. Personnel should be made aware of the TLV of the product. Detector tubes are particularly useful for detecting specific gases and vapours in tanks. Tank cleaning chemicals capable of producing a flammable atmosphere should normally be used only when the tank has been inerted.

Using chemicals for local cleaning of tanks
Some products may be used for the local cleaning of tank bulkheads and blind spots by hand wiping, provided the amount of chemical used is small and the personnel entering the tank observe all enclosed space entry requirements.

Also, any manufacturer's instructions or recommendations for the use of these products should be observed. Where these operations take place in port, local authorities may impose extra requirements.

An SDS for tank cleaning chemicals should be on the tanker before they are used, and any precautions should be followed.

11.3.6.9 N/A

11.3.6.10 Removing sludge, scale and sediment
Before the removing sludge, scale and sediment by hand, the tank atmosphere must be confirmed as safe for entry, with control measures in place to protect the safety and health of anybody entering the space. Follow the precautions in section 10.9 throughout the work.

Equipment to be used for further tank cleaning, such as removing solid residues or products in tanks that have been gas-freed, should be designed and constructed, and the construction materials chosen, to prevent any risk of ignition.

11.3.6.11 Cleaning contaminated ballast spaces
Where a leak has occurred from a cargo tank into a ballast tank, it will be necessary to clean the tank in order to comply with local environmental legislation and to make repairs.

This task is difficult when the contamination is black oils and especially so if it occurs in a double hull or double bottom space.

As far as possible, especially in the initial stages, tank cleaning should be carried out by methods other than hand hosing. This may include, but not be limited to, portable machines, detergents, or washing the bottom of the tank with water and detergent. Hand hosing should only be permitted for small areas of contamination or for final cleaning. Whichever method is used, the tank washings must always be handled in accordance with applicable environmental regulations.

After a machine or detergent wash and before entry for final hand hosing, the tank must be ventilated in accordance with the procedures in section 11.4.7, until readings at each sampling point indicate that the atmosphere meets the safe-for-entry criteria in section 10.5. Suitable control measures should be in place to protect the safety and health of personnel entering the space.

11.4 Gas-freeing

11.4.1 General
Gas-freeing is one of the most hazardous tanker operations. This is true whether gas- freeing for entry, for hot work or for cargo quality control. The cargo vapours that are displaced during gas-freeing are highly flammable, so good planning and firm overall control are essential. The additional risk from the toxic effect of cargo vapours during this time cannot be over emphasised and must be impressed on all concerned. It is essential that the greatest possible care is exercised in all operations connected with gas freeing.

It is recommended that gas-freeing is avoided as much as possible in order to reduce environmental and health impacts.

11.4.2 Gas-free for entry without breathing apparatus

To be gas free for entry without breathing apparatus, a tank or space must be ventilated until tests confirm that the cargo vapour concentration throughout the compartment is less than 1% of the LFL, that the oxygen content is 21% by volume, and that no hydrogen sulphide, benzene or other toxic gases are present, as appropriate (see section 10.3).

Before entering a tank without breathing apparatus, the atmosphere in the tank should be checked by a competent person.

11.4.3 Procedures and precautions

The following recommendations apply to gas-freeing generally:

- A Responsible Person must supervise all gas-freeing operations.
- All personnel on board should be notified that gas-freeing is about to begin.
- Appropriate 'No smoking' regulations should be enforced.
- Instruments used for gas measurement should be calibrated and tested in accordance with the manufacturer's instructions before starting operations.
- Sampling lines should, in all respects, be suitable for use with, and impervious to, the gases present.
- All tank openings should be kept closed until actual ventilation of the individual compartment is about to start.
- Venting of flammable gas should be by the tanker's approved method. Where gas-freeing involves gas escaping at deck level or through hatch openings, the degree of ventilation and number of openings should be controlled to produce an exit velocity that will carry the gas clear of the deck.
- If possible, central air conditioning intakes or mechanical ventilation systems should be adjusted to prevent the entry of petroleum gas by recirculating air within the spaces (see section 4.1).
- If at any time it is suspected that gas is being drawn into the accommodation, central air conditioning and mechanical ventilation systems should be stopped, and the intakes covered or closed.
- Tank openings within enclosed or partially enclosed spaces, e.g. beneath forecastles, should not be opened until the compartment has been sufficiently ventilated by openings in the tank that are outside these spaces. When the gas level within the tank has fallen to 10% of the LFL or lower, openings in enclosed or partially enclosed spaces may be opened to complete the ventilation. Such enclosed or partially enclosed spaces should also be tested for gas during this subsequent ventilation.

When planning gas-freeing in port (if permitted), the following should be observed:

- As a general rule, gas-freeing should not take place concurrently with cargo handling. If for any reason this is necessary, there should be close consultation with, and agreement from, the Terminal Representative and the port authority.
- The Terminal Representative should be consulted to check that conditions on the jetty do not present a hazard and to obtain agreement that operations can start.

11.4.4 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 tanker. Section 2.4 provides details of these, and section 8.2 covers their use.

Atmosphere testing should be undertaken regularly during gas-freeing to monitor progress.

Tests should be made at several levels. In large compartments, tests should be made at widely separate positions.

On the apparent completion of gas-freeing of any compartment, allow about 10 minutes before taking final gas measurements. This allows relatively stable conditions to develop within the space.

If the gas readings are not satisfactory, ventilation must be resumed.

On completion of gas-freeing, all openings, except the tank hatch, should be closed.

On completion of all gas-freeing, the gas venting system should be carefully checked, paying particular attention to the efficient working of the pressure/vacuum valves and any high-velocity vent valves. If the valves or vent risers are fitted with devices designed to prevent the passage of flame, these should also be checked and cleaned if necessary.

11.4.5 Fixed gas-freeing equipment

Fixed gas-freeing equipment may 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 using one or more permanently installed blowers, all connections between the cargo tank system and the blowers should be blanked, except when the blowers are in use.

Before putting a fixed gas-freeing system into service, the cargo piping system, including crossovers and discharge lines, should be drained thoroughly and the tanks stripped. Valves on the cargo piping system, other than those required for ventilation, should then be closed and secured.

11.4.6 Portable fans

Portable fans or blowers should only be used if they are water, hydraulically, or pneumatically driven. Given the risk of the impeller touchings the inside of the casing, the blowers should be built from materials that will not cause incendiary sparks.

Ventilation outlets should generally be as remote as possible from the fans.

Portable fans should be connected to the vessel, piping or deck in a way that creates an effective electrical bond between the fan and the deck.

11.4.7 Ventilating double-hull ballast tanks

The complexity of the structure in double-hull and double-bottom tanks makes them more difficult to gas-free than conventional ballast tanks. It is strongly recommended that the operator develops guidelines and procedures for ventilating each tank. An efficient method is to fill each tank with ballast water and then empty it. Account must be taken of the stress, trim and loadline factors. However, bear in mind that any cargo leaks into the tank will mean that the ballast will be dirty (polluted) and must be handled in accordance with applicable legislation. If polluted ballast is expected, it should not be allowed to overflow when ballasting the tank.

Whenever possible, these guidelines and procedures should be developed in conjunction with the tanker's builder.

11.4.8 Gas-freeing in preparation for hot work

In addition to meeting the requirements of section 11.4.2, the requirements of chapter 9 must also be complied with.

11.5 N/A

11.6 Ballast operations

11.6.1 Introduction

This section addresses routine ballast operations when taking extra ballast in cargo tanks to meet air-draught restrictions for navigational purposes.

11.6.2 General

Before ballasting or deballasting in port, the operation should be discussed and agreed in writing between the Responsible Person and the Terminal Representative.

The specific agreement of the Terminal Representative must be obtained before the simultaneous handling of cargo and non-segregated ballast takes place.

Ballast should be loaded and discharged in a way that does not put excessive stress on the tanker's hull at any time during the operation.

11.6.3 N/A

11.6.3.1 N/A

11.6.3.2 N/A

11.6.4 Loading segregated ballast

In general, there are no restrictions on ballasting segregated ballast tanks during the cargo discharge operation. However, take into account:

- Ballast should be taken as necessary to meet air-draught requirements on the berth, particularly when hard cargo arms are connected.
- Ballast should not be loaded if it may cause the tanker to exceed the maximum safe draught for the berth.
- Loading ballast should not cause extreme shear forces or bending moments on the tanker.
- Care should be taken to ensure that excessive free surface is does not occur as this may result in the tanker assuming an angle of loll and jeopardising the integrity of the loading arms. This is particularly relevant to double-hull tankers (see also section 11.2).

11.6.5 N/A

11.6.6 Discharging segregated ballast

To avoid pollution caused by contaminated segregated ballast, the surface of the ballast should be sighted, where possible, before deballasting. When segregated ballast is being discharged overboard, it is prudent to monitor it by visual watch. This may give the earliest warning of any inter-tank leak between cargo and ballast tanks that may have been undetected, or even undetectable, before starting the ballast operation. The operation should be stopped immediately in the event of contamination.

11.6.6.1 Air-draught management

Ballast carried in segregated tanks may be kept on board in order to reduce the freeboard. This may be necessary because of the weather or to keep within the restrictions of the terminal metal loading arms. However, take care not to exceed the maximum draught for the berth and to include the ballast weights in the hull stress calculations.

11.6.6.2 N/A

11.6.7 N/A

11.6.8 N/A

11.7 Cargo leaks into double-hull tanks

11.7.1 Action to be taken

This section addresses the actions to be taken in the event of a cargo leak into a double-hull or double-bottom tank.

If a cargo leak is discovered, the first step should be to check the atmosphere in the double-hull or double-bottom tank to establish the cargo content. Note that the atmosphere in this tank could be above the UEL, within the flammable range, or below the LFL. Regardless of the number of samples taken, any or all of these conditions may exist in different locations within the tank, due to the complexity of the structure. It is essential that gas readings are taken at different levels, at as many points as possible, in order to establish the profile of the tank atmosphere.

Bear in mind that the hazards associated with cargo leak may also relate to the cargo's toxicity, corrosiveness or other properties, and further measurements may have to be taken to confirm safe conditions for entry.

If cargo gas is detected in a double-hull or double-bottom tank, a number of options can be considered to maintain the tank atmosphere in a safe condition:

- Continuous ventilation of the tank.
- Inerting the tank.
- Filling or partially filling the tank with ballast.
- Securing with P/V valves.
- Securing the tank with flame screens in place at the vents.
- A combination of the above.

The option chosen will depend upon a number of factors, especially the degree of confidence in the cargo content of the atmosphere, bearing in mind the potential problems identified above.

If a leak is discovered, the tanker's Master should immediately consult the operator. It is strongly recommended that operators develop guidelines that take into account the tank structure and any limitations of the available atmosphere-monitoring system, which could help the tanker's personnel to choose the best way to make the atmosphere safe. The guidelines should also include the process for contacting authorities and/or the tanker's classification society.

When filling or partially filling the double-hull or double-bottom tank with ballast in order to make the atmosphere safe and/or stop any further leak of cargo into the tank, take into account prevailing stress, trim, stability and loadline factors. Also bear in mind that all ballast loaded into a tank after a leak has been found, and all tank washings associated with cleaning the tank, is classed as polluted ballast and must be processed in line with legislation. This means it must be transferred directly to a cargo or slop tank for further processing. The spool piece used to connect the ballast system to the cargo system should be clearly identified and not be used for any other purpose.

If the double-hull or double-bottom tank is ventilated or inerted in lieu of filling, it should be sounded regularly to work out the rate of liquid build-up and so the leak.

If the quantity of cargo leaking into the space can be pumped, it should be transferred to another cargo tank via the emergency ballast/cargo spool piece connection, if available (see above), or other emergency transfer method, in order to minimise contamination of the space and to facilitate subsequent cleaning and gas-freeing operations.

Written procedures should be available, indicating the actions to be taken and the operations necessary for safely transferring the cargo from the ballast space.

Entry into the tank should be prohibited until it is safe and there is no further possibility of cargo ingress. However, if it is essential to enter the tank for any reason, this must be carried out in line with section 10.7.

11.7.2 N/A

11.8 Cargo measurement, ullaging, dipping and sampling

11.8.1 General

Depending on the toxicity and/or volatility of the cargo, it may be necessary to prevent or minimise the release of vapour from the cargo tank ullage space during measurement and sampling operations.

Wherever possible, this should be achieved by the use of closed gauging and sampling equipment.

There are circumstances where it is considered essential to obtain clean samples for quality purposes, such as for high-specification aviation fuels. The use of closed sampling equipment may cause cross-contamination of product samples; where this is the case, the terminal operator may wish to undertake open sampling. A risk assessment should be carried out to check whether open sampling can be done safely, taking into account the product volatility and toxicity. Risk mitigation measures, including the use of appropriate PPE if necessary, should be put in place before starting the operation.

Closed gauging or sampling should be undertaken using the fixed gauging system or by using portable equipment passed through a vapour lock. Such equipment will enable innages, ullages, temperatures, water cuts and interface measurements to be taken while releasing a minimum of cargo vapours. This portable equipment, passed through vapour locks, is sometimes referred to as 'restricted gauging equipment'.

When it is not possible to undertake closed gauging and/or sampling operations, open gauging will need to be used. This will involve passing equipment into the tank via an ullage or sampling port or a sounding pipe, and personnel may therefore be exposed to concentrations of cargo vapour.

As cargo compartments may be in a pressurised condition, the opening of vapour lock valves, ullage ports or covers and the controlled release of any pressure should only be undertaken by authorised personnel.

When measuring or sampling, care must be taken to avoid inhaling gas. Personnel should keep their heads well away from the issuing gas and stand at right angles to the direction of the wind. Standing immediately upwind of the ullage port might create a back eddy of vapour towards the operator. Depending on the nature of the cargo being handled, consideration may also have to be given to the use of appropriate respiratory protective equipment (see sections 10.8 and 11.8.4).

When open gauging procedures are being employed, the tank opening should only be uncovered long enough to complete the operation.

11.8.2 Measuring and sampling non-inerted tanks

11.8.2.1 General

There is a possibility of electrostatic discharges whenever equipment is lowered into non-inerted cargo tanks. The discharges may come from charges on the equipment itself or from charges already present in the tank, such as in the liquid contents, on water or oil mists. If there is any possibility of a flammable mixture of cargo gas and air mixture, precautions must be taken to avoid incendive discharges throughout the system.

Precautions are necessary to deal with two distinct types of hazard:

- Introducing equipment that may act as a spark-promoter into a tank that already contains charged materials.
- Introducing a charged object into a tank.

Each requires different mitigation measures.

Table 11.2 provides a summary of the precautions to be taken against electrostatic hazards when ullaging and sampling non-inerted cargo tanks.

11.8.2.2 Introducing equipment into a tank

Measures to avoid introducing spark promoters

If any form of dipping, ullaging or sampling equipment is used in a possibly flammable atmosphere where an electrostatic hazard exists or can be created, precautions should be taken to ensure that they do not act as an unearthed conductor at any time during the operation. Metallic components of any equipment lowered into a tank should be securely bonded together and to the tank before the sampling device is introduced, and should remain earthed until after removal. Bonding and earthing cables should be metallic.

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 11.8.2.2)	Flow of static accumulator liquids (sections 11.1.7 and 11.8.2.3)	Water mist droplets (sections 3.3.4 and 11.8.2.5)
Precautions necessary for dipping, ullaging and sampling with:	(sections 11.8.2.3 and 11.3.5.2 g)	(section 11.8.2.3)	(sections 11.3.5.2 g and 11.8.2.5)
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 11.2: *Summary of precautions against electrostatic hazards when ullaging and sampling non-inerted tanks*

Equipment should be designed to facilitate earthing. For example, the frame holding the wheel of a metal measuring tape should be provided with a threaded stud that has a sturdy bonding cable bolted to it. The stud should have electrical continuity through the frame to the metal measuring tape. The other end of the bonding cable should terminate in a spring-loaded clamp suitable for attachment to the rim of an ullage opening.

Those responsible for supplying non-conductive and intermediate conductive equipment to tankers must be satisfied that the equipment will not act as spark promoters. It is essential that non-conducting components do not lead to the insulation of any metal components from earth. For example, if a plastic sample bottle holder includes a metallic weight, the weight must be bonded as described above or fully encapsulated in a minimum of 10mm-thick plastic.

Measures to avoid introducing charged objects
The suitability of equipment made wholly of non-metallic components depends upon the volume and surface resistance of the materials 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 through a gloved hand. This type of apparatus needs no special bonding or earthing.

A material of intermediate conductivity, such as wood or natural fibre, generally has enough conductivity as a result of water absorption to avoid the accumulation of electrostatic charge. At the same time, the conductivity of these materials is low enough to ensure that instantaneous release of a charge is not possible. There should be a leak path to earth from such materials, so that they are not totally insulated, but this need not have the very low resistance normally provided for the bonding and earthing of metals. In practice, such a path usually occurs naturally on tankers, either by direct contact with the tanker or by indirect contact through the operator of the equipment.

11.8.2.3 Static accumulator oils

It is prudent to assume that the surface of a non-conducting liquid (static accumulator) may be charged and at a high potential during and immediately after loading. Metallic dipping, ullaging and sampling equipment should be bonded and earthed to avoid sparks. However, the possibility remains of a brush discharge between the equipment and the charged liquid surface as the two approach each other. Since such discharges can be incendive, no dipping, ullaging or sampling with metallic equipment should take place while a static accumulator is being loaded, due to the possibility of a flammable gas mixture.

After loading is completed, there should be a 30-minute delay (settling time) for each tank before starting these operations. This is to allow gas bubbles, water or particulate matter in the liquid to settle and for any electrical potential to dissipate.

The situations in which these restrictions on the use of metallic equipment should be applied are summarised in figure 11.4.

Non-metallic equipment

Discharges between the surface of a static accumulator oil and non-metallic objects have not in practice been found to be incendive. Dipping, ullaging or sampling with non-metallic equipment lowered on a clean natural fibre line is permissible at any time.

Refer to section 3.2.1 for the use of non-metallic sampling containers.

Sounding pipes

Operations carried out through sounding pipes are permissible at any time, because it is not possible for any significant charge to accumulate on the surface of the liquid within a correctly designed and installed sounding pipe. A sounding pipe is defined as a conducting pipe that extends the full depth of the tank and is effectively bonded and earthed to the tank structure at its extremities. The pipe should be slotted in order to prevent any pressure differential between the inside of the pipe and the tank, and to ensure that true level indications are obtained.

The electrostatic field strength within a metal sounding pipe is always low due to the small volume and to shielding from the rest of the tank. Dipping, ullaging and sampling within a metal sounding pipe are permissible at any time, provided that any metallic equipment is properly earthed. Non-metallic equipment may also be used in sounding pipes, although the precautions against introducing charged objects must be applied.

11.8.2.4 Static non-accumulator oils

A flammable atmosphere may be present above a static non-accumulator oil in a non-inerted or non-gas free environment, so the precautions summarised in section 11.8.2 and figure 11.4 should be followed.

11.8.2.5 Ullaging and dipping in the presence of water mists

During tank washing, it is essential that there should be no unearthed metallic conductor in the tank, and that none are introduced while the charged mist persists, i.e. during washing and for five hours afterwards. 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 ropes, should be avoided (see section 3.3.4).

It is absolutely essential that all metallic components are securely earthed. If there is any doubt about earthing, the operation should not be permitted.

Ullaging and dipping with a full-depth sounding pipe are safe at any time in the presence of a wash water mist.

11.8.3 Measuring and sampling inerted tanks

Tankers fitted with inert gas systems will have closed gauging systems for taking measurements during cargo operations.

Sonic tapes, temperature tapes, etc, must be used in line with good safety practices and the manufacturer's instructions. The requirements for portable electrical equipment apply to these measurement devices (see section 4.3).

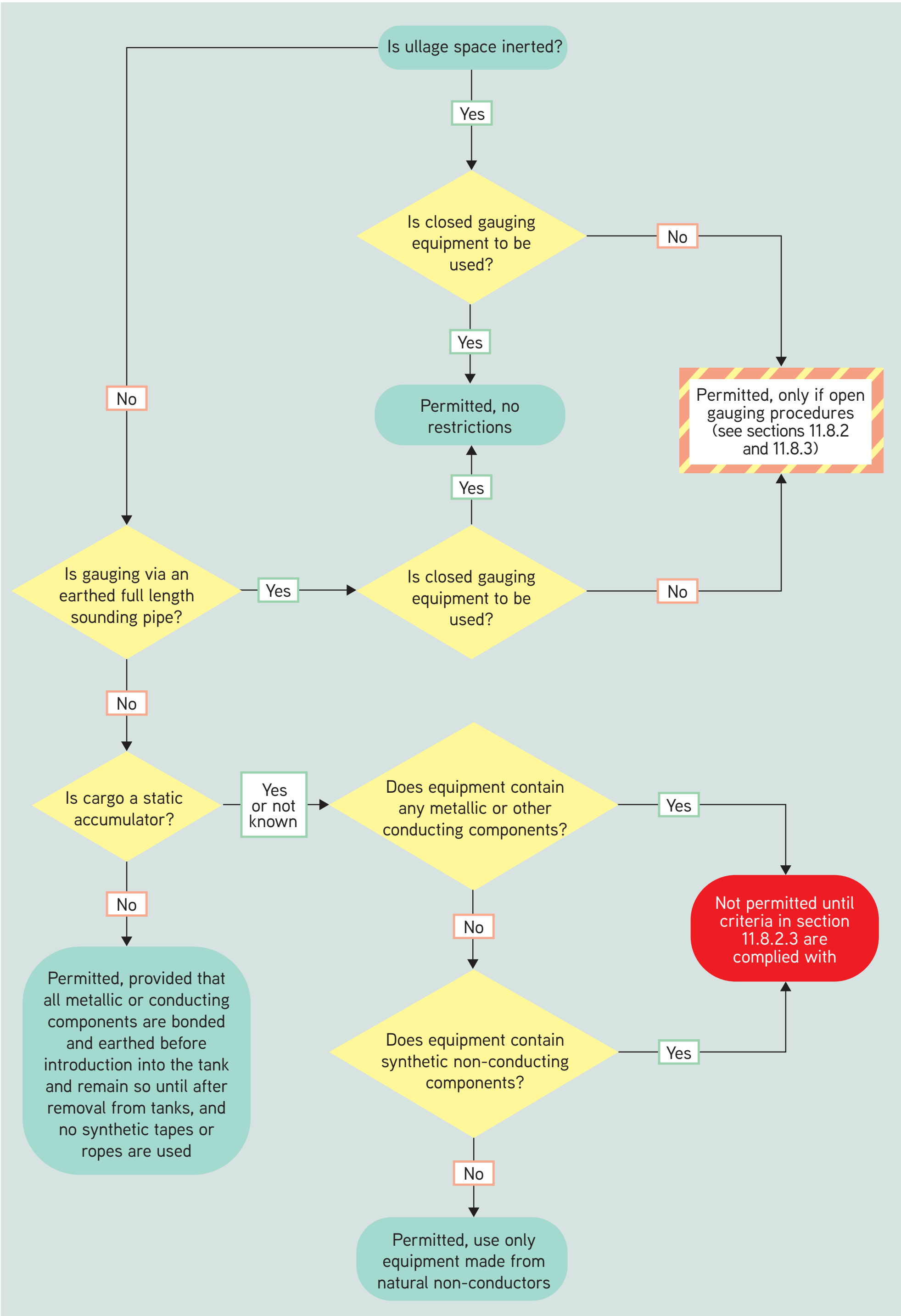


Figure 11.4: *Precautions required when using portable measuring and sampling equipment*

On tankers not equipped with vapour locks, special precautions need to be taken for the open measurement and sampling of cargo in inerted tanks. When it is necessary to reduce the pressure in any tank to allow measuring and sampling, the following precautions should be taken:

- If possible, a minimum positive inert gas pressure should be maintained during measurement and sampling. The low oxygen content of inert gas can rapidly cause asphyxiation and so care should be taken to avoid standing in the path of vented gas (see section 11.8.1). No cargo or ballast operations are to be permitted in cargo compartments while the inert gas pressure is reduced.
- Only one access point should be opened 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) the relevant access point should be kept firmly closed.
- After completing the operation and before starting to discharge cargo, all openings should be secured and the cargo tanks re-pressurised with inert gas (see section 7.1 for the operation of the tanker's inert gas system during cargo and ballast handling).
- Measuring and sampling that require the inert gas pressure to be reduced and cargo tank access points opened should not be conducted during mooring and unmooring. It should be noted that, if access points are opened while a tanker is at anchor or moored in an open roadstead, any movement of the tanker might result in the tanks breathing. To minimise this risk, care should be taken to maintain sufficient positive pressure within the tank being measured or sampled.

If it is necessary to sound the tanks when discharge is almost complete, the inert gas pressure can again be reduced to a minimum safe operational level to permit sounding through sighting ports or sounding pipes. Care should be taken to avoid the ingress of air or an excessive release of inert gas.

11.8.3.1 N/A

11.8.4 Measuring and sampling cargoes containing toxic substances

Special precautions need to be taken when tankers carry cargoes that contain toxic substances in concentrations that are hazardous.

Loading terminals have a responsibility to advise the tanker Master, by providing the SDS, if the cargo to be loaded contains hazardous concentrations of toxic substances. Similarly, it is the responsibility of the tanker Master to advise the receiving terminal, by providing the SDS, that the cargo to be discharged contains toxic substances. This transfer of information is covered by the safety checklists (see section 26.3).

The Master must also advise the terminal and any other personnel, such as tank inspectors or surveyors, if the previous cargo contained toxic substances.

Tankers carrying cargoes containing toxic substances should adopt closed sampling and gauging procedures if possible.

When closed gauging or sampling cannot be undertaken, tests should be made to assess the vapour concentrations in the vicinity of each open access point. This will ensure that concentrations of vapour do not exceed the short-term exposure limit of the toxic substances that may be present. If monitoring indicates the limit could be exceeded, suitable respiratory protection should be worn. Access points should be opened only for the shortest possible time.

If effective closed operations cannot be maintained, or if concentrations of vapour are rising because of defective equipment or still air conditions, consideration should be given to suspending operations and closing all venting points until the equipment is fixed or the weather changes and improves gas dispersion.

Refer to section 2.3 for a description of the toxicity hazards of bulk liquids.

11.8.5 Closed gauging for custody transfer

Gauging of tanks for custody transfer should be carried out via a closed gauging system or vapour locks. For the ullaging system to be acceptable for this purpose, the gauging system should be described in the tanker's tank-calibration documentation. Corrections for datum levels, and for list and trim, should be checked and approved by the tanker's classification society.

Temperatures can be taken using electronic thermometers deployed into the tank through vapour locks. Such instruments should have the appropriate approval certificates and be calibrated.

Samples should be obtained by special sampling devices using the vapour locks.

11.9 Transfers between vessels

11.9.1 Tanker-to-tanker transfers

In tanker-to-tanker transfers, both tankers should comply fully with the safety precautions required for normal cargo operations. If the safety precautions are not being observed on either vessel, the operations must not start. If already in progress, they must stop.

Tanker-to-tanker transfers undertaken in port or at sea may be subject to approval by the port or local marine authority, and certain conditions relating to the conduct of the operation may be attached to such approval.

11.9.2 Seagoing vessel-to-inland tanker and inland tanker-to-seagoing vessel

When transferring bulk liquids between a seagoing vessel-to-inland tanker or inland tanker-to-seagoing vessel, only authorised and properly equipped vessels should be used. If safety precautions are not observed on either vessel, the operations must not start. If already in progress, they must stop.

Tanker Masters should be aware Masters of seagoing vessels may work with the ICS/SIGTTO/CDI/OCIMF *Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied* Gases. See also appendices 2 and 3 for the relevant safety checklists.

The rate of pumping from seagoing vessel to inland tanker must be controlled according to the size and nature of the receiving inland tanker. Communication procedures must be established and maintained, particularly when the freeboard of the tanker is higher than the inland tanker.

If there is a large difference in freeboard between the seagoing vessel and the inland tanker, the tanker crew must make allowance for the contents of the hose on completion of the transfer.

Arrangements should be made to release the inland tanker in an emergency, taking into account other shipping or property in the area. If the seagoing vessel is at anchor, it may be appropriate for the inland tanker to drop anchor clear of the seagoing vessel, where it could remain secured to wait for assistance.

Inland tankers should be cleared from the seagoing vessel's side as soon as possible after they have finished loading or discharging volatile cargoes.

11.9.3 Tanker-to-tanker transfers using vapour balancing

Specific operational guidance should be developed to address the particular hazards associated with vapour emission control activities during tanker-to-tanker transfer operations using vapour balancing techniques.

11.9.4 Tanker-to-tanker transfers using terminal facilities

Where a tanker at a berth is transferring cargo to a tanker at another berth through the shore manifolds and pipelines, the tankers and the terminal should comply with all regulations relating to tanker-to-shore transfers, including written operating arrangements and communications procedures. The co-operation of the terminal in establishing these arrangements and procedures is essential.

11.9.5 Tanker-to-tanker electric currents

The principles for controlling arcing during tanker-to-tanker transfer operations are the same as in tanker-to-shore operations.

In tankers dedicated to tanker-to-tanker transfers, an insulating flange or a single non-conducting length of hose should be used in the hose string. However, when transferring static accumulator oils, it is essential that these measures are not taken by both tankers, leaving an insulated conductor between them that could accumulate an electrostatic charge. For the same reason, when such a dedicated tanker is involved in tanker-to-shore cargo transfers, care should be taken to ensure that there is no insulated conductor between the tanker and shore, e.g. through the use of two insulating flanges on one line.

In the absence of a positive means of isolation between the tankers, the electrical potential between them should be reduced as much as possible. If both have properly functioning impressed current cathodic protection systems, this is probably best achieved by leaving them running. Likewise, if one has an impressed system and the other a sacrificial system, the former should remain in operation.

12 Carriage and storage of hazardous materials

This chapter provides guidance on the carriage and storage of hazardous materials carried on board tankers as ship's stores, cargo samples or material stowed on deck.

ISGINTT does not attempt to give guidance on the many hazardous chemical cargoes that may be shipped from time to time.

General guidance on the properties of such materials may be obtained from national and international technical publications, which may also include recommendations on handling and storage. SDS on specific chemicals should be obtained from the shipper. Specific information may also be displayed on the packaging of the materials.

12.1 Liquefied gases

In addition to the general precautions for handling packaged petroleum and other flammable liquids given in section 12.5, the following safeguards should be observed when handling packaged liquefied gas cargoes:

- Pressurised receptacles should be suitably protected against physical damage from other cargo, stores or equipment.
- Pressurised receptacles should not be over-stowed with other heavy goods or other items.
- Pressurised receptacles should be stowed in such a position that the safety relief device is in contact with the vapour space within the receptacle.
- Valves should be protected against any form of physical damage with a suitable protection cap in place at all times when the cylinder is not in use.
- Cylinders stowed below deck should be in compartments or holds capable of being ventilated, and away from accommodation and working areas and all sources of heat.
- Oxygen cylinders should be stowed separately from flammable gas cylinders.
- 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.

12.2 Tanker's stores

12.2.1 General

Any chemical or hazardous material placed on board a tanker as stores should be accompanied by an SDS. Where an SDS is not provided, the item should be isolated and stored in line with the guidance provided on its container or packaging. It should not be put into use until satisfactory user information is provided.

Containers and packages should be stowed closed and the storage location kept clean and tidy.

12.2.2 Paint

Paint, paint thinners and associated cleaners and hardeners should be stowed in storage locations according to the applicable legislation.

12.2.3 Chemicals

All chemicals should be stowed in a designated and dedicated storage location. Care should be taken to ensure that incompatible chemicals are stowed separately. Information on handling, first aid and the fire-fighting medium for each chemical should be readily available from the product's SDS and or written dangerous goods instructions.

12.2.4 Cleaning liquids

It is preferable to use cleaning liquids that are non-toxic and non-flammable. If flammable liquids are used, they should have a high flashpoint. Highly volatile liquids, such as gasoline or naphtha, should never be used in engine and boiler rooms.

Flammable cleaning liquids should be kept in closed, unbreakable and correctly labelled containers, and should be stored in a suitable compartment when not in use.

Cleaning liquids should only be used in places where ventilation is adequate, taking into consideration their volatility. All such liquids should be stowed and used in compliance with the manufacturer's instructions.

Direct skin contact with cleaning liquids should be avoided, nor should they be allowed to contaminate clothing.

12.2.5 Spare gear storage

Spare gear is not inherently hazardous. However, there have been cases where large items of spare gear stowed on deck have broken free of their lashings, damaging the vessel and putting personnel at risk. When stowing spare gear, it should:

- Allow safe access to, and operation of, any safety equipment.
- Not interfere with mooring or other operations.
- Be properly lashed, taking into account the expected weather.

12.3 Cargo and bunker samples

No more than 30 cargo samples bottles with a maximum volume of 500mℓ may be kept on board, stored within the cargo area. Bunker barges may store up to 500 bunker sample bottles with a maximum volume of 500mℓ, stored within the cargo area. Storage must be as such that under normal circumstances the bottles cannot be damaged.

12.4 Other materials

12.4.1 Sawdust, oil-absorbent granules and pads

A designated ready-to-use spill kit, capable of dealing with small spills of around 200ℓ, is preferred.

The use of sawdust for cleaning up small oil spills on board is discouraged. Oil-impregnated sawdust and absorbent granules should be disposed of ashore as early as possible. Unused sawdust must be stored dry and cool; moist sawdust is susceptible to spontaneous combustion (see section 4.9).

Any oil-impregnated absorbent granules or pads should be stowed in dedicated containers on deck.

12.4.2 Garbage

The storage locations for garbage should be carefully selected to ensure that it presents no potential hazard to adjacent spaces.

Particular consideration should be given to the storage of garbage that is designated as special waste, such as batteries, sensors and fluorescent tubes, to ensure that only compatible materials are stowed together.

12.5 Packaged cargoes

12.5.1 Petroleum and other flammable liquids

Packaged petroleum cargoes are usually shipped in steel drums that carry around 200ℓ. Products transported in this way include gasoline, kerosene, gas oils and lubricating oil.

In addition to the general safety precautions for handling bulk petroleum, the following procedures should be observed when handling packaged petroleum products.

12.5.1.1 Loading and discharging

Packaged petroleum and other flammable liquids should not be handled while loading volatile products in bulk, except with the express permission of the Responsible Person and the Terminal Representative. When handling steel drums, bulk cargo loading should be suspended because of the increased risk of spark generation.

12.5.1.2 N/A

12.5.2 N/A

12.5.3 Entry into holds

Before entering any hold that contains, or has contained, packaged petroleum and/or other flammable liquids, all the precautions for entry into enclosed spaces should be taken (see chapter 10).

12.5.4 N/A

12.5.5 N/A

12.5.6 N/A

12.5.7 N/A

12.5.8 Material stowed on deck

When drums or other receptacles are carried on deck, they should be protected against the elements, and normally be stowed only one tier high.

12.5.9 N/A

13 Human factors

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.

13.1 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 13.6), 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.

13.2 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 9.2.3):

- 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.

13.3 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 section 9.2.5). 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.

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.

13.4 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 section 9.2.3).

13.5 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?

13.6 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 13.12 on investigation and learning).

13.7 Confidence to stop work or speak up

Tanker and terminal operators should emphasise to their personnel that everybody has Stop Work Authority (SWA) (see chapter 9).

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.

13.8 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.

13.9 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 legal minimum manning requirements 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.

13.10 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 or equivalent local regulations contain 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.

13.11 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.

Inland tankers and terminals should regularly exercise teams to practise the skills described above.

13.12 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*.

14 Special ship types

N/A

PART 3:
TERMINAL INFORMATION

15 Terminal management and information

This chapter describes the risk-based systems and processes that should be in place to ensure the safe and efficient operation of the terminal. It covers the need for full supporting documentation, such as operating manuals, drawings and maintenance records for the facility and its equipment, copies of relevant legislation, and codes of practice. It also deals with the need for a clear, documented definition of the requirements for inland tanker and berth compatibility.

Terminal manning is discussed with regard to ensuring effective supervision of operations and activities at the inland tanker/shore interface.

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.

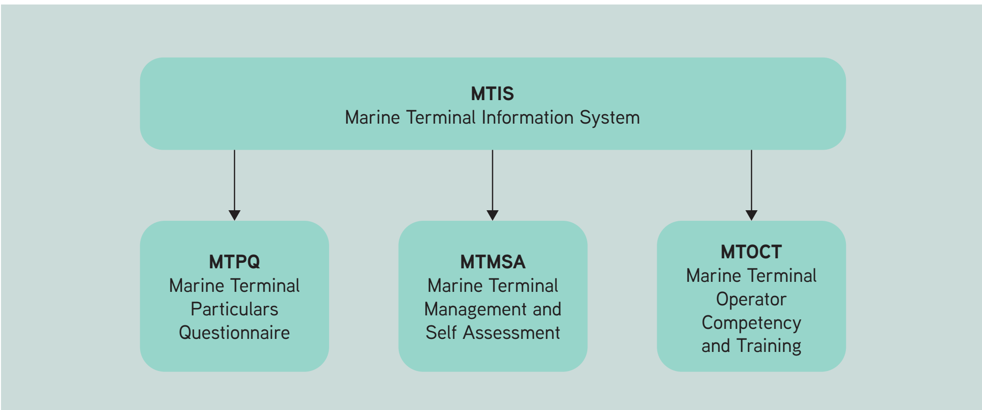


Figure 15.1: *Schematics of the available MTIS documentation*

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 Hazard identification and risk management

Terminals should have formal risk management processes in place that demonstrate how hazards are identified and quantified, and how the associated risk is assessed and managed. Details of risk assessment processes are provided in section 9.2 Risk Management.

The risk management should include formal risk assessments that address any changes in design, manning or operation, and follow on from the design-case risk assessment for the facility. Risk assessments should be structured to identify potential hazards, assess the probability of occurrence, and determine the potential consequences of the event. The output of the risk assessment should provide recommendations on prevention, mitigation and recovery. Risk assessments should be undertaken as part of the process when modifications to the terminal equipment and facilities are proposed. They should also be carried out as part of the safety management process that is used to permit the conduct of operations not covered in the current operational procedures.

Terminals should conduct reviews, typically annually, of their facilities and operations to identify potential hazards and the associated risks, which may demonstrate the need for additional or revised risk assessments. Reviews should also be carried out when there are changes to the terminal facilities or operations, e.g. changes in equipment, organisation, the product being handled, or the type of inland tankers visiting the terminal.

Terminal operating procedures should provide documentation and processes for ensuring the effective management and control of identified risks.

The effectiveness of the risk management system should be reviewed in line with guidance in Element 10 *MTMSA* with records of all reviews and assessments kept.

15.3 Operating manual

Terminals should have a written, comprehensive and up-to-date terminal operating manual.

The terminal operating manual is a working document and should include procedures, practices and drawings relevant to the specific terminal. The manual should be available in the accepted working language to all appropriate personnel.

The terminal operating manual should define the roles and responsibilities of the berth operating personnel and the procedures associated with emergencies such as fire, product spills or medical problems. A separate response manual should be provided to cover such topics as emergency call-out procedures and interaction with local authorities, municipal emergency-response organisations, or other outside agencies and organisations (see chapter 20 for more detailed guidance on emergency planning and response).

Terminals should also have a documented management-of-change process for handling temporary deviations and for making permanent changes to the procedures in the operating manual. It should define the level of approval required for such deviations and changes to a prescribed procedure.

The effectiveness of the Management of Change process should be assessed against the guidance contained in Element 8 of the *MTMSA*.

15.4 Terminal information and port regulations

Terminals should have procedures in place to manage the exchange of information between the inland tanker and the terminal, before the tanker berths and/or on arrival. This will ensure the safe and timely arrival of the tanker at the berth, with both parties ready to start operations.

Detailed information on communications at the tanker/shore interface is given in chapter 22. Also refer to chapter 6 for information on security at the tanker/shore interface.

The format of the Terminal Information should follow the OCIMF *Marine Terminal Information Booklet: Guidelines and Recommendations* (*TIB*). 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.

15.5 Supervision and control

15.5.1 Manning levels

Personnel should be trained in any operations they undertake and have site-specific knowledge of all safety procedures and emergency duties.

Terminals should provide enough manpower to ensure that all operational and emergency conditions can be conducted safely, taking into account:

- Effective monitoring of operations.
- Size of the facility.
- Volume and type of products handled.
- Number and size of berths.
- Number, type and size of inland tankers visiting the terminal.
- Degree of mechanisation employed.
- Amount of automation employed.
- Tank-farm and ancillary duties for personnel.
- Fire-fighting duties.
- Liaison with port authorities and neighbouring terminal operators.
- Personnel requirements for port operations, including handling mooring lines and hose/hard arms.
- Fluctuations in manpower owing 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.

When considering the effective monitoring of the tanker/shore interface, continuous supervision should be aimed at preventing hazardous situations developing.

In establishing manning levels, due account should be given to any local or national legal requirements. Consideration should also be given to avoiding fatigue that may result from extended hours of work, or insufficient rest periods or time off between shifts.

More information can be found in OCIMF's *Manning at Conventional Marine Terminals.*

15.5.2 De-manning berths during cargo handling

Terminal operators may wish to reduce manning at the berth or de-man berths during cargo transfer operations. Where this happens, it should not result in a reduction of safe operational standards, operational surveillance or emergency response capability. The inland tanker should always be informed before berth personnel depart, and the method of contact confirmed and agreed.

The inland tanker/shore connections should remain under continuous observation. This may be achieved remotely – e.g. by closed-circuit television – but enough personnel should always be available to take corrective action if a hazardous situation arises.

Supervision by systems incorporating CCTV should only be used where they are continuously manned and give effective control over the cargo operations. Such systems cannot in themselves take corrective action and should not be regarded as a substitute for human supervision at the inland tanker/shore interface.

15.5.3 Checks on quantity during cargo handling

The Terminal Representative should regularly check pressures in the pipeline and hose or hard arm, and compare the estimated quantity of cargo loaded or discharged with the inland tanker's estimate. An unexpected drop in pressures, or any marked discrepancy between inland tanker and terminal estimates, could indicate pipeline or hose leaks and require that cargo operations be stopped until investigations have been carried out.

15.5.4 Training

Terminals should ensure that the personnel engaged in activities relating to the inland tanker/shore interface are trained and competent. They should be thoroughly familiar with those sections of this document that are applicable to their work location and duties.

Personnel should be aware of local, national and international regulations and port authority requirements that affect the terminal operations and how they are implemented locally.

MTOCT helps marine terminal managers to ensure personnel have the necessary skills. See 15.1.3.

15.6 Documentation

Terminals should maintain a set of up-to-date documents to ensure compliance with regulations, procedures and good practice. This should provide comprehensive information on facilities and equipment associated with managing the inland tanker/shore interface.

Documentation should provide current information on topics that include:

- Legislation, including national and local operational requirements, and health and safety legislation.
- Industry guidelines, company policies, and health and safety policy.
- Operating manuals, maintenance and inspection procedures, and site plans and drawings.
- Records of internal and external audits, government inspections, health and safety meetings, permits to work and local procedures.
- Certificates issued for equipment and processes.

Documentation available on site should include a comprehensive set of 'as built' construction drawings and specifications of the berth and associated terminal facilities, including operating envelopes for marine loading arms (MLAs) or hoses and all modifications made since they were first commissioned. This documentation should form the basis of any structural, water depth or other survey carried out to inspect the fabric of the facilities.

A 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.
- Cargo transfer equipment, including MLA's/hoses, hydraulic systems, Vapour Emission Control Systems (VECS's), monitoring and warning systems, ESD systems, large valves, pumps and meters.

16 Terminal operations

This chapter provides information on a range of terminal operational procedures and activities that influence the safe receipt and handling of inland tankers. These include the assessment of limiting environmental criteria for safe operations and issues associated with providing safe means of access between the inland tanker and shore.

Operations requiring special procedures are described, including the double banking of inland tankers, and loading and discharging cargo using tidal increases in depth of water, called 'over the tide'.

The chapter also includes a brief explanation of pressure surges in pipelines and discusses how to control them.

The section on pipeline flow rates provides guidance on precautions to control static electricity generation in receiving tanks on board or ashore.

16.1 Pre-arrival communications

Terminals should provide inland tankers visiting their berths with information on all pertinent local regulations and terminal safety requirements.

Detailed information on communications at the inland tanker/shore interface is given in chapter 22.

16.2 Mooring

Mooring equipment should be appropriate for the sizes of inland tanker using the berths. The equipment provided should allow the inland tanker's mooring arrangements to hold the inland tanker securely alongside the berth in the weather and tidal conditions expected at the berth (see chapter 23).

16.2.1 Mooring equipment

The terminal should provide mooring bollards, mooring bitts or mooring hooks positioned and sized for the inland tankers visiting the berth. Where access to these mooring facilities is required from the inland tanker, they should be in accordance with guidance in sections 16.4 and 22.3.

The safe working load of each mooring point or lead should be known to the berth-operating personnel or marked on each mooring point.

Where shore mooring lines are provided, the terminal should have test certificates for the lines and the berth-operating personnel should be aware of their safe working load (see chapter 23 for information on inland tanker's mooring equipment).

16.3 Limiting conditions for operations

For each berth, terminals should establish weather operating limits defining the thresholds for stopping cargo transfer, disconnecting cargo (and bunker) hose connections and removing the inland tanker from the berth. This should take into account the safe working load of the mooring system components and, if appropriate, the operating envelopes of the loading arms.

Operating limits will normally be based on ambient environmental conditions, such as:

- Wind speed and direction.
- Wave height and period.
- Speed and direction of the current.
- Swell conditions that may affect operations at the berth.
- Electrical storms.
- Environmental phenomena, e.g. river bores or ice movement.
- Extremes of temperature that might affect loading or unloading.

The environmental limits should define the thresholds for:

- Manoeuvring during arrival and berthing.
- Stopping loading or discharging.
- Disconnecting cargo hoses or hard arms.
- Summoning tug assistance.
- Removing the inland tanker from the berth.
- Manoeuvring during unberthing and departure.

Information on environmental limits should be passed to the inland tanker at the pre-cargo transfer conference and, where applicable, be formally recorded in the safety checklist (see sections 26.3). Routine local weather forecasts received by the terminal should be passed to the inland tanker, and vice versa.

If possible, the terminal should have its own locally installed anemometer for measuring wind speeds. Alternatively, other means may be used, e.g. wind reports from a reliable local source, such as a nearby airport or an inland tanker.

Equipment for measuring other environmental factors should be considered.

16.4 Inland tanker/shore access

16.4.1 General

Means of access between the inland tanker and shore are addressed by national and/or local regulation. Any means of access must meet these regulated standards and should be correctly rigged by the inland tanker or terminal, as appropriate.

Personnel should use only the designated means of access between the inland tanker and shore.

16.4.2 Provision of inland tanker/shore access

Responsibility for providing safe inland tanker/shore access is shared between the inland tanker and the terminal.

At locations that commonly handle inland tankers but are unable to provide a gangway because of the physical limitations of the berth or the nature of the inland tanker's trade, the terminal should provide a shore-based gangway or alternative arrangements to ensure safe inland tanker/shore access. In any case, the preferred means for access between inland tanker and shore is a gangway provided by the terminal.

When terminal-access facilities are not available and an inland tanker's gangway is used, the berth must have enough landing area to provide the gangway with an adequate clear run that maintains safe, convenient access to the inland tanker at all states of tide and changes in freeboard.

Whether it is provided by the terminal or the inland tanker, the gangway should be subject to inspection as part of the inland tanker/shore safety checks that are carried out at regular intervals throughout the vessel's stay at the berth (see section 26.3).

All inland tanker and shore gangways should meet the following criteria:

- Clear walkway.
- Continuous handrail on both sides.
- Electrically insulated to eliminate continuity between inland tanker and shore.
- Adequate lighting.
- A maximum safe operating inclination (for gangways without self-levelling treads or steps).
- Lifebuoys with light and line, available on both the inland tanker and the shore.

All shore gangways should also meet the following additional criteria, as appropriate:

- Remain within deflected fender face when in the stored position.
- Provide for locking against motion in the stored position.

- Permit free movement after positioning on the inland tanker.
- Provide backup power or manual operation should primary power fail.
- Be designed for specified operating conditions known to the berth operating personnel.

16.4.3 Access equipment

16.4.3.1 Shore gangway

When provided by the terminal, a gangway should allow safe access between the shore and the inland tanker. This may be similar to an inland tanker's gangway.

At some berths, it may be necessary to provide access to small inland tankers from an internal stairway below the working level of the berth.

16.4.3.2 Inland tanker's gangway

An inland tanker's gangway consists of a straight, lightweight bridging structure with side stanchions and handrails. The floor has a non-slip surface or transverse bars to provide foot grips for when it is inclined. It is normally rigged perpendicular to the inland tanker's side and spans between the inland tanker's rail and the working deck of the berth.

16.4.3.3 Inland tanker's accommodation ladder

Given their limited size, most inland tankers are not equipped with accommodation ladders.

An accommodation ladder consists of a straight lightweight structure fitted with side stanchions and handrails, mainly intended for access to boats from the main deck. The steps are self-levelling or formed as large radius non-slip treads. The ladder is rigged generally parallel to the inland tanker's side on a retractable platform fixed to the inland tanker'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 inland tanker's deck is below the level of the berth working deck.

16.4.4 Siting of gangway

Means of access should be placed as close as practically possible to crew accommodation areas and as far away as practically possible from the manifold.

Bear in mind that the means of access also provides a means of escape. The location of any portable gangway should be carefully considered to ensure that it provides a safe access to any escape route from the jetty (see chapter 21).

Particular attention to safe access should be given where there is a large difference in level between the decks of the inland tanker and jetty. There should be special facilities at berths where the level of an inland tanker's deck can fall well below that of the jetty.

16.4.5 Safety nets

Safety nets are not required if the gangway is fixed to the shore and provided with a permanent system of handrails made of structural members. For other types of gangway, and those fitted with rope or chain handrails or removable posts, correctly rigged safety nets are recommended.

16.4.6 Routine maintenance

All gangways and associated equipment are to be routinely inspected and tested. This requirement should be included within the terminal's planned maintenance programme. Mechanically deployed gangways should also be function tested. Self-adjusting gangways should be fitted with alarms that should be routinely tested.

16.4.7 Unauthorised people

People who have no legitimate business on board, or who do not have the inland tanker Master's permission, should be refused access to an inland tanker. The terminal should restrict access to the jetty or berth, in agreement with the inland tanker's Master.

Terminal security personnel should be given a crew list and a list of authorised visitors to the inland tanker (see also section 6.4).

16.4.8 People smoking or intoxicated

Personnel on duty on a berth or jetty, or on watch on an inland tanker, must ensure that no one who is smoking approaches the berth or jetty or boards the tanker. People apparently intoxicated should not be allowed to enter the terminal area or board the tanker unless they can be properly supervised.

16.5 Double banking

Double banking occurs when two or more inland tankers are berthed at the same jetty, with the presence or operations of one inland tanker acting as a physical constraint on the other. Double banking is sometimes used to conduct multiple transfers between the shore and more than one inland tanker at the same jetty at the same time. The outermost tanker may be moored to an inner tanker or to the shore, and hose strings led from shore, across the inner tanker to the outer tanker. This causes significant complications for managing the inland tanker/shore interface.

Double banking on a berth for cargo operations should not be conducted unless a formal engineering study and risk assessment have been carried out, and a formal procedure and safety plan produced. As a minimum, before such activities are agreed, consideration and agreement must be reached by all parties concerned on safe arrival and departure, strength of jetty construction, mooring fittings, mooring arrangements, personnel access, management of operational safety, liability, contingency planning, fire-fighting and emergency unberthing.

16.6 Over-the-tide cargo operations

This is a procedure that uses tidal changes in water depth, either loading an inland tanker to its full draught as the water depth increases towards high tide or discharging cargo to lighten a tanker before the low tidal level is reached.

Terminals with draught limitations and significant tidal variations should have procedures in place if discharging or loading over the tide operations are to be permitted. These procedures should be agreed by all parties involved, before the arrival of the inland tanker.

Procedures to control over-the-tide operations should be developed from a full risk assessment process with the aim of ensuring that the inland tanker remains safely afloat, taking into account under-keel clearance requirements and contingency measures.

The terminal should seek assurance that the tanker equipment critical to the operation, e.g. cargo pumps and main engines, are operational before berthing and are kept available while the inland tanker is alongside at the critical stage.

16.6.1 Discharging over the tide

Where an inland tanker is required to use a berth when the nominated quantity of cargo will cause the tanker to arrive at a draught that exceeds the maximum always-afloat level for the berth, it may be possible for the tanker to berth and discharge enough cargo before the next low water, enabling her to remain afloat. This procedure may be adopted where all parties accept the risk involved and agree to adopt mitigating procedures to ensure that the tanker can be discharged in good time to remain afloat or be removed from the berth to a position where it can remain afloat.

16.6.2 Loading over the tide

This may be undertaken where an inland tanker cannot remain safely afloat during the final stages of loading in a low water period. The tanker should stop loading at the draught at which it can remain always afloat, and restart loading as the tide rises. Loading should not restart unless equipment critical for the departure of the tanker from the berth, e.g. the 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 under-keel clearance.

16.7 Operations where the inland tanker is not always afloat

A limited number of ports with significant tidal ranges allow inland tankers to operate if they are unable to remain afloat all the time they are alongside the cargo-handling berth. This type of operation is considered exceptional and should only be permitted following a comprehensive risk assessment and the implementation of all safeguards identified to deliver a safe operation.

The type of operation that may be undertaken varies from the tanker briefly taking the ground during its stay at the berth to the tanker being completely out of the water. In both cases, the following points are among those that need to be addressed:

- The seabed should be flat, with no protuberances or high spots that could put local or general stresses on the hull.
- The slope of the seabed should not put any excessive up-thrust on the tanker's structure or cause any loss of stability when the tanker takes the ground.
- The tanker's hull should be strong enough 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 or dry out.
- The operation should not result in the tanker losing any of its essential services, such as cooling water for the machinery or its fire-fighting capability. This may require special design features to be added to the tanker.
- As it will not be possible to remove the tanker from the berth in an emergency, port operations will need to address specific emergency procedures and the provision of appropriate fire-fighting equipment.
- Contingency plans will need to address the possibility of structural failure on the tanker and the nature and size of any resulting pollution.

16.8 Generation of pressure surges in pipelines

16.8.1 Introduction

A pressure surge is generated in a pipeline system when there is an abrupt change in the rate of flow of liquid in the line. In inland tanker loading operations, it is most likely to occur as a result of:

- An automatic shutdown valve closing.
- A shore non-return valve slamming shut.
- A butterfly-type valve slamming shut.
- A power operated valve rapidly closing.

If the pressure surge in the pipeline results in pressure stresses or displacement stresses in excess of the strength of the piping or its components, there may be a rupture, leading to an extensive oil spill.

16.8.2 Generation of a pressure surge

When a pump is used to move liquid from a feed tank down a pipeline and through a valve into a receiving tank, the pressure at any point in the system while the liquid is flowing has three components:

- Pressure on the surface of the liquid in the feed tank. In a tank with its ullage space open to atmosphere, this pressure is that of the atmosphere.
- Hydrostatic pressure at the point in the system in question.
- Pressure generated by the pump. This is highest at the pump outlet, decreasing with friction along the line downstream of the pump and through the valve to the receiving tank.

Of these three components, the first two can be considered constant during pressure surges and need not be considered in the following description, although they are always present and will contribute to the total pressure.

Rapid closure of the valve superimposes a transient pressure on all three components, owing to the sudden conversion of the kinetic energy of the moving liquid into strain energy, by compression of the fluid and expansion of the pipe wall. To illustrate the sequence of events, in the simplest hypothetical case, i.e. when the valve closure is instantaneous, there is no expansion of the pipe wall, and dissipation due to friction between the fluid and the pipe wall is ignored. This case gives the highest pressures in the system.

When the valve closes, the liquid immediately upstream of the valve is brought to rest instantaneously.

This causes its pressure to rise by an amount P. In any consistent set of units:

$P=wav$

where: w is the mass density of the liquid.
a is the velocity of sound in the liquid.
v is the change in linear velocity of the liquid, i.e. from its linear flow rate before closure.

The stopped flow of liquid is propagated back up the pipeline at the speed of sound in the fluid and, as each part of the liquid comes to rest, its pressure is increased by the amount P. So a steep pressure front of height P travels up the pipeline at the speed of sound, a disturbance known as a pressure surge.

Upstream of the surge, the liquid is still moving forward and still has the pressure distribution applied to it by the pump. Behind it, the liquid is no longer moving and its pressure has been increased at all points by the constant amount P. There is still a pressure gradient downstream of the surge, but a continuous series of pressure adjustments takes place in this part of the pipeline, ultimately resulting in a uniform pressure throughout the stationary liquid. These pressure adjustments also travel through the liquid at the speed of sound.

When the surge reaches the pump, the pressure at the pump outlet (ignoring the atmospheric and hydrostatic components) becomes the sum of the surge pressure P and the output pressure of the pump at zero throughput (assuming no reversal of flow), since flow through the pump has stopped. The process of pressure equalisation continues downstream of the pump.

Again, taking the hypothetical worst case, if the pressure is not relieved in any way, the result is a pressure wave that oscillates throughout the length of the piping system. The maximum magnitude of the pressure wave is the sum of P and the pump outlet pressure at zero throughput. The final pressure adjustment to achieve this condition leaves the pump as soon as the original surge arrives at the pump and travels down to the valve at the speed of sound. One pressure wave cycle takes a time 2L/a from the instant of valve closure, where L is the length of the line and a is the speed of sound in the liquid. This time interval is known as the pipeline period.

In this simplified description, the liquid at any point in the line experiences an abrupt increase in pressure by an amount P followed by a slower, but still rapid, further increase until the pressure reaches the sum of P and the pump outlet pressure at zero throughput.

In practical circumstances, the valve closure is not instantaneous and there is then some relief of the surge pressure through the valve while it is closing. The results are that the magnitude of the pressure surge is less than in the hypothetical case and the pressure front is less steep.

At the upstream end of the line, some pressure relief may occur through the pump and this would also serve to lessen the maximum pressure reached. If the effective closure time of the valve is several times greater than the pipeline period, pressure relief through the valve and the pump is extensive and a hazardous situation is unlikely to arise.

Downstream of the valve, an analogous process is initiated when the valve closes, except that, as the liquid is brought to rest, there is a fall of pressure that travels downstream at the speed of sound. However, the pressure drop is often relieved by gas evolution from the liquid so that serious results may not occur immediately, although the subsequent collapse of the gas bubbles may generate shock waves similar to those upstream of the valve.

16.9 Assessment of pressure surges

16.9.1 Effective valve closure time

To determine whether a serious pressure surge is likely to occur in a pipeline system, the first step is to compare the time taken by the valve to close with the pipeline period.

The effective closure time, i.e. the period during which the rate of flow is in fact decreasing rapidly, is usually significantly less than the total time of movement of the valve spindle. It depends upon the design of the valve, which determines the relationship between valve port area and spindle position. Substantial flow reduction is usually achieved only during the closure of the last quarter or less of the valve port area.

If the effective valve closure time is less than or equal to the pipeline period, the system is liable to serious pressure surges. Surges of reduced, but still significant, magnitude can be expected when the effective valve-closure time is greater than the pipeline period, but they become negligible when the effective valve-closure period is several times greater than the pipeline period.

16.9.2 Derivation of total pressure in the system

In the normal type of inland tanker/shore system handling petroleum liquids, where the shore tank communicates to the atmosphere, the maximum pressure applied across the pipe wall at any point during a pressure surge is the sum of the hydrostatic pressure, the output pressure of the pump at zero throughput, and the surge pressure. The first two of these pressures are usually known.

If the effective valve closure time is less than or equal to the pipeline period, the value of the surge pressure used in determining the total pressure during the surge should be P, derived as indicated above in section 16.8.2. If it is somewhat greater than the pipeline period, a smaller value can be used in place of P and, as already indicated, the surge pressure becomes negligible if the effective valve-closure time is several times greater than the pipeline period.

16.9.3 Overall system design

In practice, the design of a more complex system may need to be taken into account. In this section, the simple case of a single pipeline has been considered. For example, the combined effects of valves in parallel or in series may have to be examined. In some cases, the surge effect may be increased. This can occur with two lines in parallel if closure of the valve in one line increases the flow in the other line before this line, in its turn, is shut down. On the other hand, correct operation of valves in series in a line can minimise surge pressure.

Transient pressures produce forces in the piping system that can result in large piping displacements, pipe rupture, support failure, and damage to machinery and other connected equipment. This means the design must consider the structural response of the piping system to fluid induced loads resulting from fluid pressures and momentum. Restraints are also usually required to avoid damage caused by large movements of the piping itself. An important consideration in selecting restraints is the fact that the piping often consists of long runs of straight pipe that will expand considerably under thermal loads. The restraints must allow for this thermal expansion and absorb the surge forces without overstressing the pipe.

16.10 Reduction of pressure surge hazard

16.10.1 General precautions

As a result of the calculations summarised in section 16.9, if the potential total pressure exceeds or is close to the strength of any part of the pipeline system, it is advisable to get expert advice. Where manually operated valves are used, good operating procedures should avoid pressure surge problems. It is important that a valve at the end of a long pipeline should not be closed suddenly against the flow, and all changes in valve settings should be made slowly.

Where motorised valves are installed, several steps can be taken to ease the problem:

- Reduce the linear flow rate, i.e. the rate of transfer of cargo, to a value that makes the likely surge pressure tolerable.
- Increase the effective valve-closure time. In general terms, total closure times should be around 30 seconds, and preferably more. Valve-closure rates should be steady and reproducible, although this may be difficult to achieve if spring return valves or actuators are needed to ensure that valves fail-safe to the closed position. A more uniform reduction of flow may be achieved by careful attention to valve port design, or by the use of a valve actuator that gives a very slow rate of closure over, say, the final 15% of the port closure.
- Use a pressure relief system, surge tanks or similar devices to absorb the effects of the surge quickly.

16.10.2 Limiting the flow rate to avoid the risk of a damaging pressure surge

In the operational context, pipeline length and, very often, valve-closure times are fixed, so the only practical precaution against the consequences of an inadvertent rapid closure is correct operation of the valves and/or to limit the linear flow rate of the oil to a maximum value related to the maximum tolerable surge pressure.

16.11 Pipeline flow control as a static precaution

16.11.1 General

Safety procedures for transferring static accumulator cargoes require the linear flow rates of the cargo within the loading lines, both ashore and on board, to be managed to avoid generating static charges during the cargo transfer (see chapter 3).

16.11.2 Flow control requirements

The generation of static is controlled by limiting the flow rate at the tank inlet when loading starts to 1m/sec. Transfer rates equivalent to flow rates of 1m/sec through pipelines of various diameters can be determined from table 11.1 (also see section 11.1.7.3).

Once cargo has covered the tank inlet, the transfer rate can be increased to provide the maximum allowable linear flow rate as determined by the limiting pipe diameter in the inland tanker or shore piping, whichever is the smaller (see section 11.1.7.8).

16.11.3 Controlling loading rates

Due to the varying loading rates that different inland tankers need to comply with their maximum flow rate requirements, terminals should have the facility to control effectively the pumping rates to tankers loading at its berths.

Similarly, if terminals expect inland tankers to discharge to empty shore tanks, it may be necessary to use flow control or flow measuring equipment to determine that the flow rates in the shore lines and tank inlets are not exceeded, particularly in the initial phase of filling a tank.

16.11.4 Discharge into shore installations

When discharging static accumulator oils into shore tanks, the initial flow rate should be restricted to 1m/sec unless or until the shore tank inlet is covered enough to limit turbulence.

For a side entrance (horizontal entrance), the inlet is considered adequately covered if the distance between the top of the inlet and the free surface exceeds 60cm. An inlet pointing downwards is considered sufficiently covered if the distance between the lower end of the pipe and the free surface exceeds twice the inlet diameter. An inlet pointing upwards may require a considerably greater distance to limit turbulence. In floating roof tanks, the low initial flow rate should be maintained until the roof is floating. Similar requirements apply to fixed roof tanks provided with inner floats.

17 Terminal systems and equipment

This chapter describes equipment that is provided by the terminal at the inland tanker/shore interface, including fendering, lifting, lighting, and bonding and earthing equipment.

Considerable emphasis is placed on ensuring that the inland tanker and shore remain electrically isolated, and on the means of achieving isolation.

17.1 Electrical equipment

The classification of hazardous zones for the installation or use of electrical equipment within a terminal is described in section 4.4.2.

Terminals should ensure that any electrical equipment is provided in accordance with a site-specific area electrical classification drawing, which shows hazardous zones at the berths in plan and elevation.

Terminals should identify the zones and establish the type of equipment to be installed in each zone. National legislation, international standards and company-specific guidelines, where available, are all to be complied with. A planned maintenance system should address the continued integrity of the equipment installed and ensure it meets zone requirements.

Personnel carrying out maintenance on equipment within hazardous zones should be trained and certified as competent to carry out the work. Certification may be by internal process or as required by regulatory bodies. All electrical maintenance should be carried out under the control of a permit to work system (see section 19.1.3).

17.2 Fendering

Fendering systems at each berth should be engineered to suit the range of inland tanker sizes and types that use the berth and should be capable of withstanding expected loads without causing damage to the inland tanker. The design should take account of how the berth is operated. Metal to metal should be avoided. When no fendering is provided by the terminal, the crew should be allowed to apply their own.

In calculating the berthing energy to be absorbed by the fendering system, the speed at which an inland tanker closes with the berth is the most significant factor. Energy is calculated as a function of mass and the square of the speed ($E = \frac{1}{2}mv^2$) (see section 15.6.2).

The spacing of the fenders should allow the inland tanker to lie alongside, with the fenders on the parallel sides of the inland tanker, at all freeboards and all expected heights of the tide.

The terminal should advise inland tanker Masters and berth-operating personnel of the maximum permissible closing speed for each berth, recognising that this is often difficult to estimate.

17.3 Lifting equipment

17.3.1 Inspection and maintenance

All equipment used for lifting cargo-transfer equipment and/or means of access should be examined at least once a year and load-tested at least every five years, or more frequently if mandated by local regulation or company requirements.

Equipment to be tested and examined includes:

- Cargo hose-handling cranes, derricks, davits and gantries.
- Gangways and associated cranes and davits.
- Cargo loading arm cranes.
- Store cranes and davits.
- Slings, lifting chains, delta plates, pad eyes and shackles.

- Chain blocks, hand winches and similar mechanical devices.
- Personnel lifts and hoists.

Tests should be carried out by a suitably qualified individual or authority, and the equipment should be clearly marked with its safe working load, identification number and test date.

Terminals should ensure that all maintenance is carried out in line with manufacturers' guidelines and that it is incorporated into the terminal's planned maintenance system.

If certified equipment is modified or repaired, it should be re-tested and certified before being placed back in service.

Defective equipment should be withdrawn from service immediately and only reinstated after repair, examination and, where required, re-certification.

17.3.2 Training in the use of lifting equipment

All personnel engaged in operating lifting equipment should be formally trained in its use. More information can be found in OCIMF's *Marine Terminal Operator Competence and Training Guide* (*MTOCT*).

17.4 Lighting

Terminals should have a level of lighting that ensures all inland tanker/shore interface activities can be safely conducted during darkness.

Work areas designated for loading and unloading of cargo should maintain a minimum lighting level of 50 lux, or in accordance with local or 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* (*COSWOP*).

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 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.
- Lighting of water around berth to detect spills and possibly unauthorised craft.

Lighting should be included as part of the terminal inspection and maintenance plan.

17.5 Inland tanker/shore electrical isolation

17.5.1 General

Possible differences in electrical potential between the inland tanker and the berth mean there is a risk of electrical arcing at the manifold when connecting and disconnecting the shore hose or loading arm. To protect against this risk, the inland tanker/shore interface should have a means of electrical isolation. The terminal should provide this.

Note that the subject of tanker-to-shore electric currents is quite separate from static electricity, which is discussed in chapter 3.

17.5.2 Inland tanker-to-shore electric currents

Large currents can flow in electrically conducting pipework and flexible hose systems between the inland tanker and shore. The sources of these currents are:

- Cathodic protection of the jetty or the hull of the tanker provided by either an impressed-current cathodic protection system or sacrificial anodes.
- Stray currents from galvanic potential differences between tanker and shore or leakage effects from electrical power sources.

An all-metal loading or discharge arm provides a very low resistance connection between the tanker and shore and there is a real danger of an incendive arc when the ensuing large current is suddenly interrupted as the arm at the inland tanker manifold is connected or disconnected.

Similar arcs can occur with flexible hose strings that have metallic connections between the flanges of each length of hose.

To prevent electrical flow between a tanker and a berth during connection or disconnection of the shore hose or loading arm, the terminal operator should ensure that cargo hose strings and metal arms are fitted with an insulating flange. An alternative solution with flexible hose strings is to include one length only of non-conducting hose without internal bonding in each string. This resistance completely blocks the flow of stray current through the loading arm or the hose string. At the same time, the whole system remains earthed either to the tanker or the shore.

All metal on the seaward side of the insulating section should be electrically continuous to the tanker; all metal on the landward side should be electrically continuous to the jetty earthing system. This arrangement will ensure electrical discontinuity between the tanker and shore. It will also prevent arcing during connection and disconnection.

The insulating flange or single length of non-conducting hose must not be short circuited by contact with external metal. For example, an exposed metallic flange on the seaward side of the insulating flange or hose length should not make contact with the jetty structure, either directly or through hose-handling equipment.

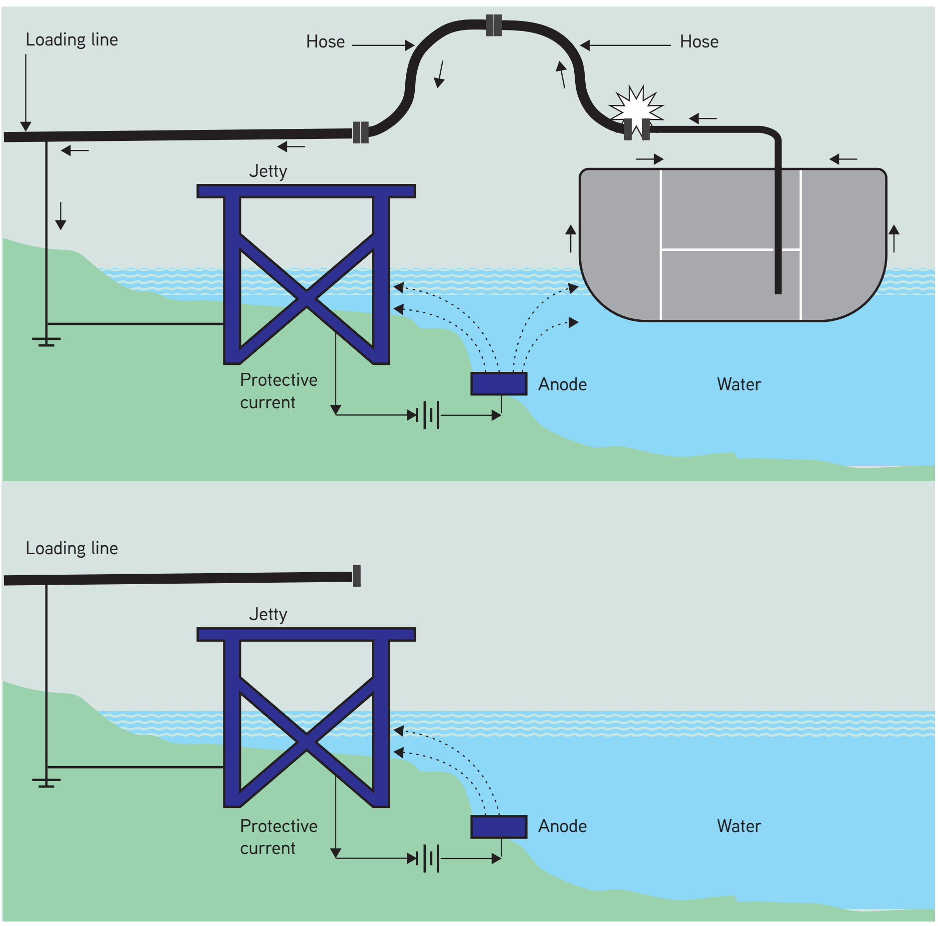


Figure 17.1: *Stray currents from cathodic protection*

Note that the requirements for using insulating flanges or an electrically discontinuous length of hose also apply to the vapour-recovery connection.

In the past, it was usual to connect the inland tanker and shore systems with a bonding wire via a flameproof switch before the cargo connection was made. This bonding wire was maintained in position until after the cargo connection was broken. The use of this bonding wire had no relevance to electrostatic charging. It was an attempt to short circuit the tanker/shore electrolytic/cathodic protection systems and to reduce the tanker/shore voltage so that currents in hoses or in metal arms would be negligible. However, because of the large current and the difficulty of achieving a small-enough electrical resistance in the tanker/shore bonding wire, this method has been found to be ineffective for the intended use and has itself created a possible hazard to safety. Tanker/shore bonding wires are not recommended (see section 17.5.4).

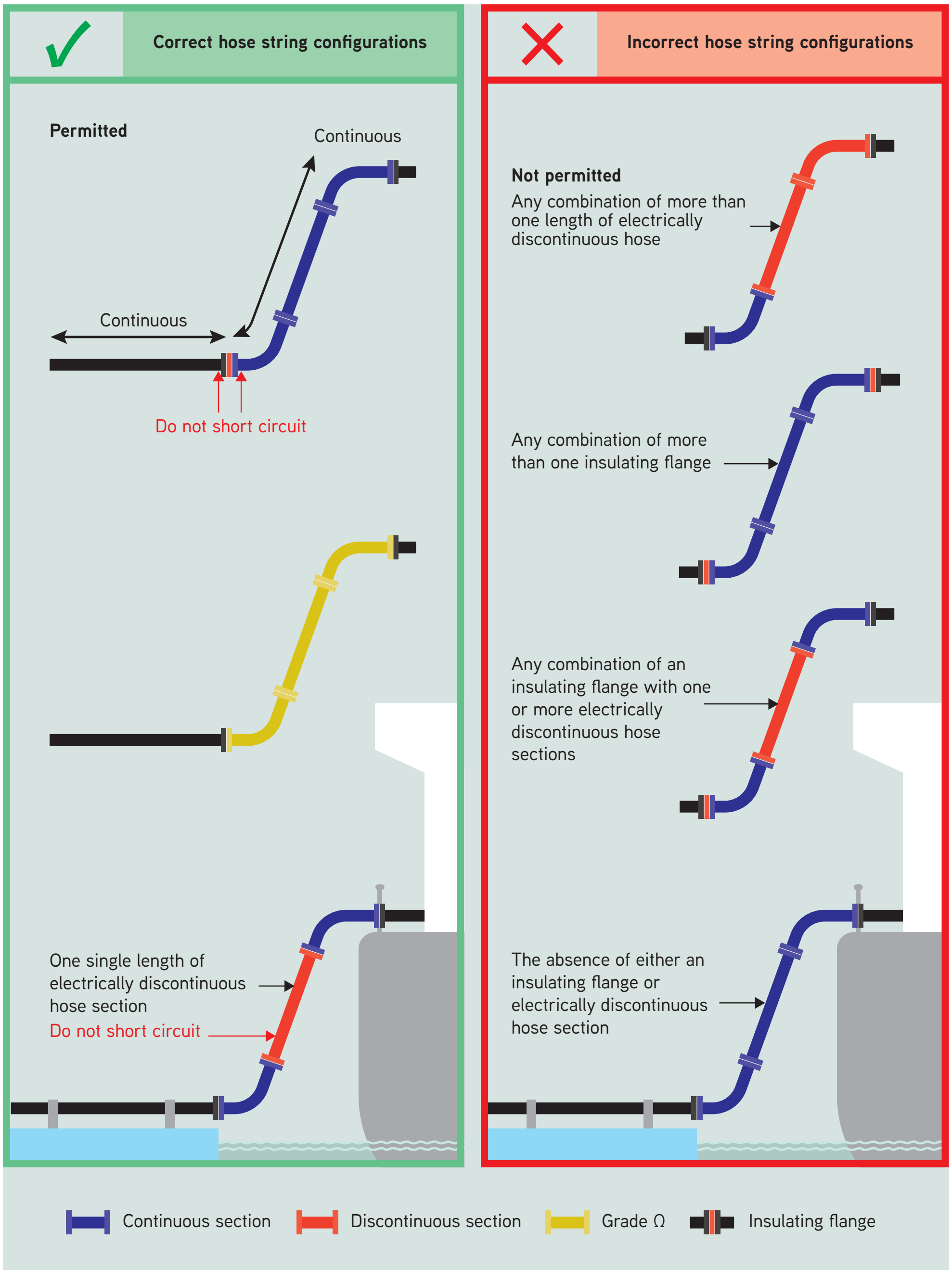


Figure 17.2: *Hose string configurations for electrical isolation*

Current flow can also occur through any other electrically conducting path between tanker and shore, e.g. mooring wires or a metallic ladder or gangway. These connections may be insulated to avoid draining the jetty cathodic protection system by the added load of the 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 impressed-current cathodic protection systems (required in some national and local regulations) either ashore or on the tanker is not considered a feasible method of minimising tanker/shore currents in the absence of an insulating flange or hose. A jetty handling a succession of inland tankers would need to have this cathodic protection switched off almost continuously and would lose its corrosion resistance. Also, if the jetty system remains switched on, it is probable that the difference of potential between tanker and shore 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 time before arriving in port.

17.5.3 N/A

17.5.4 Inland tanker/shore bonding cables

An inland tanker/shore bonding cable does not replace the requirement for an insulating flange or hose as described above. Using a tanker/shore bonding cable may be dangerous, so the following should be considered.

Although the potential dangers of using an inland tanker/shore bonding cable are widely recognised, some national and local regulations may still require a bonding cable to be connected. It should be noted that the International Maritime Organization (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 as described in 17.5.2 above.

If a bonding cable must be used, it should first be inspected to see that it is mechanically and electrically sound. The connection point for the cable should be well clear of the manifold area. There should always be a switch on the jetty in series with the bonding cable and it should be 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 inland tanker should the switch be closed. The cable should be attached before the cargo hoses are connected and removed only after the hoses have been disconnected.

17.5.5 Insulating flange

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.

17.5.5.1 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.

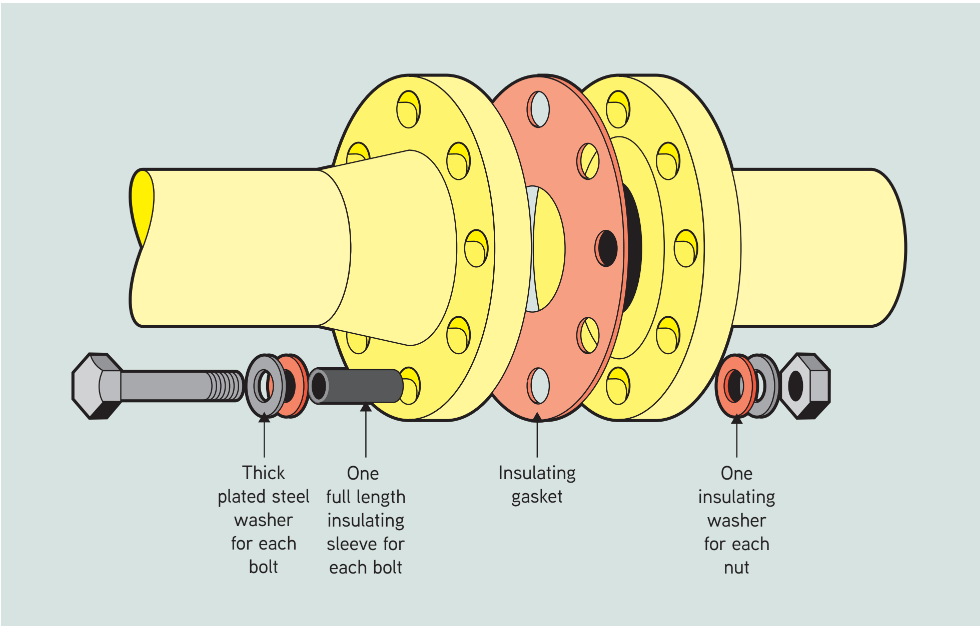


Figure 17.3: *Typical insulating flange joint*

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.

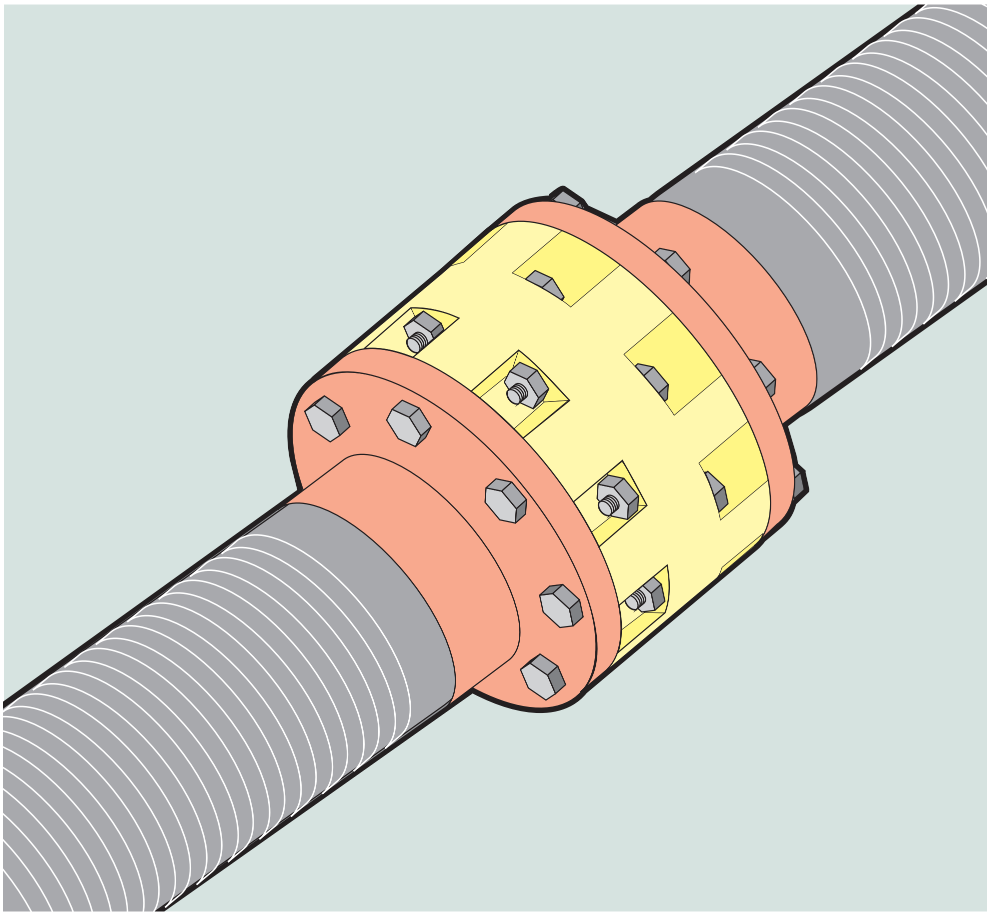


Figure 17.4: *Cast-nylon insulating flange joint*

17.5.5.2 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).

17.5.5.3 Safety

Testing should be undertaken with instruments and methods selected to be compatible with any hazardous area associated with the location of the flange. 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).

17.6 Earthing and bonding practice in the terminal

Earthing and bonding minimises the dangers arising from:

- Faults between electrically live conductors and non-current carrying metalwork.
- Atmospheric discharges (lightning).
- Accumulations of electrostatic charge.

Earthing is achieved by establishing an electrically continuous low-resistance path between a conducting body and the general mass of the earth. Earthing may occur inherently through intimate contact with the ground or water or be deliberately provided by an electrical connection between the body and the ground.

Bonding occurs where a suitable electrically continuous path is established between conducting bodies. This may be done between two or more bodies without earthing but earthing more commonly leads to bonding when the general mass of the earth acts as the electrical connection. Bonding may also occur by bolting metallic bodies together, so creating electrical continuity, or by providing an additional bonding conductor between them.

Most earthing and bonding devices that protect against electrical faults or lightning are permanently installed parts of the equipment they protect, so their characteristics must conform to the national standards in the country concerned or to classification society rules where relevant.

The acceptable resistance in the earthing system depends on the type of hazard it is guarding against. To protect electrical systems and equipment, the resistance value is chosen to ensure the correct operation of the protective device (e.g. cut out or fuse) in the electrical circuit. For lightning protection, the value depends on national regulations, and is typically in the range of five to 25 ohms.

17.7 Vigilance control (dead man's switch)

A dead man's switch is automatically operated when an operator becomes incapacitated. At some terminals this switch guards the loading or unloading operation. Normally, if the dead man's switch is not reset at regular intervals an alarm will activate. If this alarm is not acknowledged within a certain time, the cargo operations will stop automatically.

If a vigilance control system is installed, it is recommended that:

- The switch should be remotely controlled.
- If remote control is not possible, the continuation button should at least be in a portable box on the inland tanker, readily accessible and away from the ship/shore interface.
- To prevent confusion with any other buttons or switches provided by the terminal, the continuation button should be clearly marked.
- During inland tanker discharging, the vigilance alarm should not initiate automatic closure of the terminal's valve because it could cause a pressure surge.
- For vessels certified for supervision from the wheelhouse or control room, the vigilance control should preferably be placed in this location.

18 Cargo transfer equipment

This chapter describes hard arms and flexible hoses used to make the connection between inland tanker and shore. The equipment is described, together with recommendations for its operation, maintenance, inspection and testing. If not properly engineered and maintained, this equipment will be a weak link that may jeopardise the cargo system's integrity.

18.1 Marine Loading Arms

18.1.1 Operating envelope

All Marine Loading Arms (MLAs) have a designed operating envelope that takes into account the:

- Range of water level in berth.
- Maximum and minimum freeboards of the largest and smallest inland tankers for the berth.
- Minimum and maximum manifold setbacks from the deck edge.
- Limits for changes in horizontal position due to drift off and ranging.
- Maximum and minimum spacing when operating with other arms in a bank.

The limits of this operating envelope should be thoroughly understood by berth operators. Metal arm installations should have a visual indication of the operating envelope and/or have alarms to indicate excessive range and drift.

The person in charge of operations on a berth should ensure that the tanker's manifolds are kept within the operating envelope during all stages of loading and discharging. To achieve this, the tanker may need to ballast or deballast (see also section 11.6).

18.1.2 Forces on manifolds

Most MLAs are counterbalanced so that no weight, other than the liquid content of the arm, is placed on the manifold. Because the weight of oil in the arms can be considerable (particularly for larger diameter arms), it may be advisable for this weight to be relieved by a support or jack provided by the terminal.

Some arms have integral jacks that are used to prevent the weight of the arm or other external forces such as the wind overstressing the tanker's manifold.

Terminals should have detailed information on the forces exerted on the tanker's manifold by each loading arm. If in doubt, this information should be readily available to the berth operator.

The berth operator's training should include the correct rigging and operation of cargo arms. Operators should be aware of the consequences of inappropriate operation that may cause excessive forces on the tanker manifold.

Where supports or jacks are used, they should be fitted so that they stand directly on the deck or some other substantial support. They should never be placed on fixtures or fittings that are not suitable or capable of supporting the load.

Some counterbalanced arms are made slightly tail heavy to compensate for clinging oil and to help the arm return to the parked position without using power when released from the tanker's manifold. Also, in some positions the arm can place an upward force on the manifold. For both these reasons, manifolds should be secured against upward forces.

18.1.3 Inland tanker manifold restrictions

The material, support and cantilever length of a tanker's manifold, together with the spacing intervals of adjacent outlets, must be checked for compatibility with the arms. It is best practice for manifold flanges to be vertical and parallel to the tanker's side. The spacing of the manifold outlets will sometimes dictate the number of arms that can be connected, while interference between adjacent arms is to be avoided. In most cases, cast iron manifolds will be subjected to excessive stress unless jacks are used. Cast iron reducers and spool pieces should not be used (see section 24.6.3). In some cases cast iron reducers and/or spool pieces are permanently fitted to the tanker's lines. If so, supports or jacks should be fitted directly onto the deck or some other substantial support. Connecting directly to any cast iron valves should be avoided at all times.

18.1.4 Inadvertent filling of arms while parked

Loading arms are usually empty when parked and locked, but inadvertent filling may occur. The parking lock should be removed only after it has been verified that the arm is empty, to avoid the possibility of a filled loading arm falling onto the tanker's deck.

18.1.5 Ice formation

Ice formation will affect the balance of the arm. Any ice should be cleared from the arm before the parking lock is removed.

18.1.6 Mechanical couplers

To achieve a tight seal, most mechanical couplers require that the tanker's manifold flange face is smooth and free of rust. Care should be taken when connecting a mechanical coupler to ensure that the coupler is centrally placed on the manifold flange and that all claws or wedges are pulling up on the flange. Where 'O' rings are used in place of gaskets, these should be renewed on every occasion.

18.1.7 Wind forces

Wind loading on metal arms may place an excessive strain on the arms and the inland tanker manifolds. The terminal should establish appropriate wind limits for operation. At terminals where wind loading is critical, a close watch should be kept on wind speed and direction. If wind limits are approached, operations should be suspended, and the arms drained and disconnected.

18.1.8 Precautions when connecting and disconnecting arms

Due to the risk of unexpected movements of powered and unpowered arms during connection and disconnection, operators should ensure that all personnel stand well clear of moving arms and do not stand between a moving arm and the tanker's structure. When connecting manually operated arms, consider fitting two lanyards to control the movement of the connection end.

18.1.9 Precautions while arms are connected

Take the following precautions during the time that cargo arms are connected:

- Moorings should be monitored frequently by tanker and shore personnel and tended as necessary, so that any movement of the tanker is restricted to within the operating envelope of the metal arm.
- If any drift or range alarms are activated, all transfer operations should be stopped, and remedial measures taken.
- The arms should be free to move with the motion of the tanker. Care should be taken to ensure that hydraulic or mechanical locks cannot be inadvertently engaged.
- The arms should not foul each other.
- Excessive vibration should be avoided.

18.1.10 Powered emergency-release couplings

A powered emergency-release coupling (PERC) is a hydraulically operated device to provide quick disconnection of a marine loading arm in an emergency, or when the operating envelope of a loading arm is exceeded. It has a valve on each side of the release point to minimise spills. On release, from ashore the lower part of the coupling and its attendant valve remain attached to the inland tanker's manifold while the upper part and its attendant valve remain attached to the cargo arm, which is then free to rise clear of the tanker.

The emergency-release system is initiated in the following ways:

- Automatically, when the arm reaches the specified limit. Alarms usually sound.
- Manually, from the central control panel ashore.
- Manually, using hydraulic valves in the event of loss of electrical power supply ashore.

The emergency-release system valves above and below the emergency-release coupling are hydraulically or mechanically interlocked to ensure they close fully before the emergency-release coupling is operated.

Once the emergency disconnection has been initiated, the valves next to the powered emergency-release coupling will close rapidly (typically in less than five seconds) and therefore precautions need to be taken to avoid a pressure surge (see section 16.8). It is usual for the terminal to provide surge-control facilities for this purpose, but if these are not available then special operating procedures may be necessary.

Special attention should be given to transportation bolts or other means of securing the PERC during the swing towards/from the vessel. Only trained terminal personnel control these devices.

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.

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.

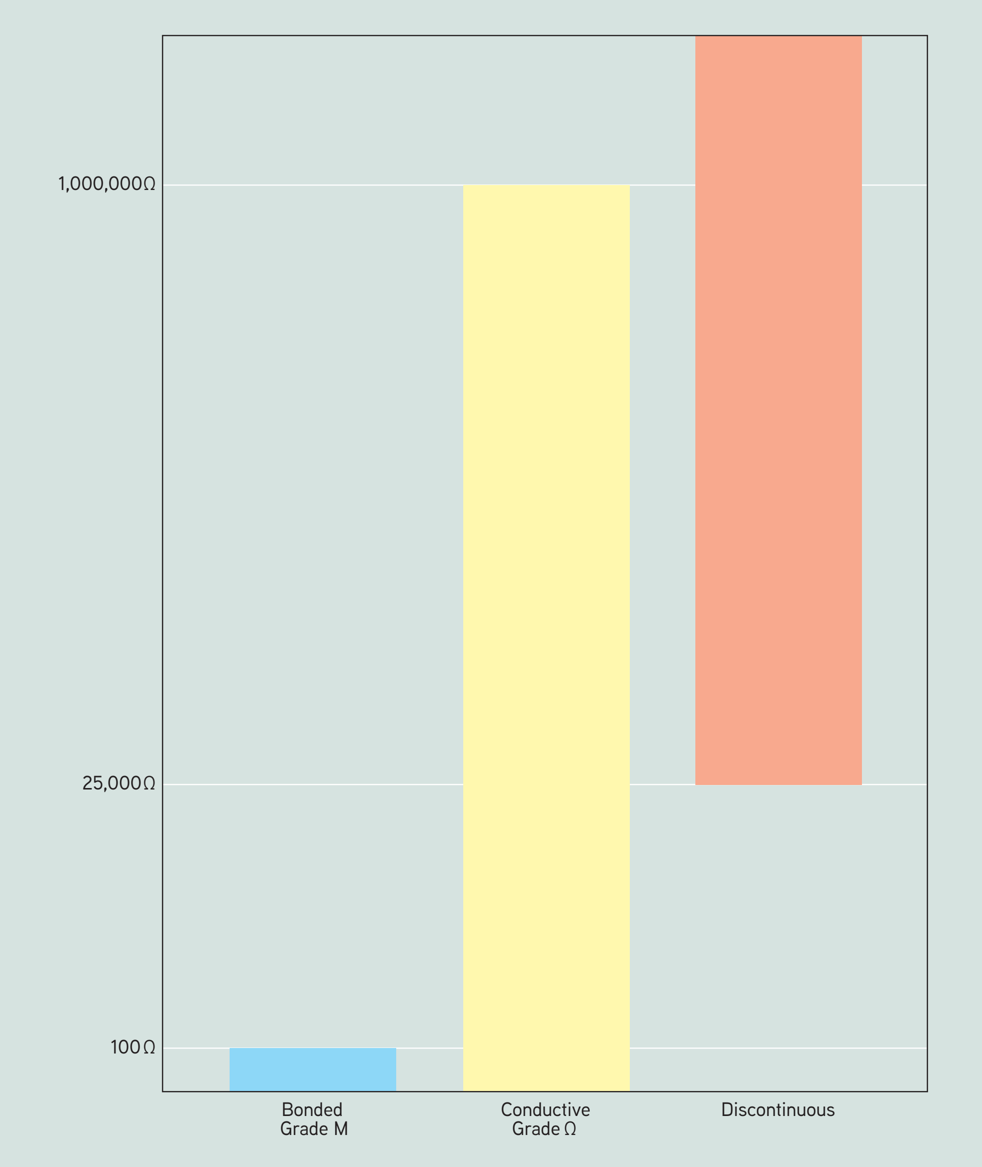


Figure 18.1: *Differences in resistance between Grade M, Grade Ω and discontinuous hose types*

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 11.1.7 and 7.3.3.2).

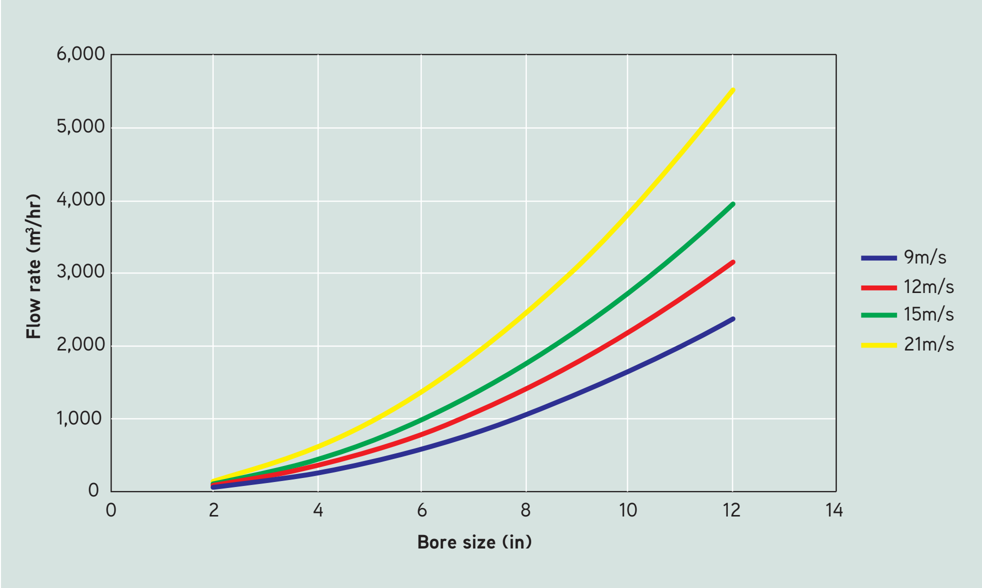


Figure 18.2: *Maximum flow rate for given flow velocity and bore size*

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.

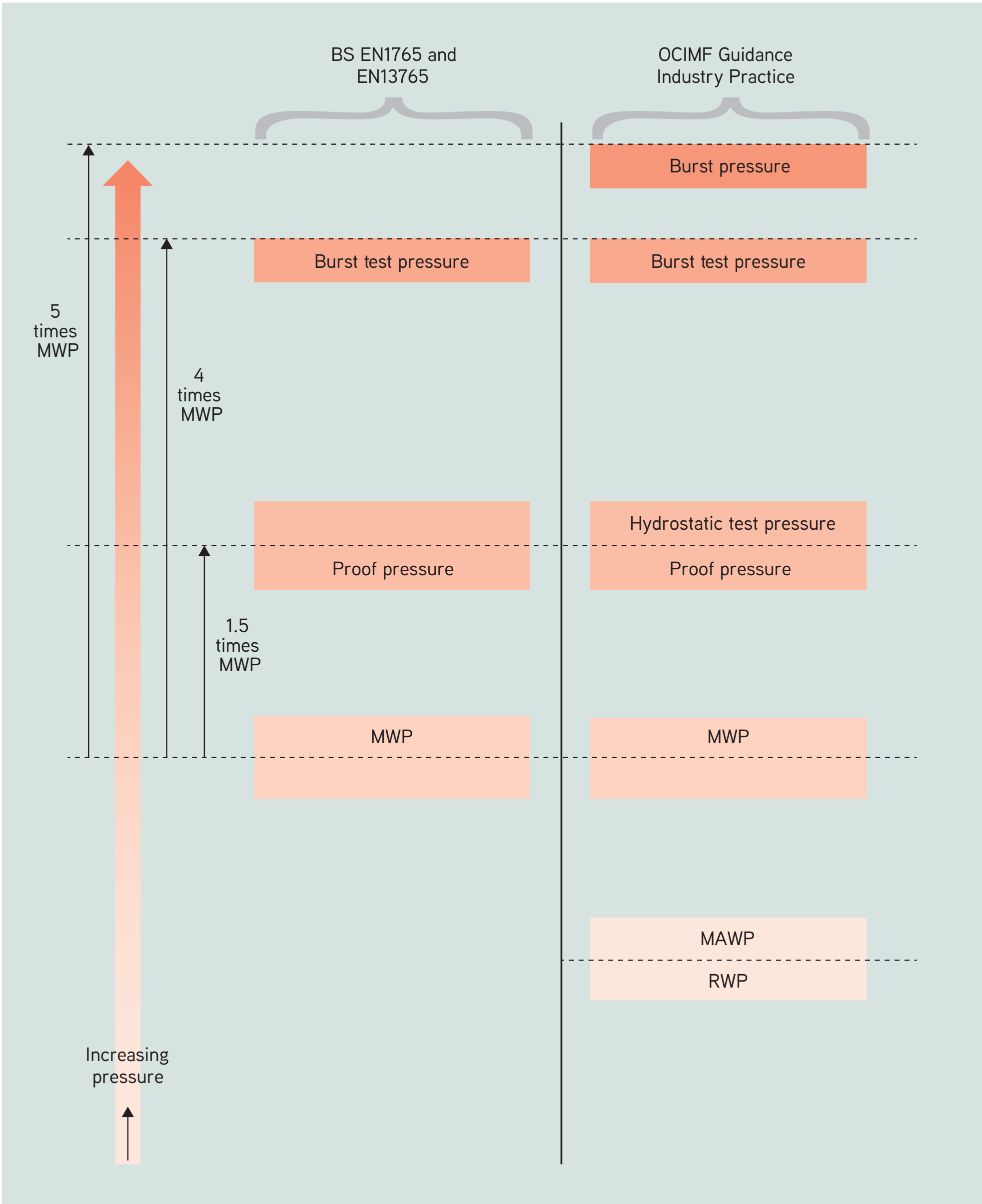


Figure 18.3: *Illustration of terminology used for defining hose pressures*

18.2.7 Hose flange standards

Flange dimensions and drilling should conform to the local common standard (e.g. DIN/ISO/EN/ASA/ANSI, preferably PN10) for flanges on shore pipeline and inland tanker manifold connections.

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.

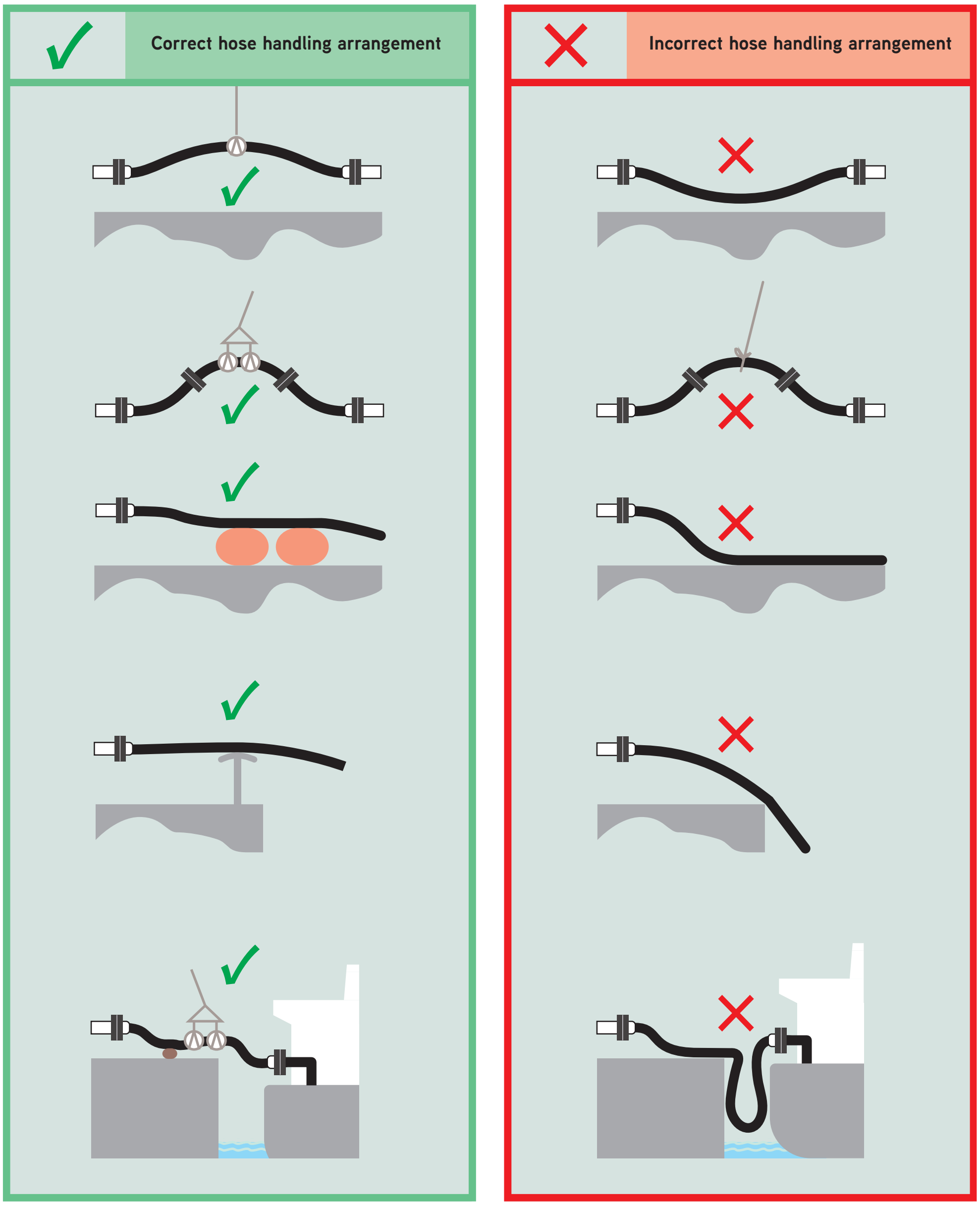


Figure 18.4: *Hose handling arrangement*

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

N/A

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. Inland tankers that regularly undertake lightering of vessels (including barge to barge transfers) frequently have their own hose strings and sometimes these are hired from third-party suppliers. These hoses should 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 11.9.5).

18.3 Vapour emission control systems

Some terminals have vapour emission control systems to receive and process vapours displaced from an inland 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 should also include details of the vapour recovery system for the information of visiting tankers.

All shore personnel in charge of transfer operations should complete a structured training programme covering the particular vapour emission control system installed in the terminal. This training should include details of typical equipment installed on board inland tankers and related operating procedures.

During pre-transfer discussions, tanker and shore personnel should agree any constraints associated with the operation of the vapour emission control system. Confirmation that this information has been exchanged and agreed will be included within the safety checklist (see section 26.3).

Refer to section 11.1.13 for information on the primary safety issues relating to cargo transfer operations using vapour recovery.

19 Safety and fire protection

This chapter contains general guidance on safety management at terminals and specific recommendations on the design and operation of fire detection and protection systems.

The guidance on fire-fighting equipment in this chapter should be read in conjunction with chapter 5, which addresses fire-fighting theory.

19.1 Safety

19.1.1 Design considerations

The layout and facilities at a terminal will be determined by many factors, including:

- Local topography and water depth.
- Access to the berth(s) – open sea, river, channel or inlet.
- Types of cargo handled.
- Quantities of cargo handled.
- Local facilities and infrastructure.
- Local environmental conditions and restrictions.
- Current and tide.
- Local and international regulations (e.g. escape routes, emergency stops).

Most of the decisions regarding the layout will have been decided at the initial planning and design stage for the terminal. However, many terminals have developed over time and may handle a greater variety of products, larger quantities of cargoes and larger inland tankers than anticipated when the terminal was originally designed. Terminals may also be subjected to reduced throughputs or changing environmental conditions, new standards and/or legislation.

All terminals should be subjected to regular review to ensure that the facilities provided remain fit for purpose in the context of the operations being undertaken and current legislation. Such reviews should cover elements listed in the following sections, which will enable the terminal to maintain the necessary level of safety.

19.1.2 Safety management

Every terminal should have a comprehensive safety programme that delivers an appropriate level of safety performance. The safety programme should address the following topics:

- Emergency management.
- Casualty response and casualty evacuation.
- Periodic fire and oil spill drills. These drills should address all aspects and locations of potential incidents. They should also include inland tankers at a berth.
- Feedback from emergency drills and exercises.
- Hazard identification and risk assessment.
- Permit to work systems.
- Incident reporting, investigation and follow-up.
- Near-miss reporting, investigation and follow-up.
- Site safety inspections.
- Safe work practices and standards of housekeeping.
- PPE. The equipment provided and requirements for its use should include associated third parties – e.g. tug and mooring boat crews, mooring gangs or cargo surveyors.
- Safety meetings across the terminal's manning structure, encompassing all personnel.
- Work team safety briefings.
- Pre-task safety discussions.
- Safety management of visitors, contractors and inland tanker's crew.
- On-site training and familiarisation.

19.1.3 Permit to work systems: general considerations

Permit to work systems are widely used throughout the industry. The permit is essentially a document that describes the work to be done and the precautions to be taken when doing it, and that sets out all the necessary safety procedures and equipment (permit to work systems are fully described in section 9.3).

For operations in hazardous and dangerous areas, permits should normally be used for tasks such as:

- Hot work.
- Work with a spark potential.
- Work on electrical equipment.
- Diving operations.
- Heavy lifts.
- Entry into enclosed spaces (see chapter 10).
- Work at heights and near waterfront.
- Opening tank and line systems.

The permit should specify clearly the particular item of equipment or area involved, the extent of work permitted, the conditions to be met and the precautions to be taken, and the time and duration of validity. The latter should not normally exceed a working day. At least two copies of the permit should be made, one for the issuer and one for the person at the work site.

The layout of the permit should include a checklist to provide both the issuer and the user with a methodical procedure to check that it is safe for work to begin and to stipulate all the necessary conditions. If any of the conditions cannot be met, the permit should not be issued until remedial measures have been taken.

It is advisable to have distinctive permit to work systems for different hazards. The number of permits required will vary with the complexity of the planned activity. Care must be taken not to issue a permit for subsequent work that negates the safety conditions of an earlier permit. For example, a permit should not be issued to break a flange next to an area where a hot work permit is in force.

Before issuing a permit and during its validity, the Terminal Representative must be satisfied that the conditions at the site, or of the equipment to be worked on, are safe for the work to be performed, taking account of the presence of any inland tankers that will be alongside while the work is being carried out.

For certain types of work, permission also has to be requested from the port authorities.

19.2 Terminal fire protection

19.2.1 General

Fire safety at terminals is provided through overlapping levels of protection as follows:

- Prevention and isolation.
- Detection and alarm facilities.
- Protection equipment.
- Emergency and escape routes.
- Emergency planning.
- Evacuation procedures.

Fire safety at terminals requires an appropriate balance between good design features, safe operational procedures and good emergency planning.

Fire protection alone will not provide an acceptable level of safety. Fire protection measures should not interfere with mooring or other operations.

Fire protection measures are not effective in limiting the frequency and size of spills or in minimising sources of ignition.

Automatic detection of fire, and the subsequent fire protection equipment, will limit the spread of fire and the hazard to life and property at unmanned locations or at locations with limited numbers of personnel.

Fire protection facilities should be designed to contain and control fires 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.

19.2.2 Fire prevention and isolation

Safety at terminals begins with fire prevention features inherently designed into the overall facility. Terminal fire-fighting equipment is usually dispersed around the site and much of it is exposed to the weather. To ensure that it is fit for use, it is essential that all fire-fighting equipment is regularly inspected, maintained in a constant state of readiness, and tested periodically to ensure reliable operation. Terminals should ensure that all fire-fighting equipment is maintained under the control of a planned maintenance system. Careful design of a terminal is no guarantee of safe operation. The training and competence of personnel are critical. Periodic simulated emergency drills, both announced and unannounced, are recommended to ensure operability of the equipment, operator proficiency in the use of equipment, and familiarity with emergency procedures.

19.2.3 Fire detection and alarm systems

The selection and fitting of fire detection and alarm systems at a terminal depends on the risk exposure presented by the product being handled, inland tanker sizes and terminal throughput. This topic is discussed in more detail in section 19.4.1.

The location of all detectors should take into account natural and mechanical ventilation effects, since heat is carried and stratified by convection currents. Other considerations, such as the ability of flame detectors to 'see' flames, should be taken into account. Before installation, the advice of manufacturers and fire and safety experts should be sought, along with a compliance check against local regulations.

In general terms, the purpose of automatic detection and alarm systems is to alert personnel and initiate a response system that aims to reduce loss of life and property caused by fires or other hazardous conditions. These systems may have one or more circuits that connect to automatic fire detectors, manual activation points, water flow alarm devices, combustible gas detectors and other initiating devices. They may also be equipped with one or more indicating device circuits that connect to alarm indicating signals, such as control panel indicator and warning lamps, outdoor flashing lights, bells and horns.

19.2.4 Automatic detection systems

Automatic detection systems consist of mechanical, electrical or electronic devices that detect environmental changes created by fire or by the presence of toxic or combustible gases. Fire detectors operate on one of three principles: sensitivity to heat, reaction to smoke or gaseous products of combustion, or sensitivity to flame radiation. Examples are given below, but be aware that technology changes quickly:

- Heat-sensing fire detectors fall into two general categories: fixed temperature devices and rate-of-rise devices. Some devices combine both principles (rate-compensated detectors). Generally, heat detectors are best suited for fire detection in confined spaces subject to rapid and high heat generation, directly over hazards where hot flaming fires are expected, or where speed of detection is not the prime consideration.
- Smoke-sensing fire detectors are designed to sense smoke produced by combustion. They operate on various principles, including ionisation of smoke particles, photo-electric light obscuration or light scattering, electrical resistance changes in an air chamber and optical scanning of a cloud chamber.

- Gas-sensing fire detectors are designed to sense and respond to one or more of the gases produced during the combustion of burning substances. These detectors are seldom a preferred option as fire tests have shown that detectable levels of gases are reached after detectable smoke levels.
- Flame-sensing fire detectors are optical detection devices that respond to optical radiant energy emitted by fire. Flame detectors responsive to infrared or ultraviolet radiation are available, but ultraviolet sensitive detectors are generally preferred.

19.2.5 Selection of fire detectors

When planning a fire detection system, detectors should be selected based on the types of fires that they are protecting against. The type and quantity of fuel, possible ignition sources, ranges of ambient conditions, and the value of the protected property should all be considered.

In general, heat detectors have the lowest cost and lowest false alarm rate but are the slowest to respond. Since the heat generated by small fires tends to dissipate fairly rapidly, heat detectors are best used to protect confined spaces, or be located directly over hazards where flaming fire could be expected. To avoid false alarms, the actuation temperature of a heat detector should be at least 13°C above the maximum expected ambient temperature in the area protected.

Smoke detectors respond faster to fires than heat detectors. Smoke detectors are best suited to protect confined spaces and should be installed either according to prevailing air currents or on a grid layout.

Photoelectric smoke detectors are best used in places where smouldering fires, or fires involving low temperature pyrolysis, may be expected. Ionisation smoke detectors are useful where flaming fires would be expected.

Flame detectors offer extremely fast response but will warn of any source of radiation in their sensitivity range. False alarm rates can be high if this kind of detector is improperly used. Their sensitivity is a function of flame size and distance from the detector. They are usually available in explosion-proof housings, so can be used to protect areas where explosive or flammable vapours might occur.

19.2.6 Location and spacing of fire detectors

Fire detection at terminals is usually provided at remote, unmanned, high-risk facilities, such as pumping stations, control rooms, and electrical switch gear rooms. Detectors may also be fitted at valve manifolds, loading arms, operator sheds and other equipment or areas susceptible to hydrocarbon leaks and spills, or that contain ignition sources.

To function effectively, fire detection devices must be properly positioned. Detailed requirements for spacing can be found in appropriate fire codes.

Heat, smoke and fire gas detectors should be installed in a grid pattern at their recommended spacing, or at reduced spacing for faster response. Each system should be engineered for the specific area being protected, with due consideration given to ventilation characteristics.

Detection systems that activate fire-extinguishing systems should be arranged using a cross-zone array. In a cross-zone array, no two adjacent ionisation type detectors should be in the same detection circuit zone. The first detector activated should trigger the fire alarm system, while the activation of a detector on an adjacent circuit should set off the fire-extinguishing system.

19.2.7 Fixed combustible and toxic gas detectors

These gas detectors are designed to sense the presence of combustible or toxic gases and to provide an early warning. They continually monitor potentially hazardous areas to safeguard against fire or explosion and for personnel protection from toxic gas leaks.

The operating principles of combustible and toxic gas detectors are similar to those for the product of combustion-gas sensing fire detectors. See also sections 2.3 and 2.4.

Terminals that handle crude oil or products containing toxic components should consider installing fixed gas-detection and alarm equipment in areas where personnel may be exposed.

Consideration should be given to placing sensors in locations where leaks or spills could occur, e.g. loading arms, valve manifolds and transfer pumps, or where gas could accumulate due to inadequate ventilation. Toxic gas detectors may also be installed in the supply air-intakes of pressurised control rooms and inside non-pressurised control rooms.

19.2.8 Locating fixed combustible and toxic gas detectors

General considerations in positioning combustible and toxic gas detectors include the following:

- Elevations depending on relative density of air and any potential gas leakage.
- Possible flow direction of leaking gas.
- Proximity to potential hazards.
- Accessibility of detectors for calibration and maintenance.
- Sources of damage, such as water and vibration.
- Manufacturer's recommendations for sensors connected to analysers.

19.2.9 Fixed combustible and toxic gas analysers

Continuous analysers are typically permanently installed, electrically operated devices for the continuous analysis of air samples, often using multiple sensors, to detect combustible and toxic gases.

The analysers may be the remote-detection type, where individual diffusion sensors are connected to the analysers by electrical cable. In this case, the central equipment is available either for installation in non-hazardous locations, such as pressurised control rooms, or in explosion-proof enclosures for location in hazardous areas.

The remote-detection type, which uses remote diffusion detectors, provides rapid response and good reliability, making this the preferred design.

Alternatively, continuous analysers may also employ a central detection unit, using a suction pump to draw samples from hazardous areas through tubing to the central location. Central diffusion detection units that use sample lines have relatively slow response times. Also, particulates must be taken into account and the lines must be heated to prevent condensation. As a result, central detection units are not generally recommended.

Gas analysers should continuously record data, have readout and alarm functions, and also usually be provided with the following features:

a. Channels to connect with individual diffusion detection sensors so that each sampling circuit can analyse samples continuously. So when an alarm condition occurs, the analyser will home on the sensor registering the alarm and the alarm will remain active until manually reset.
b. The combustible gas analyser is calibrated to a percentage of the LFL and should be provided with a channel selector, indicator lamps to show the samples being analysed, and a meter. Visual and audible alarms should be provided for two levels of detection. The system should have two alarm points to alert for high and high-high, based upon a risk assessment, international standards and national requirements. The high level most frequently used is 10% LFL. The second or high-high level of detection is usually 20% LFL. Silencing the audible alarm should not extinguish the visual alarm until gas detection falls below the alarm level. Contacts are provided at the two levels of detection to permit automatic operation of a purging or fire prevention system.
c. Alarm levels should be adjustable, and alarms may be activated by contact meters, recorder limit switches, solid-state signal level detectors, or optical meter relays. Multi-level alarms can be provided with means to activate ventilation equipment, to shut down transfer pumps, or to trigger fire-extinguishing systems.
d. A means to disconnect the detectors safely from the actuating circuit. Disconnection is necessary for proper routine calibration and maintenance activities. A key-operated switch with supervisory alarm is recommended.
e. On complicated or extensive systems, the indication of alarms on a graphic display, such as an outline plan of a facility, is recommended.

f. Toxic gas analysers should be set to sound alarms at the monitored location and in the control room when the gas reaches the predetermined level, e.g. when an H_2S concentration reaches 5ppm. Alarms should generally be both audible and visual.

g. The gas detector head assembly should be suitable for the electrical classification of the hazardous area and, if installed outdoors, be weatherproof and corrosion resistant.

h. The detecting unit included in the head should provide adequate sensitivity and the necessary stability under all conditions in order to repeat any reading within ±2% of the full-scale range.

19.2.10 Fire-extinguishing system compatibility

Where a detection system is part of an automatic fixed fire-extinguishing system, complete compatibility between the systems is essential. Detection devices and systems that are highly susceptible to false alarms should be avoided, especially when they are connected to fixed fire-extinguishing systems for automatic activation (see section 19.3.5).

19.3 Alarm and signalling systems

An alarm and signalling system must perform four significant functions. It should:

- Rapidly transmit an alarm or signal to indicate the detection of fire before there is significant damage.
- Initiate a sequence of events to evacuate personnel in the vicinity of fire.
- Transmit an alarm or signal to notify responsible parties or initiate an automatic extinguishing system.
- Have the capability to automatically self-test and warn of malfunction.

19.3.1 Types of alarm systems

Alarm systems are used to indicate an emergency and to summon assistance.

There are many different types, ranging from a local system providing an alert signal at the protected facility to one that alerts a remote station attended by trained personnel 24 hours a day, such as a fire or police station or a third-party answering service.

The type of system installed at a particular location should be based on a thorough risk assessment with input from competent personnel in the field of fire protection, taking due account of any applicable local regulations.

19.3.2 Types of signal

Fire alarm systems provide several distinct types of signal, which can be audible, visual or both. They include relatively simple trouble signals, such as alarms for power interruptions; supervisory signals that activate when critical equipment is in an abnormal condition; and either coded or non-coded alarm signals that sound continuously or in the form of a prescribed pattern when a fire alarm is activated.

19.3.3 Alarm and signalling system design

Any variation or combination of the types of alarm and signalling systems previously described can be used to meet local circumstances.

In a large terminal, or where the terminal is an integral part of a large plant or processing facility, a coded signal system is usually preferred. The facility should be divided into a grid system, with each area of the grid identified by a numbered code. The coded signal system should include a code transmitter that triggers an alert at the specific location and also activates the general alarm.

Emergency reporting can also be achieved by using a dedicated emergency telephone system. Manual fire alarm stations can be installed instead of, or to supplement, the telephone reporting system.

When a dedicated telephone system is used, a special telephone should be installed in the control room or supervisory station to receive emergency calls. The telephone should be capable of receiving incoming calls only. Extensions should be provided at other locations that have preliminary emergency responsibility.

As a minimum, the general alarm system should 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 capable of being heard in all areas of the terminal regardless of background noise.

Auxiliary alarm devices should be provided for indoor locations or remote areas where the general alarm cannot be heard. These alarms may be bells, or air or electric horns. Whichever devices are provided, they should be the same throughout the facility and be distinct from other warning devices.

19.3.4 Alternative alarm and signalling system design

Although a coded alarm system is generally preferable for large terminals, a non-coded announcement-type system can be used. Either system can consist of telephones or manual fire alarm stations at strategic locations. Coded manual fire alarm stations can be connected to the general alarm to sound a coded signal without manual intervention. Non-coded stations can be arranged to show fire location on a fire alarm indicator in the central control room or supervisory station so that the attendant can activate the code transmitter. Either a coded or non-coded announcement-type system should be controlled from a central fire alarm control panel.

19.3.5 Interface between detection systems and alarm or fire-extinguishing systems – circuit design

Actuation relays, where required between detectors and alarm or extinguishing systems, should consist of closed loops that are normally de-energised and require an input of enough electrical energy to activate the alarm or extinguishing system. This arrangement will prevent a false activation of an alarm or extinguishing system on loss of power. It also allows for a separate fault signal on power loss.

19.3.6 Electric power sources

Electric power should be available from two highly reliable sources. The usual arrangement is an alternating current (AC) primary power supply, with a trickle charger supplying an emergency battery system for standby power. In some locations, authorities may require an engine-driven generator as a secondary power supply in case the primary supply fails.

The capacity of secondary power supplies varies with the type of alarm system and the requirements of local regulatory authorities. For local or proprietary alarm systems where signals are registered only at the terminal or plant central control room or central supervisory centre, the battery size usually provides power for a minimum of eight hours, and for at least 12 hours if the supply is not reasonably reliable.

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 capacity is usually required so that the emergency supply can operate the entire system if the power is cut over a weekend.

19.4 Detection and alarm systems at terminals handling crude oil, petroleum and chemical products

19.4.1 General

The specification for the detection and alarm systems on terminals transferring crude oil and flammable liquids will depend on a number of factors, including:

- The commodities or products transferred.
- Inland tanker size and number berthed per year.
- Pumping rates.
- The proximity of hazardous equipment to other equipment or hazards, i.e. equipment spacing, electrical area classification.
- The proximity of inland tankers to the terminal and to hazardous terminal equipment.
- The proximity of the terminal to residential, commercial or other industrial properties, or to environmentally sensitive areas.
- The installation of emergency isolation valves.
- The number and nature of fixed fire-extinguishing systems that are connected to detection and alarm systems.
- Whether the terminal is continuously manned or periodically unmanned.
- The ability of the emergency response unit at the terminal or within the terminal's organisation to provide a timely and effective response.
- Proximity to any outside emergency response units, and their capacity, availability and time of response.
- Requirements imposed by local regulatory bodies.
- The desired degree of protection beyond regulatory requirements.
- The degree of effective protection that a particular manufacturer's detection and alarm system offers.

The alarm system should be able to raise local audible and visual alarms, and possibly a general alarm if the terminal is manned and depending upon local circumstances. It should indicate an alarm at a continuously attended central fire control panel, showing the location of the activated detection and fire-extinguishing system. Where fixed gas-detection equipment is installed or the detection system covers more than a single detection zone, the panel should indicate the location of the activated gas detector.

Use of fire-detection equipment that is designed to activate fixed fire-fighting equipment automatically may be advisable where a terminal extends away from shore, making manual fire-fighting difficult, dangerous or ineffective. This may also be advisable where fire-fighting boats are not available and accessibility with fire-fighting vehicles is poor, or at locations where trained fire-fighting personnel are limited or not always available for rapid response.

In most cases, a manually operated fire-protection system is preferred. When a detector activates, the detection system should sound a local alarm and send a signal to a continuously attended control panel. If conditions warrant, the fire-protection system may be manually activated by an operator, the fire brigade, or personnel who monitor the alarm.

Equipment and terminal areas that are sometimes monitored with automatic fire or gas-detection systems include transfer pumps, valve manifolds, loading-arm areas, control rooms, electrical switch gear enclosures, operator's sheds, below-deck areas, and other equipment or areas susceptible to hydrocarbon leaks and spills or that contain ignition sources.

19.4.2 Control rooms/control buildings

When determining necessary detection and alarm equipment for control rooms, the first consideration should always be the requirements of local regulations. Once these are met, any further gas and fire-detection devices with associated alarm equipment depends on site-specific factors such as control room pressurisation and attendance.

The following general detection and alarm facilities are suggested for all control rooms or buildings:

- Manual fire alarm stations should be provided at all exits. The operation of a manual fire station should sound a local alarm and activate an alarm at the main fire control panel, if provided.
- A fire-detection system should be installed in any area of a control building that is normally unattended. Each detector should raise a local alarm in the areas of the control room that are normally occupied and should activate an alarm at the main fire control panel in a continuously attended area.
- Combustible gas detectors should be installed in the supply air-intake vents of pressurised control rooms and inside non-pressurised control rooms. Each gas detector should sound a local alarm and set off an alarm at a main fire control panel in a continuously attended area.

Control rooms that are not continuously attended may sometimes be equipped with additional facilities. If the terminal handles volatile liquids, a fixed fire-extinguishing system, activated automatically on detection of combustible gas or fire, may be installed. The gas or fire-detection system should then be arranged in a cross-zone array (see section 19.2.6).

19.5 Fire-fighting equipment

Fire-fighting systems are required to protect potentially exposed equipment in order to avoid fire escalation and to minimise fire damage. Ideally, most fires should be controlled and extinguished by first isolating the source of the fuel and then, if necessary and feasible, extinguishing the fire with appropriate agents.

Where terminals have land connections with refineries or related installations, the fire-fighting system on the terminal is usually an integral part of the fire-fighting scheme for the whole of the complex.

Fixed fire-fighting systems should be capable of full operation by the personnel locally available within the first five minutes of the outbreak of a fire.

19.5.1 Terminal fire-fighting equipment

In ports with many terminals or in congested industrial locations, the local authority or port authority may provide the main fire-fighting capability. The type and quantity of fire-fighting equipment should be related to the terminal size and location, the frequency of terminal use, and the additional factors identified in section 19.1. Other relevant factors include any reciprocal arrangements and the physical layout of the terminal.

These many variables mean it is impractical to make specific recommendations concerning fire-fighting equipment. Each terminal should be studied individually when choosing the type, location and use of the equipment.

As well as national regulatory requirements, capability should be based on the general guidance contained within this chapter and the results of a formal risk assessment. The risk assessment should take into account the following criteria for each berth:

- The sizes of inland tankers that can be accommodated.
- Location of the terminal and the berth.
- Nature of the cargoes handled.
- Potential impact of oil spills.
- Areas to be protected.

- Regional fire response capability.
- Level of training and experience of local emergency response organisations.

19.5.2 Portable and wheeled fire extinguishers and monitors

Portable and wheeled fire extinguishers should be provided at every terminal berth on a scale relative to the size, location and frequency of use of the berth (see table 19.1).

Portable fire extinguishers should be located so that a fire extinguisher can be reached without travelling more than 15 metres. Wheeled extinguishers should normally be located in accessible positions at each end of loading arm gantries or at the berth approach access point.

Fire extinguisher locations should be permanent and conspicuously identified by luminous background paint or suitably coloured protective boxes or cabinets. The top or lifting handle of a fire extinguisher should normally not be at a height of more than one metre.

Carbon dioxide extinguishers have little value at berths or on jetties, except at points where minor electrical fires could occur. However, enclosed electrical sub-stations or switch rooms within terminals should be equipped with enough carbon dioxide extinguishers or should have a fixed carbon dioxide system.

Foam extinguishers with a capacity of around 100 litres of pre-mix foam solution are suitable for berths. They are capable of producing approximately 1,000 litres of foam and provide a typical jet length of about 12 metres.

In most cases, small foam extinguishers with capacities of about ten litres are too limited to be effective in fighting a fire at a terminal.

Where portable foam/water monitors are recommended in table 19.1, they may be either portable or wheeled, but should have a discharge capacity of at least 115 cubed metres per hour (m^3/h) of foam and water in solution.

At least two portable foam/water monitors should be provided for each wharf or jetty, together with adequate lengths of foam-induction hose and fire hose to facilitate deployment at their maximum range.

19.5.3 Terminal fixed fire-fighting equipment

19.5.3.1 Fire water supply

Fire water at terminals is often provided by the unlimited supply available from the river, canal or dock basin.

Where the fire water supply is obtained from static storage, such as a tank or reservoir, the reserve for fire-fighting purposes should be equivalent to at least four hours continuous use at the maximum design capacity of the fire-fighting system. The reserve for fire fighting would normally be additional to that required by any other user taking water from the same static storage. The piping arrangements at such storage facilities should be arranged to prevent use of the fire-fighting reserve for other purposes, and the integrity of the make-up water supply to such a reserve would need to be assured.

Fire water flow rates and pressures should be enough to cover the extinguishing and cooling required for any fire that might realistically occur. For typical flow rates, refer to table 19.1.

19.5.3.2 Fire pumps

Where practical, permanently installed fire pumps should be provided on a scale that ensures adequate reserve capacity in contingencies such as fire pump maintenance, repairs or breakdowns during emergencies.

Electric motor, diesel engine and steam turbine-driven pumps are acceptable. However, the choice of steam turbine and electric drivers should take into account the reliability of the steam and power supplies at a particular installation. Typically, a combination of diesel and electric-driven pumps is preferred.

When the fire pumps are to be located on a wharf or jetty, a safe and protected location is essential in order to ensure that the fire pumps will not become immobilised during a fire at the terminal or do not in themselves present a potential ignition source. When selecting a location for the fire pumps, consider the loading gantry and the nearest moored inland 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.

Where practical, fire pump installations should be protected from a water surface fire penetrating the underside or below-deck area of the installation. Protection may be achieved by structural barriers, booms or water-spray systems. In this context, the fire pump should be installed on a solid deck. Whenever electric motor driven pumps are installed, consider the careful routing and fire protection of power cables.

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 115m^3/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 350m^3/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 700m^3/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*

19.5.3.3 Fire-main piping

Permanent fire water mains and/or foam-water solution mains should be installed in terminals and along the approach routes to berths. Mains should extend as near to the head of the terminal as possible and be provided with a number of accessible water take-off (hydrant) points.

The hydrant points generally consist of headers with individually valved outlets fitted with a fire hose connection suitable for the particular type of fire hose coupling in use locally. Isolating valves should be fitted to prevent the loss of all fire-fighting systems caused by a single fracture or blockage of the fire-main network. The isolating valves should be positioned so that if the fire-main fails in the berth area there will still be a supply at the berth approach. Where the berth fire-main is extended from a shore installation, an isolating valve or valves should be provided at the shore-side end of the wharf or jetty. Additional fire hydrants should then be provided upstream of an isolating valve.

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 to produce foam, and on the length of jet required.

In freezing conditions, fire-mains that are not maintained in the dry mode should be protected from freezing. In particular, where the fire water supply is obtained from an on-shore grid, any wet section of the grid should be buried below the frost line or otherwise protected from freezing. Buried fire-mains need to be suitably coated and wrapped to prevent corrosion. Cathodic protection might also be necessary.

Drain valves should be conveniently and suitably located on the fire-mains, and flushing points should be provided at the extremities of the fire-main grid.

19.5.3.4 Fire hydrants

The location and spacing of hydrants at terminals will generally be determined by the character of the facilities to be protected. At the berth or loading-arm areas, it will often be difficult to achieve uniform spacing of fire hydrants, whereas on approach or access routes this usually will be possible. For guidance purposes, hydrants should be spaced at intervals of not more than 45 metres in the berth or loading arm areas and not more than 90 metres along the approach or access routes.

Hose connections should be compatible with those of the local or national fire authorities.

Hydrants should be readily accessible from roadways or approach routes and located or protected in such a way that they will not be prone to physical damage.

19.5.3.5 International shore fire connection

All 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 19.1. 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.

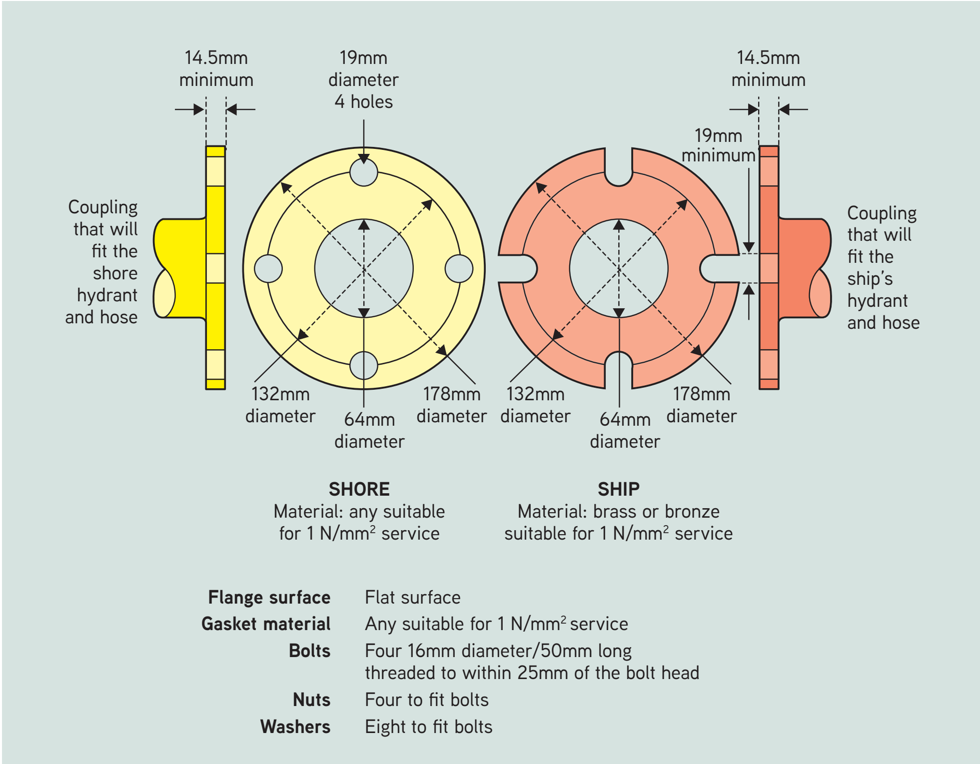


Figure 19.1: *Details of the international shore fire connection*

19.5.3.6 Pump-in points for fire-fighting boats

If tugs or fire-fighting boats are available, they may be equipped to pump fire-fighting water into the terminal's fire-main system.

Pump-in points should be provided at suitable, accessible locations near the extremities of the fire-mains and preferably where fire-fighting boats/tugs can be securely moored. In an extreme emergency, a fire-fighting boat/tug 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 hose inlets should have screw-down valves and/or be fitted with non-return valves and be installed to minimise the possibility of hose kinking.

The location of these inlets should be distinctively highlighted.

19.5.3.7 Foam systems

Foam concentrate should be properly proportioned and mixed with water at some point downstream of fire water pumps, and upstream of foam-making equipment and application nozzles.

Fixed pipelines for expanded (aerated) foam are not recommended because the fully developed foam cannot be projected effectively through such systems due to loss of kinetic energy and high frictional losses.

The type of foam concentrate selected – i.e. protein, fluoro-protein, aqueous film-forming foam or alcohol/polar solvent resistant type concentrate (hydrocarbon surfactant type concentrate) – depends on the fuel type and formulation, whether aspirating or non-aspirating equipment is installed, and the ease of re-supply.

Several systems can be adopted for feeding foam concentrate into foam-making equipment at the berths. Some of the principal systems are briefly described.

Direct foam pick-up from atmospheric tanks
This method incorporates direct foam induction via a flexible pick-up tube connecting a monitor to an adjacent foam storage tank at atmospheric pressure, a tank truck, portable trailer or drum. One storage tank may be used to supply more than one fixed monitor. Such monitors would be positioned near ground or deck level.

Displacement proportioner foam unit utilising pressure vessels
This unit may comprise foam concentrate in one large pressure vessel, possibly of 4.5 cubic metres capacity or two smaller pressure vessels of 2.3 cubic metres. The foam proportioner unit is positioned between the fire pumps and the downstream foam-making equipment. The system uses by-passed fire-main water to pressurise the storage vessel and displace the foam concentrate from the storage vessel into a foam-main.

Enough hydrants should be provided on the foam-main from where 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 foam concentrate into the foam pipeline grid. The pumps may be electric motor or water turbine-driven, using a bypass from the fire main.
3. Pipeline grid, possibly of 75mm diameter, traversing the berth approach and the berth, providing numerous take-off points for attaching 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 a number of accessible hydrant points, which should be spaced not more than two or three standard hose lengths apart. Isolating valves should be fitted to retain the use 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/h.

Foam concentrate can also be distributed through a smaller bore pipe system to the tanks that supply the inductors of fixed or mobile foam-making appliances.

Variable flow injection incorporating atmospheric foam tank and foam pump(s)
This system involves pumping foam concentrate into a foam-main via a metering device or variable flow injector. The foam pump(s) would normally be driven by an electric motor and would take suction from an atmospheric foam tank.

The bulk foam concentrate supplies associated with any fixed foam-monitor or foam-water sprinkler system should be enough to ensure continuous foam application until the arrival of adequate back-up fire-fighting resources, either water-borne or land-based. In any case, the bulk foam concentrate supply should be enough to ensure continuous foam application at design flow conditions.

19.5.3.8 Monitors (or cannons)
Monitors may be used for foam and water, although specific types may be designed solely for foam. Large capacity monitors would normally be on a fixed mounting or on a 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.

19.5.3.9 Below-deck fixed protection systems

Below-deck fixed protection systems are installed when the terminal extends over water and away from shore a way that makes fire-fighting difficult or dangerous, or when fire-fighting boats are not available. In these situations, this type of system may provide a safe base for operations during an inland tanker fire and is especially useful where large spill fires on the water beneath the berth are possible.

With a local fire on the surface of the water, and when fire-fighting boats are available to provide a quick response, a fixed water-spray system may be installed below deck for cooling non-fire resistant, unprotected supports and exposed structure. The rate of discharge for such a system should be based on a risk assessment taking into account issues that include the type of operations and the jetty layout.

When fire-fighting boats are not available or cannot provide a quick response to a fire, a fixed system of foam/water sprinklers may be installed below deck for cooling and protecting the supporting structure that is constructed of non-fire resistant, unprotected materials. The rate of discharge for this system should be at least 10.2 litres per minute per square metre.

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, e.g. concrete, a fixed system of foam/water sprinklers discharging at lower application rates may be acceptable following a risk assessment.

19.6 Water-borne fire-fighting equipment

Water-borne fire-fighting equipment, normally fire-fighting boats or fire tugs, can be highly effective, particularly when there is the scope to manoeuvre upwind of a fire.

Where fire-fighting boats are well equipped, continuously available and able to attend very quickly from the time of the call, e.g. 15-20 minutes, the scale of fire-fighting equipment provided at a berth may be established after considering the calibre of local water-borne fire-fighting equipment.

The water-borne fire-fighting capability is normally best provided by working tugs or workboats fitted with fire-fighting equipment, including foam facilities, which should be capable of tackling a deck fire on the largest inland tanker likely to use the port.

Where the fire-fighting capability of tugs is part of a terminal's planned response to fires on tankers or on the terminal itself, they should be made available as soon as they are required if their contribution is to be effective. If these tugs are helping a tanker to berth or unberth at the terminal or in some other part of the harbour when a fire starts, arrangements should be made to ensure they can be released as quickly as possible to assist in fighting a fire. When these tugs are idle between routine tasks, they should be moored with easily slipped moorings, within easy reach and within sight of the terminal, if possible, and must keep a continuous radio and visual watch on the terminal. When fire-fighting tugs cannot be assured to attend a fire within a reasonable time, their contribution should not be included when assessing the firefighting requirements for the terminal.

In special circumstances, such as terminals handling a high number of tankers or harbours with multiple terminals, consideration may be given to providing a specifically equipped fire-fighting boat.

The decision to use tugs to help fight a fire on a tanker or on the terminal, or to unberth other tankers in danger of becoming involved, should be made by the person in overall charge of the fire fighting and in conjunction with the harbour authority. Fire-fighting tugs should have UHF/VHF radio with separate channels for towing and fire fighting; when fire fighting, they must be in direct contact with, and under the control of, the person in overall charge of the fire fighting.

Tugs with fire-fighting equipment should be inspected regularly to ensure their equipment and foam compound stocks are in good condition. Tests of the fire pump and monitors should be carried out weekly. The foam-filling points on the tugs should be kept clear, so they are ready for immediate use.

As part of the terminal emergency plan, it should be decided whether trained fire-fighters will board the tug or whether the crew will be used for fire-fighting duties. The decision should be supported with appropriate training for the designated fire-fighters.

19.7 Protective clothing

All fire protective clothing gives some protection against radiant heat and burns. Conventional, heavy fire-fighting jackets are very good in this respect.

However, modern practice is to provide fire protective clothing that is manufactured from a lightweight, fire resistant fabric incorporating an aluminium covering, sometimes referred to as a fire-proximity suit. This type of suit is not suitable for direct fire exposure. Heavier suits, termed fire-entry suits, will allow personnel wearing breathing apparatus with suitable rescue and backup provisions to withstand direct flame exposure for a limited period.

Depending on local fire-fighting arrangements, provision at the terminal of a minimum of one or two complete sets of fire-proximity and fire-entry suits, including helmets, gloves and boots, may be advisable.

All protective clothing should be kept serviceable and dry. It should be properly fastened while being worn.

19.8 Access for fire-fighting services

Parking areas should be provided for fire-fighting vehicles close to terminal approaches. The provision of a lay-by or passing area on jetty-approach structures should also be considered. Consideration must also be given to any limitations on the maximum axle weights for vehicles accessing berth structures.

20 Emergency preparedness

A comprehensive and well-practised plan is essential if a terminal is to respond to emergencies in an orderly and effective manner. This chapter deals with the preparation of terminal emergency response plans and with the provision of resources and training necessary to support them.

The action to be taken by the terminal and the inland tanker in the event of an emergency at the inland tanker/shore interface are given in section 26.5.

Additional information on fire protection in terminals is in chapter 19.

20.1 Overview

All terminals should have procedures that can be immediately implemented in an emergency. The procedures should cover all types of emergency that can be envisaged in the context of the activities at the terminal, e.g. major oil spills, gas leaks resulting in an unconfined vapour cloud, fires, explosions, and ill or injured people. While any emergency procedure is likely to include the deployment of fire-fighting equipment, it should also cover equipment such as breathing apparatus, resuscitation equipment, stretchers and means of escape or exit.

Personnel should be familiar with the emergency procedures, be adequately trained and clearly understand the action they would need to take in responding to an emergency. This should include sounding alarms, setting up a control centre and organising personnel to deal with the emergency.

Information on the hazards associated with products handled at the terminal should be immediately available. It is recommended that SDS are available to provide personnel and emergency workers with procedures for handling or working with each particular product. The SDS should include details of physical data (melting point, boiling point, flashpoint, etc), toxicity, health effects, first aid, reactivity, storage, disposal and the PPE to be used.

Sufficient manpower is necessary to initiate and then successfully sustain any response plan. Therefore, a thorough study should be made to determine the total manpower requirements over the whole period of any emergency. Where appropriate, assistance may be sought from local emergency organisations, nearby airports, industrial plants or military installations. However, it should be ensured that terminal manpower is enough to mount an initial response to any emergency.

As well as addressing incidents that may occur during normal operational times, terminal emergency plans should cover those that may occur outside normal working hours, when operations are continuing with fewer personnel on site.

The most important and critical elements of every emergency plan are the organisation and resources to support it. The plan will only be effective if careful consideration has been given to these elements in its preparation so that it will fully meet the requirements of the individual terminal.

When drawing up the plan, all parties who are likely to be involved should be consulted.

It will be necessary to:

- Analyse probable emergency scenarios and identify potential problems.
- Agree on the best practical approach to respond to the scenarios and to resolve identified problems.
- Agree on an organisation with the necessary resources to execute the plan efficiently.
- Document training and practice schedules.

The plan should be reviewed and updated regularly to ensure that it reflects any changes within the terminal, current best practice and any key lessons from emergency exercises/previous emergencies.

20.2 Terminal emergency planning – plan components and procedures

20.2.1 Preparation

All terminals should develop an emergency plan to cover all aspects of the action to be taken in the event of an emergency. The plan should be drawn up in consultation with the port authority, fire brigade, police, etc, and should integrate with any other relevant plans, such as the port emergency plan. The plan should include:

- The specific action to be taken by those at the location of the emergency to raise the alarm.
- Initial action to contain and overcome the incident.
- Procedures to be followed in mobilising the resources of the terminal, as required by the incident.
- Evacuation procedures.
- Assembly points.
- Emergency organisation, including specific roles and responsibilities.
- Communications systems.
- Emergency control centres.
- Inventory and location of emergency equipment.

Each terminal should have an emergency team whose duties include planning, implementing and revising emergency procedures, and executing them. When formulated, an emergency plan should be properly documented in an emergency procedures manual, which should be available to all personnel whose work is connected with the terminal.

The main elements forming the initial response to an emergency, such as reporting and action to contain and control, together with the location of emergency equipment, should be displayed conspicuously on notices at all strategic locations within the terminal.

Inland tankers alongside the terminal should be advised of the terminal's emergency plan as it relates to the tanker, particularly the alarm signals, emergency escape routes and the procedure for a tanker to summon help in the event of an emergency on board.

The terminal emergency plan should harmonise and, as appropriate, be integrated with:

- Other parts of the company organisation and facilities.
- Relevant outside organisations (other companies, public bodies, etc).

Those outside bodies involved in an emergency should be familiar with all appropriate parts of the terminal emergency plan and should participate in joint exercises and drills.

The essential elements of a terminal emergency plan are summarised in section 20.4.

20.2.2 Control

The terminal emergency plan should make absolutely clear the person or persons who have overall responsibility for dealing with the emergency, listed in order of priority. It should also clearly establish who else within the terminal organisation is responsible taking action to contain and control the emergency.

Failure to define lines of responsibility can lead to confusion and the loss of valuable time.

If there is no dedicated control centre, an office should be pre-designated for this purpose and kept ready for use in emergencies. The location of the control centre, and a list of personnel assigned to it, should be clearly described in the plan. The control centre should be located at a convenient central point, not next to likely hazardous areas, and possibly in the main terminal office.

During an emergency, the control centre should be manned by leading representatives from the terminal and those from the port authority, fire brigade, tug company, police or other appropriate civil authority, as relevant. If the emergency involves, or is likely to involve, an inland tanker, it may also be desirable that a responsible crew member from the casualty tanker attends the control centre to give advice. An information officer should be designated to relay information to the public, other port users and all involved parties.

During an emergency, it is important that key personnel are easily recognisable in the field, e.g. by wearing different coloured safety helmets. The emergency plan should include such details.

The plan should also identify those authorised to declare that an emergency is over. See OCIMF's *MTMSA* Element 12.

20.2.3 Communications and alarms

20.2.3.1 Alarms

All installations should have an emergency alarm system.

Alarm protocols will vary, depending on the terminal. For example, a single common alarm may be appropriate for a small terminal while a complex terminal/refinery may have to install a differentiated alarm system to reflect a hierarchy of possible emergencies.

It may be beneficial to include the option of a silent alarm, so no audible general alarms are raised but a small number of key personnel are informed by telephone or portable radio and are put on alert. Typical applications would be in response to bomb threats and other forms of sabotage.

20.2.3.2 Contact lists

The terminal emergency plan should include full contact details, inside and outside office hours, for those inside and outside the organisation who must be called in an emergency.

It should also include the names of alternates who will be available if the appointed person is absent or unavailable. Alternates should be fully aware of their responsibilities and trained in the proper execution of their duties.

The contact list should be sufficiently comprehensive to eliminate the need to refer to other documents, such as telephone directories.

20.2.3.3 Communication system requirements

Reliable communications are essential for dealing successfully with an emergency situation. Alternative power supplies should be provided in case the primary system fails.

The system should be able to handle three basic elements:

- Terminal emergency alarm.
- Summoning assistance.
- Co-ordination and control of all emergency activities, including the movement of inland tankers.

The communications system should have the flexibility to cover operations on the jetty, on an inland tanker, on adjacent waters or from elsewhere within the terminal.

As a minimum, small terminals should be able to sound a clearly identifiable evacuation signal. However, radio and telephone communications will be high on the list of priorities in most emergency plans.

Larger terminals should be equipped with a complete range of communication systems, which may include VHF/UHF radio and public address equipment. Key personnel should always be supplied with portable radio equipment. A communication centre should be established in the emergency control centre.

If dedicated telephone lines are not used, the emergency communications system should be capable of suppressing other calls using the same line.

The emergency control centre should facilitate the direction, co-ordination and control of all emergency activities, including providing advice and information to other port users. For these purposes, it should have a suitable communications system linking it with all necessary contacts inside and outside the terminal.

20.2.3.4 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.

20.2.4 Site plans and maps

Plans showing fire-fighting equipment, major facilities and road access should be kept up to date and be readily available for use in an emergency, with copies kept in the control centre.

The locations and details of fire-fighting equipment and other emergency kit on or near a berth should also be displayed on the berth.

20.2.5 Access to equipment

All emergency equipment should be readily accessible and kept free of obstructions at all times.

20.2.6 Road traffic movement and control

Roadways in the terminal approaches and areas in way of jetty heads should be kept free of obstructions at all times. Vehicles should only be parked in designated areas and ignition keys should be left in place.

During an emergency, traffic into a terminal or onto berths should be strictly restricted to those vehicles and people required to deal with the emergency or give help. In allowing emergency vehicles access to jetty areas, due account must be taken of any limitations on vehicle weights.

20.2.7 Outside services

The terminal emergency plan should make the best possible use of external services. The success in responding to an emergency may depend on the degree of co-operation from third parties and this will often depend on their familiarity with the terminal and its response procedures. It is important that external service providers are involved in joint training.

Combined drills involving tugs, inland tankers and shore emergency services, as appropriate, should be held at least annually.

If the terminal is located in an area with other industry activities, it may be practical to establish a mutual assistance plan.

20.2.7.1 Harbour authorities, vessel traffic control centres, police and fire services

The terminal emergency plan should provide for the local harbour authority and vessel traffic control centre, if applicable, to be fully informed of any emergency involving the terminal, or inland tankers berthed or moored at the terminal, including details of the:

- Nature and extent of the emergency.
- Tanker or inland tankers involved, with locations and cargo details.
- Assistance required.

This information will enable the harbour authority and vessel traffic control centre to decide whether to restrict navigation within the port area or close the port.

The emergency plan should also ensure any emergency that requires, or might require, assistance beyond the resources of the terminal is immediately reported to the local fire services or the local police.

20.2.7.2 Pilots

If it is decided to partially or totally evacuate jetties during an emergency, the local pilot organisation may be called upon at short notice to provide several pilots to advise on the handling of inland tankers not directly involved in the incident. The emergency plan should make provision for this.

20.2.7.3 Rescue launches

A launch or launches, if available, should be included in the plan to assist with the:

- Recovery of personnel who may be in the water.
- Evacuation of personnel trapped on a tanker or berth.

Launches detailed for these duties should have the following equipment and supplies:

- A communication link capable of being integrated into the control centre's communication system.
- Fixed or portable searchlights for operations during darkness or in reduced visibility.
- Thermal blankets, as personnel recovered from the water are likely to be suffering from cold and shock.
- Equipment to assist in the recovery of personnel from the water into the launch, as personnel may have little or no reserve energy and may be unable to help themselves.
- Resuscitation or lifesaving equipment.
- First aid kits.
- Lifejackets for personnel recovered from the water.

The crews of the launches should receive instruction in rescuing survivors from the water, bearing in mind that casualties may be seriously injured or suffering from extensive burns or hypothermia. Crews should also receive instruction in how to operate breathing assistance equipment including artificial respirators. They should be made aware that survival time in water could be short and that fast action can save lives.

20.2.7.4 Medical facilities

Depending on the nature of the emergency, it may be necessary to alert medical facilities inside and outside the terminal. The emergency plan should make provision for this.

Any medical facilities likely to be used will need to be told:

- The nature and location of the emergency.
- The likelihood or number of casualties.
- Whether medical staff are required at the location of the emergency.
- Actual details of the casualties, including their names, as soon as these are known.

20.2.8 Training for emergencies

Training should be provided in the following emergency activities, as appropriate:

- Fire fighting, using equipment that will be available in an emergency.
- Transfer of hazardous materials away from the site of the fire.
- Fire isolation.
- Use of PPE.
- Media response and public affairs.
- Co-ordinated operation with outside bodies.
- Rescue, including training for selected personnel in life saving from water.
- Spill containment and clean-up.
- Evacuation drills.
- Security threats and terrorist attacks.

Unannounced drills should be held in different parts of the terminal, followed by discussions to highlight any deficiencies encountered. Evacuation drills are an essential part of training and help to minimise panic in an actual emergency.

Local operating procedures for an emergency should be available to all concerned, and thorough training given in their use. The terminal emergency plan should be exercised regularly.

Records should be kept, and deficiencies or lessons learnt should be recorded and formally followed up.

20.3 Definition and hierarchy of emergencies

20.3.1 General

Whether a certain event would represent an emergency or operational incident that requires swift action will depend on local circumstances. For instance, it may be possible for a large terminal, with adequate equipment and manpower, to deal with a local fire or similar event without calling on the full terminal emergency plan. The same incident at a small terminal might require the emergency plan to be activated.

The following guidelines are not intended to be prescriptive but to provide a framework or starting point that can be customised to suit a particular terminal. For terminals that already have emergency plans, the guidance provides a checklist against which the existing plans can be assessed. It should be noted that the guidelines only provide a minimum basis for developing and sustaining an effective terminal emergency plan.

20.3.2 Hierarchy of emergencies

Before establishing a terminal emergency plan, a study should be made of the terminal, available resources (during and outside normal working hours) and the potential emergencies at the location. Based on this study, a hierarchy of emergencies should be established, e.g.:

- Local emergency.
- Terminal emergency.
- Major emergency.

20.3.2.1 Local emergency

A local emergency is one of minor consequence for life and property that can be dealt with locally, e.g. at the jetty or on board an inland tanker, by available staff, with or without assistance. Such an emergency does not normally influence operations in other parts of the terminal or port.

20.3.2.2 Terminal emergency

A terminal emergency is one that is more complex or of a larger size or scope that requires an emergency plan to be initiated. It influences operations in the whole terminal, or has the potential to do so, may affect more than one inland tanker and may influence the port environment.

20.3.2.3 Major emergency

A major emergency is one that is similar to a terminal emergency but is of such size and scope, and of such serious consequence for life and property, that the whole terminal and the neighbouring port environment is involved, and/or greatly endangered.

20.3.2.4 Escalation

Not every operational incident should be handled as an emergency. However, an incident may develop into an emergency and the plan should clearly describe the procedures for escalating the response to a higher level.

20.3.3 Assessing risks

In assessing the range of emergencies that a terminal may have to deal with, consideration should be given to incidents at the terminal itself and those in the port environment that may threaten the terminal or would require major assistance from the terminal.

The suggested approach is to begin with a broad view of risks and then prioritise them by evaluating the potential effect on the terminal operation if the risk were to materialise, together with the likelihood of its occurrence. A review of incidents in the recent past can provide a guide.

20.3.3.1 Incident checklist

Incidents that should normally be covered within the scope of the terminal risk assessment include:

- Fire or explosion at the terminal and on or around a berthed inland tanker.
- Major escape of flammable and/or toxic vapours, gases, oil or chemicals.
- Collisions, both ship-shore or ship-ship.
- An inland tanker drifting and breaking away from a jetty, dragging anchor or grounding.
- Major port accidents involving inland tankers, tugs, mooring boats, ferries, etc.
- Meteorological hazards, such as floods, hurricanes, heavy electrical storms.
- Attack, sabotage and threat against inland tankers or the terminal.

20.3.3.2 Special situations

The terminal emergency plan should apply to an otherwise normal operational environment. Special situations, such as acts of war, require different responses.

20.4 Terminal emergency plan

20.4.1 Format

The format of the terminal emergency plan will depend on local circumstances, the scope of the plan and its relationship to other documentation.

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 flow charts and decision diagrams with multicolour print symbols to minimise 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.

Tanker 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 the relevant sections of the terminal emergency plan and should participate in joint response exercises.

20.4.2 Preparation

In developing a terminal emergency plan, it is important that the functions concerned are involved, such as operations, engineering, marine and safety. This can best be achieved with a part-time task force under appropriate leadership. However, one member of the task force should be retained full-time, if possible, until completion of the plan. This person should also take care of the necessary liaison with outside parties who are included in the plan.

One of the greatest drawbacks of a terminal emergency plan is its potential for rapid obsolescence. As staff members and organisations change, the plan should be updated to accommodate such changes. It is recommended that one appointed staff member should be responsible for keeping the plan up to date, using a single master copy. Only the appointed staff member should be entitled to make changes to the emergency plan.

Where the plan is in a hard copy format it should:

- Be in loose-leaf format to facilitate amendments.
- Be bound in a distinctively coloured binder.
- Have good quality paper with a strong texture.
- Ensure each page is dated and sequentially numbered.
- Contain minimal cross-references to other parts of the plan.

Every staff member with a specific role in the emergency plan should have their own copy of the plan. One or more copies should be available and always accessible in the relevant control rooms. Records should be kept of copies in circulation and of each revision issued (names, locations, contact details, etc), receipt of which is to be acknowledged in writing.

Where plans are made available to all relevant personnel in electronic form, such as via a local server, the electronic copy is normally considered to be the controlled or extant copy and any printed versions are uncontrolled.

Unless other satisfactory arrangements exist, it is recommended that the plan administrator is also nominated as room manager for the emergency control centre. The role will include ensuring that the centre is kept stocked with emergency materials, up-to-date documents and other materials, and that it is kept clean and ready for immediate occupation.

20.4.3 Miscellaneous organisational items

The following additional items are intended to help terminals develop their emergency planning. In general, an emergency plan should:

- Be specific to the terminal and cover only those emergencies that are feasible.
- Not include references to unlikely occurrences, to products not handled or to resources not available.
- Be as complete but also as short as possible. Instructions should be to the point and not so elaborate that they detract from a quick response.
- Be organised in the following structure: the top priority is 'objectives' (e.g. safety of life, minimise impact to the environment, regularly and accurately engage with stakeholders, etc.). Once the senior response team members have defined the objectives of the response, the response team(s) should develop 'strategies' that support those objectives and then 'tactics' that support the strategies. Tactics might need to be developed by smaller strike teams, sub-groups or contractors.
- Not normally include instructions on how to combat the emergency physically, e.g. fire fighting, pollution abatement, etc. It should be limited to people, equipment, organisation and communications. An exception to this can be more 'predictable' emergencies, such as hurricanes and/or flood warnings. In these cases, the plan can specify emergency precautions to be organised. This also applies to pre-planned evacuations of personnel and similar activities.
- Allow operations and other activities not directly affected by the emergency to continue in an orderly and safe manner. Sufficient staff/supervision and resources should be kept non-assigned for that purpose. If this is not possible, the plan should include safe shutdown procedures.
- Be integrated with, or at least compatible with, other industry or port emergency plans. However, for the primary activities covered by the plan, rely on in-house staff and resources and not on those from outside.
- Avoid overreaction in any part of the organisation.
- Contain an organisation diagram illustrating the key personnel involved and their immediate actions and communications. The extent and amount of detail in this diagram should be limited to standard actions.
- Itemise actions in a proper sequence. For example, the priority action to protect life and then property, and to terminate the emergency, must not be frustrated by communications with secondary parties such as the police, harbour authorities, etc.
- List the reporting line and authority of each key person mentioned both inside and outside working hours. For each person, include a short checklist of important actions and communications.
- Ensure that key personnel have a manageable task and that they can be released to deal with an emergency on a full-time basis, if necessary. Where required, replacement staff should be brought in to take over those operations of the terminal that are not directly involved or influenced by the emergency. All functions in the plan that require special abilities or skills, e.g. fire tender operation, boatmen and special radio operations, should be provided with back-up.
- Specify that all staff and contractors not assigned duties in the plan must return to and remain available at their normal work location. Alternatively, certain staff should assemble at pre-nominated central locations.

Recommended pre-arrangements to be dealt with in the plan include:

- Tug/fireboats either on standby or ready to proceed at short notice.
- Craft for water-borne assistance or the evacuation of personnel, including designated landings, to be manned.
- Pilots on standby to assist in removing inland tanker(s) from berths.
- Cars, buses, etc, directed to evacuation-collection points, including craft-landing areas.
- Unmooring crew and transport on standby.
- Emergency traffic regulations.

- Properly manned reception points to be assigned to receive evacuated inland tanker crew and/or family members of terminal staff, press representatives, etc.

It should be possible to test the effectiveness of the plan without causing undue disruption to day-to-day operations.

No emergency plan can embrace all factors. Users should be made aware that the particular circumstances of an emergency might dictate that they or others have to deviate from the plan.

It is important that staff at all levels of the organisation are drilled on the plan, specific to their level of accountability and responsibility.

20.5 Spill response

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 Oil Spill Response Organisation (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.

20.5.1 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*.

20.5.2 Resource availability

It may be necessary to plan for mobilisation of resources, such as materials, equipment and manpower, additional to those immediately available at a location. Should this be necessary, the plan should contain instructions regarding the accessibility and availability of these resources, both those owned by the terminal organisation and those available from outside.

The plan should include details of who is entitled to call on additional resources and information, such as who holds keys to the resources out of hours. The additional resources and waste will immediately require a staging area which should be pre-determined and can be quickly secured. The resources can include, but need not be limited to:

- Craft for assistance, rescue and evacuation.
- Road transport, including buses and trucks.
- Earthmoving equipment.
- Aircraft for oil spill tracking and surveillance.
- Floodlights for night operation.
- Spill containment, pollution control and clean-up equipment.
- Sand, dispersants, fire hose and foam-making equipment, fire extinguishers and additional stocks of fire-fighting foam concentrate.
- Breathing equipment.
- Fire suits, helmets and other fire-protective clothing.
- Rescue devices such as hydraulic spreaders and jacks, life lines, life buoys, ladders and stretchers.
- Emergency showers and eye wash stations.
- Medical resources and portable life-support systems.
- Food and drinks.
- Human resources – e.g. drivers, electricians, mechanics and general manpower to enable deployment of the necessary material resources.

For each resource group, the plan should list:

- Availability, amounts and numbers.
- Main characteristics and performance data.
- Accessibility on a 24-hour basis.
- Addresses of people and location of stores, telephones, radios, etc, as applicable.
- Lead time for supply/mobilisation.

20.6 Emergency removal of inland tanker from berth

When the emergency is on an inland tanker, it is recognised that in the interest of the tanker, the safety of the shore installation, and often that of the whole port, the tanker should be kept alongside whenever possible. This would improve the possibility of shore-based personnel and equipment being used to tackle an emergency on board.

However, if a fire on a tanker or on a berth cannot be controlled, it may be necessary to consider removing the tanker from the berth. Planning for such an event may require consultation between a port authority representative or Harbour Master, the Terminal Representative, the Master of the tanker and the senior local authority fire officer.

If an incident escalates, the plan may include deciding to remove other, presently unaffected, tankers from adjacent or downwind berths.

The plan should stress the need to avoid precipitate action that might increase, rather than decrease, the danger to the tanker, the terminal, other tankers or barges berthed nearby and other adjacent installations.

21 Emergency evacuation

The primary consideration in the event of a fire, explosion or other emergency at a terminal will be the safety of personnel. Therefore, the means by which personnel can be safely evacuated are of great importance.

This chapter describes the elements that should be included within a terminal's evacuation plan and provides guidance on options to ensure that safe and effective methods of emergency escape are available.

21.1 General

To ensure the effective evacuation of personnel, all terminals should provide adequate evacuation facilities and have a documented evacuation plan. The plan should be given to visiting tankers and included in the Terminal Information Booklet (TIB).

The evacuation plan will vary from terminal to terminal and depends on the design, location and the availability of equipment. However, in general, the design of the facility should provide safe escape path(s) not likely to be involved simultaneously in a fire.

T-head jetties and finger piers
Terminal facilities with a shore connection, such as T-head jetties and finger piers, have the advantage of providing a means of evacuation by road transport. Some facilities are designed with oil and gas pipelines supported on the underside of the pier. For this type of facility, evacuation via water transport may be required unless a second escape path via the shore is provided.

The possible evacuation of inland tanker personnel should be considered. The nature of oil and gas operations does not require a large number of operating personnel to be involved at marine terminals and it is probable that a tanker's crew will outnumber the shore personnel. It may also be possible that maintenance personnel will, on occasions, outnumber operational personnel, and the evacuation plan should recognise and cater for this.

21.1.1 Inland tanker evacuation

There should be an arrangement between the inland tanker and the terminal in any evacuation plan, and it is important that Masters of all inland tankers using the facility are aware of the emergency evacuation arrangements. These arrangements should be discussed at the pre-cargo safety conference and identified during the completion of the Ship/Shore Safety Checklist (SSSCL). There may be occasions when the safest and most efficient means of evacuation, especially if the tanker is not involved in the emergency, is removing the inland tanker from the terminal (see section 20.5).

21.1.2 Non-essential personnel

If it is evident that an emergency situation may develop into a significant incident, all personnel not directly involved in remedial or fire-fighting operations should be evacuated.

The decision to evacuate all non-essential personnel, including the tanker crew, or to unberth the tanker, should on every occasion be made at an early stage of an emergency, after liaison between the tanker, terminal, port authority and fire brigade. This early evacuation will always serve to reduce the overall responsibility for personnel safety, allowing the person in charge to concentrate on the emergency and to attend to the needs of those personnel in immediate danger.

The most important and critical elements of every emergency evacuation plan are organisational control and communications, and the resources necessary to support them. Guidance on these essential elements is included in chapter 20.

21.2 Evacuation and personnel escape routes

21.2.1 Primary and secondary escape routes

Terminal facilities should have at least two separate evacuation routes from all occupied or work areas and from berthed inland tankers. Escape routes should be located such that, in a fire, at least one route provides a safe evacuation path, sufficiently far from the source of probable fire to give personnel protection during evacuation. Evacuation routes and secondary evacuation routes should be clearly marked, and preferably numbered, so that precise instructions can be given to personnel to proceed via a designated route and/or disembarkation position.

If escape routes cannot be led clear of sources of probable fire, the route should be protected, where practicable, by fire walls/barriers or heat shields and should protect personnel from exposure to burning hydrocarbons on water, on the topside of loading/unloading facilities, or on shore.

Evacuation routes should be designed and maintained obstacle-free in order to eliminate the need for personnel to jump into the water to reach refuge.

Berths and jetties can be difficult to escape from during fires or other emergencies. Consequently, careful thought should be given to designing escape routes. Access ways to and from offshore berths and dolphins require special attention as personnel must not be left unattended on isolated dolphins. Moreover, steps or steel ladders are usually required between berths and the water level.

21.2.2 Boat access

All terminals should be designed or modified to provide an adequate emergency evacuation of personnel. Particular emphasis should be given to safe disembarkation positions at suitably protected locations. T-head jetties and finger piers should provide fixed means for embarking personnel into tugs, boats and other rescue craft in the event of the shore route being inaccessible.

21.2.3 Availability of rescue craft

When evacuation is required to be undertaken by rescue craft, such transport should be alerted at an early stage of the emergency and be kept as close as possible to the evacuation point so they can be on scene rapidly, preferably no later than 15 minutes from initial advice. The mobilisation of all available harbour or terminal rescue craft would form part of any emergency plan.

Harbour craft and tugs not under the control of the terminal but available for use in rescue operations should be identified for use in an emergency. Early warning should be given for the assembly of all craft used for evacuation, which will then be under the control of the person in charge of managing response to the incident.

21.2.4 Life-saving appliances

Every terminal should be equipped with life-saving appliances for use in evacuation and rescue, such as life buoys, personal flotation devices for every person located at the site and, where appropriate, life rafts or lifeboats. Personal flotation devices should be located in prominent and accessible positions.

Life buoys and life rafts are not suitable for use in evacuation in the case of fire on water. These devices are typically used for emergency rescue from water in the case of someone going overboard. However, such life-saving equipment may be required under local regulations.

21.3 N/A

21.4 Training and drills

Training should be given for the following emergency activities:

- Firefighting using equipment available at 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 clear up.
- Evacuation drills.
- Security threats and terrorist attacks.

The effectiveness of evacuation plans depends on the training and familiarity of personnel in the use of such plans, preferably with engagement of the ship's crew.

Evacuation drills should be frequent, at least once every three months if there is no legal period, and all key and supervisory personnel at the facility should have a thorough knowledge of the evacuation plans. The evacuation plan should be reviewed from time to time, particularly in the light of findings from routine drills and exercises.

PART 4:
MANAGEMENT OF THE INLAND TANKER AND TERMINAL INTERFACE

22 Communications

This chapter deals with communications required between the inland tanker and the shore, including pre-arrival communications between the inland tanker and local authorities, and between the inland tanker and the terminal. It addresses communication exchanges between the inland tanker and the terminal before berthing, and before and during cargo, ballast or bunkering operations, including emergency communication procedures.

22.1 Procedures and precautions

22.1.1 Communications equipment

Telephone and portable VHF/UHF and radiotelephone systems should comply with the appropriate safety requirements.

The provision of adequate means of communication, including a back-up system between inland tanker and shore, is the responsibility of the terminal.

Communication between the Responsible Person on the tanker and the Terminal Representative should be maintained in the most efficient way.

When telephones are used, they should be continuously manned by personnel, on board and ashore, who can immediately contact their superior. Additionally, it should be possible for that superior to override all calls.

When VHF/UHF systems are used, units should preferably be portable and carried by the Responsible Person on duty and the Terminal Representative, or by personnel who can contact their respective superior immediately. Where fixed systems are used, they should be continuously manned.

The selected system of communication, together with the necessary information on telephone numbers and/or channels to be used, should be recorded on an appropriate form. This form should be signed by inland tanker and shore representatives.

22.1.2 Communications procedures

To ensure the safe control of operations at all times, it should be the responsibility of both parties to establish, agree in writing and maintain a reliable communications system.

Before loading or discharging starts, the system should be tested. A secondary standby system should also be established, tested and agreed. Allowance should be made for the time required for action in response to signals.

The following signals should be agreed at the pre-transfer conference and before start of cargo transfer:

- Emergency signals including emergency stop.
- Identification of inland tanker, berth and cargo.
- Stand by.
- Start loading or start discharging.
- Slow down.
- Stop loading or stop discharging.

Any other necessary signals should be agreed and understood.

When different products or grades are to be handled, their names and descriptions should be clearly understood by the tanker and shore personnel on duty during cargo handling operations.

The use of one VHF/UHF channel by more than one tanker/shore combination should be avoided.

Where there are difficulties in verbal communication, these can be overcome by appointing a person with adequate technical and operational knowledge and a sufficient command of a language understood by tanker and shore personnel. Where a non-common language is identified, English should be the default language used.

22.1.3 Compliance with terminal and local regulations

Terminals should have security, safety and pollution regulations, which must be complied with by inland tanker and terminal personnel. Terminals should make all tankers aware of regulations by transmitting the TIB well in advance, together with any other regulations relating to the safety of shipping that the appropriate port authority may issue.

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).

22.2 Pre-arrival exchange of information

Before the inland tanker arrives at the terminal, there should be an exchange of information on matters such as the following:

22.2.1 Exchange of security information

Security protocols should be agreed between the inland tanker and the port or terminal security officer where applicable. Pre-arrival communications should establish who performs these functions and how they will be carried out.

22.2.2 Inland tanker to appropriate competent authority

The inland tanker should provide information as required by international, regional, national and local regulations and recommendations.

22.2.3 Inland tanker to terminal

Wherever possible, the following information should be provided before arrival:

- Name and ENI number of the inland tanker.
- Country of registration.
- Overall length and beam of the tanker and draught on arrival.
- Estimated time of arrival at designated arrival point.
- If loaded, a list of all cargo (proper shipping name and/or UN number), including any toxic properties, on board on arrival.
- Maximum draught expected during and on completion of cargo handling.
- Any defects of hull, machinery or equipment that could affect safe operations or delay commencement of cargo handling.
- Where tanks are required to be inerted, confirmation that they are in an inert condition, and, where fitted with an inert gas system, that the system is fully operational.
- If an alternative fuel system is used e.g. Liquefied Natural Gas (LNG), confirmation that the control systems are operational.
- Any requirement for tank-cleaning and/or gas-freeing.
- The tanker's manifold details, including type, size, number, distance between centres of connections to be presented.
- Advance information on proposed cargo handling operations, including grades, sequence, quantities and any rate restrictions.
- Information, as required, on quantity and nature of slops, and last cargo (proper shipping name and/or UN number) of empty tanks if not gas-freed. Identification of any toxic components, such as hydrogen sulphide (H_2S) or benzene.
- Quantities and specifications of bunkers required, if applicable.

22.2.4 Terminal to inland tanker

The terminal should ensure that the inland tanker has been provided with relevant port information via the TIB as soon as practicable. The information that should be contained in the TIB is contained in the latest edition of the OCIMF *Marine Terminal Information Booklet: Guidelines and Recommendations*, which should as a minimum include:

- Depth of water at chart datum and range of salinity that can be expected at the berth (draught will increase from salt water to fresh water).
- Maximum permissible draught and maximum permissible air draught.
- Availability of tugs and mooring craft, and with any terminal requirements on their usage.
- Details of any shore moorings that will be provided.
- Which side to be moored alongside.
- Number and size of hose connections and manifolds.
- Where fitted, the working envelope for any marine loading arms being utilised.
- Whether a vapour emission control system is in use.
- Inert gas requirements.
- Cargo measurement requirements.
- Closed loading requirements.
- For jetty berths, arrangement of second access/gangway landing space or availability of terminal access equipment.
- Advance information on proposed cargo specification, handling operations or changes in existing plans for cargo operations. Such information should include identification of any toxic components, such as hydrogen sulphide and benzene.
- Any applicable restrictions on tank-cleaning and gas-freeing.
- Advice on environmental and load restrictions applicable to the berth.
- Facilities for the reception of slops and garbage.
- Security levels in effect within the port.

22.3 Pre-berthing exchange of information

22.3.1 Inland tanker to terminal and/or pilot

On arrival at the port, the inland tanker's Master will establish direct communications with the terminal and/or pilot station. The Master should advise the terminal of any deficiencies or incompatibilities in the tanker's equipment that might affect the safety of the mooring.

22.3.2 Terminal to inland tanker

Before berthing, the terminal should provide the inland tanker's Master with details of the mooring plan. The procedure for mooring the tanker should be specified, and it should be reviewed by the Master and agreed with the terminal.

Information should include:

For all types of berth:

- The plan for approaching the berth, including turning locations, environmental limits and maximum speeds.
- Any special conditions e.g. weather, depth of water, tidal currents and marine traffic, that may be expected during passage.
- Tanker's mooring arrangements.
- Safe access arrangements.

For jetty berths:

- Minimum number of inland tanker's moorings.
- Number and position of bollards or quick-release hooks.
- Number and location of jetty manifold connections or hard arms.

- Limitations of the fendering system and of the maximum displacement, approach velocity and angle of approach, for which the berth and the fendering system have been designed.
- Any particular feature of the berth that it is considered essential to bring to the prior notice of the tanker's Master.
- Limitations on use of spud posts.

Any deviation from the agreed mooring plan made necessary by changing weather should be communicated to the tanker's Master as soon as possible.

22.4 Pre-transfer exchange of information

Completion of safe and efficient cargo, ballast and bunkering operations depends on effective co-operation and co-ordination between all parties involved. This section covers information that should be exchanged before those operations begin.

22.4.1 Inland tanker to terminal

Before transfer operations start, the Responsible Person should inform the terminal of the general arrangement of the cargo, ballast and bunker tanks, and should have available the information listed below.

22.4.1.1 Information in preparation for loading cargo and bunkers

- Details of last cargo carried, method of tank-cleaning (if any) and state of the cargo tanks and lines.
- Where the inland tanker has part cargo on board on arrival, the grade, volume and tank distribution.
- Maximum acceptable loading rates and topping-off rates.
- Maximum acceptable pressure at the tanker/shore cargo connection during loading.
- Cargo quantities acceptable from terminal nominations.
- Proposed distribution of nominated cargo and preferred order of loading.
- Testing overfill and emergency equipment.
- Maximum acceptable cargo temperature (where applicable).
- Maximum acceptable TVP (where applicable).
- Proposed method of vapour emission control.
- Quantities and specifications of bunkers required.
- Distribution and quantities of ballast together, if relevant, with time required for discharge and maximum light freeboard.
- Quantity, quality and distribution of slops.
- Quality of inert gas (if applicable).
- Communication system for loading control, including the signal for emergency stop.

22.4.1.2 Information in preparation for cargo discharge

- Cargo specifications.
- Whether the cargo includes toxic components, e.g. hydrogen sulphide, benzene, lead additives or mercaptans.
- Any other characteristics of the cargo requiring special attention, e.g. high TVP.
- Proposed method of vapour emission control.
- Flashpoint (where applicable) of products and their temperatures on arrival, particularly when the cargo is non-volatile.
- Distribution of cargo on board by grade and quantity.
- Quantity and distribution of slops.
- Any unaccountable change of ullage in the tanker's tanks since loading.
- Water dips in cargo tanks (where applicable).
- Preferred order of discharge.

- Maximum attainable discharge rates and pressures.
- Whether tank-cleaning is required.
- Approximate time of start and duration of ballasting into permanent ballast tanks.
- Testing pump emergency system.
- Testing overfill and emergency equipment.

22.4.2 Terminal to inland tanker

The following information should be made available to the Responsible Person.

22.4.2.1 Information in preparation for loading cargo and bunkers

- Cargo specifications and preferred order of loading.
- Whether the cargo includes toxic components, e.g. hydrogen sulphide, benzene, lead additives or mercaptans.
- Proposed method of vapour emission control.
- Any other characteristics of the cargo requiring attention, e.g. high TVP.
- Flashpoints (where applicable) of products and their estimated loading temperatures, particularly when the cargo is non-volatile.
- Bunker specifications, including hydrogen sulphide content.
- Proposed bunker loading rate.
- Nominated quantities of cargo to be loaded.
- Maximum shore loading rates.
- Standby time for normal pump stopping.
- Maximum pressure available at the tanker/shore cargo connection.
- Number and sizes of hoses or arms available and manifold connections required for each product or grade of the cargo, and vapour emission control systems, if appropriate.
- Limitations on the movement of hoses or arms.
- Communication system for loading control, including the signal for emergency stop.
- SDSs or similar for each product to be handled.
- Testing overfill and emergency equipment.

22.4.2.2 Information in preparation for cargo discharge

- Order of discharge of cargo acceptable to terminal.
- Nominated quantities of cargo to be discharged.
- Maximum acceptable discharge rates.
- Maximum pressure acceptable at tanker/shore cargo connection.
- Any booster pumps that may be on stream.
- Number and sizes of hoses or arms available and manifold connections required for each product or grade of the cargo, and whether or not these arms are common with each other.
- Limitations on the movement of hoses or arms.
- Any other limitations at the terminal.
- Communication system for discharge-control, including the signal for emergency stop.
- Testing overfill and emergency equipment.
- Statement of follow-up action triggered by the overfill alarm.
- (Efficient) stripping and discharging the last of the cargo drainings.

22.5 Agreed loading plan

On the basis of the information exchanged, an operational agreement and an inland tanker/shore safety checklist should be made in writing between the Responsible Person and the Terminal Representative covering the following as appropriate:

- Tanker's name, berth, date and time.
- Names of tanker and shore representatives.
- Cargo distribution on arrival and departure.
- The following information on each product:
  - Quantity.
  - Tanker's cargo tank(s) to be loaded.
  - Shore tank(s) to be discharged.
  - Lines to be used tanker/shore.
  - Cargo transfer rate.
  - Operating pressure.
  - Maximum allowable pressure.
  - Temperature limits.
  - Venting system.
  - Sampling procedures.
- Restrictions necessary because of:
  - Electrostatic properties.
  - Use of automatic shutdown valves.

This agreement should include a loading plan indicating the expected timing and covering the following:

- The sequence in which the inland tanker's cargo tanks are to be loaded, taking into account:
  - Deballasting operations.
  - Tanker and shore tank change over.
  - Avoidance of cargo contamination.
  - Pipeline clearing for loading (line-up).
  - Other movements or operations that may affect flow rates.
  - Trim and draught of the tanker.
  - The need to ensure that permitted stresses will not be exceeded.
- The initial and maximum loading rates, topping-off rates and normal stopping times, in regard to:
  - The nature of the cargo and/or the density of the vapor to be loaded.
  - The arrangement and capacity of the tanker's cargo lines and gas-venting system.
  - The maximum allowable pressure and flow rate in the tanker/shore hoses or arms.
  - Precautions to avoid accumulation of static electricity.
  - Any other flow control limitations.
  - Line displacement after loading.
- The method of vapour emission control to avoid or reduce gas emissions at deck level, taking into account:
  - The TVP of the cargo to be loaded.
  - The loading rates.
  - Atmospheric conditions.
- Any bunkering or storing operations.
- Emergency stop procedure.

Once the loading plan has been agreed, it should be signed by the Responsible Person and Terminal Representative.

22.6 Agreed discharge plan

On the basis of the information exchanged, an operational agreement and an inland tanker/shore safety checklist should be made in writing between the Responsible Person and the Terminal Representative covering the following:

- Inland tanker's name, berth, date and time.
- Names of tanker and shore representatives.
- Cargo distribution on arrival and departure.
- The following information on each product:
  - Quantity.
  - Shore tank(s) to be filled.
  - Tanker's cargo tank(s) to be discharged.
  - Lines to be used tanker/shore.
  - Cargo transfer rate.
  - Operating pressure.
  - Maximum allowable pressure.
  - Temperature limits.
  - Venting systems.
  - Sampling procedures.
  - (Efficient) stripping and discharging last of the cargo's drainings.
- Restrictions necessary because of:
  - Electrostatic properties.
  - Use of automatic shutdown valves.

The discharge plan should include details and expected timing of the following:

- The sequence in which the inland tanker's cargo tanks are to be discharged, taking account of:
  - Tanker and shore tank change over.
  - Avoidance of cargo contamination.
  - Pipeline clearing for discharge.
  - Tank-cleaning.
  - Other movements or operations that may affect flow rates.
  - Trim and freeboard of the tanker.
  - The need to ensure that permitted stresses will not be exceeded.
  - Ballasting operations.
  - (Efficient) stripping and discharging the last of the cargo drainings.
- The initial and maximum discharge rates, in regard to:
  - The specification of the cargo to be discharged.
  - The arrangements and capacity of the tanker's cargo lines, shore pipelines and tanks.
  - The maximum allowable pressure and flow rate in the tanker/shore hoses or arms.
  - Precautions to avoid accumulation of static electricity.
  - Any other limitations.
- Bunkering or storing operations.
- Emergency stop and shutdown procedure.

Once the discharge plan has been agreed, it should be signed by the Responsible Person and the Terminal Representative.

22.7 Agreement to carry out repairs

22.7.1 Repairs on the inland tanker

When any repair or maintenance is to be done on board an inland tanker moored at a berth, the Responsible Person must inform the Terminal Representative and the competent authority, if required. Agreement should be reached on the safety precautions to be taken, with due regard to the nature of the work. Where the agreement is breached the Terminal Representative should have a right to withdraw the approval and terminate the works until an agreed safe operation is resumed.

22.7.1.1 Immobilisation of the inland tanker

While an inland tanker is berthed at a terminal, all equipment essential for manoeuvring should normally be kept in a condition that will permit the tanker to be moved away from the berth in an emergency.

Repairs and other work that may immobilise the tanker should not be undertaken at a berth without prior written agreement with the terminal and the competent authority, if required.

Any unplanned condition that results in the loss of operational capability, particularly to any safety system, should be immediately communicated to the terminal.

22.7.1.2 Hot work on the inland tanker

Hot work on board the inland tanker must be prohibited until all applicable regulations and safety requirements have been met and a permit to work has been issued (see section 9.3). This may involve the Master of the tanker, company, chemist, shore contractor, Terminal Representative and competent authority, as appropriate.

When alongside a terminal, no hot work should be allowed until the Terminal Representative and, where appropriate, the competent authority has been consulted and approval obtained.

A hot work permit should only be issued after obtaining a gas-free certificate from an authorised chemist.

22.7.2 Repairs on the terminal

No construction, repair, maintenance, dismantling or modification of facilities should be carried out on an inland tanker berth without the permission of the Terminal Representative. If a tanker is moored at the berth, the Terminal Representative should also obtain the agreement of the Master.

22.7.3 Use of tools while an inland tanker is alongside a terminal

No hammering, chipping or grit blasting should take place, nor should any power tool be used, outside the engine room or accommodation spaces on an inland tanker, or on a terminal at which a tanker is berthed, without agreement between the Terminal Representative and the Responsible Person, and unless a permit to work has been issued.

In all cases, the Terminal Representative and the Responsible Person should satisfy themselves that the area is gas-free and remains so while the tools are in use. The precautions in section 4.5 should be observed.

23 Mooring

This chapter deals with the preparations and procedures necessary to provide and maintain an efficient mooring arrangement while the inland tanker is berthed at a jetty. Exchange of information between the tanker and the terminal on matters relating to mooring arrangements is dealt with in chapter 22.

The use of mooring equipment is described in detail in applicable national and international publications/regulations. Tanker and berth operators are strongly recommended to bring the appropriate information to the attention of their respective workforces to ensure that the mooring operation can be undertaken safely.

23.1 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.

23.1.1 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.

23.2 Security of moorings

Any excessive movement or the breaking adrift of an inland tanker from the berth owing to inadequate moorings could cause injury to personnel and damage to the jetty installations and tanker.

Although responsibility for the adequate mooring of a tanker rests with the Master, the terminal has an interest in ensuring that tankers are securely and safely moored. Cargo hoses or arms should not be connected until both the Terminal Representative and the tanker Master are satisfied that the tanker is safely moored.

23.3 Preparations for arrival

23.3.1 Tanker's mooring equipment

Before a tanker arrives at a port or berth, all necessary mooring equipment should be ready for use. Anchors should be ready for use if required, unless anchoring is prohibited There should always be an adequate number of crew available to handle the moorings.

23.3.2 N/A

23.3.3 N/A

23.4 Mooring at jetty berths

Effective mooring management for inland tankers requires a sound knowledge of mooring principles, information about the mooring equipment installed on the tanker, proper maintenance of this equipment and regular tending of mooring lines. All personnel should use OCIMF's *Effective Mooring* guide for a basic understanding of the operational and safety considerations involved in berthing.

Further reference to the more comprehensive OCIMF *Mooring Equipment Guidelines* is also recommended for inland tanker operators and Masters. This guide is prepared for seagoing tankers, but it contains significant detailed information that is applicable to all vessel types (e.g. use of HMSF lines) that provides the fullest understanding of technical, operational and safety considerations. *Effective Mooring* is a complementary guide to the *Mooring Equipment Guidelines*, aiding the preparation of mooring plans and safety procedures.

The safety of the tanker, including its proper mooring, is the prime responsibility of the tanker's Master. However, the terminal has local knowledge of the operating environment at the site and knows the capabilities of shore equipment. It should therefore be in a position to advise the tanker's Master on mooring line layout and operating limits.

23.4.1 Type and quality of mooring lines

Mooring lines should preferably all be of the same material and construction. Ropes with low elastic elongation properties are recommended for all inland tankers, as they limit the tanker's movement at the berth.

Moorings composed entirely of high elasticity ropes are not recommended as they can allow excessive movement from strong wind or current forces, or through interaction from passing tankers. Within a given mooring pattern, ropes of different elasticity should never be used together in the same direction.

Mooring conditions and regulations may differ from port to port.

Standard synthetic fibre ropes will deteriorate more rapidly than steel wires or high modulus synthetic fibre ropes. All ropes and wires should be inspected regularly and replaced when there are signs of damage.

23.4.2 Management of moorings at alongside berths

23.4.2.1 Tending of moorings

The crew of the inland tanker are responsible for the frequent monitoring and careful tending of the moorings, but suitably qualified shore personnel should check the moorings periodically to satisfy themselves that they are being properly tended.

When tending moorings that have become slack or too taut, an overall view of the mooring system should be taken so that the tightening or slackening of individual lines does not allow the tanker to move or place undue loads on other lines. The tanker should maintain contact with the fenders, and moorings should not be slackened if the tanker is lying off the fenders.

Once the mooring lines are secured to the shore, the mooring winch clutches should be disengaged to permit release of the moorings in an emergency, e.g. a fire rendering electrical systems inoperative.

23.4.2.2 N/A

23.4.2.3 Self-stowing mooring winches

Many inland 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). Some features of these winches need to be clearly understood by tanker crew in order to avoid tankers breaking adrift from berths as the result of slipping winch brakes.

The physical condition of the winch gearing and brake-shoe linings or blocks has a significant effect on brake-holding capacity in service. Mooring winch brakes should be tested at regular intervals, at least every 12 months. A record of regular maintenance, inspections and tests should be kept on the tanker. More detailed information on winch brake testing requirements and test kits are found in OCIMF's *Mooring Equipment Guidelines.*

If the deterioration is significant, the linings or blocks must be renewed.

A number of operational procedures can also seriously reduce the holding capacity of winch brakes if they are not correctly carried out. These include:

The number of layers of wire on the drum
The designed holding capacity of the winch brake is usually calculated for the first layer. For each additional layer, the holding capacity is reduced. This 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.

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 manufacturers 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 guidance in *Mooring Equipment Guidelines* or *Effective Mooring.*

Winches fitted with disc brakes do not have this limitation.

The condition of brake linings and drum
Oil, moisture or heavy rust on the brake linings or drum can seriously reduce the brake holding capacity. Moisture may be removed by running the winch with the brake applied lightly, but care must be taken not to cause excessive wear. Oil impregnation cannot be removed so contaminated brake linings will need to be renewed.

The application of the brake
Brakes must be adequately tightened to achieve the required holding capacity. If brakes are applied manually, they should be checked for tightness.

23.4.2.4 Shore moorings

At some terminals, shore moorings are used to supplement the inland tanker's moorings. Where shore personnel handle shore moorings, they must be fully aware of the hazards of the operation and should adopt safe working practices.

23.4.2.5 Anchors

While moored alongside, anchors not in use should be properly secured by brake and guillotine, but otherwise be available for immediate use.

23.5 N/A

24 Precautions on inland tankers and terminals during cargo handling

This chapter provides guidance on precautions to be observed by inland tankers and the shore when cargo handling, ballasting, bunkering, tank-cleaning, gas-freeing and purging operations are to be carried out in port. Eliminating the risk of fire and explosions is paramount. The hazards associated with smoking, galleys, electrical equipment and other potential sources of ignition are discussed in chapter 4.

Detailed information on equipment and operations principally related to either the inland tanker or the terminal is contained in parts 2 and 3 of this guide.

24.1 External openings in accommodation and engine rooms

The accommodation and machinery spaces on an inland tanker contain equipment that is not suitable for use in flammable atmospheres. It is important that volatile cargo vapours are kept out of these spaces.

During loading, unloading, gas-freeing, tank-cleaning and purging operations, all external doors, ports and similar openings on the tanker should be closed.

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 due to structural peculiarities of the tanker.

If external doors have to be opened for access, they should be closed immediately after use. Where practical, a single door should be used for working access in port. Doors that must be kept closed should be clearly marked.

Doors should not normally be locked in port. However, where there are security concerns, steps may need to be taken to prevent unauthorised access while at the same time ensuring there is a means of escape for the crew inside. Although discomfort may be caused to crew in accommodation that is completely closed during conditions of high temperatures and humidity, this may be necessary in the interests of security and safety.

24.2 Air conditioning and ventilation systems

On inland tankers with air conditioning units, it is essential that the accommodation is kept under positive pressure to prevent the entry of cargo vapours. Intakes for air conditioning units are usually positioned in a safe area, so vapours will not be drawn into the accommodation under normal conditions. A positive pressure will be maintained only if the air conditioning system is operating with its air intakes open and if all access doors are kept closed, except for momentary entry or exit. The system should not be operated with the intakes fully closed, i.e. in 100% recirculation mode, because the operation of extraction fans in galley and sanitary spaces will reduce the atmospheric pressure in the accommodation to less than that of the ambient pressure outside.

There is a benefit from having a gas-detection and/or alarm system fitted to air conditioning intakes. In the event that hydrocarbon vapours are present at the inlets, the ventilation system should be shut down and cargo transfer suspended until the surrounding atmosphere is free of hydrocarbon vapours.

The same principles of positive pressure and gas-detection apply to tankers that have alternative air conditioning systems or where additional units have been fitted. The overriding consideration in all cases is that hydrocarbon vapours must not be permitted to enter the accommodation.

Externally located air conditioning units should not be operated during any of the operations listed in section 24.1 unless they are either in safe areas or are certified as safe for use in the presence of flammable vapours.

On tankers that depend on natural ventilation, ventilators should be kept trimmed to prevent vapour entry. If ventilators are located so that vapours can enter regardless of the direction in which they are trimmed, they should be covered, plugged or closed.

24.3 Openings in cargo tanks

24.3.1 Cargo tank lids[5]

During the handling of volatile products and the loading of non-volatile products into tanks containing hydrocarbon or chemical vapour, all cargo tank lids should be closed and secured.

Cargo tank lids or coamings should be clearly marked with the number and location (port, centre or starboard) of the tank they serve.

24.3.2 Sighting and ullage ports[5]

During any of the cargo and ballast-handling operations referred to in section 24.1, sighting and ullage ports should be kept closed, unless required to be open for measuring and sampling, and when agreed between the inland tanker and the terminal.

If the system design means sighting or ullage ports are required to be open for venting purposes, the openings should be protected by a flame screen/arrester, which may be removed/opened for a short time during ullaging, sighting, sounding and sampling. These screens/arresters should be a good fit and should be kept clean and in good condition.

24.3.3 Cargo tank vent outlets[5]

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 which also serves tanks where non-volatile cargo is loaded, it is important to prevent flammable gas entering the tanks receiving non-volatile cargo. Particular attention should be paid to the setting of Pressure/ Vacuum (P/V) valves, the associated venting system and vapour line isolation valves, and any IG system (where fitted).

Whenever tanks are isolated to prevent cross-contamination, the likelihood of oxygen entering the tank due to pressure variations during passage should be taken into consideration. Plans may need to be drawn up to restore the inert condition before discharge.

24.3.4 Tank washing openings[5]

During tank-cleaning or gas-freeing operations, tank washing cover plates should only be removed from the tanks where these operations are taking place and should be replaced immediately on completion. Any openings in the deck should be covered by gratings. Other tank-washing covers may be loosened in preparation but should be left in their fully closed position.

24.4 Inspection of inland tanker cargo tanks before loading[6]

Generally, cargo tank inspections before loading should be made without entering the tanks.

It may sometimes be necessary to remove tank-cleaning opening covers to sight parts of the tank not visible from the ullage or sighting ports. The covers must be replaced and secured immediately after the inspection. The person carrying out the inspection should take care not to inhale vapours or inert gas when inspecting tanks that have not been gas-freed.

When the cargo to be loaded has a critical specification, if it is necessary for the inspector to enter a tank, all the precautions contained in section 10.5 must be followed.

---

[5] Attention should be given to national or international dangerous goods legislation with specific requirements in this respect.

[6] Attention should be given to International or National Dangerous Goods legislation with specific requirements in this respect.

Cargo tank atmospheres that are, or have been, inerted should be handled with care due to the risk of low oxygen contents. Inerted cargo tanks should be marked with appropriate warning signs.

Before entering a tank that has been inerted, it must be gas-freed for entry. Unless all tanks are gas-freed and the inert gas system is completely isolated, each individual tank to be entered for inspection must be isolated from the inert gas system (see section 10.5).

24.5 Segregated ballast tank lids

Before ballast discharge starts, segregated ballast tank lids may be opened to allow the surface of the ballast to be inspected, e.g. for contamination. However, segregated ballast tank lids should normally be kept closed when cargo or ballast is being handled because petroleum or chemical vapours could be drawn into them.

Segregated ballast tank lids must be clearly marked to indicate the tank they serve.

24.6 Inland tanker and shore cargo connections

24.6.1 Flange connections

Flanges for inland tanker-to-shore cargo connections at the end of the terminal pipelines and on the tanker's manifold should be in accordance with national or international legislation.

Flange faces, gaskets and seals should be clean and in good condition. When in their storage location, flange faces should be suitably protected from corrosion/pitting.

Where bolted connections are made, all bolt holes should be used. Care should be taken when tightening bolts because uneven or over-tightened bolts could result in leaks or fractures. Improvised arrangements using 'G' clamps or similar devices must not be used for flange connections.

24.6.2 Removal of blank flanges

Each inland tanker and terminal manifold flange should have a removable blank flange made of steel or other approved material, such as phenol resin, and preferably fitted with handles.

Precautions should be taken to ensure that before removing blanks from tanker and terminal pipelines, the section between the last valve and blank does not contain product under pressure. Precautions must also be taken to prevent any spillage.

Blank flanges shall be capable of withstanding the working pressure of the line or system to which they are connected. Blank flanges should normally be of a thickness equal to that of the end flange to which they are fitted.

24.6.3 Reducers and spools

Reducers and spools should be made of steel and be fitted with flanges that conform to ANSI B16.5, Class 150 or equivalent. Ordinary cast iron should not be used.

There should be an exchange of information between the inland tanker and terminal when manifold reducers or spools are made of any material other than steel, since they are carefully manufactured to achieve the equivalent strength of steel and to avoid the possibility of fracture.

Manifold pressure gauges should be fitted to the spool pieces on the outboard side of the manifold valves.

24.6.4 Lighting

During darkness, adequate lighting should be arranged to cover the area of the inland tanker-to-shore cargo connection and any hose-handling equipment, so that the need for any adjustment can be seen in good time and any leaks or spills of product can be quickly detected.

24.6.5 Emergency release

A special release device can be used for the emergency disconnection of cargo hoses or arms.

If possible, the hoses or arms should be drained, purged or isolated as appropriate before emergency disconnection so that spills are minimised (see section 11.1.15.1).

Regular checks should be made to ensure that all safety features are operational.

(See also section 18.1.10).

24.7 Accidental product spills and leaks

24.7.1 General

Inland tanker and shore personnel should maintain a close watch for the escape of product at the start of and during cargo transfer operations. In particular, care should be taken to ensure that pipeline valves, including drop valves, are closed when not in use.

The ullages of cargo or bunker tanks that have been topped-up should be checked from time to time during the loading to ensure that overflows do not occur as a result of leaking valves or incorrect operations.

On double-hull tankers, attention should be given to stability during ballast and cargo operations. Care should be taken not to reduce the transverse metacentric height (GM) so that it induces an angle of list or loll when deballasting double-bottom tanks after some cargo tanks have been topped-off, as this could cause an overflow of cargo (see section 11.2).

If a leak occurs from a pipeline, valve, hose or metal arm, operations through that item should be stopped until the cause has been found and the defect rectified. If a pipeline, hose or arm bursts, or there is an overflow or other spill, all cargo operations should stop immediately and not restart until the fault has been rectified and all hazards from the released oil or chemicals have been eliminated. If there is any possibility of the released oil/chemicals or associated vapours entering an engine room or accommodation space intake, appropriate preventive measures must be taken quickly.

Means should be provided for the prompt removal of any spills on deck. Any oil spill should be reported to the terminal and competent authorities, and the relevant shore and tanker oil pollution emergency plans should be activated.

Competent authorities and any nearby ship or shore installations should be warned of any potential hazard caused by the spill.

24.7.2 N/A

24.7.3 Scupper plugs

Before cargo handling starts, all deck scuppers[7] and, where applicable, open drains on the jetty must be effectively plugged to prevent spilled products escaping into the water around the tanker or terminal. Accumulations of water should be drained regularly, and scupper plugs replaced immediately after the water has been run off.

Product-contaminated water should be transferred to a slop tank or other suitable receptacle. The tank pressure should be reduced to facilitate draining, if necessary.

24.7.4 Spill containment

A permanent drip tray, provided with suitable means of draining, should be fitted under all inland tanker and shore manifold connections. If no permanent trays are fitted, portable drip trays should be placed under each connection in use to catch any leaks. The use of plastic should be avoided unless provision for bonding is made.

---

[7] Attention should be given to international, national or local legislation with specific requirements in this respect.

24.7.5 Inland tanker and shore cargo and bunker pipelines not in use

The tightness of valves should not be relied upon to prevent the escape or seepage of products. All shore pipelines, marine loading arms and hoses not in use at a berth must be securely blanked.

All inland tanker cargo and bunker pipelines not in use must be securely blanked at the manifold. Where fitted, cargo pipelines to stern or bow manifolds should be drained of cargo and isolated from the inland tanker's main pipeline system.

24.8 Fire-fighting equipment

When an inland tanker is alongside a berth, fire-fighting equipment is to be ready for immediate use.

On board the tanker, this is normally done by having fire hoses/monitors with spray/jet nozzles ready for use. Portable dry chemical powder extinguishers in the cargo area provide additional protection against small flash fires.

On the jetty, fire-fighting equipment should be ready for immediate use. While this may not involve the rigging of fire hoses, the preparations for emergency operation of the fire-fighting equipment should be apparent and communicated to the tanker. Consideration should be given to having portable extinguishers available for use next to the jetty manifold area.

24.9 Proximity to other vessels

24.9.1 Inland tanker at adjacent berths

Flammable and/or toxic concentrations of product vapours may be encountered if another inland tanker at an adjacent berth is handling cargo or ballast, purging, tank-cleaning or gas-freeing. In such circumstances, appropriate precautions should be taken as in section 24.1.

24.9.2 General cargo ship at adjacent berths

It is unlikely that a general cargo ship will be able to comply as fully as an inland tanker with the safety requirements relating to possible sources of ignition, such as smoking, naked lights, cooking and electrical equipment.

Accordingly, when a general cargo ship is at a berth near an inland tanker that is loading or discharging volatile petroleum, loading non-volatile products into tanks containing hydrocarbon vapour, or purging or gas-freeing after discharging volatile products, it will be necessary for the terminal to evaluate any related safety hazards and to take precautions additional to those set out in this chapter. Such precautions should include inspecting the general cargo ship and clearly defining the precautions to be taken on board the tanker.

24.9.3 Inland tanker operations at general cargo berths

Where inland tanker operations are conducted at general cargo berths, it is unlikely that personnel on those berths will be familiar with the safety requirements relating to possible sources of ignition, or that cranes or other equipment will comply with the design and installation requirements for electrical equipment in hazardous areas.

Accordingly, the terminal should take precautions additional to those set out in this chapter. Such precautions should include restricted vehicle access, removable barriers to control access to the berth, additional fire-fighting equipment, and control of sources of ignition, together with restrictions on the movement of goods and equipment and the lifting of loads.

24.9.4 Tugs and other craft alongside

The number of craft that come alongside an inland tanker, and the length of their stay, should be kept to a minimum or be prohibited. Subject to any port authority regulations, only craft that have the permission of the tanker's Master and the Terminal Representative (where applicable), should be permitted to come or remain alongside while the tanker is handling volatile products or is ballasting tanks containing product vapour. The Master should instruct the crew that smoking and naked lights are not allowed on the craft. Any breach of the regulations should cause operations to stop.

Terminals should issue appropriate instructions to the operators of authorised craft on the use of engines and other apparatus and equipment, to avoid sources of ignition when going alongside a tanker or jetty. Where necessary, these will include providing spark arresters for engine exhausts, and instructions on proper fendering. Terminals should also ask for suitable notices to be posted prominently on the craft, informing crew and passengers of the safety precautions to be observed.

If any unauthorised craft come alongside or secure in a position that may endanger the operations, this should be reported to the competent authority and/or the Terminal Representative. If necessary, operations should stop.

24.10 Notices

24.10.1 Notices on the inland tanker

Whenever alongside a terminal, an inland tanker should display notices on deck, visible on two sides, or at the gangway(s) according to international (dangerous goods) legislation:

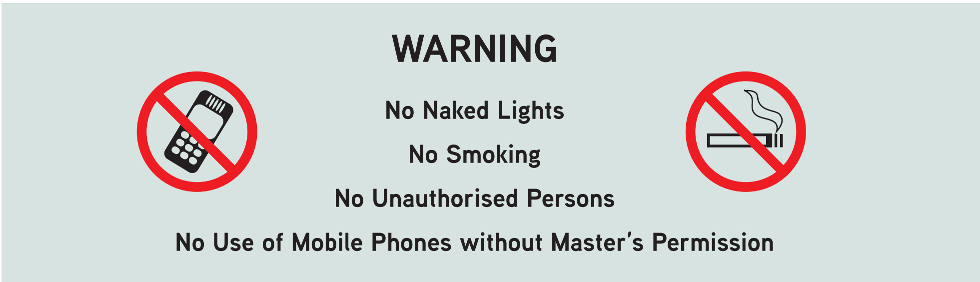


Figure 24.1: *Notices on the inland tanker*

24.10.2 Notices on the terminal

Permanent notices and signs indicating that smoking and naked lights are prohibited should be displayed conspicuously on the jetty in appropriate languages. Similar permanent notices and signs should be displayed at the entrance to the terminal area or the shore approaches to the jetty.

Figure 24.2: *Notices on the terminal*

In buildings and other shore locations where smoking is allowed, notices to this effect should be displayed conspicuously.

Emergency escape routes from the inland tanker berth to safe areas ashore should be indicated clearly.

24.11 Manning requirements

The level of manning should ensure that all operations related to the inland tanker/terminal interface are carried out safely. It should also ensure that emergency situations and security can be managed at all times during the inland tanker's stay at a terminal.

Details of manning levels on the inland tanker and the terminal should be discussed during the pre-transfer conference to ensure all parties involved in the inland 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.

Those personnel involved with the operations should be familiar with the risks associated with handling products and should be trained to deal with an emergency.

24.12 Control of naked flames and other potential ignition sources

The hazards associated with smoking, galleys, electrical equipment and other potential sources of ignition are covered in chapter 4.

24.13 Control of vehicles and other equipment

The use of vehicles and equipment should be controlled, particularly in hazardous zones. Routes to and from workplaces and parking areas should be clearly indicated. Where necessary, barriers or fencing should be provided to prevent unauthorised access.

24.14 N/A

25 Bunkering operations

Spills and leaks during bunkering operations are a primary source of oil pollution. Experience has shown that many of the bunker overflows and spills that occur can be attributed to human error.

Increasing concern over the impact of the transport by inland navigational vessels on the environment has seen the industry moving towards alternative fuels, including hydrogen, methanol, electricity and LNG as a prime or hybrid source of energy for propulsion.

Pending further best practice guidance in this Chapter on LNG and alternative fuels, users should refer to the Society for Gas as a Marine Fuel (SGMF). A downloadable introductory guide is available from https://sgmf.info.

This chapter provides guidance on the planning and execution of bunkering operations and includes an example of a pre-transfer safety checklist.

25.1 General

All bunkering operations should be carefully planned and executed in accordance with applicable regulations.

The crew involved in bunkering operations on board should have no other tasks and should remain at their workstations during topping-off. Generally, bunkering during cargo operations is not considered best practice owing to the need to avoid conflicts of interest for operational personnel. Spillages often occur when crew members are distracted by another task.

When bunkers are being delivered by barge, refer to section 11.9.2.

25.2 Bunkering procedures

Operators should require that all bunkering operations are controlled under procedures that are incorporated in an SMS.

These procedures should ensure that the risks associated with the operation have been assessed and that controls are in place to mitigate these risks. The procedures should also address contingency arrangements in the event of a spill. The operator should consider among other topics the following items when producing the procedures:

- Determining there is adequate space for the volume of bunkers to be loaded.
- Establishing maximum loading volumes for all tanks.
- Controls for setting bunker system valves.
- Determining loading rates for the start of loading, bulk loading and topping-off.
- Special precautions when loading into double-bottom tanks.
- Arrangements of bunker tank ventilation.
- Overflow arrangements.
- Verification of gauging system operation and accuracy.
- Alarm settings on overfill alarm units.
- Bunker overfill protection. (In general, the bunker overfill protection is an emergency stopping device only. It should not be used as a standard method of stopping bunkering).
- Communication between the supplier and receiver must be established before bunkering can be undertaken, including communication procedures for the bunkering operation and emergency stop.
- Manning requirements to execute the operation safely (e.g. deck watch).
- Monitoring the bunkering operation and checking it conforms to the agreed procedure.
- Changing over tanks during bunkering.
- Containment arrangements and clean-up equipment to be available.
- Define weather operating limitations

Once the procedure is produced, it should be implemented using a checklist, an example of which is included in appendix 5.

25.3 The bunkering operation

Wear the correct PPE as required by the ship's SMS and the product SDS.

Before starting the operation, all pre-loading checks should be carried out and communication systems verified as working.

The loading rate should be checked regularly.

When changing over from one tank to another, care should be taken to ensure that an excessive back pressure is not put on the hose or loading lines.

When topping-off tanks, the loading rate should be decreased to reduce the possibility of air locks in the tank causing mist carry-over through the vents, and to minimise the risk of the supplier not stopping quickly enough.

On completion of bunkering and before disconnection, all hoses and lines should be drained to the tank or, if applicable, back to the delivery bunker supplier. Blowing lines with air into bunker tanks has a high risk of causing a spill unless the tank is only part full and has sufficient ullage on completion of loading.

25.4 The bunkering safety checklist for bunker delivery to inland ships

25.4.1 General

Responsibility and accountability for the safe conduct of bunker operations is shared between the receiver and the supplier. Before the bunkering operation starts, the responsible personnel should:

- Agree in writing the handling procedures, including the maximum transfer rates.
- Agree in writing the action to be taken in an emergency during transfer operations.
- Complete and sign the bunkering safety checklist for bunker delivery to inland ships.

An example of the checklist is in appendix 5. The checklist is primarily structured for loading bunkers from a barge or a jetty, or when loading bulk lubricating oil or gas oil from a road tanker.

25.4.2 Guidelines for use

The following guidelines have been produced to help receiver and supplier personnel in their joint use of the bunkering safety checklist.

The checklist uses statements assigning responsibility and accountability. Ticking or initialling the appropriate box, and finally signing the declaration, confirms the acceptance of obligations. Once signed, it provides the minimum basis for safe operations as agreed through a mutual exchange of critical information.

Responsible personnel completing the checklist should be the people carrying out the bunkering operation.

The receiver's responsible personnel should check all considerations within the responsibility of the receiver. Similarly, the supplier's responsible personnel should check all considerations that are within the responsibility of the supplier. In fulfilling their responsibilities, responsible personnel should assure themselves that the standards of safety on both sides of the operation are fully acceptable. This can be achieved by means such as:

- Confirming that a competent person has satisfactorily completed the checklist.
- Sighting appropriate records.
- By joint inspection, where appropriate.

For mutual safety, before the start of operations, and from time to time after, both parties involved should verify that their obligations, as accepted in the checklist, are being effectively managed.

The bunkering safety checklist contains the following items:

1. Bunkers to be transferred
   - A joint agreement on the quantity and grades of bunkers to be transferred, together with the agreed transfer rate.
2. Bunker tanks to be loaded
   - An identification of the tanks to be loaded with the aim of ensuring there is enough space to safely accommodate the bunkers to be transferred. Space is provided to record each tank's maximum filling capacity and the available volume.
3. Safety checks by both parties prior to bunkering
   - The safety of operations requires that all relevant statements are considered, and the associated responsibility and accountability for compliance accepted.
   - The joint declaration should not be signed until all parties have checked and accepted their assigned responsibilities and accountabilities.

25.4.3 Bunkering safety checklist for bunker delivery to inland ships

See Appendix 5.

26 Safety management

This chapter provides a summary of information for assisting the inland tanker and the terminal to jointly manage personnel and operational safety. Reaction to changing weather during cargo handling is addressed. The correct use of personal protective equipment for inland tanker and shore personnel is also discussed.

The diligent and conscientious joint completion of the appropriate safety checklists provides the foundation for a safe transfer operation. A number of checklists are described in this chapter and included in appendices, together with guidelines to assist their completion.

This chapter also includes guidance on the interface between inland tanker and terminal emergency procedures.

26.1 Climatic conditions

26.1.1 Terminal advice of bad weather

The terminal should establish limiting parameters for controlling or stopping cargo operations based on the design of the berth and its equipment. The parameters may be determined by environmental conditions, such as wind speed, ice conditions, tidal current and swell, or by the physical limitations of the berth, such as fender loads or mooring point strength. Any limitations should be discussed with the inland tanker before operations start and recorded in the safety checklists.

The inland tanker and terminal operators should assess, determine and have clear guidance on operations that need to immediately cease in the event weather conditions, including the presence of electrical storms, that exceed limiting parameters.

Inland tanker and terminals 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 systems.
- Risk associated with stopping an activity or operation.

The Terminal Representative should alert the tanker to any forecast of bad weather that may require operations to be stopped, or loading or discharge rates to be reduced. In some instances, necessary information may be provided by third parties in the immediate vicinity or by the tanker.

Where environmental conditions are critical to the operation of the berth, the terminal should consider providing appropriate measuring instruments to provide information that will assist in managing the risk.

26.1.2 Wind conditions

If there is little air movement, product gas may persist on deck in heavy concentrations. If there is a wind, eddies can be created on the lee side of an inland tanker’s accommodation or deck structure and can carry vented gas towards the structure. Either of these effects may result in local heavy product gas concentrations and it may be necessary to extend the precautions set out in section 24.1 or to stop loading, ballasting of non-gas-free tanks, purging, tank-cleaning or gas-freeing while these conditions persist. All operations should also be stopped if wind conditions cause funnel sparks to fall on deck.

26.1.3 Electrical storms (lightning)

When an electrical storm is anticipated near the inland tanker or terminal, the following operations must be stopped, whether or not the tanker’s cargo tanks are inerted:

- Handling of volatile products.
- Handling of non-volatile products in tanks not free of flammable vapour.

- Ballasting of tanks not free of flammable vapour.
- Purging, tank-cleaning or gas-freeing after the discharge of volatile products.

All tank openings and vent valves must be closed, including any bypass valves fitted on the tank-venting system.

26.2 Personnel safety

26.2.1 Personal Protective Equipment

Protective clothing and equipment should be worn by all personnel engaged in operations on board and ashore. It is recommended that this should comprise a boiler suit (or similar clothing providing full cover, anti-static and flame retardant), safety boots/shoes, safety glasses and a safety helmet as appropriate. All personnel should also wear life vests or other similar buoyancy devices where there is a risk of falling into the water.

Storage places for PPE, including breathing apparatus, should be protected from the weather and should be clearly marked. Personnel should use the equipment and clothing whenever the situation requires.

Personnel who are likely to be required to use breathing apparatus should be trained in its safe use.

Inland tankers should establish the PPE requirements for visitors, including appropriate clothing, safe footwear, eye protection, life vest and a safety helmet. Likewise, terminals should establish requirements for all people passing through the terminal. A clearly marked safe route and/or safe transport through the terminal should be provided.

26.2.2 Slip and fall hazards

Due to the high incidence of slips and falls on inland tankers, owners, operators and crew should pay particular attention to on board arrangements and the changing conditions that may contribute to these accidents.

Particular attention should be given to providing non-skid coatings or gratings on the deck in working areas and walkways. It is suggested that these areas are clearly marked so that personnel are aware of their existence and extent. Areas for consideration include:

- Mooring areas.
- Manifold areas.
- Dipping and sampling locations.
- Access walkways.
- Pipeline step-overs.

Whatever the arrangements to prevent slips and falls, it is essential that personnel use the prescribed walkways and keep them clear and free of spills. Shore personnel and visitors should also use the prescribed areas.

The risk of trips and slips is significantly higher when using access ladders, ladders on bunker booms and companionways. The ship’s gangway should be the preferred means of boarding.

Good design and construction will help to prevent accidents of this nature. Trip hazards, such as high plate edges at the top of ladders and unevenly spaced steps, should be avoided. Where the design cannot be modified, trip hazards should be clearly marked or highlighted with contrasting paint.

26.2.3 Personal hygiene

In view of the danger to health that may arise from prolonged contact with products, personal hygiene is most important. Wherever possible, direct skin contact with product or contaminated clothing should be avoided.

26.2.4 Clothing made of synthetic materials

The tendency for synthetic material to melt and fuse when exposed to high temperatures creates a concentrated heat source that can cause severe damage to body tissue. Clothing made of synthetic material is not considered suitable for personnel who may be exposed to flame or hot surfaces during their work.

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.

Several items manufactured from synthetic materials are available for use onboard inland tankers and in terminals such as coveralls and gloves (in addition to ropes, bottles, portable drip trays, hoses, etc).

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 onboard.

26.3 The safety checklists

26.3.1 General

The responsibility and accountability for the safe conduct of operations while an inland tanker is at a terminal are shared between the inland tanker's Master (between both Masters during ship-to-ship operations) and the Terminal Representative. Before cargo or ballast operations commence, the Master(s) or his representative, and/or the Terminal Representative should:

- Agree in writing on the transfer procedures, including the maximum loading or unloading rates.
- Agree in writing on the action to be taken in an emergency during cargo or ballast handling operations.
- Complete and sign the appropriate safety checklist(s).

Terminals may wish to issue an explanatory letter to the Masters of visiting tankers advising them of the terminal's expectations regarding the joint responsibility for the safe conduct of operations, and inviting the co-operation and understanding of the tanker's crew. An example of the text for such a letter is in section 26.3.3.

While the safety checklist is based on cargo-handling operations, it is recommended that the same practice is adopted when a tanker presents itself at a berth for tank cleaning.

26.3.1.1 Overview of appended checklists

The following provides a summary of the checklists included in the appendices:

Inland tanker – shore safety checklists	Cargo transfer	See ISGINTT appendix 1
Seagoing – inland tanker/inland tanker safety checklists	Cargo transfer	See ISGINTT appendix 2
Hazardous disposal safety checklists	Hazardous disposal	See ISGINTT appendix 3
Non-hazardous disposal safety checklist	Non-hazardous disposal	See ISGINTT appendix 4
Bunkering safety checklists for bunker delivery to inland ships*	Bunkering	See ISGINTT appendix 5
Bunkering safety checklists for bunker delivery to maritime ships*	Bunkering	See ISGINTT appendix 6

* Bunkering checklists in this edition of ISGINTT do not currently cover deliveries of alternative fuels e.g. LNG. Some terminal operators or port authorities may require more specific checklists for these bunker fuel deliveries. These may include, for example, those provided in ISGOTT 6th Edition.

26.3.2 Guidelines for use

Guidelines for completing the checklists and to assist in responding to each individual statement are included in appendix 7. They have been produced to help berth operators and inland tanker Masters in their joint use of the safety checklists.

Masters and all under their command should adhere strictly to these requirements throughout the tanker's stay alongside. The Terminal Representative and all shore personnel should do likewise. Each party will be committed to co-operate fully in the mutual interest of achieving safe and efficient operations.

Responsibility and accountability for the statements within the safety checklists are assigned within the documents. The acceptance of responsibility is confirmed by ticking or initialling the appropriate box and finally signing the declaration at the end of the checklists. Once signed, the checklists detail the minimum basis for safe operations as agreed via the mutual exchange of critical information.

Some of the checklist statements are directed to considerations for which the tanker has sole responsibility and accountability, some to considerations for which the terminal has sole responsibility and accountability, and others assign joint responsibility and accountability. Shaded boxes are used to identify statements that generally would be applicable to only one party, although the tanker or terminal may tick or initial such sections if they wish. Each party's Responsible Person has to tick or fill in the empty boxes alongside the relevant provisions in the proper column.

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 ensure clear identification of the party responsible for initial and continued compliance throughout the tanker's stay at the terminal or alongside the other vessel.

The Responsible Person should personally check all considerations lying within the responsibility of the tanker. Similarly, the Terminal Representative should personally check all considerations that are the terminal's responsibility. In fulfilling these responsibilities, representatives should assure themselves that the standards of safety on both sides of the operation are fully acceptable. This can be achieved by:

- Confirming that a competent person has satisfactorily completed the checklists.
- Sighting appropriate records.
- Joint inspection, where appropriate.

For mutual safety, before the start of operations and then from time to time, a Terminal Representative and, where appropriate, a Responsible Person should inspect the tanker to ensure that it is effectively managing its obligations, as accepted in the safety checklists. Similar checks should be conducted ashore. Where basic safety requirements are found to be insufficient, either party may require that cargo and ballast operations are stopped until corrective action is implemented satisfactorily.

26.3.2.1 Composition of the checklists

The safety checklists in appendices 1 and 2 comprise four parts, the first two of which address the transfer of bulk liquids. These are applicable to all operations. Part A identifies the required physical checks and Part B identifies the elements that are verified verbally.

Part C contains additional considerations relating to the transfer of bulk liquid chemicals and Part D contains those for bulk liquefied gases.

The safety of operations requires that all relevant statements are considered and that the associated responsibility and accountability for compliance are accepted, either jointly or singly. Where either party is not prepared to accept an assigned accountability, a comment must be made in the 'Remarks' column and due consideration given to assessing whether operations can proceed.

Where a particular item is considered not to be applicable to the inland tanker, the terminal or to the planned operation, a note to this effect should be entered in the 'Remarks' column.

26.3.2.2 Coding of items

The presence of the letters A, P or R in the column entitled 'Code' indicates the following:

A. (Agreement). This indicates an agreement or procedure that should be identified in the 'Remarks' column of the checklist or communicated in some other mutually acceptable form.

P. (Permission). In the case of a negative answer to the statements coded P, operations should not be conducted without the written permission from the appropriate authority.

R. (Re-check). This indicates items to be re-checked at appropriate intervals, as agreed between both parties, at periods stated in the declaration.

The joint declaration should not be signed until both parties have checked and accepted their assigned responsibilities and accountabilities.

The numbers and the letters in the first column indicate the following:

Number. This number indicates that the provision in question is based on the recommendations from ISGOTT/ISGINTT. The number corresponds with the relevant item in the ISGOTT checklist.

B Number. This B number indicates that the provision in question is based on those in the ADN (agreement concerning carriage of dangerous goods by barge) relating to the transfer of cargo from ship to shore. The B number corresponds with the relevant item in the ADN checklist.

L (legislation). This indicates that the provisions in question are related to regional legislation and/or requirements.

26.3.3 Example safety letter

Company ……….....…....………………………..
Terminal …………….......…...……………………..
Date………………………......…......……………………..
The Master MV ……………......…......……………….
Port ………………………………..........………….

Dear Sir,

Responsibility for the safe conduct of operations while your inland tanker is at this terminal rests jointly with you, as Master of the inland tanker, and with the responsible Terminal Representative. We wish, therefore, before operations start, to seek your full co-operation and understanding on the safety requirements set out in the Inland tanker/Shore safety checklists, which are based on safe practices that are widely accepted by the oil and inland tanker industries.

We expect you, and all under your command, to adhere strictly to these requirements throughout your inland tanker's stay alongside this terminal and we, for our part, will ensure that our personnel do likewise, and co-operate fully with you in the mutual interest of safe and efficient operations.

Before the start of operations, and from time to time thereafter, for our mutual safety, a member of the terminal staff, where appropriate together with a Responsible Crew Member, will make a routine inspection of your inland tanker to ensure that elements addressed within the scope of the Inland tanker/Shore safety checklists are being managed in an acceptable manner. Where corrective action is needed, we will not agree to operations commencing or, should they have been started, we will require them to be stopped.

Similarly, if you consider that safety is being endangered by any action on the part of our staff or by any equipment under our control, you should demand immediate cessation of operations.

There can be no compromise with safety.

Please acknowledge receipt of this letter by countersigning and returning the attached copy.

Signed:……………......……..........…………………….
Terminal Representative

Terminal Representative on duty is:

…………………………………....……....…………..

Position or Title: ………………………....…...…….

Contact Details: ……………….....…………....……….

Signed: ……..........................……....……………….
Master

Inland Tanker's Name: ……......…......……...……..

Date/Time: ………………………......…......………..

26.4 Guidelines for completing the inland tanker-shore safety checklists

See Appendix 7.

26.5 Emergency actions

The actions to be taken in an emergency at a terminal should be contained in the terminal's emergency plan (see chapter 20). In many cases where the emergency arises on an inland tanker, the safest course of action is for the inland tanker to remain alongside to allow shore-based personnel and equipment to support emergency response onboard. Particular attention should be given to factors to be taken into consideration when deciding whether to remove an inland tanker from the berth in an emergency (see also section 20.5).

26.5.1 Fire or explosion on a berth

Action by inland tankers

Should a fire or explosion occur on a berth, the inland tanker or tankers at the berth must immediately report the incident to the terminal control room by the quickest possible method (VHF/UHF, telephone contact, sounding siren, etc). All cargo, bunkering, deballasting and tank-cleaning operations should be shut down and all cargo arms or hoses should be drained ready for disconnection.

The tanker's fire-mains should be pressurised, and water fog applied in strategic places. The tanker's engines, steering gear and unmooring equipment must be brought to a state of immediate readiness. A pilot ladder, or equivalent, should be available to be deployed on the offshore side. Based on local circumstances, competent authorities may prescribe requirements for the availability of means of evacuation (see also section 16.4).

Action by inland tankers at other berths

On hearing the terminal alarm being sounded or on being otherwise advised of a fire at the terminal, an inland tanker at a berth not directly involved in the fire should shut down all cargo, bunkering and ballasting operations. Fire-fighting systems should be brought to a state of readiness. Engines, steering gear and mooring equipment should be made ready for immediate use.

26.5.2 Fire on an inland tanker at a terminal or on the other inland tanker

Action by inland tanker personnel

If a fire breaks out on an inland tanker while at a terminal or alongside another tanker, it must raise the alarm by sounding the recognised alarm signal consisting of a series of long blasts on the tanker's whistle. Each blast should last at least ten seconds, unless the terminal or the other tanker has notified the tanker with the fire of some other locally recognised alarm signal. All cargo, bunkering or ballasting operations must be stopped, and the main engines and steering gear brought to a standby condition.

Fire Action - Ship

Fire on your Ship

- Raise alarm
- Fight fire with aim of preventing spread
- Inform terminal
- Cease all cargo/ballast operations and close all valves
- Stand by to disconnect hoses or arms
- Bring engines to standby

Fire on another Ship or Ashore

- Raise alarm

Stand by, and when instructed:

- Cease all cargo/ballast operations and close all valves
- Disconnect hoses or arms
- Bring engines and crew to standby, ready to unberth

Fire Action - Ashore

Fire on a Ship

- Raise alarm
- Contact ship
- Cease all cargo/ballast operations and close all valves
- Stand by to disconnect hoses or arms
- Stand by to assist fire-fighting
- Inform all ships
- Implement terminal emergency plan

Fire Ashore

- Raise alarm
- Cease all cargo/ballast operations and close all valves
- Fight fire with aim of preventing spread
- If required, stand by to disconnect hoses or arms
- Inform all ships
- Implement terminal emergency plan

In case of fire, do not hesitate to raise the alarm

Terminal Fire Alarm

At this terminal, the fire alarm signal is

In Case of Fire:

1. Sound one or more blasts on the ship's whistle, each blast of not less than ten seconds duration supplemented by a continuous sounding of the general alarm system.

2. Contact the terminal.

Telephone	UHF/VHF channel

In the case of fire, personnel will direct the movement of vehicular traffic ashore

Figure 26.1: *Example of fire instructions notice*

Once the alarm has been raised, responsibility for fighting the fire on board the inland tanker(s) will rest with the Master or other Responsible Person, assisted by the tanker's crew. The same emergency organisation should be used as when the tanker is at anchor or under way (see section 9.9.2.2), with an additional group under the command of the Responsible Person to prepare, where possible, for disconnecting marine arms or hoses from the manifold.

On mobilisation of the terminal and, where applicable, the civil fire-fighting forces and equipment, the Master or Responsible Person, in conjunction with the professional fire-fighters, must make a united effort to bring the fire under control.

Action by terminal personnel
On hearing an inland tanker sounding its fire alarm, the person in charge of a berth should immediately advise the person in charge of terminal cargo operations. This person should sound the terminal fire alarm, inform the competent authority and start shutting down any loading, discharging, bunkering or deballasting operations taking place.

The terminal's fire emergency plan should be activated. This may involve shutting down cargo, bunkering and ballast handling operations on tankers on adjacent or neighbouring berths. All other tankers at the terminal should be informed of the emergency and, where necessary, make preparations to disconnect marine arms or hoses and ready their engines and steering gear.

Where there are fire-fighting tugs, the person in charge of terminal cargo operations will summon them to help fight the fire until a decision is made by the person in overall control whether to use them to help evacuate unaffected tankers (see section 20.5).

The person in charge of terminal cargo operations should be responsible for summoning any outside assistance, such as the civil fire brigade, rescue launches, medical aid and ambulances, police, harbour authority and pilots.

These emergency procedures may be summarised for the information of visiting tankers in a fire-instructions notice, an example of which is in figure 26.1.

Action by the other inland tanker
Should a fire or explosion occur on an inland tanker while alongside another tanker, the following actions should be taken:

- Stop the transfer.
- Sound the emergency signal.
- Inform crews on both tankers of the nature of the emergency.
- Man emergency stations.
- Implement emergency procedures.
- Drain and disconnect cargo hoses.
- Send mooring gangs to stations.
- Confirm main engine is ready for immediate use.
- Advise standby boat of the situation and any requirements.
- Masters should decide jointly, particularly in cases of fire, whether it is to their mutual advantage for the tankers to remain alongside each other.

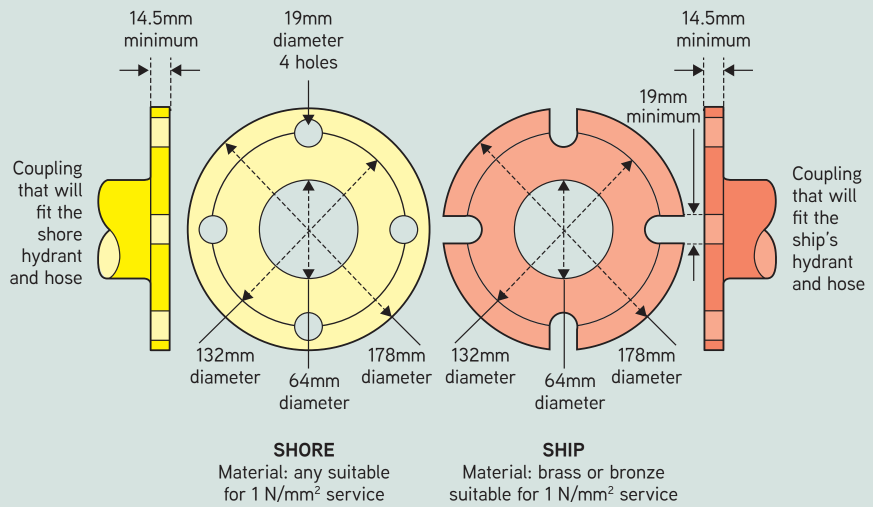
These basic actions should be included in individual ship-to-ship contingency plans and be consistent with the ships' SMS.

26.5.3 International shore fire connection (if required)

As described in section 19.5.3.5, all terminals that handle international inland tankers should be provided with means to enable the fire-mains on board and ashore to be interconnected. The international shore fire connection provides a standardised means of connecting two systems that might otherwise have couplings or connections that do not match.

The flanges on the connection should have the dimensions shown on figure 26.2. It should have a flat face on one side and on the other should be a coupling that will fit the hydrant or hose on the tanker or shore, as appropriate.

If fixed on a tanker, the connection should be accessible from both sides of the tanker and its location should be clearly marked.



Flange surface	Flat surface
Gasket material	Any suitable for 1 N/mm^2 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 26.2: *Details of international shore fire connection*

To interconnect the two fire-mains, a fire hose having a shore connection on the end is led to its counterpart and the flange joints are bolted together.

The shore connection should be ready for use whenever an inland tanker is in port.

26.5.4 Emergency release procedures

Means should be provided to permit the quick and safe release of the inland tanker in an emergency. The method used for the emergency release operation should be discussed and agreed, taking into account the possible risks involved.

26.5.5 Emergency towing-off pennants

Unless specifically required by legislation emergency towing-off pennants are not recommended for inland barges.

PART 5:
GAS

27 Basic properties of liquefied gases

This chapter provides an overview of liquefied gases carried by inland waterways.

It also deals with the basic physics and chemistry of liquefied gases. The text then discusses the theory of ideal gases and continues its application on board tankers. Certain sections explain particular problems encountered, such as hydrate formation, polymerisation and stress corrosion cracking. Many of these issues are more fully appraised in other publications, which should be referred to for further information.

27.1 Liquefied gases

A liquefied gas is the liquid form of a substance that, at ambient temperature and at atmospheric pressure, would be a gas.

Most liquefied gases are hydrocarbons. The key property that makes hydrocarbons the world's primary energy source – combustibility – also makes them inherently hazardous. Because these gases are handled in large quantities it is imperative that all possible steps are taken to prevent leaks and to eliminate all sources of ignition.

In relation to pumping and storage, the most important property of a liquefied gas is its saturated vapour pressure. This is the absolute pressure (see section 27.17) exerted at a given temperature when the liquid is in equilibrium with its own vapour.

An alternative way of describing a liquefied gas is to give the temperature at which the saturated vapour pressure is equal to atmospheric pressure – in other words, the liquid's atmospheric boiling point.

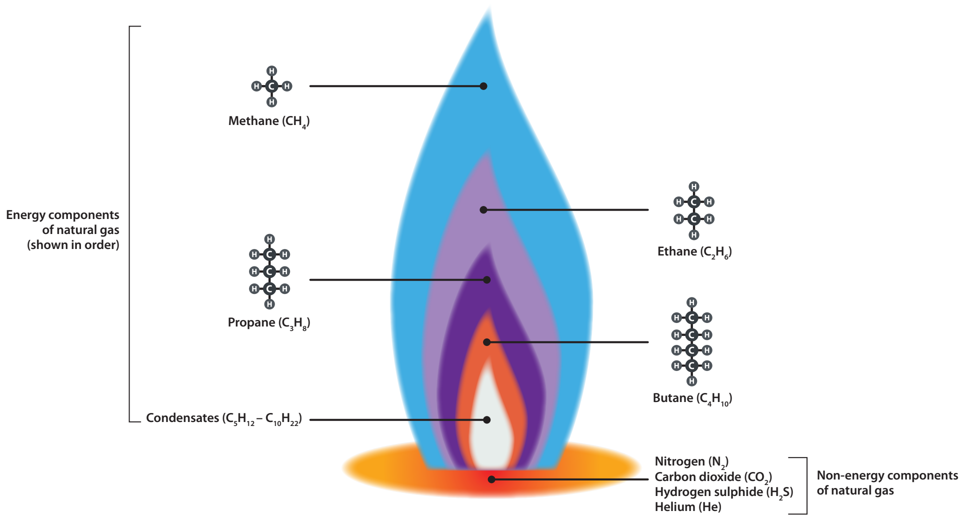


Figure 27.1: *Constituents of natural gas*

27.2 Liquefied gas production

This section discusses the manufacture of liquefied gases and describes the main gas carrier cargoes transported by ship. First, it is necessary to differentiate between some of the raw materials and their constituents. The relationship between natural gas, Natural Gas Liquids (NGLs) and Liquefied Petroleum Gases (LPGs) is in figure 27.1.

27.2.1 Liquified Natural Gas production

Natural gas may be found in:

- Underground wells, which are mainly gas-bearing (non-associated gas).
- Condensate reservoirs (pentanes and heavier hydrocarbons).
- Large oil fields (associated gas).

In the case of oil wells, natural gas may be either in solution with the crude oil or as a gas cap above it.

Natural gas contains smaller quantities of heavier hydrocarbons (collectively known as NGLs). This is in addition to varying amounts of water, carbon dioxide, nitrogen and other non-hydrocarbon substances. These relationships are shown in figure 27.1.

Regardless of origin, natural gas requires treatment to remove heavier hydrocarbons and non-hydrocarbon constituents. This ensures that the product is in an acceptable condition for liquefaction or for use as a gaseous fuel.

Figure 27.2 is a flow diagram for a typical liquefaction plant used to produce Liquefied Natural Gas (LNG). The raw feed gas is first stripped of condensates. This is followed by the removal of acid gases. For acid gas removal the gas stream is saturated with water vapour and this is then removed by the dehydration unit.

The gas then passes to a fractionating unit where the NGLs are removed and further split into propane and butane. Finally, the main gas flow, now mostly methane, is liquefied into the end product, LNG.

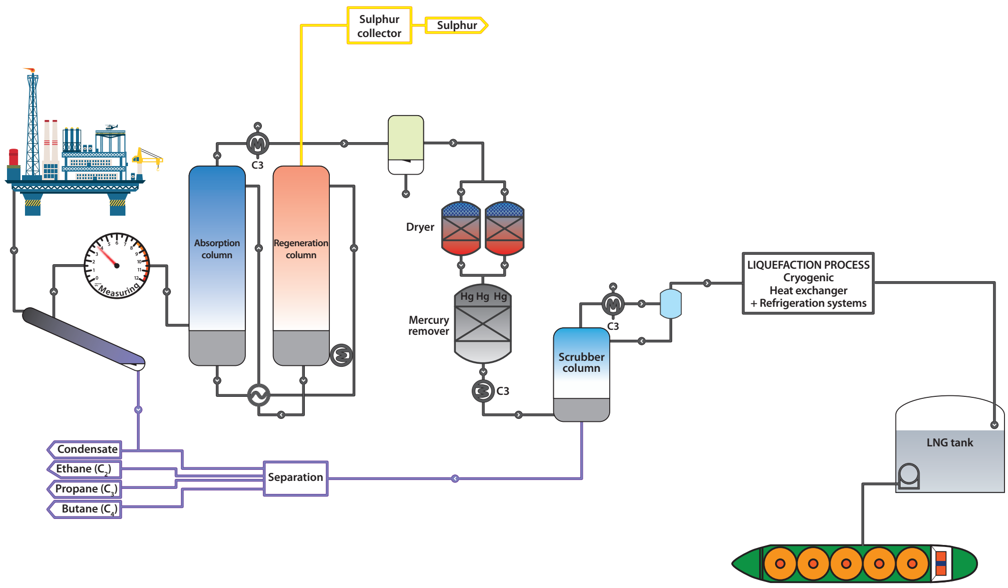


Figure 27.2: *Typical flow diagram for LNG liquefaction*

To lower temperature of the methane gas to about -162°C (its atmospheric boiling point) there are three basic liquefaction processes in current use:

- Pure refrigerant cascade.
- Mixed refrigerant.
- Pre-cooled mixed refrigerant.

27.2.2 Liquid Petroleum Gas production

Liquefied Petroleum Gas (LPG) is the general name for propane, butane and mixtures of the two. These products can be obtained from refining crude oil. When produced in this way they are usually manufactured in pressurised form.

The main production of LPG is found within petroleum-producing countries. At these locations, LPG is extracted from natural gas or crude oil streams coming from underground reservoirs. However, as in figure 27.2, in this process it is normal for NGLs to be produced and LPG may be extracted from them as a by-product.

Figure 27.3 is a flow diagram illustrating the production of propane and butane from oil and gas reservoirs. After fractionation and chill-down, LPG is pumped to terminal storage tanks before shipment for export.

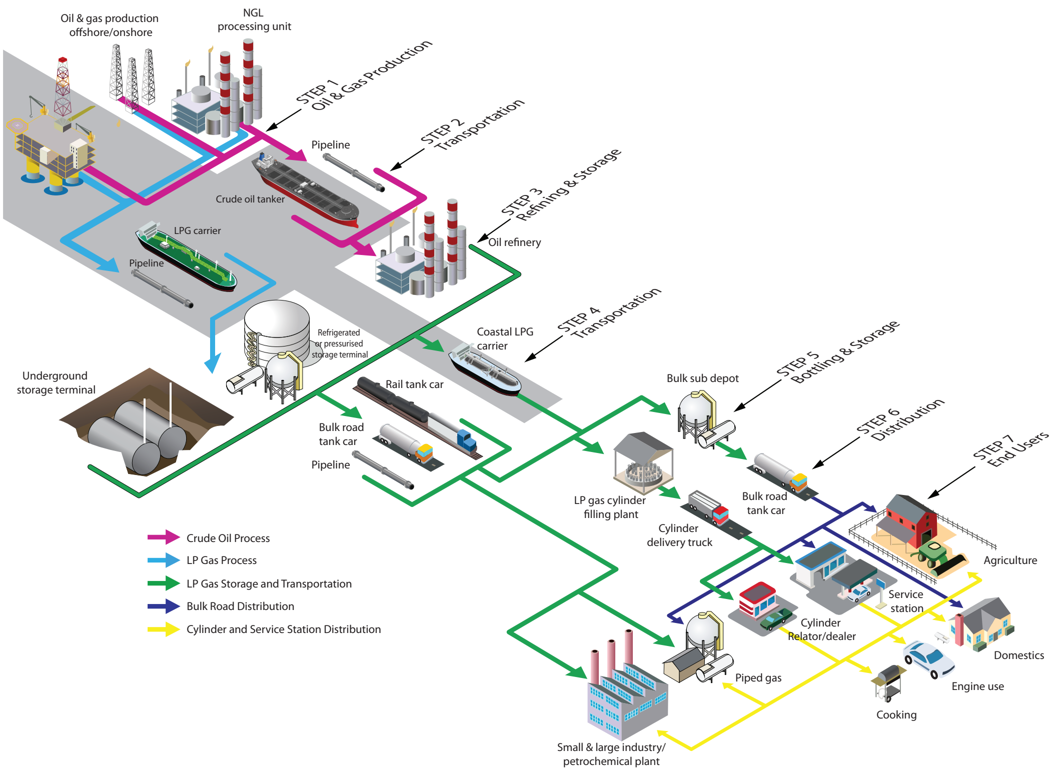


Figure 27.3: *The production, transport and use of LPGs*

27.2.3 Production of chemical gases

Figure 27.4 is a simplified diagram for the production of the chemical gases, vinyl chloride monomer (VCM), ethylene and ammonia. These three chemical gases can be produced indirectly from propane.

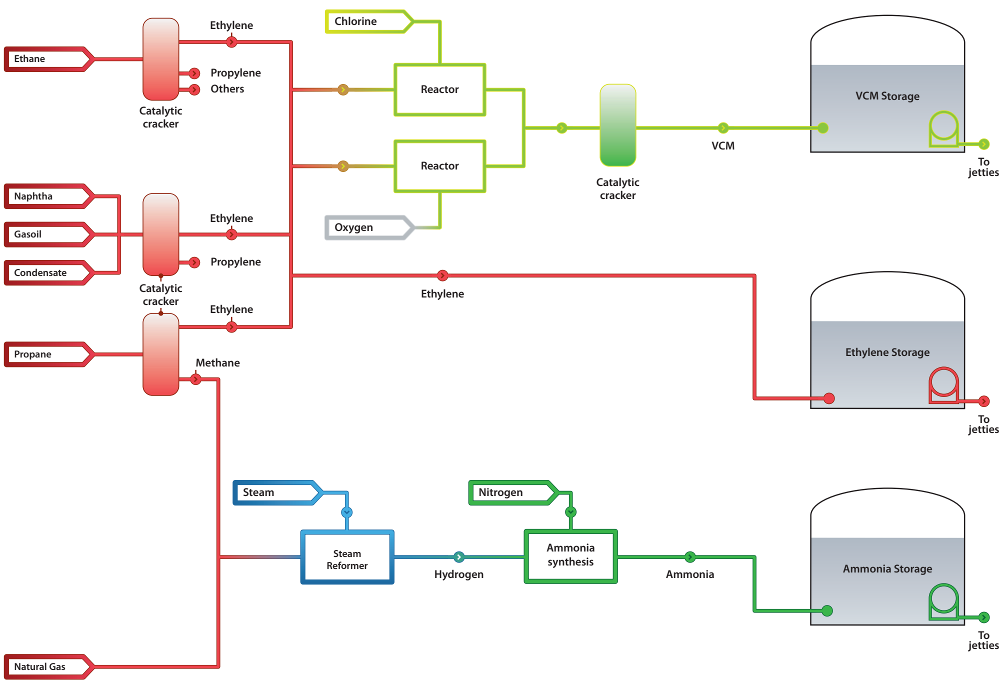


Figure 27.4: *Typical production of chemical gas (simplified)*

27.2.4 The principal products

While the hydrocarbon gases methane, ethane, propane and butane may be regarded principally as fuels, the LPGs are also important as feedstock in the production of the chemical gases.

Liquefied Natural Gas
Natural gas is transported either by pipeline as a gas or by sea in its liquefied form as LNG.

Natural gas comes from underground deposits. Its composition varies according to where it is found but methane is by far the predominant constituent, ranging from 70% to 99%. Natural gas is now a major commodity in the world energy market.

Natural Gas Liquids
Associated gas, found in combination with crude oil, comprises mainly methane and NGLs. As in figure 27.1, the NGLs are made up of ethane, LPGs and gasoline. A small number of terminals, including several facilities in Europe, have the ability to strip methane from the gas stream and to load raw NGLs onto semi-pressurised gas carriers. These NGLs are carried at -80°C at an atmospheric pressure, or at -45°C at a vapour pressure of 5 bar.

Liquefied Petroleum Gases
LPGs comprise propane, butane and mixtures of the two. Butane stored in cylinders, known as bottled gas, has widespread use as a fuel for heating and cooking in remote areas. Propane is also used as a bottled gas, especially in cold climates (to which its vapour pressure is more suited). However, LPG is mainly used in power generation, for industrial purposes such as metal cutting and as a petrochemical feedstock. It is also an important octane enhancer for petrol and a major petrochemical feedstock.

Ammonia
With increased pressure on the world's food resources, the demand for nitrogen-containing fertilisers, based on ammonia, expanded strongly during the 1970s and 1980s. Large-scale ammonia plants continue to be built in locations rich in natural gas, which is the raw material most commonly used to make this product. Ammonia is also used as an on-shore industrial refrigerant in the production of explosives and for numerous industrial chemicals such as urea.

Ethylene
Ethylene is one of the primary petrochemical building blocks. It is used in the manufacture of polyethylene plastics, ethyl alcohol, polyvinyl chlorine (PVC), antifreeze, polystyrene and polyester fibres. It is obtained by cracking either naphtha, ethane or LPG.

Propylene
Propylene is a petrochemical intermediate used to make polypropylene and polyurethane plastics, acrylic fibres and industrial solvents.

Butadiene
Butadiene is a highly reactive petrochemical intermediate. It is used to produce styrene, acrylonitrile and polybatudiene synthetic rubbers. Butadiene is also used in paints and binders for non-woven fabrics, and as an intermediate in plastic and nylon production. Most butadiene output stems from the cracking of naphtha to produce ethylene.

Vinyl chloride
Vinyl chloride is an easily liquefiable, chlorinated gas used in the manufacture of PVC, the second most important thermoplastic in the world in terms of output. Vinyl chlorine not only has a relatively high boiling point (-14°C) but also has a specific gravity of 0.90, which is much denser than the other common gas carrier cargoes.

Carbon dioxide
Carbon dioxide is a colourless, odorless gas. When inhaled at concentrations much higher than usual atmospheric levels, it can produce a sour taste in the mouth and a stinging sensation in the nose and throat. These effects result from the gas dissolving in the mucous membranes and saliva, forming a weak solution of carbonic acid. Amounts above 5,000ppm are considered very unhealthy, and those above about 50,000ppm (equal to 5% by volume) are considered dangerous to animal life.

Solid carbon dioxide is normally called ‘dry ice’. Dry ice is commonly used as a cooling agent and is relatively inexpensive. A convenient property for this purpose is that solid carbon dioxide sublimes directly into the gas phase leaving no liquid. It can often be found in grocery stores and laboratories, and it is also used in the shipping industry.

27.3 Chemical structure of gases

Chemical compounds with the same chemical structure are often known by different names. An alternative name given to the same compound is called a synonym. Table 27.1 lists the synonyms of the main liquefied gases against each common name and its simple formula. The more complex compounds tend to have a larger number of synonyms than the simple compounds.

Hydrocarbons are substances whose molecules contain only hydrogen and carbon atoms. The molecules can be in various arrangements and the products may be gases, liquids or solids at ambient temperatures and pressures, depending upon the number of the carbon atoms in the molecular structure. Generally, those hydrocarbons with up to four carbon atoms are gaseous at ambient conditions

Hydrocarbons with five to about 20 carbon atoms are liquid at ambient conditions and those with more carbon atoms are solid.

The carbon atom has four bonds that can unite with other atoms of other elements. However, a hydrogen atom has only one bond and can unite with only one other atom.

Saturated hydrocarbons
Where the relative numbers of carbon and hydrogen atoms in a hydrocarbon molecule permit the atoms to use their bonds singly to other atoms, the molecule is said to be saturated. Figure 27.5 illustrates the saturated molecular structure of iso-butane (i-butane) and normal butane (n-butane). Examination of these examples shows that, for saturated hydrocarbons, the proportion of carbon and hydrogen atoms in the molecule is in accordance with the formula C_nH_{2n+2}. So methane (CH_4), ethane (C_2H_6), and propane (C_3H_8) are all saturated hydrocarbons.

These saturated hydrocarbons, methane, ethane, propane and butane are colorless and odorless liquids. They are all flammable gases and burn with air or oxygen and produce carbon dioxide and water vapor. They do not result in chemical compatibility issues when they come into contact with the construction materials who are present in the gas handling. However, in the presence of water the saturated hydrocarbons can hydrate (see section 27.9).

Unsaturated hydrocarbons
Where there is less than the full complement of hydrogen atoms, as given by the above formula, two or more carbon atoms become inter-linked by double or triple bonds. For this reason they are called unsaturated. These double or triple links between carbon atoms are weaker than single bonds, with the result that such compounds are chemically more reactive than the single-bonded compounds.

The unsaturated hydrocarbons, ethylene, propylene, butylene, butadiene and isoprene are colorless liquids with a faint, sweet odor. Like the saturated hydrocarbons, they are all flammable in air or oxygen and produce carbon dioxide and water vapor upon combustion. They are from a chemical point of view more reactive than the saturated hydrocarbons and can react dangerously with chlorine.

Ethylene, propylene, butylene does not cause chemical compatibility issues with the construction materials. Butadiene and isoprene, which each have two pair of double bonds are far the most reactive within this family. They may react with air and form unstable peroxides which have a tendency to polymerise (see section 27.8). Butadiene is in chemical terms incompatible with copper, silver, mercury, magnesium, aluminum and monel. Throughout the production, butadiene streams often contain traces of acetylene, which can react with brass and copper and form explosive acetylides.

Water is soluble in butadiene, especially at high temperatures. The solubility of water reduces when the temperature drops. Upon further cooling to below zero, the water layer becomes deeper and freezes. Nowadays butadiene is always transported anhydrous, i.e. having a water content of a few ppm.

Common name	Simple formula	Synonyms
Methane	CH_4	Fire damp; marsh gas; natural gas; LNG
Ethane	C_2H_6	Bimethyl; dimethyl; methyl methane
Propane	C_3H_8	–
n-Butane	C_4H_{10}	Normal-butane
i-Butane	C_4H_{10}	Iso-butane; 2-methlypropane
Ethylene	C_2H_4	Ethene
Propylene	C_3H_6	Propene
α-Butylene	C_4H_8	But-1-ene; ethyl ethylene
β-Butylene	C_4H_8	But-2-ene; dimethyl ethylene; pseudo butylenes
γ-Butylene	C_4H_8	Isobutene; 2-methylprop-2-ene
Butadiene	C_4H_6	b.d.; bivinyl; 1,3 butadiene; butadiene 1-3; divinyl; biethylene; erythrene; vinyl ethylene
Isoprene	C_5H_8	3-methyl – 1,3 butadiene; 2-methyl – 1,3 butadiene; 2-methylbutadiene – 1,3
Vinyl chloride	C_2H_3Cl	Chloroethene; chloroethylene; VCM; Vinyl chloride monomer
Ethylene oxide	C_2H_4O	Dimethylene oxide; EO; 1,2 epoxyethane; oxirane
Propylene oxide	C_3H_6O	1,2 epoxy propane; methyl oxirane; propene oxide
Ammonia	NH_3	Anhydrous ammonia; ammonia gas; liquefied ammonia; liquid ammonia

Table 27.1: *Synonyms for the main liquefied gases*

Note: Commercial propane contains some butane. Similarly, commercial butane contains some propane. Both may contain impurities such as ethane and pentane, depending on their permitted commercial specification. Some further data on mixtures is given in sections 27.19 and 27.20.

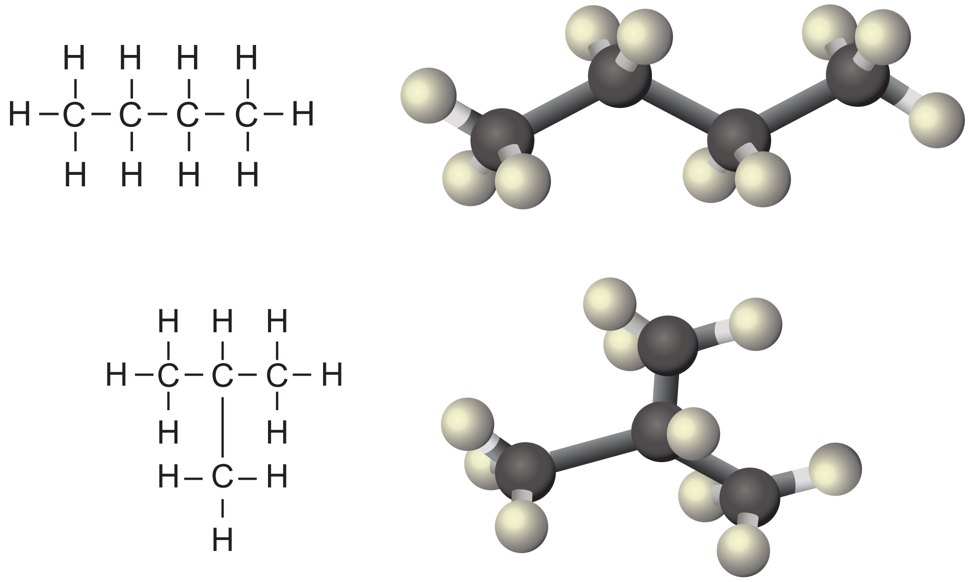


Figure 27.5: *Molecular structure of some saturated hydrocarbons (single bonds)*

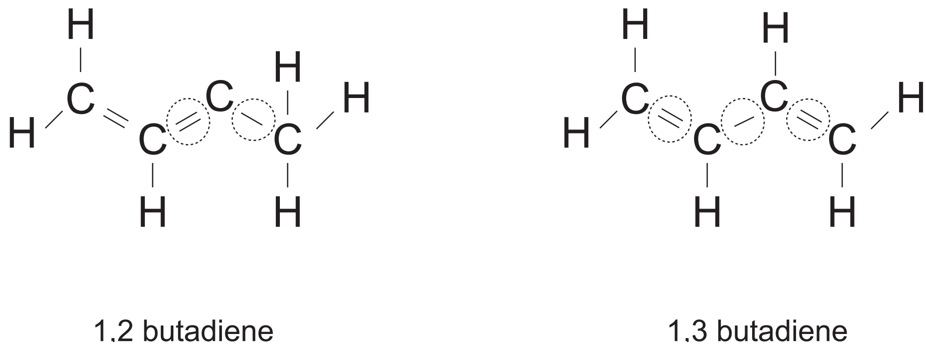


Figure 27.6: *Molecular structure of some unsaturated hydrocarbons (double bonds)*

Figure 27.6 illustrates the molecular structure of two unsaturated hydrocarbons, 1,2 butadiene (double bonds adjacent) and 1,3 butadiene (double bonds separated). Propylene (C_3H_6) and ethylene (C_2H_4) are further examples of unsaturated hydrocarbons.

No hydrocarbons (chemical gases)
The third group of liquefied gases consists of the chemical gases. These are characterised by additional atoms other than carbon and hydrogen. Figure 27.7 shows the molecular structure of three such compounds, ethylene oxide (C_2H_4O), propylene oxide (C_3H_6O) and vinyl chloride (C_2H_3Cl). Most compounds in this grouping are chemically reactive.

The chemical gases commonly transported in liquefied gas carriers are ammonia, vinyl chloride, ethylene oxide and propylene oxide. Apart from the latter two, since these gases do not belong to one particular family, their chemical properties vary considerably. At sea propylene oxide is transported in chemical tankers. It belongs to the Class 3 liquids, but due to the high vapour pressure in the inland trade (in Europe) it is transported in gas tankers.

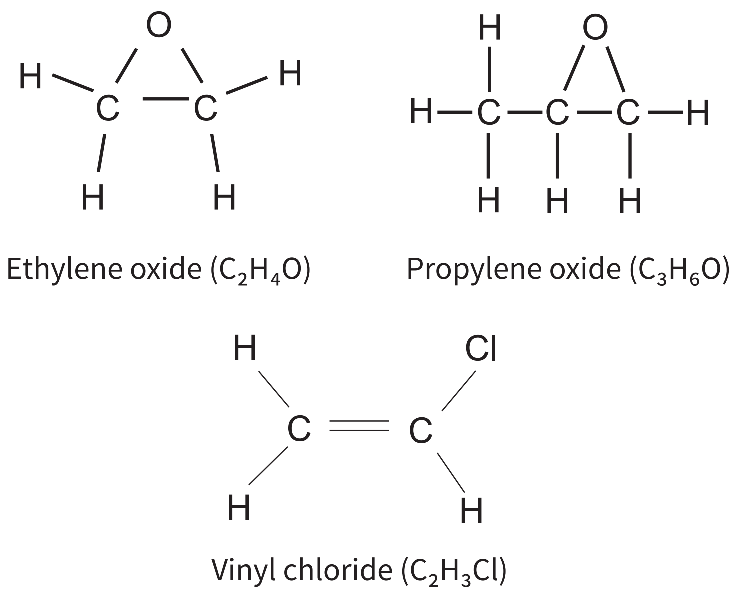


Figure 27.7: *Molecular structure of some chemical gases*

Ammonia is a colourless alkaline liquid with a pungent odour. The vapours of ammonia are flammable and burn with a yellow flame, forming water vapour and nitrogen. However, ammonia vapour in air requires a high concentration (14-28%) to be flammable, has a high ignition energy requirement (600 times that for propane) and burns with low combustion energy. Nevertheless, ammonia must always be regarded as a flammable cargo.

Ammonia is toxic and highly reactive. It can form explosive compounds with mercury, chlorine, iodine, bromine, calcium, silver oxide and silver hypochlorite. Ammonia vapour is extremely soluble in water and will be absorbed rapidly and exothermically to produce a strong alkaline solution of ammonium hydroxide. One volume of water will absorb approximately 200 volumes of ammonia vapour. For this reason, it is unsafe to introduce water into a tank containing ammonia vapour, as this can result in a vacuum condition rapidly developing within the tank (see also section 32.9.5). When water is introduced in a cargo tank with ammonia vapour for cleaning purposes, the tank should first be pressurised with nitrogen.

Since ammonia is alkaline, ammonia vapour/air mixtures may cause stress corrosion on cargo tank shells. The factors contributing to stress corrosion cracking are the material of construction, residual stress within structures (from tank fabrication) and the nature of the cargo (including its temperature, pressure and impurities). Stress corrosion cracking occurs as a result of a chemical reaction and so will happen faster at higher temperatures. Stress corrosion cracking is identified as cracking in a containment vessel where (typically) fine cracks may be formed in many directions. Cracks caused by stress corrosion cracking are usually fine and brittle.

The risk of stress corrosion cracking occurring can be reduced by the following measures:

- Refrigerated storage at a temperature of below -30°C.
- During construction, using steels with a low-yield strength.
- During construction, having tank welds stress-relieved by thermal methods.
- Adding 0.2% water to the ammonia.

Because of ammonia's highly reactive nature, copper alloys, aluminium alloys, galvanised surfaces, phenolic resins, polyvinyl chloride, polyesters and viton rubbers are unsuitable for ammonia service. Mild steel, stainless steel, neoprene rubber and polythene are suitable.

Vinyl chloride is a colourless liquid with a characteristic sweet odour. It is highly reactive, though not with water, and may polymerise in the presence of oxygen, heat and light. Its vapours are highly toxic and flammable. Aluminium alloys, copper, silver, mercury and magnesium are unsuitable for vinyl chloride service. Steels are chemically compatible.

Ethylene oxide and propylene oxide are colourless liquids with an ether-like odour. They are flammable, toxic and highly reactive. Both polymerise; ethylene oxide does so more readily than propylene oxide, particularly in the presence of air or impurities. Both gases may react dangerously with ammonia. Cast iron, mercury, aluminium alloys, copper and alloys of copper, silver and its alloys, magnesium and some stainless steels are unsuitable for the handling of ethylene oxide. Mild steel and certain other stainless steels are suitable as tank shell construction materials for both ethylene and propylene oxides.

Note: propylene oxide is legally a Class 3 liquid, but due to its high vapour pressure it is commonly transported in gas tankers.

Chlorine is a much less frequently carried cargo and restricted to special tankers. It is a yellow liquid which evolves a green vapour. It has a pungent and irritating odour and is highly toxic. It is non-flammable but it can support combustion of other flammable materials in much the same way as oxygen. It is soluble in water forming a highly corrosive acidic solution and can form dangerous reactions with all the other liquefied gases. In the moist condition, because of its corrosivity, it is difficult to contain. Dry chlorine is compatible with mild steel, stainless steel, monel and copper. Chlorine is very soluble in caustic soda solution which can be used to absorb chlorine vapour.

27.4 Chemical properties

The chemical properties and compatibilities of many liquefied gases are in tables 27.2, 27.3(a) and 27.3(b).

	Methane	Ethane	Propane	Butane	Ethylene	Propylene	Butylene	Butadiene	Isoprene	Ammonia	Vinyl chloride	Ethylene oxide	Propylene oxide	Chlorine
Flammable	X	X	X	X	X	X	X	X	X	X	X	X	X	
Toxic								X		X	X	X	X	X
Polymerisable								X	X		X	X		

REACTIVE WITH

	Methane	Ethane	Propane	Butane	Ethylene	Propylene	Butylene	Butadiene	Isoprene	Ammonia	Vinyl chloride	Ethylene oxide	Propylene oxide	Chlorine
Magnesium								X	X			X	X	
Mercury								X	X	X		X	X	X
Zinc										X				X
Copper								X	X	X		X	X	
Aluminium								X	X	X	X	X	X	X
Mild carbon steel	X3				X1									
Stainless steel												X2		
Iron												X	X	
PTFE*										X				
PVC†										X				
Polyethylene	X3	X	X	X			X							
Ethanol														X
Methanol														X

Table 27.2: *Chemical properties of liquefied gases*

Notes: Study can be made to the data sheets in the IGC Code for further details on chemical reactivity.
1. Stainless steel containing 9% nickel is the usual containment material for ethylene.
2. Refer to IGC Code – Section 17.16.3.
3. Not suitable with liquid methane due to brittle fracture.
* PTFE: polytetrafluoroethylene (jointing material)
† PVC: polyvinyl chloride (electric cable insulation)

	Methane	Ethane	Propane	Butane	Ethylene	Propylene	Butylene	Butadiene	Isoprene	Ammonia	Vinyl chloride	Ethylene oxide	Propylene oxide	Chlorine	Water vapour	Oxygen or Air	Carbon dioxide
Carbon dioxide										X							
Oxygen or Air								X	X		X	X					
Water vapour								X	X					X			
Chlorine	X	X	X	X	X	X	X	X	X	X	X				X		
Propylene oxide										X							
Ethylene oxide										X						X	
Vinyl chloride														X		X	
Ammonia												X	X	X			X
Isoprene														X	X	X	
Butadiene														X	X	X	
Butylene														X			
Propylene														X			
Ethylene														X			
Butane														X			
Propane														X			
Ethane														X			
Methane														X			

Table 27.3(a): *Chemical compatibilities of liquefied gases X = incompatible*

Tank Cleaning Table											
Next Cargo											
	Butane	**Butadiene**	**Butylene**	**C4-Raff***	**Ethylene**	**Propane**	**Propylene**	**Propylene oxide**	**Propane Propylene mix**	**Vinyl chloride**	**C4-Crude***
O_2 content	<0.5%	<0.2%	<0.3%	<0.3%	<0.3%	<0.5%	<0.3%	<0.1%	<0.3%	<0.1%	<0.3%
Dew-point	<-10°C	<-10°C	<-10°C	<-10°C	<-50°C	<-40°C	<-25°C	<-40°C	<-40°C	<-20°C	<-10°C
Last cargo											
Ammonia	Loading cargoes after ammonia is often subject to specific terminal requirements										
Butane		N_2 <5%	N_2I <5%	ET	VN_2	S	VN_2	VN_2	ET	VN_2	ET
Butadiene	ET		N_2I <25%	N_2I <25%	VN_2	ET	VN_2	VN_2	VN_2	VN_2	ET
Butylene	ET	N_2 <5%		ET	VN_2	ET	VN_2	VN_2	VN_2	VN_2	ET
C4-Raff*	ET	N_2 <5%	N_2I <25%		VN_2	ET	VN_2	VN_2	VN_2	VN_2	ET
Ethylene	S Heat	N_2 <5%	N_2I <5%	S		S	N_2 <3000ppm	VN_2	ET Heat	N_2 <1000ppm	S Heat
Propane	ET	N_2 <5%	N_2I <5%	ET	N_2 <1000ppm		N_2 <5%	VN_2	ET	N_2 <1000ppm	S
Propylene	ET	N_2 <5%	N_2I <9%	ET	N_2 <1000ppm	ET		VN_2	ET	N_2 <1000ppm	S
Propylene oxide	WVN_2I	WVN_2	WVN_2I	WVN_2I	WVN_2	WVN_2I	WVN_2		WVN_2	WVN_2	WVN_2
Propane Propylene mix	ET	N_2 <5%	N_2I <9%	ET	VN_2	S	N_2 <25%	VN_2		N_2 <1000ppm	S
Vinyl chloride	VN_2I	VN_2	VN_2I	VN_2I	VN_2	VN_2I	VN_2	VN_2	VN_2		VN_2
Butane & Propane wet	S	N_2 <5%	N_2I <9%	ET	VN_2	ET	VN_2	VN_2	S	VN_2	
C3/C4*	ET	N_2	N_2I	ET	VN_2	S	VN_2	VN_2	VN_2	VN_2	

*These cargoes are mixtures of various liquefied gases and are not listed in the IGC Code.

This is a general procedure. However, the final state of cleanliness of the cargo tanks has to be agreed with the concerning consignee.

Table 27.3(b): *Previous cargo compatibilities of liquefied gases*

Code	Description
W	Water wash
V	Visual inspection
N_2	Inert with nitrogen only
N_2I	Inert with nitrogen or inert gas
ET	Empty tank: which means as far as the pumps can go
S	Standard requirements: cargo tanks and cargo piping to be liquid-free and 0.5 bar overpressure (ship-type dependant) prior to loading, but based on terminal or independent cargo surveyor's advice

Note: Before any inerting starts the tank bottom temperature should be heated to about 0°C.

Note: A cargo tank should not be opened for inspection until the tank temperature is close to ambient conditions.

27.5 Inert gas and nitrogen

Inert gas is used on gas carriers to inert cargo tanks and on some type of tankers to maintain positive pressures in hold and inter barrier spaces (see sections 31.7, 32.2.3, 32.9.3). This is done to prevent the formation of flammable mixtures. For cargo tanks the inerting operation is a necessary preliminary to aerating for inspection or drydock but it can be time-consuming. Inerting is also required before moving from a gas-free condition into the loaded condition. Regarding inerting levels, prior to gassing-up, a tank should have an **oxygen content** of less than 5% but normally a lower figure is required by loading terminals. Before aeration, the inerting process should have achieved a **hydrocarbon content** of below 2%.

In addition to oxygen, another essential element regarding inert gas quality is its dryness. Any moisture contained within the gas can condense and form free water at the encountered cold cargo temperatures. To prevent hydrate formation in the products loaded and to prevent serious condensation and corrosion in tanks and hold spaces, inert gas is thoroughly dried as it leaves the generator.

Each type of inert gas (fuel burning, shipboard nitrogen production, or pure nitrogen from the shore) has its own particular use. Note that based on qualitative reasons the inert gas generator is seldom used for chemical gases.

Component	Inert gas by combustion	Nitrogen membrane separating process
Nitrogen	85 to 89%	Up to 99.5%
Carbon dioxide	14%	–
Carbon monoxide	0.1% (max)	–
Oxygen	1 to 3%	> 0.5%
Sulphur oxides	0.1%	–
Oxides of nitrogen	traces	–
Dew point	-45°C	-65°C
Ash and soot	present	–
Density (air=1.00)	1.035	0.9672

Table 27.4: *Inert gas*

Only nitrogen of high purity is fully compatible, in the chemical sense, with all the liquefied gases. Many components of combustion-generated inert gas can put the liquefied chemical gases off specification. In particular, as far as personal safety and chemical reactivity are concerned, the following points regarding the constituents of inert gas should be noted:

Carbon particles in the form of ash and soot can influence the quality of many chemical gases.

Carbon dioxide will freeze at temperatures below -55°C, contaminating the cargo if carriage temperatures are particularly low, such as in the case of ethylene. Carbon dioxide will also contaminate ammonia cargoes by reacting to produce carbamates (urethane). Both solid carbon dioxide and carbamate formation result in cargo contamination and operational difficulties, such as clogging of pumps, filters and valves. Carbon dioxide can also act as a catalyst in complicated chemical reactions with sulphur compounds in some LPG cargoes.

Carbon monoxide, if generated in sufficient quantities, can cause difficulties during any subsequent aeration operation. When aeration is thought complete, the levels of toxic carbon monoxide may still be unacceptable from the view of personal safety. (Note that carbon monoxide has a TLV-TWA of 50ppm.)

Moisture in inert gas can condense and in so doing hydrates can form in cargoes and inerted spaces can suffer from severe corrosion. When cold cargo is to be loaded, it is important that the inert gas in cargo tanks has a sufficiently low dew point to avoid any water vapour freezing out and other operational difficulties. Furthermore, moisture can create difficulties particularly with butadiene, isoprene, ammonia and chlorine cargoes.

Oxygen even in the small percentages found in shipboard produced inert gas is incompatible with butadiene, isoprene, vinyl chloride and ethylene oxide. In contact with oxygen, these cargoes may combine to form peroxides and polymers.

For these reasons, only pure nitrogen taken from the shore can be considered fully inert, in the chemical sense, for all the liquefied gases. Nevertheless, for inerting hold spaces and cargo tanks on tankers carrying LPG cargoes at temperatures down to about -48°C, inert gas generation by good quality fuel burning under carefully controlled combustion or by the air separation process can provide an inert gas of acceptable quality.

27.6 Polymerisation

While many of the liquefied gases are polymerisable (as indicated by a double bond in their molecular structure), cargo polymerisation difficulties only arise in practice in the case of butadiene, isoprene, ethylene oxide and vinyl chloride. Polymerisation may be dangerous under some circumstances but can be delayed or controlled by the addition of inhibitors.

Polymerisation takes place when a single molecule (a monomer) reacts with another molecule of the same substance to form a dimer. This process can continue until a long- chain molecule is formed, possibly having many thousands of individual molecules (a polymer). The mechanism is illustrated for vinyl chloride, also known as VCM, in figure 27.8. The process can be rapid and involves the generation of a great deal of heat. It may be initiated spontaneously or catalysed by the presence of oxygen (or other impurities) or by heat transfer during cargo operations (see also section 32.6). During polymerisation, the cargo becomes more viscous until, finally, a solid and unpumpable polymer may be formed.

Polymerisation may be prevented, or at least the rate of polymerisation may be reduced, by adding a suitable inhibitor to the cargo. However, if polymerisation starts, the inhibitor will be consumed gradually until a point is reached when polymerisation may continue unchecked. In the case of butadiene, tertiary butyl catechol is added primarily as an anti-oxidant but, in the absence of oxygen, it can also act, to a limited extent, as an inhibitor.

The difference between the vapour pressure of an inhibitor and its cargo has an important bearing on the effectiveness of the inhibitor. Generally, inhibitors have a vapour pressure lower than the cargo in which they sit. Accordingly, the greatest protection is provided in the liquid. This leaves the gases in the vapour space relatively unprotected. It follows that in the vapour space an increased chance of polymerisation is present.

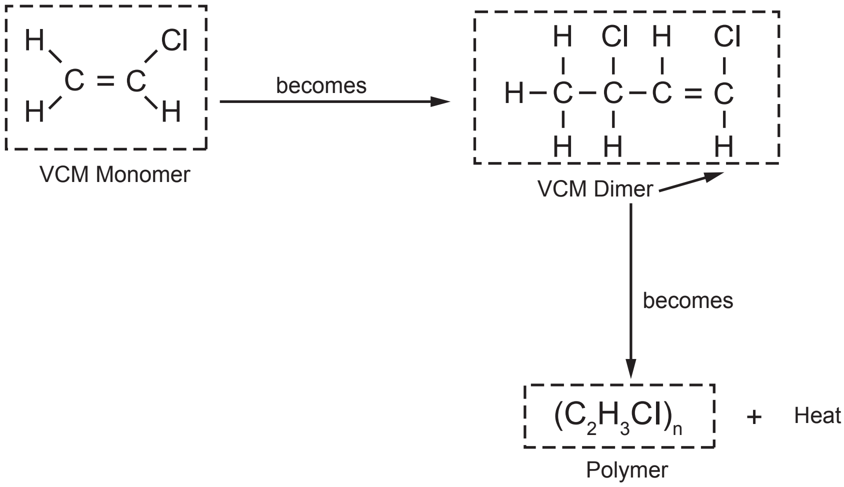


Figure 27.8: *The polymerisation of vinyl chloride/VCM*

Inhibitors can be toxic. Those most commonly used are hydroquinone and tertiary butyl catechol. Health and safety data for these products is in section 28.1. As will be noted, care should be taken when handling inhibitors and cargoes with inhibitor added.

The tankers' crew should ensure that before leaving the berth an inhibitor information form from the cargo shipper is received. This certificate should provide the information in the figure below:

Liquefied Gas — Inhibitor Information Form

To be completed before loading an inhibited cargo

Ship .... Date ....

Port & berth .... Time ....

1. Correct technical name of cargo ....
2. Correct technical name of inhibitor ....
3. Amount of inhibitor added ....
4. Date added ....
5. Expected lifetime of inhibitor ....
6. Any temperature limitations affecting inhibitor ....
7. Action to be taken if voyage exceeds effective lifetime of inhibitor ....

If the above information is not supplied, the cargo should be refused (IGC Code, Section 18.4.3)

For ship .... (Signed) For shore .... (Signed)

Figure 27.9: *Inhibitor information form*

In addition, the quantity of inhibitor required for effective inhibition and the toxic properties of the inhibitor should be advised.

A similar but more difficult reaction to control is known as dimerisation. This cannot be stopped by inhibitors or any other means. The only way to avoid or slow down dimerisation is to keep the cargo as cool as possible and cooling is recommended, especially during longer voyages.

27.7 Hydrate formation

Propane and butane may form hydrates under certain conditions of temperature and pressure in the presence of free water. This water may be present in LPG as an impurity or may be extracted from cargo tank bulkheads if rust is present. Rust that has been dehydrated in this way by LPG loses its powers of adhesion to tank surfaces and may settle to the tank bottom as a fine powder.

LPG hydrates are white crystalline solids that may block filters and reliquefaction regulating valves. They may also damage cargo pumps.

Hydrate inhibitors such as methanol or ethanol may be added at suitable points in the system, but nothing should be added without the consent of the shipper and ship operator. It should be noted that in some countries the use of methanol is banned. Some chemical gases may also be put off specification by the addition of methanol. Care must be taken if a hydrate inhibitor is added to a polymerisable cargo as the polymer inhibition mechanism may be negated.

Since methanol is toxic, care should be taken regarding its safe handling.

27.8 Lubrication

The property of a fluid that restricts one layer of the fluid moving over an adjacent layer is called viscosity. Viscosity is important in determining the lubricating properties of liquid. The majority of liquefied gases have poor lubricating properties by comparison with lubricating oils or even water, as shown in table 27.4(a).

Liquid (temperature)	Lub oil (at +70°C)	Water (at +100°C)	Propane (at -45°C)
Viscosity (centipoise)	28.2	0.282	0.216
Specific heat (kcal/kg °C)	0.7	1.0	0.5
Latent heat of vaporisation (kcal/kg)	35	539	101

Table 27.4(a): *Factors affecting lubrication*

Liquefied hydrocarbon gases can dissolve in lubricating oil and, for certain applications, such admixture can result in inadequate lubrication of pump seals and compressors. The solvent action of liquefied gases on grease can cause the degreasing of mechanical parts with similar loss of lubrication in fittings such as valves.

In addition to low viscosity, liquefied gas has relatively poor cooling properties and liquids are not able to effectively carry heat away from a shaft bearing. Any excessive heat will result in a relatively rapid rise in the temperature of the bearing (specific heat of propane is about half that of water). Under these circumstances, the liquid will vaporise when its vapour pressure exceeds the product pressure in the bearing. The vapour will expel liquid from the bearing and result in bearing failure due to overheating.

It should also be noted that the lubricating oil used in a compressor must be compatible with the grade of cargo being carried (see section 32.6.1).

27.9 Physical properties

The physical properties of a liquefied gas depend on its molecular structure. Some compounds have the same molecular formula, but the ways in which the atoms are arranged within the molecule may be different. These different compounds of the same basic substance are called isomers. They have the same molecular mass but differing physical and chemical properties. Examples are n-butane and iso-butane, shown in figure 27.5. The principal physical properties of the main liquefied gases are listed in table 27.5. From this data the different physical properties of the isomers of butane and butylene should be noted.

The most important physical property of a liquefied gas is its saturated vapour pressure/temperature relationship. This property, which will be studied in detail later, governs the design of the tank containment system best suited to each cargo and has a strong influence on economic considerations.

27.10 States of matter

27.10.1 Solids, liquids and gases

Most substances can exist in either the solid, liquid or vapour state. In changing from solid to liquid (fusion) or from liquid to vapour (vaporisation), heat must be given to the substance. Similarly, in changing from vapour to liquid (condensation) or from liquid to solid (solidification), the substance must give up heat. The heat given to or given up by the substance in changing state is called latent heat. For a given mass of the substance the latent heats of fusion and solidification are the same. Similarly, the latent heats of vaporisation and of condensation are the same, although of different values from the latent heat of fusion or solidification.

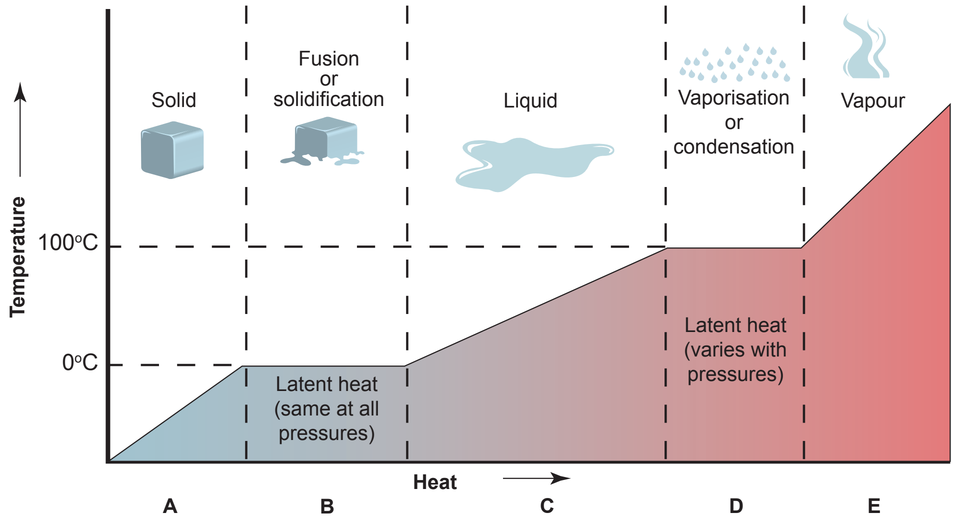


Figure 27.10: *Temperature/heat diagram for varying states of matter*

Fusion or solidification occurs at a specific temperature for each substance and this temperature is virtually independent of the pressure. However, vaporisation or condensation of a pure substance occurs at a temperature that varies widely depending upon the pressure exerted. It should also be noted that the latent heat of vaporisation varies with pressure. Figure 27.10 illustrates these temperature/heat relationships as a substance is heated or cooled through its three states: here the temperatures of fusion or solidification and of vaporisation or condensation are shown.

For liquefied gases, the solid state is not of concern since this can only occur at temperatures well below those at which such gases are carried. However, temperatures, pressures and latent heats of vaporisation are of fundamental importance.

Gas	Atmospheric boiling point (°C)	Critical temperature (°C)	Critical pressure (bars, absolute)	Condensing ratio dm^3 liquid $1m^3$ gas	Liquid relative density at atm. boiling pt. (water = 1)	Vapour relative density (air = 1)
Methane	-161.5	-82.5	44.7	0.804	0.427	0.554
Ethane	-88.6	32.1	48.9	2.453	0.540	1.048
Propane	-42.3	96.8	42.6	3.380	0.583	1.55
n-Butane	-0.5	153	38.1	4.32	0.600	2.09
i-Butane	-11.7	133.7	38.2	4.36	0.596	2.07
Ethylene	-103.9	9.9	50.5	2.20	0.570	0.975
Propylene	-47.7	92.1	45.6	3.08	0.613	1.48
α-Butylene	-6.1	146.4	38.9	4.01	0.624	1.94
γ-Butylene	-6.9	144.7	38.7	4.00	0.627	1.94
Butadiene	-5.0	161.8	43.2	3.81	0.653	1.88
Isoprene	34	211.0	38.5		0.67	2.3
Vinyl chloride	-13.8	158.4	52.9	2.87	0.965	2.15
Ethylene oxide	10.7	195.7	74.4	2.13	0.896	1.52
Propylene oxide	34.2	209.1	47.7		0.830	2.00
Ammonia	-33.4	132.4	113.0	1.12	0.683	0.597
Chlorine	-34	144	77.1	2.03	1.56	2.49

Table 27.5: *Physical properties of gases*

27.10.2 Liquefied gas spills

Against the background of the preceding paragraphs, it needs to be considered what happens when a liquefied gas is spilled. Firstly, consider the escape from its containment of a fully refrigerated liquid. Here the liquid is already at or near atmospheric pressure but, on escape, it is brought immediately into contact with the ground or water at ambient temperature. The temperature difference between the cold liquid and the material it contacts provides an immediate heat transfer into the liquid, resulting in the rapid evolution of vapour. If the spill is lying in a pool on the ground, the removal of heat from the ground beneath narrows the temperature difference. Eventually, temperature differences stabilise and the rate of evaporation continues at a lower level. Under these conditions, the liquid will continue to boil until completely evaporated. For spills on the water surface, the strong convection currents in the water may maintain the initial temperature difference and evaporation will probably continue at the higher initial rate. In this case, the large quantities of cold vapour produced from the liquid will diffuse into the atmosphere and cause condensation of the water vapour in the air. By this process, a white vapour cloud is formed.

Initial spills of a liquefied gas from a pressure vessel behaves differently to that described above. In this case the liquid, on escape, is at a temperature close to ambient. However, the high pressure at release quickly falls to ambient and this results in extremely rapid vaporisation, the necessary heat being taken primarily from the liquid itself. This is called flash evaporation and, depending on the change in pressure, much of the liquid may flash-off in this way. By this means any remaining liquid is cooled rapidly to its refrigerated temperature (and even lower) at atmospheric pressure. High-pressure liquids escaping in this way cause much of it to spray into the atmosphere as small droplets. These droplets take heat from the atmosphere and condense the water vapour in the air to form a visible, white cloud. The liquid droplets soon vaporise to gas, causing further cooling, so maintaining the white cloud formation for longer. Then, any remaining liquid pools attain an equilibrium temperature and evaporate, as described in the preceding paragraph, until wholly vaporised.

Depending on the liquid spilled, the spill size and whether the spill is on land or water, the rate of vaporisation and the temperature and density of the ensuing vapour cloud will vary. Almost certainly the cloud will be low-lying (only methane, when warmer than -100°C, ethylene and ammonia are lighter than air – see table 27.5).

The hazard introduced by the escape of vapour into the atmosphere is that, on mixing with the air, it becomes flammable. The white vapour cloud can give warning of the presence of a hazardous condition but note that the flammable extent of the gas cloud will not necessarily coincide with the visible cloud. Initially, the cloud will be cold and drift downwind. In general, it will be visible as a white cloud, which is condensed atmospheric water vapour. The characteristics of this cloud in terms of its flammability and oxygen content are discussed in sections 27.22 and 28.2.2.

Apart from the hazards introduced by vapour-in-air mixtures, the cold liquid can cause frostbite on human tissue and may convert metals to a brittle state. Furthermore, on exposure to air it is likely that a liquefied gas will become sub-cooled to a temperature below its atmospheric boiling point.

Liquefied gas spilled onto tankers' decks not designed for low temperatures may chill the steel to temperatures where it becomes brittle. Stress already within the steel, together with that resulting from differential contraction, can cause fractures in the cooled areas. The resultant fractures are unlikely to propagate beyond the cooled areas. Spills can have serious consequences and tankers have been taken out of service for extensive periods for this reason. Care should be taken, and appropriate drip-trays should be provided as a protection against such spills on tankers carrying particularly cold liquids such as ethylene.

27.11 Principles of refrigeration

The principles of heat transfer, evaporation and condensation are applied in refrigeration. Cold liquid refrigerant is vaporised in an evaporator which, being colder than its surroundings, draws in heat to provide the latent heat of vaporisation. The cool vapour is drawn off by a compressor which raises both the pressure and the temperature of the vapour and passes it to the condenser. Here, the vapour is condensed to a high-pressure liquid and the sensible heat from desuperheating, together with latent heat of condensation, is removed by means of the condenser coolant, which is warmed in the process. The high-pressure liquid then passes through an expansion valve to the low-pressure side of the refrigerator and, in doing so, flash evaporates to a two-phase mixture of cold liquid and vapour. This mixture then passes to the evaporator (cargo tank) to complete the cycle.

Figure 27.11 shows a simplified cascade refrigeration cycle for LNG. It consists of three stages, each using a different pure refrigerant. Only one stage for each refrigerant cycle is shown for simplicity, but additional stages can be employed to increase overall efficiency.

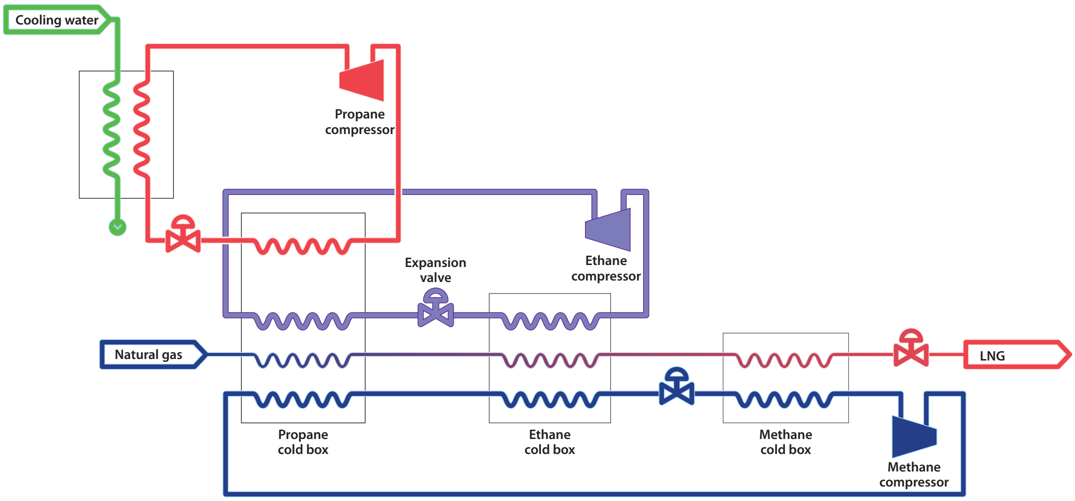


Figure 27.11: *Simplified cascade refrigeration cycle for LNG*

27.12 Critical temperatures and pressures

The critical temperature of a gas is the temperature above which it cannot be liquefied no matter how great the pressure. The critical pressure of a gas is the pressure required to compress it to a liquid state at its critical temperature. Critical temperatures and pressures for the principal gases are listed in table 27.5. As will be seen, all the gases, with the exception of methane (at times also ethane and ethylene), can be liquefied by pressure alone at temperatures within the normal ambient range. Accordingly, for carrying or storing ethane or ethylene as a liquid, a reliquefaction process is required.

27.13 Liquid/vapour volume relationships

As a guide to the relative sizing of equipment to handle a vapour compared with that to handle its liquid condensate, it is useful to note the condensing ratio of the various liquefied gases. This ratio gives that quantity of liquid (in dm^3) at its atmospheric boiling point which will condense from one cubic metre of its vapour at the standard conditions of one bar absolute and 0°C. If at 0°C the gas is at a higher temperature than its critical temperature (such as for methane), the ratio is given for the vapour at the atmospheric boiling point of the liquid. Condensing ratios are listed in table 27.5.

27.14 Ideal gas laws

The ideal gas laws are appropriate just to vapours; indeed, they are most appropriately applied to non-saturated vapours. Liquid/vapour mixtures and liquids possess characteristics different from those described below. Relating what follows to the principles of refrigeration (as in section 27.13) that portion of the cycle involving vapour compression is most relevant.

An ideal gas is one that obeys the gas laws by virtue of its molecules being so far apart that they exert no force on one another. In fact, no such gas exists, but at room temperature and at moderate pressures many non-saturated gases approach this concept. The ideal gas laws govern the relationships between absolute pressure, volume and absolute temperature for a fixed mass of gas. The relationship between two of these variables is commonly investigated by keeping the third variable constant.

For a gas to perform according to these principles, it must be in its unsaturated form and removed from its own liquid.

Boyle's Law states that, at constant temperature, the volume of a fixed mass of gas varies inversely with the absolute pressure. This relationship is illustrated in figure 27.12(a) and can be written:

PV = constant, or

$P_1V_1 = P_2V_2$

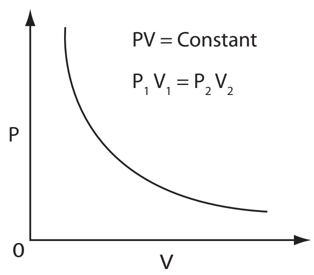


Figure 27.12(a): *Boyle's Law for gases (constant temperature)*

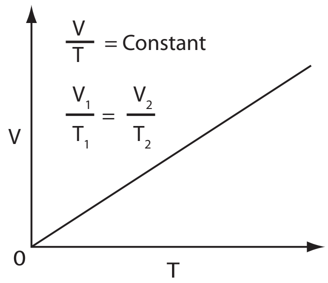


Figure 27.12(b): *Charles' Law for gases (constant pressure)*

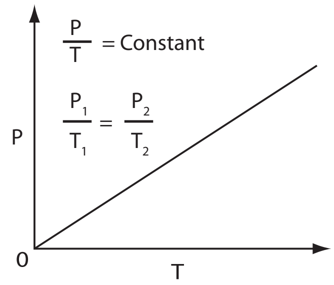


Figure 27.12(c): *Pressure Law for gases (constant volume)*

Charles' Law states that at constant pressure, the volume of a fixed mass of gas increases by 1/273 of its volume at 0°C for each degree centigrade rise in temperature. An alternative definition is that the volume of a fixed mass of gas at constant pressure varies directly with its absolute temperature. This law is illustrated in figure 27.12(b) and can be written:

$\frac{V}{T}$ = constant, or

$$\frac{V^1}{T^1} = \frac{V^2}{T^2}$$

The Pressure Law states that, at constant volume, the pressure of a fixed mass of gas increases by 1/273 of its pressure at 0°C for each degree centigrade rise in temperature. Alternatively, it can be stated that the pressure of a fixed mass of gas at constant volume, varies directly with its absolute temperature. The pressure law can be written:

$\frac{P}{T}$ = constant, or

$$\frac{P^1}{T^1} = \frac{P^2}{T^2}$$

These three laws may be combined into:

$\frac{P^1V^1}{T^1} = \frac{P^2V^2}{T^2}$ = constant,

Or, more generally, for an ideal gas, using the universal ideal gas constant:

$$\frac{PV}{T} = \frac{M}{m} = R$$

Where all the quantities are in consistent units, e.g.

where: P is absolute pressure in Pascals (N/m_2) V is in cubic metres
T is in Kelvin
M is the mass of the gas in kilograms
m is the molecular weight (dimensionless), and
R is the universal gas constant = 8.314kJ/kg mol.K.

Figure 27.12 outlines the three basic gas laws. They cover changes at constant temperature (isothermal); changes at constant pressure (isobaric); and changes at constant volume (isovolumetric).

However, a fourth process involving the ideal gas is also of relevance to refrigeration. This is called the adiabatic compression and may be reversible or irreversible. A reversible process is one involving constant entropy. Changes in pressure, involving constant entropy (isentropic), are shown on the Mollier diagram in figure 27.17.

A reversible adiabatic (or isentropic) expansion is one where the heat flow to or from an external source is zero. In the compressor of a refrigeration plant, work is done on the gas as it passes through the compressor, although no heat is assumed to be transmitted to or from the outside. The work is converted into internal energy and so the temperature of the gas is increased. By this means, temperatures at the compressor discharge are raised (a) by increased pressure and (b) by increases in internal energy.

In practice, to approximate to an adiabatic compression, work on the gas must be carried out very quickly. By this means, little time is allowed for heat to escape from the system. The adiabatic curve is shown by the curve A/B in figure 27.13. On the other hand, and by way of comparison, an isothermal compression, as shown by the curve A/C, must be carried out very slowly otherwise temperature changes will become obvious.

It follows that the actual changes taking place, say in a compressor (with respect to pressure, volume and temperature), follow a curve somewhere between the adiabatic and the isothermal. This could approximate to the curve A/D shown in figure 27.13.

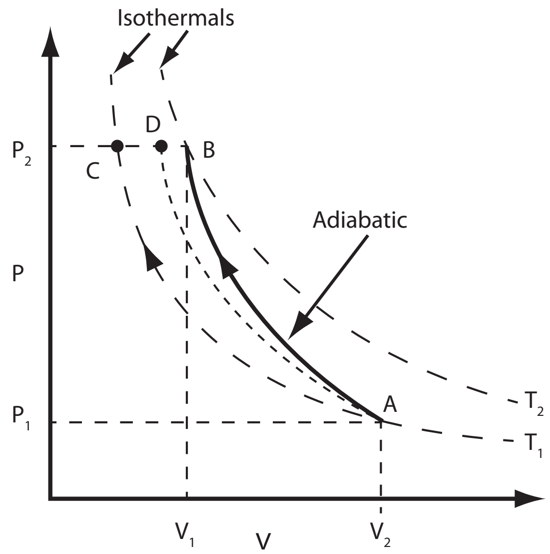


Figure 27.13: *Relationship between adiabatic and isothermal compression*

Figure 27.13 is produced on similar axes as figure 27.12(a). However, figure 27.13 includes two isothermal lines – one for a low temperature (T_1) and one for a higher temperature (T_2). For a compressor, as the changes lie closer to the adiabatic line than the isothermal line, it is usual to assume an adiabatic change in such cases.

As covered at the beginning of this section under the discussion on Boyle's Law, the equation for an isothermal compression is:

PV = constant

It may be of interest to note that the equation for the adiabatic compression is:

PV_k = constant

where 'k' is the ratio of principal specific heats for the substance. This is the ratio of specific heat of the liquid divided by the specific heat of the vapour.

27.15 Saturated vapour pressure

In section 27.16, discussion centred on pure gases isolated from their liquids. In this section, attention is given to gases in contact with their own liquids. It is in this respect that the concept of saturated vapour pressure becomes important.

Vapour in the space above a liquid is in constant motion. Molecules near the liquid surface are constantly leaving to enter the vapour-phase and molecules in the vapour are returning to the liquid-phase. The vapour space is said to be unsaturated if it can accept more vapour from the liquid at its current temperature. A saturated vapour is a vapour in equilibrium with its liquid at that temperature. In that condition, the vapour space cannot accept any further ingress from the liquid without a continuous exchange of molecules taking place between vapour and liquid.

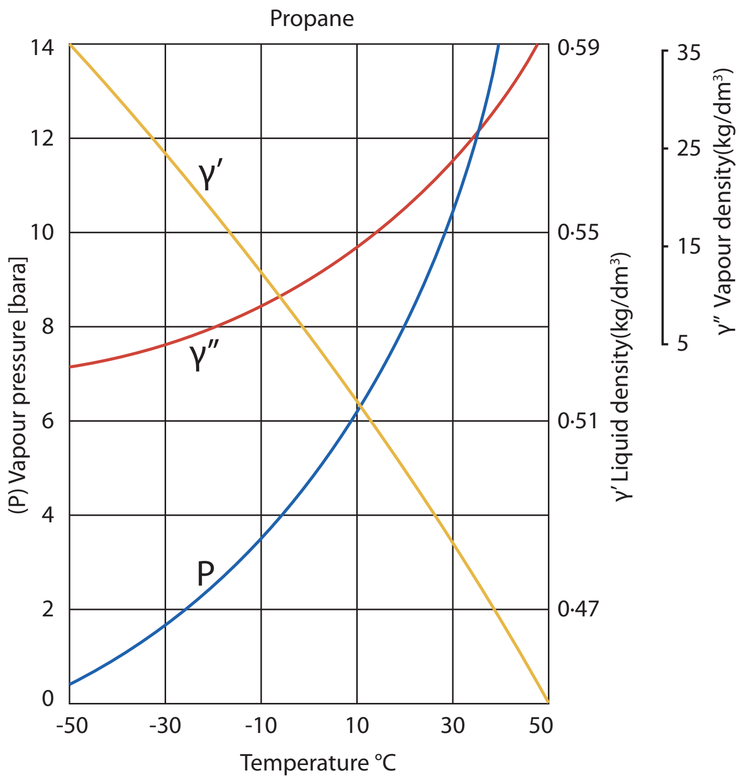


Figure 27.14: *Characteristics of propane*

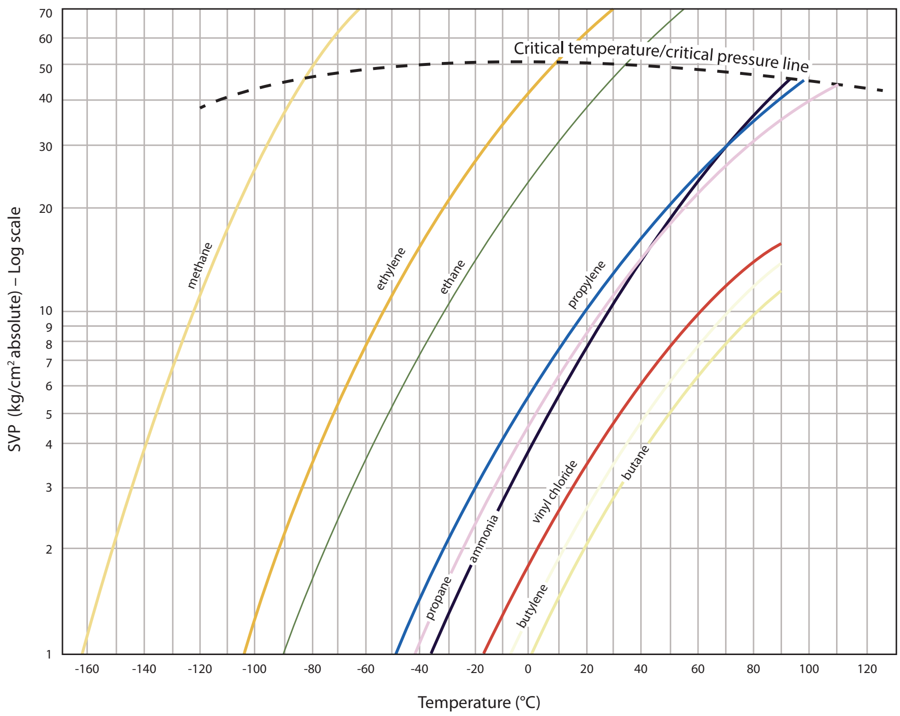


Figure 27.15: *Pressure/temperature relationship for liquefied gases*

The pressure exerted by a saturated vapour at a particular temperature is called the saturated vapour pressure of that substance at that temperature. Various methods exist for measuring saturated vapour pressures. Evaporation is a phenomenon where the faster-moving molecules escape from the surface of a liquid. However, when boiling occurs, it takes place in the body of the liquid. This happens when the external vapour pressure is equal to the pressure of the liquid. By varying the pressure above the liquid, the liquid boils at different temperatures. Decreasing the pressure above the liquid lowers the boiling point, and increasing the pressure raises the boiling point. The curve marked P in figure 27.14 illustrates the variation in saturated vapour pressure with temperature for propane. Note that an increase in liquid temperature causes a non-linear increase in the saturated vapour pressure. The non-linear shape of the curve shows also that the saturated gas does not behave exactly in accordance with the gas laws (see also figure 27.12(c)). Also shown on figure 27.14 are the variations of propane liquid density (γ') and saturated vapour density (γ") with temperature.

Different liquefied gases exert different vapour pressures. This can be seen from figure 27.15. The vertical axis gives the saturated vapour pressure on a logarithmic scale. (The use of the logarithmic scale changes the shape of the curves from that shown for P in figure 27.14). The graph shows that smaller molecules exert greater vapour pressures than larger ones. In general the chemical gases exert much lower saturated vapour pressures than the small hydrocarbon molecules such as methane. The point of intersection of these curves with the horizontal axis indicates the atmospheric boiling point of the liquid (the temperature at which the saturated vapour pressure is equal to atmospheric pressure). This is the temperature at which these cargoes would be transported in fully refrigerated or fully insulated containment systems.

While the bar is now the most frequently used pressure unit in the gas industry, other units such as kgf/cm^2 (kilogrammes force per square centimetre), atmospheres or millimetres of mercury are frequently encountered. However, the only legal units are the SI units with kilopascal as the usual pressure unit. The conversion factors for these units of pressure are given in table 27.6.

	kPa	bar	std atm	$kg.f/cm^2$	$lb.f/inch^2$ (p.s.i.)	$lb.ft/ft^2$ (p.s.i.)	mm (mercury)	inch (mercury)	inch (water)	ft (water)	m (water)
kPa	1	0.01	0.0099	0.0102	0.1450	20.88	7.50	0.2953	4.015	0.3346	0.1020
bar	100	1	0.9869	1.020	14.50	2,089	750.1	29.53	402.2	33.52	10.22
std atm	101.325	1.013	1	1.033	14.70	2,116	760	29.92	407.5	33.96	10.35
$kg.f/cm^2$	98.039	0.9807	0.9678	1	14.22	2,048	735.6	28.96	394.4	32.87	10.02
$lb.f/inch^2$ (p.s.i.)	6.8966	0.06895	0.06805	0.07031	1	144	51.72	2.036	27.73	2.311	0.7044
$lb.f/ft^2$	0.0479	4.788x10-4	4.725x10-4	4.882x10-4	0.006944	1	0.3591	0.01414	0.1926	0.01605	0.004891
mm Hg	0.1333	0.001330	0.001316	0.001360	0.01934	2.785	1	0.03937	0.5362	0.04469	0.01362
inch Hg	3.3864	0.03386	0.03342	0.03453	0.4912	70.73	25.4	1	13.62	1.135	0.3459
inch H_2O	0.2491	0.002486	0.002454	0.002535	0.03606	5.193	1. 865	0.07342	1	0.0833	0.02540
ft H_2O	2.9886	0.02984	0.02944	0.03042	0.4327	62.31	22.38	0.8810	12	1	0.3048
m H_2O	9.8039	0.09789	0.09660	0.0998	1.420	204.4	73.42	2.891	39.37	3.281	1

Table 27.6: *Conversion factors for units of pressure*

All gauges used for measuring pressure measure pressure difference. Gauge pressure is therefore the pressure difference between the pressure to which the gauge is connected and the pressure surrounding the gauge (atmospheric pressure). The absolute pressure is obtained by adding the external pressure (such as atmospheric pressure) to the gauge pressure.

Vapour pressures, though they may be found by means of a pressure gauge, are a fundamental characteristic of the product. Accordingly, they are essentially absolute pressures. However, tank design pressures and relief valve settings, like pressure gauge indications, are tuned to the physical difference between internal and external pressure and so are gauge pressures. For consistency throughout this guide, most pressures are given in bars but, to avoid confusion, the unit is denoted as barg where a gauge pressure (over pressure) is intended.

It is appropriate that a liquefied gas is defined in Europe in terms of its vapour pressure as a substance having a vapour pressure at 50°C equal to or greater than 300kPa *absolute*.

27.16 Liquid and vapour densities

27.16.1 Liquid density

The density of a liquid is defined as its mass per unit volume and is commonly measured in kilogrammes per cubic metre (kg/m^3). Alternatively, liquid density may be quoted in kg/litre or in kg/dm^3. The variation with temperature of the liquid density of a liquefied gas (in equilibrium with its vapour) is shown for propane in curve y' in figure 27.14. As can be seen, the liquid density decreases with increasing temperature. The large changes seen are due to the comparatively large coefficient of volumetric expansion of liquefied gases. Values for liquid density (relative to water) of liquefied gases at their atmospheric boiling points are in table 27.5. All the liquefied gases, with the exception of chlorine and carbon dioxide, have liquid relative densities lower than one. This means that in the event of a spill onto water, these liquids would float prior to evaporation.

Rollover
A danger associated with cargo density is the phenomenon of rollover. The conditions for rollover are set when a tank's liquid contents stratify so that a heavier layer forms above a less-dense lower layer. Rollover is the spontaneous mixing that takes place to reverse this instability. Rollover, in either a ship or shore tank, can result in boil-off rates ten times greater than normal, causing over-pressurisation, the lifting of relief valves and the release to atmosphere of considerable quantities of vapours or even two-phase mixtures.

When liquids of differing density are loaded – without mixing – into the same tank, there is a possibility that layering will take place. This may be due to cargo mixing (see below). Instability will occur between the layers if the lower layer becomes less dense than the upper.

The phenomenon is largely limited to large tanks, although it is known to have occurred on LNG and large LPG carriers. Furthermore, a number of recorded rollover incidents involving the shore storage of ammonia are known. For most other liquefied gases, being pure products, the risk of rollover is less severe. However, if two different cargoes, such as butane and propane, are loaded into the same tank, layering can become acute. Loading a ship's tank by this means is not recommended unless a thorough thermodynamic analysis of the process is carried out and the loading takes place under strictly controlled conditions.

The following measures which can help prevent rollover:
- Store liquids of differing density in different shore tanks.
- Load shore tanks through nozzles or jets to promote mixing.
- Use filling pipework at an appropriate level in the shore tank.
- Do not allow prolonged stoppages when loading tankers.
- Monitor cargo conditions and boil-off rates for unusual data.
- Transfer cargo to other tanks or recirculate within the affected shore tank.

27.16.2 Vapour density

The density/temperature relationship of the saturated vapour of propane is given by curve γ' in figure 27.14. The density of vapour is commonly quoted in units of kg/m^3). The density of the saturated vapour increases with increasing temperature. This is because the vapour is in contact with its liquid and, as the temperature rises, more liquid transfers into the vapour-phase in order to achieve the higher vapour pressure. This results in a considerable increase in mass per unit volume of the vapour space. The densities of various vapours (relative to air) at standard temperature and pressure are given in table 27.5. Most of the liquefied gases produce vapours that are heavier than air. The exceptions are methane (at temperatures greater than -113°C), ethylene and ammonia. Vapours released to the atmosphere that are denser than air tend to seek lower ground and do not disperse readily.

27.17 Physical properties of gas mixtures

If the components of a gas mixture are known, it is possible to perform a variety of calculations using the following relationships.

Molecular mass
Molecular mass of gas mixture = $M_iV_i/100$

where: M_i = component molecular mass
V_i = percentage component volume

Percentage mass
Percentage mass of component = V_iM_i/M_{mix}

where: M_{mix} = molecular mass of gas mixture

Relative vapour density
Relative vapour density of gas mixture (at 0°C and 1 bar) = M_{mix}/M_a

where: M_a = molecular mass of air = 29

For example, given the percentage by volume of the components in a gas mixture, table 27.7 shows how the molecular mass of the mixture can be determined. The example taken considers the composition of a typical natural gas.

Gas component	Percentage by volume (V_i)	Component molecular (M_i)	$\frac{M_i V_i}{100}$	Percentage by mass
Methane	83.2	16.04	13.35	67.6
Ethane	8.5	30.07	2.56	13.0
Propane	4.4	44.09	1.94	9.8
Butane	2.7	58.12	1.57	7.9
Nitrogen	1.2	28.02	0.34	1.7
	100.00	M_{mix} = 19.76	19.76	100.00

Relative density of mixture $\frac{19.76}{29} = 0.681$

Table 27.7: *Calculation for the molecular mass of a gas mixture*

Vapour pressure of liquid mixtures

Dalton's Law of Partial Pressure states that when several gases occupy a common space, each behaves as though it occupies the space alone. The pressure that each gas exerts is called its partial pressure and the total pressure exerted within the enclosing space is the sum of the partial pressures of the components.

Using Dalton's Law, it is possible to calculate the saturated vapour pressure of a mixture of liquids at a given temperature. The partial pressure exerted by the vapour of a liquid component, is equal to the product of the saturated vapour pressure of that component, if it existed alone at that temperature, multiplied by the mole fraction of the component in the liquid mixture. The total saturated vapour pressure of the mixture will be the sum of the partial pressures of each component.

Thus, $P_{mt} = \Sigma(P_{nt} \times F_n)$

where: P_{mt} is saturated vapour pressure of liquid mixture (m) at temperature (t)

P_{nt} is saturated vapour pressure of component (n) at temperature (t)

F_n is mole fraction of component (n) in liquid mixture. This is the mass of that component divided by the mass of the whole mixture. For example, in table 27.7 the mole fraction of the gas mixture is given by:

$$\frac{M_i V_i}{M_{mix} \times 100}$$

For example, for an LPG of the following composition at -40°C:

Component (n)	Mole fraction in mixture (F_n)	SVP of component at -40°C (P_{nt}) (bar)	Partial pressure of component at -40°C (P_{nt} x F_n)	Composition of vapour (Partial pressure/SVP of mixture x 100) (5 by volume)
Ethane Propane n-Butane i-Butane	0.002 0.956 0.030 0.012	7.748 1.13 0.17 0.284	0.0155 1.0803 0.0051 0.0034	1.4 97.8 0.5 0.3
	1.000		1.1043	100.0
Saturated vapour pressure of mixture = 1.1043				

It is clear from the above example how the presence of a small amount of a very volatile component in the liquid mixture can add significantly to the vapour pressure. Because the components of the liquid mixture are in solution with each other, a low boiling component, such as the ethane in the above example, can remain in the liquid phase at temperatures well above the boiling point of the pure substance. However, the vapour phase will contain a higher proportion of such low boiling point material than does the liquid mixture.

27.18 Bubble points and dew points for mixtures

As outlined in section 27.12 and illustrated in figure 27.10, a pure liquid will start to boil at a temperature depending upon the pressure above it. The liquid will continue to boil at that temperature provided the pressure is kept constant. On cooling superheated vapour to that same pressure, the vapour will become saturated at the same fixed temperature and will condense to liquid at that temperature. However, because of the differing volatilities of its components, a mixture of liquefied gases will behave differently. The bubble point, or TVP of a liquid mixture, at a given pressure, is defined as that temperature at which the liquid will begin to boil as the temperature rises.

The dew point of a vapour mixture, at a given pressure, is defined as the temperature at which the vapour begins to condense as the temperature decreases. For a liquid mixture in equilibrium with its vapour, the bubble point and the dew point are at different temperatures.

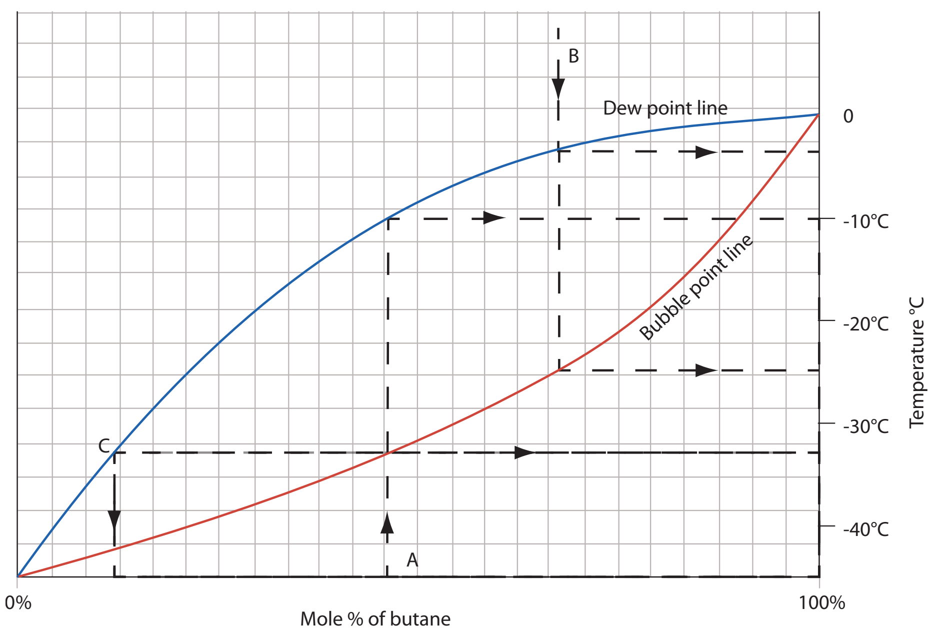


Figure 27.16: *Equilibrium diagram for propane/butane mixtures*

This behaviour can be represented on an equilibrium diagram. A typical example for propane/butane mixtures is in figure 27.16. The diagram here gives vapour/liquid equilibrium data for mixtures in terms of the mol percentage content in the liquid of the less-volatile component (butane). Equilibrium data must be related to a unique pressure and in this case the data is given for atmospheric pressure.

The two curves of figure 27.16 show the bubble points and dew points of the mixture over a range from pure propane (0% butane) to pure butane (100%). It will be noted that at the two extremes, denoting either pure butane or pure propane, the bubble points and dew points become coincident. Interpreting the diagram, it can be seen that a liquid mixture of composition (A) will start to boil at its bubble point of -32.5°C but can only completely vaporise in equilibrium with its vapour provided the temperature rises to -10°C.

Similarly, a vapour mixture of composition (B) will start to condense at its dew point of -3°C but can only condense completely with a fall in temperature to -25°C.

A further use of such diagrams is to estimate the differing proportions of the components in a liquid mixture and in its equilibrium vapour mixture. Taking again a liquid of composition (A), and assuming it is carried on a fully refrigerated tanker at its initial bubble point of -32.5°C, at this temperature the vapour composition that will be in equilibrium with the liquid is given by (C).

27.19 Reliquefaction and enthalpy

27.19.1 Enthalpy

The enthalpy of a mass of a substance is a measure of its thermodynamic heat (or energy) content, whether the substance is liquid or vapour or a combination of the two. Within the SI system it is measured in kiloJoules per kilogram. Enthalpy (H) is defined as:

$$H = U + \frac{PV}{M}$$

where: H = enthalpy (kJ/kg)
U = internal energy (kJ/kg)
P = absolute pressure (kN/m^2)
V = total volume of the system – liquid plus vapour (m^3)
and M = mass in the system (kg)

[Note: Newtons = kg m/sec^2; Joules = kg m^2/sec^2]

The total internal energy of a fluid is the thermodynamic energy attributable to its physical state. It includes sensible heat, latent heat, kinetic energy and potential energy. The PV term in the foregoing formula represents the energy available within a fluid due to pressure and volume.

Absolute values of enthalpy are not normally of practical interest – it is the changes of enthalpy that are important in the thermodynamic analysis of a process. Accordingly, the enthalpy of a system is usually expressed from an arbitrarily chosen zero. Since a change in enthalpy expresses the total energy change in a fluid as it passes through any thermodynamic process, it is a useful unit for the analysis of energy changes. This is particularly so in cyclic processes involving compression, expansion, evaporation or condensation such as those encountered in the reliquefaction of boil-off vapours. In such processes, changes in kinetic energy and potential energy are negligible and thus enthalpy changes are calculable from well-established thermodynamic data. Tabular presentation of enthalpy changes for some liquefied gases are available, but for many applications the most widely used presentation is that found in Mollier diagrams. On one comprehensive chart, the Mollier diagram plots many different factors against absolute pressure (log scale) and enthalpy (linear scale). Mollier diagrams are available for a wide range of fluids, including all the liquefied gases.

27.19.2 Refrigeration

Figure 27.17 depicts the principal features of the Mollier diagram for propane. In this diagram, the heat unit used is the kiloJoule. (The enthalpy scale is based upon the assumption of 419kJ/kg at 0°C in the liquid phase.) The predominant feature of the diagram is the rounded conic shape of the liquid/vapour mixture area. This is enclosed by the saturated liquid line and the saturated vapour line that meet at the apex, which is the critical point. As will be seen, the diagram also contains lines of constant temperature, constant volume, constant entropy and dryness factor.

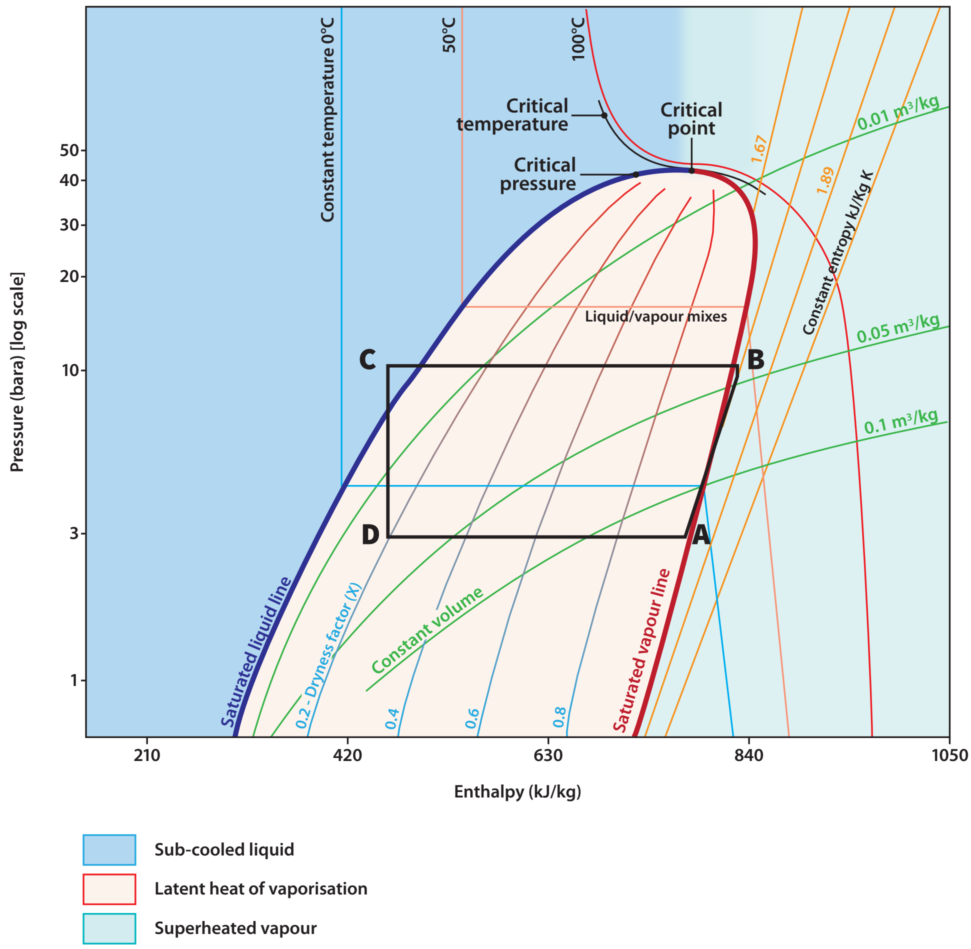


Figure 27.17: *Mollier diagram for propane*

Reliquefaction

Superimposed on the Mollier diagram is an example of the pressure and enthalpy changes taking place in a simple shipboard reliquefaction cycle. This covers the boil-off from a semi- pressurised cargo of propane being carried at 3 bars and -14°C (in following this example also refer to section 27.13 and figure 27.11). At A on the diagram, the boil-off vapour is drawn off from the cargo tank and compressed to 10 bars at B. It is generally assumed that the compression is adiabatic, ie. with no heat lost from the vapour during the compression (see also section 27.16). For such an ideal adiabatic process, the change in entropy is zero and the line AB follows a line of constant entropy. The difference in enthalpy between B and A (approximately 840 – 790 = 50kJ/kg) represents the work input to the vapour by the compressor. It will also be noticed that the line AB crosses lines of constant volume; this indicates decreasing volume due to compression.

From B to C, the vapour has heat taken from it and is condensed to liquid. The position of C in this example shows that the condenser has achieved some degree of subcooling of the liquid. The enthalpy change from B to C (approximately 840 – 470 = 370kJ/kg) represents the heat removed by the condenser.

The liquid condensate is then expanded through a regulating valve (expansion valve) and returned to the ship's tank at a pressure of 3 bars. In this procedure, the condensate neither gives up nor receives heat and so there is no change in enthalpy. In the expansion process, the change in sensible heat (cooling) exactly matches the ingress of latent heat required for flash evaporation. Therefore, the line CD is vertical and the position of D indicates a dryness fraction of 0.2 for the returned condensate: that is 20% mass of vapour and 80% mass of liquid.

The total refrigeration effect of the cycle is given by the difference in enthalpy of the vapour drawn to the compressor at A and that of the condensate return at D (approximately 790 – 470 = 320kJ/kg).

27.20 Flammability

Combustion

Combustion is a chemical reaction, initiated by a source of ignition, in which a flammable vapour combines with oxygen to produce carbon dioxide, water vapour and heat. Under ideal conditions the reaction for propane can be written as follows:

C_3H_8		50_2	Combustion	$3CO_2$		$4H_20$
propane	+	oxygen	→	carbon dioxide	+	Water vapour + Heat

Under certain circumstances, e.g. when oxygen supply to the fuel is restricted, carbon monoxide or carbon can also be produced.

The three requirements for combustion to take place are fuel, oxygen and ignition. Furthermore, for ignition to occur, the proportions of vapour to oxygen (or to air) must be within the product's flammable limits.

The gases produced by combustion are heated by the reaction. In open spaces, gas expansion is unrestricted and combustion may proceed without undue over-pressures developing. If the expansion of the hot gases is restricted in any way, pressures will rise and the speed of flame travel will increase. This depends on the type of confinement. Increased flame speed gives rise to a more rapid increase in pressure, with the result that damaging over-pressures may be produced. Even in the open, if the confinement resulting from surrounding pipework, plant and buildings is enough, the combustion can take on the nature of an explosion. In severely confined conditions, such as within a building or ship's tank, where the expanding gases cannot escape, the internal pressure and its rate of increase may be enough to burst the containment. Here, the explosion is not due to high combustion rates and flame speed: it results more from the surge of high pressure upon containment rupture.

The Boiling-Liquid/Expanding-Vapour Explosion

A Boiling-Liquid/Expanding-Vapour Explosion (BLEVE) is an explosion resulting from the catastrophic failure of a vessel containing a liquid significantly above its boiling point at normal atmospheric pressure. The container may fail for any of the following reasons: mechanical damage, corrosion, excessive internal pressure, flame impingement or metallurgical failure.

The most common cause of a BLEVE is probably when a fire increases the internal tank pressure of the vessel's contents and flame impingement reduces its mechanical strength; particularly at that part of the vessel not cooled by internal liquid. As a result, the tank suddenly splits and pieces of the vessel's shell can be thrown a considerable distance, with concave sections, such as end caps, being propelled like rockets if they contain liquid. On rupture, the sudden decompression produces a blast and the pressure immediately drops. At this time the liquid temperature is well above its atmospheric boiling point and, accordingly, it spontaneously boils off, creating large quantities of vapour that are thrown upwards along with liquid droplets.

Where the gas/air mixture is within its flammable limits, it will ignite from the rending metal or the surrounding fire to create a fireball reaching gigantic proportions, and the sudden release of gas provides further fuel for the rising fireball. The rapidly expanding vapour produces a further blast and intense heat radiation.

BLEVE incidents have occurred with rail tank cars, road vehicles and in a number of terminal incidents. There have been no instances of this kind on liquefied gas carriers. Under the relevant legislation, pressure relief valves are sized to cope with surrounding fire, which helps, as for shore tanks, to limit this risk. It must be said that the chance of a fire occurring in the enclosed space beneath a cargo tank on a barge is much smaller than on an equivalent tank situated on shore. This minimises the possibility of a surrounding fire occurring on a tanker and almost excludes the possibility of a BLEVE occurring on a gas carrier.

Flammable range

The concept of a flammable range gives a measure of the proportions of flammable vapour to air for combustion to occur. The flammable range is the range between the minimum and maximum concentrations of vapour (% by volume) in air which form a flammable mixture. The lower and upper limits are usually abbreviated to LFL and UFL. This concept is illustrated for butane, ethylene and methane in figure 27.18.

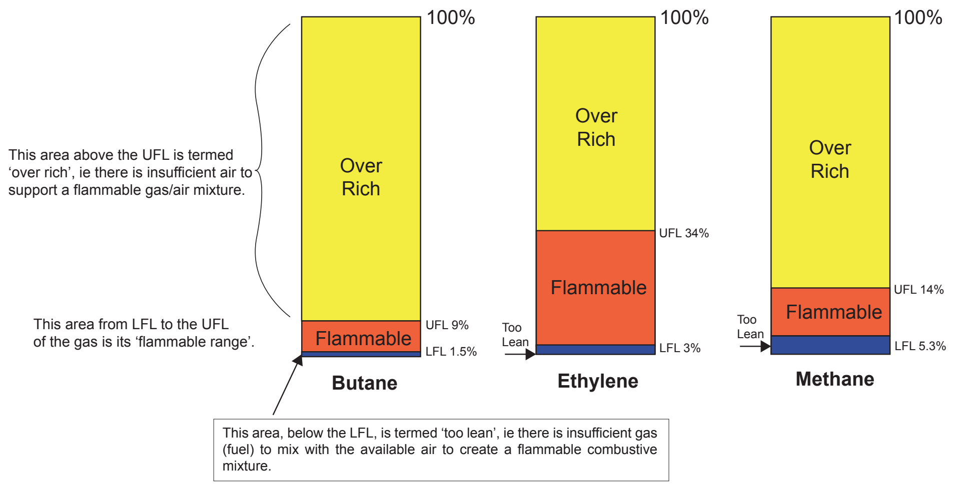


Figure 27.18: *Flammable range for butane, ethylene and methane (percent in air)*

All the liquefied gases, with the exception of chlorine and carbon dioxide, are flammable but the limits of the flammable range vary depending on the particular vapour. These are listed in table 27.8. The flammable range of a vapour is broadened in the presence of oxygen in excess of that normally found in air. In such cases the LFL is changed little but the UFL is considerably raised. Comparative flammable ranges in air and in oxygen are quoted in table 27.9 for propane, n-butane and vinyl chloride. All flammable vapours exhibit this property and, as a result, oxygen should not normally be introduced into an atmosphere where flammable vapours exist.

Liquefied gas	Flashpoint (°C)	Flammable range (% by vol. in air)	Auto-ignition temperature (°C)
Methane	-175	5.3-14	595
Ethane	-125	3.0-12.5	510
Propane	-105	2.1-9.5	468
n-Butane	-60	1.5-9.0	365
i-Butane	-76	1.5-9.0	500
Ethylene	-150	3.0-34.0	453
Propylene	-108	2.0-11.1	453
∝-Butylene	-80	1.6-10	440
β-Butylene	-72	1.6-10	465
Butadiene	-60	1.1-12.5	418
Isoprene	-50	1.1-9.7	220
Vinyl chloride	-78	4.0-33.0	472
Eyhylene oxide	-18	3.0-100	429
Propylene oxide	-57	14-28	465
Ammonia	-57	14-28	615
Chlorine	Non-flammable		
Carbon dioxide (CO_2)	Non-flammable		

Table 27.8: *Ignition properties for liquefied gases*

	Flammable range (% by volume)	
	(In air)	(In oxygen)
Propane	2.1-9.5	2.1-55.0
n-Butane	1.5-9.0	1.8-49.0
Vinyl chloride	4.0-33.0	4.0-70.0

Table 27.9: *Flammability range in air and oxygen for some liquefied gases*

Flash point

The flash point of a liquid is the lowest temperature at which that liquid will evolve enough vapour to form a flammable mixture with air. High vapour pressure liquids such as liquefied gases have extremely low flash points, as seen from table 27.8. However, although liquefied gases are never carried at temperatures below their flash point, the vapour spaces above such cargoes are non-flammable since they are filled entirely with cargo vapour and are thus safely above the UFL.

Auto-ignition temperature

The auto-ignition temperature of a substance is the temperature to which its vapour-in-air mixture must be heated to ignite spontaneously. The auto-ignition temperature is not related to the vapour pressure or to the flash point of the substance and, since the most likely ignition sources are external flames or sparks, it is the flash point rather than the auto-ignition temperature that is used for the flammability classification of hazardous materials. Nevertheless, when vapour escapes are considered in relation to adjacent steam pipes or other hot surfaces, the auto-ignition temperature is worthy of note. Accordingly, they are listed in table 27.8.

Energy required for ignition
Accidental sources of ignition of a flammable vapour can be flames, thermal sparks (due to metal-to-metal impact) and electric arcs or sparks (short circuits or static discharges). The minimum ignition energy necessary to set fire to hydrocarbon vapours is very low, particularly when the vapour concentration is in the middle of the flammable range. Minimum ignition energies for flammable vapours in air are typically less than one millijoule. This is an energy level substantially exceeded by any visible flame, by most electric circuit sparks or by electrostatic discharges down to the lowest level detectable by human contact. The presence of oxygen in excess of its normal proportion in air further lowers the minimum ignition energy.

Only the flammable mixtures of ammonia have minimum ignition energies outside this typical range. Ammonia requires energies some 600 times higher than the other gases for ignition. Nevertheless, the possibility of igniting ammonia vapours cannot be completely discounted.

Flammability within vapour clouds
Should a liquefied gas be spilled in an open space, the liquid will rapidly evaporate to produce a vapour cloud (see also section 27.12.2), which will gradually disperse downwind. The vapour cloud or plume is flammable only over part of its area. The situation is illustrated in figure 27.19.

The region (B) immediately next to the spill area (A) is non-flammable because it is over-rich. It contains too low a percentage of oxygen to be flammable. Region (D) is also non-flammable because it is too lean, containing too little vapour to be flammable. The flammable zone lies between these two regions as indicated by (C).

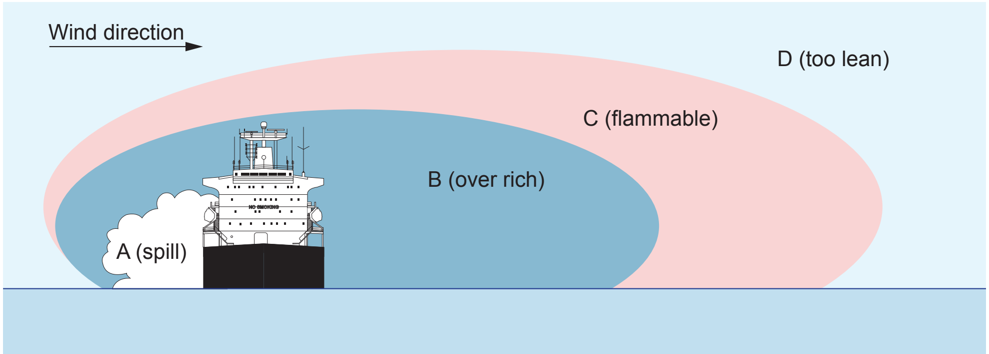


Figure 27.19: *Flammable vapour zones – a liquefied gas spill*

27.21 Suppression of flammability by inert gas

Whereas increasing the oxygen concentration in a flammable mixture causes a broadening of the flammable range and a lowering of the energy necessary for ignition, decreasing the oxygen causes the flammable range to be narrowed and the minimum ignition energy to be increased. If the oxygen availability is reduced enough, the mixture will become non-flammable no matter what the combustible vapour may be. Figure 27.20 illustrates this concept for typical hydrocarbon gas mixtures with air and nitrogen. The mixtures are represented on the horizontal axis by the percentage oxygen content in the total mixture. The diagram provides much useful information. The narrowing of the flammable range as the oxygen is reduced can be seen from the shape of the area labelled flammable. It is also clear that an oxygen content of less than that at the left-hand extremity of the flammable envelope renders the mixture non-flammable. This value, for most hydrocarbon vapours, is around 10-12% by volume. However, for an atmosphere to be adequately non-flammable on a gas carrier, less than 5% (sometimes 2%) by volume oxygen is needed.

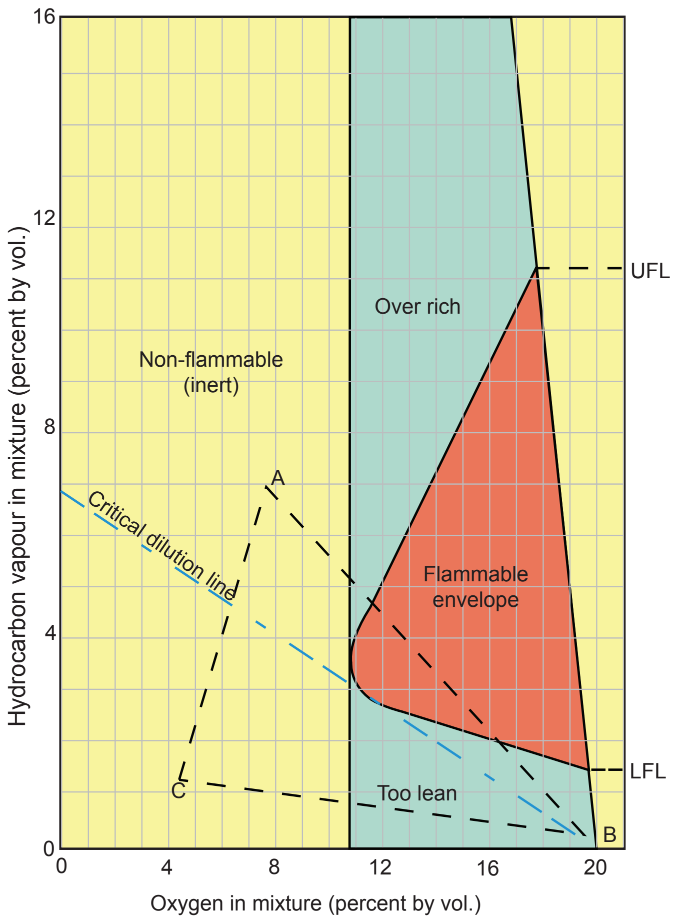


Figure 27.20: *Flammable limits of gas mixtures in air and nitrogen*

The diagram is also useful in illustrating proper inerting and gas-freeing procedures. For example, assume that a tank atmosphere is determined to be at point A. If the tank is then gas-freed directly with air, the composition of the tank atmosphere will move along the line AB to the fully gas-free condition at point B. In so doing, the atmosphere passes through the flammable envelope. This can be avoided by first inerting the tank along, say, the line AC to a point below the critical dilution line. Aerating to point B may then be undertaken without the tank atmosphere passing through the flammable envelope. This result can only be safely achieved if regular measurements are taken, using properly calibrated instruments to evaluate the atmosphere throughout the tank at the various stages. In this process, it is important to use reasonable margins of safety since the shape of the flammable envelope is ill-defined for mixtures and any non-homogeneity of the tank atmosphere must be allowed for. Also, the varying range of flammable limits for the different gases must be considered (see table 27.8).

27.22 Sources of ignition

Refer to section 4.2 for information on the control of potential ignition sources.

28 Hazards of gases

This chapter mainly concentrates on the quality of the atmosphere to which personnel can be exposed. In addition to the risk to personnel encountering hydrocarbon vapours of a toxic nature, the risk of oxygen deficiency is also covered. Methods of checking atmospheres are described.

28.1 Cargo hazards

All gas carriers are designed so that, in normal operation, personnel should never be exposed to the hazards posed by the products being carried. This assumes that the tanker and its equipment are maintained properly and that procedures are followed.

In the event of accidental leaks, emergency inspections or maintenance tasks, personnel may be exposed to liquid or gaseous product. This chapter reviews the hazards to health and safety that such circumstances present and outlines means of hazard avoidance.

The overall approach in avoiding hazards to personnel should always be, in order of preference:

- Hazard removal.
- Hazard control.
- Personal protection.

This listing suggests that reliance of personal protection should only be used in cases where hazard removal or hazard control are found impossible to accomplish.

An essential requirement is the thorough training of all personnel. Effective supervision of all tasks where hazards may be present is also vital. Training should go beyond basic instruction on the use of equipment or the execution of procedures, and should include the nature of the hazards, including those that are sometimes not immediately obvious.

Broadly, the hazards of liquefied gases or their vapours may be five-fold. These hazards are discussed more fully later. The essential components are:

- Flammability – see section 28.2.
- Toxicity (poisoning) – see section 28.3.1.
- Asphyxia (suffocation) – see section 28.3.2.
- Low temperature (frostbite) – see section 28.4.
- Chemical burns – see section 28.5.

Chapter 27 describes the properties of the liquefied gas cargoes normally carried. The cargo information data sheets or SDS also provide detailed health and safety data for products. The risks of flammability, low temperature and asphyxia apply to nearly all liquefied gas cargoes. However, the hazard of toxicity and chemical burns apply to only some of them.

Table 28.1 lists the main liquefied gases together with their flammable and toxic hazards. Where appropriate, asphyxiant hazards are also noted in the column headed TLV. However, this applies only when the gas has asphyxiant hazards and is not recorded as having any toxic effects or where the toxic effects are limited.

The table is subdivided horizontally by a double line. The products above this line are mainly the hydrocarbon liquefied gases and those below the line are mainly chemical gases. It should be noted that the chemical gases tend to have stronger toxic effects.

Cargo vapour in air				Toxic effects of vapour or liquid	
Substance	**Flammable**	**Toxic**	**Typical TLV-TWA (ppm)**	**Corrosive/ Irritant**	**Effects on nervous systems**
Methane	Yes	–	A	No	–
Propane	Yes	–	A	No	Yes
Butane	Yes	–	600	No	Yes
Propylene	Yes	–	500	No	Yes
Butylene	Yes	–	800	No	Yes
Isoprene	Yes	–	No data	No	Yes
Butadiene	Yes	Yes	10	Yes	Yes
Ammonia	Limited	Yes	25	Very	–
Vinyl chlorine	Yes	Yes	5	Yes	Yes
Ethylene oxide	Yes	Yes	10	Very	Yes
Propylene oxide	Yes	Yes	3	Very	Yes
Gases marked with an A in the TLV column do not have recorded TLVs. These gases are relatively non-toxic. They are known as asphyxiant gases and will kill when their concentration in air is sufficient to displace the oxygen needed to sustain life (see 28.3.2).					

Table 28.1: *Health data – cargo vapour*

The last two columns of the table show how a liquefied gas may affect a person. Broadly, the initial toxic effects on the human body can be corrosive or narcotic (effects on the nervous system). In certain cases, both may apply. In the case of a corrosive compound, depending on exposure and toxicity, its effects may be minor or major. In the case of minor effects, only limited irritation of the skin, eyes or mucous membranes may be felt. An example of a more serious case may be that debilitating effects on the lungs are experienced. In the case of exposure to a narcotic gas, the major initial effect is on the body's nervous system. In such cases, severe disorientation and mental confusion can result. The corrosive and narcotic effects are worthy of note. They are of help in identifying the gas to which a person has been exposed, and they also help in identifying proper medical treatment (see section 28.3.3).

Cargo inhibitors				Toxic effects	
Substances	**Flammable**	**Toxic**	**Typical TLV-TWA (ppm)**	**Corrosive/ Irritant**	**Effects on nervous system**
Hydroquinone	Limited	Yes	1	Very	Yes
Tertial butyl catechol	Limited	Yes	–	Very	–

Table 28.1(a): *Health data – cargo inhibitors*

Table 28.1(a) provides similar information to that in table 28.1 but covers the potential hazards of cargo inhibitors. Information on the type of inhibitor used in particular cargoes is in section 27.6.

Substance	Frostbite	Chemical burn
Methane	Yes	–
Propane	Yes	–
Butane	Yes	–
Propylene	Yes	–
Butylene	Yes	–
Isoprene	Yes	–
Butadiene	Yes	–
Ammonia	Yes	Yes
Vinyl chlorine	Yes	–
Etylene oxide	Yes	Yes
Propylene oxide	Yes	Yes

Table 28.2: *Additional health data – cargo liquid (effects on the human body) cargo inhibitors*

This information is discussed further in sections 28.4 and 28.5.

28.2 Flammability

28.2.1 Operational aspects

The single most hazardous aspect of liquefied gases is the flammable nature of their vapours. Much effort is put into tanker design to ensure effective cargo containment to avoid vapours escaping to atmosphere. Tankers and terminals also have design specifications for electrical equipment to ensure that within well-defined operating zones such sources of ignition are eliminated. Furthermore, in the tanker and terminal working environments, operational procedures should apply that limit other possible sources of ignition, such as those described in section 27.22, to areas outside established safe distances (see also section 28.2.2).

All liquefied gases transported in bulk by inland waterways with the exception of carbon dioxide, are flammable. The vapours of other liquefied gases are easily ignited. The exception to this is ammonia, which requires much higher ignition energy than the other flammable vapours. Accordingly, fires following ammonia leaks are less likely than with the other cargoes. However, in practice, it is usual to consider the possibility of ammonia ignition.

28.2.2 Emergency aspects

Because of the rapid vaporisation of spilled liquefied gases, the spread of flammable vapour will be far more extensive than in the case of a similar spill of oil. The chances of ignition following a spill of liquefied gas is much greater. For this reason, many terminals establish ignition-free zones around jetties. The extent of these zones is based on a hazard analysis, taking into account local conditions and involving the dimensions of the gas cloud that could form. To establish the size of a cloud, it is necessary first to estimate the size of the maximum credible spill. This estimation may be carried out in various ways and numerous methods are available. One simplified method is published in the SIGTTO publication *Guidelines for Hazard Analysis.* Results of such estimations at jetties often show the need for safety distances of around several hundred metres.

The hazards to personnel in fighting oil cargo fires are well known and apply generally to liquefied gas fires. There are some points of difference to note (see sections 27.20, 27.21 and 27.22). Because of the rapidity of vapour production, radiation from liquefied gas fires can be intense and fire-fighting should only be attempted when personnel are wearing protective clothing suited for purpose.

28.3 Air deficiency

28.3.1 Toxicity

General

Toxicity is the ability of a substance to cause damage to living tissue, including impairment of the nervous system. Illness or, in extreme cases, death may occur when a dangerous gas or liquid is breathed, taken orally or absorbed through the skin (in general, the terms 'toxic' and 'poisonous' can be considered synonymous).

Some liquefied gases present toxic hazards, principally if the vapours are inhaled. Ammonia, ethylene oxide and propylene oxide, are also very corrosive to the skin. Vinyl chloride is known to cause cancer, and butadiene is suspected to have similar harmful effects.

Incomplete combustion of hydrocarbon vapours may produce the toxic gas carbon monoxide, which is found in inert gas in quantities that can vary with the quality of combustion in the generator. Combustion of vinyl chloride may produce toxic carbonyl chloride (also called phosgene).

Toxic substances are often ranked according to a system of toxicity ratings. One such scale is shown below:

Unknown for products with insufficient toxicity data available.

No toxicity for products causing no harm (under conditions of normal use) or for those that produce toxic effects only because of overwhelming dosages.

Slight toxicity for products producing only slight effects on the skin or mucous membranes or other body organs.

Moderate toxicity for products producing moderate effects on the skin or mucous membranes or other body organs from either acute or chronic exposure; and,

Severe toxicity for products that threaten life or cause permanent physical impairment or disfigurement from either acute or chronic exposure.

In summary, toxic substances may result in one or more of the following effects:

1. **Permanent damage to the body.** With a few chemicals, such serious ill-effects may occur. Vinyl chloride is a known human carcinogen and butadiene is suspected of having similar effects.
2. **Narcotics.** A patient suffering from exposure to a narcotic product can be oblivious to the dangers around him. Narcosis results in ill-effects to the nervous system. The sensations are blunted, clumsy body movements are noticeable and distorted reasoning occurs. Prolonged exposure to a narcotic may result in loss of consciousness.
3. **Corrosion/lrritation** of the skin, lungs, throat and eyes.

Threshold Limit Values

Research into toxicity considers such factors as:

- The length of exposure.
- Whether contact is by inhalation, ingestion or through the skin.
- The stress of the person.
- The toxicity of the product.

As a guide to permissible vapour concentrations in air, such as might occur in terminal operation, various government authorities publish systems of Threshold Limit Values (TLVs). These systems cover many of the toxic substances handled by the gas industry. As published, the TLVs are usually quoted in ppm (parts per million of vapour-in-air by volume) but may be quoted in mg/m^3 (milligrams of substance per cubic metre of air).

The TLV-Time Weighted Average (TLV-TWA) for the main liquefied gases are given in table 28.1. These are provided for illustration and help to identify the relative toxicity of vapours. However, the application of a specific TLV to the workplace is a specialist matter. It is not just the safe level that must be known, it is also the resultant effect on the body that must be understood.

The most widely quoted TLV system is that of the American Conference of Governmental Industrial Hygienists (ACGIH). TLV systems used by advisory bodies in other countries are generally similar in structure. The TLVs in most systems are republished annually and updated in light of new knowledge. The latest revision of these values should be made known to operating personnel by their management.

The ACGIH system contains the following three categories of TLVs that describe the concentration in air it is believed personnel may be exposed to, under certain specific circumstances, without adverse effects:

1. TLV-TWA. This is the concentration of vapour in air that may be experienced for an eight-hour day or 40-hour week throughout a person's working life. It is the most commonly quoted TLV. It shows the smallest concentration (in comparison to (2) and (3) below) and is the value reproduced in table 28.1.
2. TLV-STEL. This is known as the Short-Term Exposure Limit. It is the maximum concentration of vapour in air allowable for up to 15 minutes provided there are no more than four exposures per day and at least one hour between each. It is always greater than (1) above but is not given for all vapours.
3. TLV-C. This is the Ceiling concentration of the vapour in air that should never be exceeded. Only those substances that are predominantly fast-acting are given a TLV-C. Of the main liquefied gases only the more toxic products, such as ammonia and chlorine, have been given such a figure.

As explained earlier, TLVs should not be regarded as absolute dividing lines between safe and hazardous conditions. It is always good operating practice to keep all vapour concentrations to an absolute minimum so limiting personal exposure. It should be remembered that in some countries local legislation differs and this should not be ignored.

28.3.2 Asphyxia (suffocation)

For survival, the human body requires air with a normal content of about 21% oxygen. However, a gas-free atmosphere with somewhat less oxygen can support life for a period without ill-effects being noticed. The susceptibility of people to reduced oxygen levels vary but at levels below about 19% impaired mobility and mental confusion rapidly occur. This mental confusion is particularly dangerous as the victim may be unable to appreciate his predicament. Accordingly, self-assisted escape from a hazardous location may be impossible. At levels below 16% unconsciousness takes place rapidly and, if the victim is not removed quickly, permanent brain damage and death will result.

In general, such a problem is limited to enclosed spaces. Oxygen deficiency in an enclosed space can occur with any of the following conditions:

- When large quantities of cargo vapour are present.
- When large quantities of inert gas or nitrogen are present.
- Where rusting of internal tank surfaces has taken place.

For the above reasons, it is essential to prohibit entry to any space until an oxygen content of 20.9% is established. This can be assured by using an oxygen analyser and sampling the atmosphere from a number of points. These should be at different levels and widely dispersed within the space. As appropriate for the space being entered, tests for (hydrocarbon) gas and carbon monoxide may also be required (see section 10.3).

With regard to table 28.1, some gases are known as asphyxiant gases. This is because they have limited toxic side effects but can be dangerous if present in quantities that exclude oxygen. Accordingly, a casualty having been exposed to these products is likely to be suffering from suffocation. Immediate action is necessary in such cases as outlined in section 28.3.3.

If tank entry is absolutely necessary and the above gas-free condition cannot be ensured, personnel entering the space must be protected by independent breathing apparatus and should follow the advice given in section 10.7.

28.3.3 Medical treatment

The section summarises the symptoms and medical treatment for casualties of asphyxia or from the effects of toxic materials.

Medical treatment for exposure to gas first involves the removal of the casualty to a safe area. Where necessary it may also involve artificial respiration, external cardiac massage and the administration of oxygen. Professional medical treatment should always be sought in cases where casualties have been overcome by gas.

Further advice on these issues is available from the material's data sheets and if available, in the Medical First Aid Guide (MFAG) published by IMO. This publication has a number of associated chemical tables that categorise the main liquefied gases into groups, as shown in table 28.3.

MFAG Table	310 Hydrocarbons	340 Chlorinated hydrocarbons	365 Alipatic oxides	620 Liquefied gases	725 Ammonia
Product	Butadiene	Vinyl chlorine	Ethylene oxide	Methane	Ammonia
	Butane		Propylene oxide		
	Butylene				
	Ethane				
	Ethylene				
	Propane				
	Propylene				

Table 28.3: *Liquefied gas groups – for medical first-aid purposes*

In the MFAG, each of the main categorisations (the top row of table 28.3) has medical first-aid advice attached to it. This is divided into general advice, signs and symptoms and treatment. If a person is affected by any of the gases listed, consult the tables in the MFAG. With regard to medical treatment, the MFAG has advice for:

- Inhalation.
- Skin contact.
- Eye contact.
- Ingestion.

The main points to be remembered in treating patients for gas poisoning or asphyxiation are outlined below (other points are covered later).

Treatment for asphyxia and inhalation of toxic fumes

Remove the casualty at once from the dangerous atmosphere. Ensure that rescuers are equipped with self-contained breathing apparatus so that they do not become the next casualty.

To check that the patient is breathing tilt the head firmly backwards as far as it will go to relieve obstructions and listen for breathing with the rescuer's ear over the patient's nose and mouth.

Patient not breathing:

- Give artificial respiration at once.
- Give cardiac compression if the pulse is absent.

Patient breathing but unconscious:

- Place the patient in the unconscious position.
- Check there are no obstructions in the mouth.
- Remove any dentures.
- Insert an Airway; leave in place until the patient regains consciousness.
- Give oxygen (see the sub-section that follows).
- Keep the patient warm.
- Give no food or drinks.
- Give no alcohol, morphine or stimulant.

Patient conscious but having breathing difficulty:

- Place the patient in a high sitting-up position and keep warm.
- Give oxygen (see the sub-section that follows).

If breathing does not improve despite these measures, then asphyxia or other lung problems may have occurred. In such circumstances, or if the patient's condition deteriorates rapidly, obtain medical advice.

28.3.4 Oxygen therapy

Oxygen resuscitators

Oxygen resuscitators are used to provide oxygen-enriched respiration to help the recovery of victims overcome by oxygen deficiency or toxic gas. The equipment can be taken into enclosed spaces to give immediate treatment to a casualty. Oxygen resuscitators consist of a face mask, pressurised oxygen cylinder and automatic controls to avoid damage to the victim, and give audible warning in the event of airway obstructions.

The equipment is provided with a standard eight-metre long extension hose so that the carrying case (with cylinder and controls) may be securely placed and the mask taken to the victim if he is lying in a confined location. Some tankers provide a further 15-metre extension hose. If the equipment is taken into a contaminated atmosphere, it must be remembered that, if adjustable, the instrument must be set to supply only pure oxygen. When used in a flammable atmosphere, caution is necessary. If the instrument is used when the victim has been removed from the contaminated space, there are means to vary the air/oxygen mix.

Note that the couplings on oxygen resuscitators should not be greased.

Warning: smoking, naked light or fires must not be allowed in the same room during the administration of oxygen because of the risk of fire.

Oxygen must be given with care since it can be dangerous to patients who have had breathing difficulties such as bronchitis.

An accident in which a patient may require oxygen can be divided into two stages:

Stage 1. During rescue

The patient should be connected to the portable oxygen resuscitation apparatus and oxygen administered until transferred to safety.

Stage 2. When the patient is in a safe room

The unconscious patient

1. Ensure there is a clear passage to the lungs and that an *Airway* is in place.
2. Place mask over the nose and mouth and give 35% oxygen.
3. Connect the mask to the flowmeter and set it at four litres per minute.

The conscious patient

1. Ask if the patient suffers with breathing difficulty. If the patient has severe bronchitis, give only 24% oxygen. All others should be given 35% oxygen.
2. The mask is secured over the patient's mouth and nose.
3. The patient should be placed in the high sitting-up position.
4. Turn on the oxygen flowmeter to four litres per minute.

Oxygen therapy should be continued until the patient no longer has difficulty in breathing and has a healthy colour. If the patient has difficulty in breathing, or if the face, hands and lips remain blue for longer than 20 minutes, seek urgent medical assistance.

Additional measures necessary after exposure to toxic vapours include:

- The removal of affected clothing.
- Eye washing.
- Skin washing.

28.4 Frostbite

The extreme coldness of some liquefied gases is a significant hazard. If the skin is exposed to severe cold, the tissue becomes frozen. This danger is ever-present in gas terminals and on a tanker handling fully refrigerated cargoes. For fully pressurised gases, while containment systems will normally be at or near ambient temperature, liquid leaks will quickly flash to the fully refrigerated temperature. Such areas should never be approached without proper protective clothing.

The symptoms of frostbite are extreme pain in the affected area (after thawing), confusion, agitation and possibly fainting. If the affected area is large, severe shock will develop.

Initial symptoms

- The skin initially becomes red, but then turns white.
- The affected area is usually painless.
- The affected area is hard to the touch.
- If the area is left untreated, the tissue will die and gangrene may occur.

Treatment

- Warm the area quickly by placing it in water at 42°C until it has thawed.*
- Keep the patient in a warm room.
- Do not massage the affected area.
- Severe pain may occur on thawing: give a pain killer or morphine if serious.
- Blisters should never be cut, or clothing removed if it is firmly stuck.
- Dress the area with sterile dry gauze.
- If the area does not regain normal colour and sensation, obtain medical advice.

* As immediate action is necessary, and without warm water close to hand, in the first instance the affected part can be warmed with body heat or woollen material. If a finger or hand has been affected, the casualty should hold his hand under his armpit. Blood circulation should be allowed to re-establish itself naturally. If appropriate, the casualty should be encouraged to exercise the affected part while it is being warmed.

28.5 Chemical burns

As shown in table 28.2, chemical burns can be caused by ammonia, ethylene oxide and propylene oxide. The symptoms are similar to burns by fire, except that the product may be absorbed through the skin causing toxic side-effects. Chemical burning is particularly damaging to the eyes.

Symptoms

- A burning pain with redness of the skin.
- An irritating rash.
- Blistering or loss of skin.
- Toxic poisoning.

Treatment

- Attend first to the eyes and skin.
- Wash the eyes thoroughly for ten minutes with copious amounts of fresh water.
- Wash the skin thoroughly for ten minutes with copious amounts of fresh water.
- Cover with a sterile dressing.

Otherwise, the treatment is as for burns, details of which are contained in the IMO *Medical First Aid Guide.*

On gas carriers authorised to transport these products, deck showers and eye baths are provided for water dousing. Their locations should be clearly indicated.

28.6 Hazardous atmospheres

28.6.1 The need for gas testing

The atmosphere in enclosed spaces must be tested for oxygen, explosive and toxic contents in the following circumstances:

- Before entry by personnel (with or without protective equipment).
- During gas-freeing, inerting and gassing-up operations.
- As a quality control or cleaning/purging before changing cargoes.
- To establish a gas-free condition before dry dock or tanker repair yard.

The atmosphere in a cargo tank is rarely, if ever, homogeneous. With the exception of ammonia and methane, most cargo vapours at ambient temperatures are denser than air. This can result in layering within the cargo tank. Internal structures can also hold local pockets of gas. Whenever possible, samples should be drawn from several positions within the tank.

Note: always start with such tests from the deck. With smaller tanks, such as inland waterway vessels, it may be enough to test from the deck only.

Atmospheres that are inert or deficient in oxygen cannot be checked for flammable vapours with a combustible gas indicator. So oxygen concentrations should be checked first, followed by checks for flammable and then toxic substances. All electrical instruments used should be approved as intrinsically safe.

28.6.2 Oxygen analysers

Several different types of oxygen analyser are available. Refer to sections 2.4.9 and 2.4.10 for a description of typical analysers in use.

28.6.3 Combustible gas indicators

Refer to section 2.4 for descriptions of various types of combustible gas indicators.

28.6.4 Toxicity detectors

Refer to section 2.4.7 for a description of toxic gas detectors.

29 Static electricity

This chapter describes hazards of static electricity.

The risks presented by static electricity discharges occur where a flammable atmosphere is likely to be present.

29.1 Electrostatics

As with many other hydrocarbon liquids, a static electrical charge can be built up within a liquefied gas as it is being pumped. It has been found that the charge will increase as pumping velocity rises. That is, when the flow rate through the cargo piping increases.

This phenomenon occurs due to a (electrostatic) charge difference between layers within the fluid. The charge is then retained for some time within the liquid mass by its non-conducting property.

The danger of such charges is that they have the potential to create incendive sparks. Particularly in cargo tanks, electrical arcing is possible. Therefore, it is vital that the handling of liquefied gas cargoes only takes place in cargo tanks having atmospheres outside the flammable range.

Problems with static electricity can also arise within vapour flows but only when the gas is contaminated with debris, dust particles or when a condensed mist is present. In such cases it is the debris (or the mist that forms as it exits to atmosphere) that attains a static charge. Vapours that can attain a static charge in this way include carbon dioxide (as a fire extinguishing agent) and steam.

Liquid hydrocarbons that are most prone to static build-up are called static accumulators. Refer to the guidance in chapter 3.

30 Fire-fighting

This chapter discusses events that may follow cargo spills and the procedures to be adopted to protect life and property in such circumstances.

It also describes the types of fire that may be encountered on a gas tanker.

30.1 The principal hazards

The products transported by gas tankers are either flammable or toxic or even both.

Gasses are transported in a liquefied state. They are therefore stored and handled at sub-zero temperatures or under pressure. When the gasses are released, the main hazards are vapours, flammability, toxicity and the effects of sub-zero temperatures on personnel and structures.

30.1.1 Flammability

As already described in section 27.20, when a gas is released to atmosphere, if within its flammable range and if exposed to a source of ignition, it will burn. Depending upon the conditions under which combustion takes place, some degree of over-pressure will occur due to the rapid expansion of the heated gas.

A liquid spill or vapour cloud burning over open water will develop little over-pressure due to the unconfined nature of the surroundings. A slight pressure surge may arise, and a significant heat radiation. At the other extreme, the ignition of vapour within an enclosed space will rapidly create an over-pressure enough to burst or deform the boundaries. This can result in significant damage.

A leak of liquid or vapour from a pipeline under pressure will burn, if ignited, as a jet that will continue as long as fuel is supplied.

A particularly destructive form of vapour burn associated with the storage of liquefied gas in pressurised containers is the BLEVE. This is described in section 27.20. So far, no known cases of a BLEVE have taken place on a ship.

30.2 Liquefied gas fires

30.2.1 General

It is not proposed in this guide to deal with fires that can occur in terminal buildings, store rooms, the tanker's accommodation or machinery spaces. The characteristics and methods of fighting such fires are covered elsewhere. As long as cargo containment is not ruptured and adequate firefighting systems are present, it is rare for such fires to spread to the cargo.

Cargo-related fires may be broadly categorised as:

- Jet fires from leaks at pumps or pipelines.
- Fires from confined liquid pools.
- Fire from unconfined spills.
- Fires in enclosed spaces, such as compressor rooms.
- Manifold fires.

30.2.2 Jet fires

Small leaks from pump glands, pipe flanges or from vent risers will initially produce vapour. This vapour will not ignite spontaneously but if the escape is large, there may be a risk of the vapour cloud spreading to a source of ignition. All openings of spaces facing the cargo area or the dangerous area should always be closed. If necessary, they may be opened for a short period, but must be closed immediately afterwards. Furthermore, the vapour cloud should be directed or dispersed away from ignition sources by fixed or mobile water sprays (see 30.3.1).

If ignition occurs, it will almost certainly flash back to the leak. Leaks from pipelines are likely to be under pressure and, if ignited, will give rise to a jet flame. An emergency shutdown of pumping systems and closure of ESD valves should have already occurred, but pressure may persist in a closed pipeline until the liquid trapped within has been expelled through the leak. In such a case, the best action is often to allow the fire to burn out. The alternative of extinguishing the fire has a high risk of further vapour cloud production and flash back causing re-ignition. While the fire is being allowed to burn itself out, the surroundings should be protected with cooling water.

Only professional firefighters normally succeed in extinguishing hydrocarbon fires with water. Due to the cooling effect, activating a spray or sprinkler system is of great importance to keep a fire manageable.

30.2.3 Liquid (pool) fires

Significant pool fires are not likely on tanker decks because the amount of liquid that can be spilled in such a location is limited. The arrangement of the deck, with its camber and open scuppers, will allow liquid spills to flow quickly and freely away over the side. In case of cargo leaks, open scuppers on gas carriers are an important feature to allow cold liquids to escape quickly, so reducing the risk of metal embrittlement and the possibility of small pool fires on a tanker's deck. If spilled liquid flows overboard it can spread over the water surface and be ignited. This way the fire can also reach the accommodation, adjacent vessels or the berth. Extra vigilance is required when liquid spills overboard.

Prompt initiation of ESD systems and fire-fighting installations further limits the effects of spilled cargo considerably.

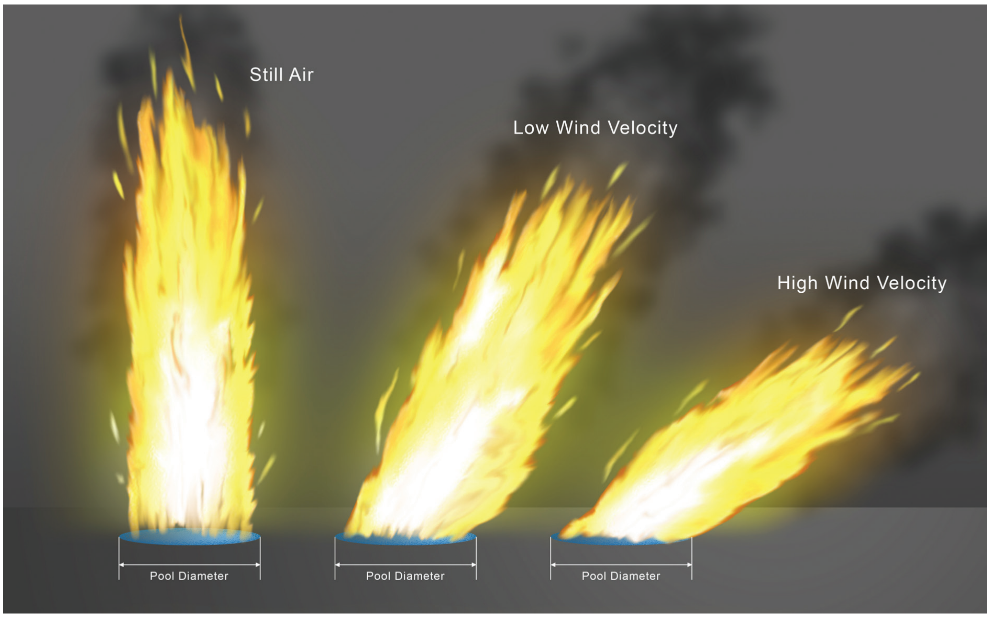


Figure 30.1: *Pool fire configurations*

A liquid spill on shore, from tank or pipeline ruptures may involve large quantities but should be contained in bunded areas or culverts. In a terminal area, pipe systems are most of the time located besides the roads. Any ignition of the ensuing vapour cloud would then result in a pool fire. The flame height from such a fire, in the absence of wind, is as illustrated in figure 30.1. This also illustrates the effect of wind in deflecting the axis of the flame and in shortening flame-length. The emissive power of a flame surface increases with pool diameter. Heat radiation levels of LPG pool fires dictate that unprotected personnel must escape from the immediate vicinity as quickly as possible.

Heat radiation from a fire falls away approximately as the inverse square of the distance between the object and the flame. The human body will feel extreme pain on bare skin after only ten seconds of incident radiation of 6kW/m^2 and will suffer severe blistering after ten seconds exposure to 10kW/m^2. Incident radiation greater than 10kW/m^2 will quickly vaporise PVC cables and will seriously affect fibreglass lifeboats. The estimation of safe distances from a pool fire involves complex factors but, for a large pool fire such safe distances are likely to be some tens of metres.

Because of the damage that radiation can inflict on surrounding tanks and plant, such equipment is always protected (often by insulation or by remotely operated water deluge systems). Also, the bunds, culverts and pipe systems where pool fires may occur are often provided with remotely operated dry powder installations. Alternatively, they may be fitted with a high-expansion foam system for rapidly building up and maintaining a depth of foam to control the rate of burning.

30.2.4 Fires in compressor rooms

Enclosed spaces containing cargo plant such as compressors, heat exchangers or pumps will normally be provided with a fixed and remotely activated fire extinguishing system, such as extinguishing gas systems with carbon dioxide, novec1230 or Fm200. In case of fire, these systems should be immediately effective.

30.2.5 Manifold fires

Manifold fires may consist of a jet fire (see 30.2.2) as a result of a leak from the manifold flanges, or of a pool fire from a drip tray (see 30.2.3), although the amount of liquid in a drip tray is comparably small. Prompt initiation of ESD procedures further limits the availability of liquid cargo and can prevent further expansion of the incident.

30.3 Liquefied gas fire-fighting

30.3.1 Extinguishing mediums

There are a number of established and proven methods for dealing with gas fires, but to be effective the appropriate extinguishing medium must be used. Unless someone knows to stop the outflow, often only professional firefighters manage to extinguish a gas fire.

Water
Water should never be applied to a burning liquefied gas pool. This would provide a heat source for more rapid vaporisation of the liquid and increase the rate of burning. Nevertheless, water remains a prime fire-extinguishing medium for liquefied gas fire-fighting. Abundantly available, water is an excellent cooling agent for surfaces exposed to radiation or direct fire impingement. Also, it may be used in spray form as a radiation screen to protect fire-fighters. In some circumstances, water can be used to extinguish a jet of burning gas, but this is not always desirable.

Fixed water deluge systems are customary for surfaces such as tankers' structures, deck tanks and piping, shore storage tanks, plant and jetties. Such systems are designed to supply a layer of water over the exposed surfaces and so provide a useful cooling effect. Provided a water layer of some thickness can be maintained, the surface temperature cannot exceed 100°C. Application rates vary with the distance of the structure to be protected from the envisaged fire source and range from two to ten or more litres of water per square metre of protected surface.

Water spray from fixed monitors or from hand-held hose nozzles can provide radiation protection for personnel in their approach to shut-off valves. Additionally, they can provide protection when approaching jet fires in order to deliver more effectively an attack by dry chemicals to extinguish the flame.

A special application of water sprayed from hoses is to deflect an unignited vapour cloud away from ignition sources.

Dry chemical powders
Dry chemical powders such as sodium bicarbonate, potassium bicarbonate and urea potassium bicarbonate can be very effective in extinguishing small LPG fires.

It is also usual for jetty manifold areas to be protected by substantial portable or fixed dry powder systems. Dry chemical powders are effective in dealing with gas fires on deck or in extinguishing jet fires from a holed pipeline.

Dry chemicals attack the flame by absorbing free radicals in the combustion process but have a negligible cooling effect. Re-ignition from adjacent hot surfaces should be guarded against by cooling any hot areas with water before extinguishing the flame with dry powder.

Foam
High-expansion foam, adequately applied to the surface of a (burning) liquid pool, suppresses the radiation from the flame into the liquid beneath and reduces the vaporisation rate. Consequently, the intensity of the pool fire is limited. Continuous application is required to maintain a thick layer of foam. High-expansion foam of about five-hundred to one expansion ratio has been found to be the most effective for this purpose.

However, foam will not extinguish a liquefied gas fire and, while effective for the above purposes, requires to be applied to a substantial depth. For liquefied gases foam is only appropriate for use in bunded areas and for this reason is only found at terminals and is not provided on gas carriers.

Extinguishing gas (e.g. inert gas, Novec1230, Fm200 and carbon dioxide)
Inert gas or nitrogen is commonly used on seagoing gas carriers and in terminals for the permanent inerting of inter barrier spaces or for protective inerting of cargo-related spaces. These spaces can include tankers' hold spaces or enclosed plant spaces (on shore) that are normally air-filled but in which flammable gas may be detected.

For European inland gas tankers it is legally not required to inert the hold spaces.

In engine rooms the extinguishing gas (high-pressure bottled carbon dioxide gas, novec1230 or Fm200) is injected through multiple nozzles. Before activation of the firefighting system, the mechanical ventilation system and ventilation openings to the space must be shut off. Before the system is activated a visual and audible signal must be given and personnel should immediately leave the area.

While carbon dioxide injection systems are effective in enclosed spaces, they have two disadvantages. Their fire extinguishing action is achieved by displacing oxygen in the space that is protected, but it has no cooling effect. Secondly, the injection of carbon dioxide produces electrostatic charging, which can be an ignition hazard if carbon dioxide is injected inadvertently or as a precautionary measure into a flammable atmosphere.

After carbon dioxide or another extinguishing gas has been injected into an enclosed space, the boundaries of the space should be kept cool, usually with water sprayed from a hose. The space should remain sealed until it is established that the fire is extinguished and has cooled enough so that it will not re-ignite with the introduction of oxygen.

30.3.2 Training

For effective use of any of these systems, a thorough knowledge of the capabilities of each is essential. Speed in correctly tackling a fire is vital if escalation is to be minimized, and life and property safeguarded. This knowledge can only be achieved by a serious approach to training by personnel and crew. Training of ship and shore personnel who may have to lead a fire party should be given in shore-based fire schools where fire-extinguishing techniques can be demonstrated and practised. The training should be consolidated by frequent exercises on board and in terminals. These should be realistically staged.

Proper maintenance of fire-fighting equipment is also of importance. Inspection and maintenance should be incorporated into on board and on-site training programmes and these aspects should help to familiarise personnel with the equipment and to provide them with a fuller understanding of its operation. In addition, much fire extinguishing material is subject to annual or biannual inspections. Official inspection reports must be available at the terminal or on board for monitoring purposes.

30.3.3 Immediate measures

A liquefied gas fire may only occur after liquefied gas has been spilled. So preventing a spill is a prerequisite. In addition, securing electrical equipment and other sources of ignition are of great importance, even if these are designed as explosion-proof.

It is very important to raise the alarm onboard and ashore. Then professional help can be initiated. It is inadvisable to solely fight a fire with water sprays or other means. Unless it is a small fire that can be extinguished with powder, normally it is unsuccessful to solely extinguish a fire.

Immediate actions include:

- Activate emergency stop.
- Alert crew.
- Alert terminal and authorities.

In what order this is done will depend on the location where the on-duty crew member is located at the time of the occurrence of the emergency situation. Valuable time will be lost if the alarm is not raised immediately.

Alerting the terminal or vessel traffic post must be done as quickly as possible because then additional help will be provided.

31 Shipboard systems

This chapter describes the principle tanker systems that are used during cargo and ballast operations in port.

It also covers gas carrier cargo handling equipment and related instrumentation. It reviews pipeline and valve design issues and considers cargo pumps and ancillary equipment on board gas tankers. The inert gas generation equipment is also covered.

31.1 Cargo pipelines and valves

31.1.1 Cargo pipelines

Gas carriers are fitted with liquid and vapour manifolds. These are connected to liquid and vapour pipelines (see figure 31.1) with branches leading into each cargo tank. The liquid loading line is led through the tank dome to the bottom of each cargo tank. The vapour connection is taken from the top of each cargo tank.

Cargo pipelines are not allowed beneath deck level on gas carriers. All pipe connections to tanks must be taken through the cargo tank domes that penetrate the main deck. Vapour relief valves are also fitted on the tank domes. These are piped to the vent riser via a vent header. The vent risers on seagoing tankers are fitted at a safe height and distance. On inland tankers, because of their air draft in relation to their bridges, they at a much lower height above the deck. This in line with relevant legislation.

The design and fitting of cargo pipelines must allow for thermal expansion and contraction. This is best achieved by the fitting expansion loops or by using the natural geometry of the pipework. In a few cases, such as blow-off lines of safety relief valves, expansion bellows may be fitted. In normal piping systems, expansion bellows are not desirable because of their vulnerability. Where expansion bellows are fitted in vapour lines, it should be ensured their pressure rating at least meets the liquid pipeline design criteria. The use of bellows in liquid lines is not recommended. Expansion bellows are also often subject to considerable wear and tear while a tanker is in service – in particular, sea-water corrosion must be carefully avoided otherwise pinhole leaks are liable to develop.

It is also important not to alter or adjust adjacent pipeline supports once the tanker has entered into service, since they form an integral part of the expansion arrangements.

Note that parts of pipeline systems are fitted with strong anchor points to resist displacement from surge pressures caused by thermal expansion. Similarly, when replacing parts take care to ensure that the new parts are of the correct material for the service.

Removable spool pieces are taken in or out of pipelines to connect sections of line for special operational reasons, such as using the inert gas plant or ensuring incompatible cargoes are segregated. These spool pieces should not be left in position after use but should be removed and properly stowed as they are likely to be used again. Open flanges must always be closed by a blind flange.

31.1.2 Cargo valves

Isolating valves for cargo tanks must be provided in line with applicable gas codes. The liquid and vapour connections on the tank dome on inland gas tankers should be fitted with a double valve arrangement. This should comprise one manually operated valve and a remotely operated isolation valve fitted in series. There are some possible exemptions, e.g. one manual valve and one excessive flow valve (an excessive flow valve is not used often today). For very small sample points and gauge connections, it is possible to use only one valve. In this case an orifice should be in place to avoid excessive flow. For sampling it is better to fit two small valves in series. Upon sampling, the valve closest to the tank is opened completely. The outer valve is used to control the sampling operation. If the outer valve is frozen and cannot be operated, the other valve should be closed immediately.

Remotely operated emergency shutdown valves are provided at the liquid and vapour manifolds for all gas carriers. These are connected to the emergency shutdown system.

Figure 31.1 shows the piping system on a cargo tank dome, including the valving arrangement. This particular drawing is typical for a semi-pressurised seagoing tanker (5-7 bar maximum tank pressure) and for fully pressurised inland tankers without isolation (15-17 bar maximum tank pressure).

The types of isolation valve normally found on gas tankers are ball, globe, plug or butterfly valves. These valves are usually fitted with pneumatic or hydraulic actuators. Ball valves for liquefied gas service are provided with a means of internal pressure relief. This is usually a hole drilled between the ball cavity and the downstream side of the valve.

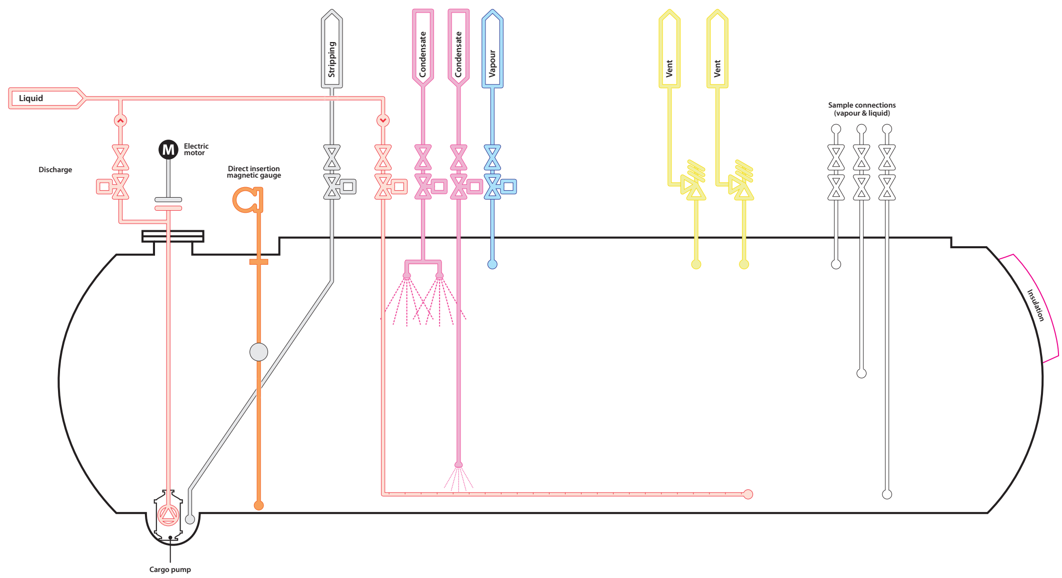


Figure 31.1: *Cargo tank dome piping arrangement*

31.1.3 Emergency shutdown systems

At a number of locations around the tanker (bridge front, gangway, compressor room), push buttons are provided to activate the emergency shutdown system. Normally these are electric push buttons, which should be clearly marked. When operated, these controls close remotely activated valves and stop cargo pumps and compressors (where appropriate). Such emergency shutdown is also required to be automatic upon loss of electric control or valve actuator power. Individual tank filling valves are required to close automatically on the activation of an overfill sensor in the tank to which they are connected. Emergency shutdown valves may be either pneumatically or hydraulically operated but in either case they must be fail-safe. In other words, they must close automatically on loss of actuating (electric or pneumatic) power.

A vital consideration, particularly during loading, is the possibility of surge pressure generation when the tanker's emergency shutdown system is activated. The situation varies from terminal to terminal and is a function of the loading rate, the length of the terminal pipeline, the rate of valve closure and the valve characteristic itself. The phenomenon of surge pressure generation is complex, and its effects can be extreme, such as the rupture of hoses or hard arm joints. Precautions are necessary to avoid damage and loading jetties are sometimes fitted with surge tanks (see section 16.10). Terminals should confirm a tanker's emergency shutdown valve closure times and adjust loading rates accordingly or place on board a means to allow the tanker to activate the terminal emergency shutdown system and halt the flow of cargo before the tanker's emergency shutdown valves start to close (see also section 18.1). In this respect consultation between the ship and shore must always take place to establish the parameters relevant to surge-pressure generation and to agree on a safe loading rate (see also section 22.4 and 22.5). These parameters are registered in a ship-shore safety checklist.

31.1.4 Relief valves for cargo tanks and pipelines

Best practice requires at least two pressure relief valves of equal capacity to be fitted to any cargo tank. This includes a system (e.g. a three-way valve) to avoid both valves being closed at the same time. It is not allowed (on the tank side as on the relief side) to connect valves to the safety relief valves. Both valves must be open during operations. The types of valves normally fitted are spring-loaded. When a safety relief valve is leaking the three-way valve must be operated so that the leaking safety relief valve is closed, and the other safety relief valve remains operational. Normally inland gas tankers have a fixed set of safety relief valves. **If one of the safety relief valves leaks, the operation may continue with one safety valve while the leaking valve is repaired and re-installed.**

Cargo tank relief valves exhaust via the vent header. From there, the vapour is led to atmosphere via one or more vent risers. Vent riser drains should be provided. These drains should be closed and checked regularly to ensure no accumulation of rain water in the riser.

Pressure relief valves on tanks require routine maintenance. For further information on this subject, refer to the manufacturer's literature.

The best practice according to the relevant regulations requires all pipelines that may be isolated when full of liquid to be provided with relief valves to allow for thermal expansion of the liquid. These valves usually exhaust back into cargo tanks (the safest option).

31.2 Cargo pumps

Cargo pumps fitted on inland gas tankers are normally a centrifugal design, such as the deepwell type.

Displacement pumps are not allowed. Some gas tankers can also use a booster pump to realise acceptable discharge speed during high back-pressures.

Pump performance curves
An understanding of pump performance is important when considering the work done by cargo pumps. Figure 31.2 shows a typical set of performance curves for a multistage deepwell pump (see also figure 31.5).

The flow-head curve (curve A)
Curve A shows the pump capacity in terms of flow rate (m^3/h), as a function of the head developed by the pump in terms of metres liquid column (mlc).

This curve is called the pump characteristic. By adopting metres liquid column and flow as the main criteria, the pump characteristic is the same, irrespective of the fluid being pumped. Taking curve A, shown in figure 31.2, the pump will deliver $100m^3/h$ against a head difference of 115mlc between ship and shore tanks. To convert this head into pressure, the specific gravity of the cargo being pumped must be known.

For example, at a head of 105mlc, the increase in pressure across the pump when pumping butane with a specific gravity of 0.60 would be:

105 x 0.60 = 63 mwc (water) = 63/10.2 = 6.2 barg.

(Note that the factor 10.2 in this equation denotes the height, in metres, of a water column maintained solely by atmospheric pressure – see table 27.6.)

The net positive suction head curve (curve B)
Curve B shows the net positive suction head requirement for the pump as a function of flow-rate. This requirement at any flow rate is the positive head of fluid needed at the pump suction above the cargo's vapour pressure to prevent cavitation at the impeller. For example, at a capacity of $100m^3/h$ the net positive suction head requirement for the pump is 0.5mlc. This means that with a flow rate of $100m^3/h$ a minimum head of cargo equivalent to 0.5 metres is required at the pump suction to prevent cavitation. An over-pressure of 0.035 bar in the cargo tank is equivalent to 0.5 metres head when pumping butane.

Net positive suction head considerations are particularly significant when pumping liquefied gases because this fluid is always at its boiling point. Remember that if cavitation is allowed within a pump, not only will damage occur to the impeller but the shaft bearings will be starved of cargo. This will restrict cooling and lubrication at the bearings, so damage will quickly result.

The power consumption curve (curve C)
Curve C shows the power absorbed as a function of pump capacity. This curve is normally given for a specific liquid density and can be converted for any liquid by multiplying by the ratio of specific gravities. Of the cargoes normally transported in gas carriers, vinyl chloride has the highest specific gravity. This is about 0.97 at its atmospheric boiling point (table 27.5 gives details for other liquefied gases). In cases where cargo pump motors have been sized on the basis of LPG and ammonia cargoes, it will be necessary to reduce discharge rates when pumping vinyl chloride in order to avoid overloading the motor. As a rule, the electric motors are protected from excessive loads and automatically switch off in such a case.

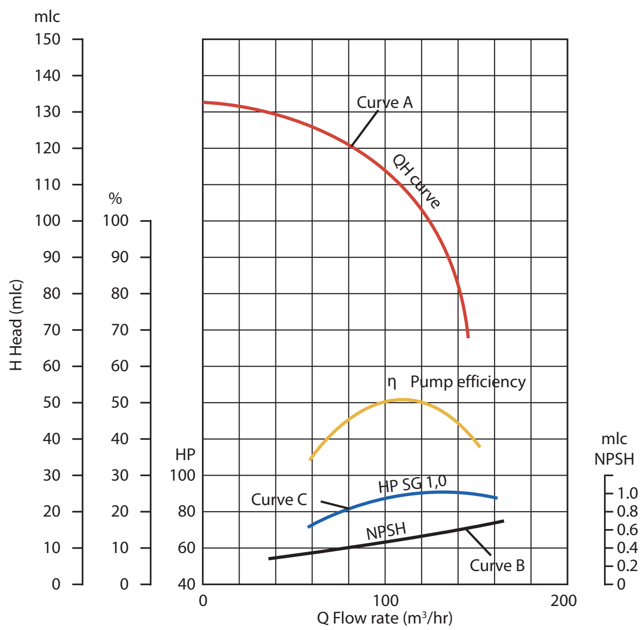


Figure 31.2: *Pump performance curves – a deepwell pump*

Running pumps in parallel and in series
During a gas carrier discharge, cargo pumps are usually run in parallel, but when a refrigerated tanker discharges to pressurised storage, cargo tank pumps are run in series with a booster pump, as in section 32.7.3.

When pumps are run in parallel, their individual pump characteristics can be combined, e.g. to give a flow/head curve for two, three or four pumps when running together. Taking the pump characteristic as given in figure 31.2, the flow/head curve for running two pumps in parallel can be easily plotted by doubling the flow rate at the appropriate head for a single pump. This is shown in figure 31.3. Similarly, when running three pumps in parallel, the flow rate at the appropriate head can be obtained by multiplying the single pump flow rate, at the same head, by three. So a series of curves can be built up from the pump characteristic curve of a single pump.

When pumps are run in series, the individual pump characteristics curves can again be combined to give the appropriate curve for the series configuration. Figure 31.4 shows how this can be done using two similar pumps in series (also see figure 31.2). This time, for each value of flow rate the appropriate head developed by a single pump is doubled to give the resultant head.

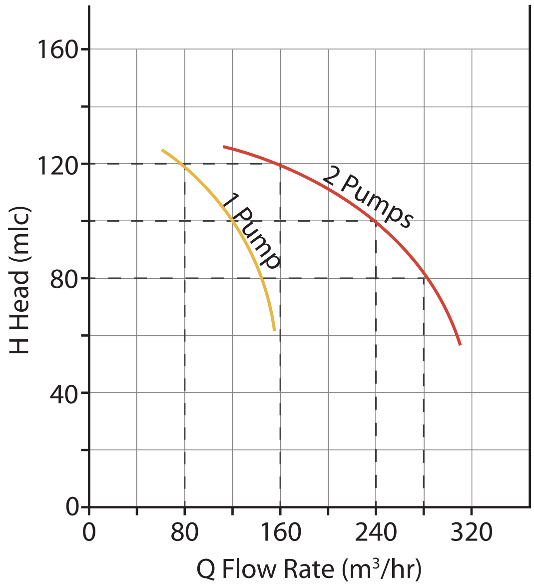


Figure 31.3: *Centrifugal pumps in parallel – combined characteristics*

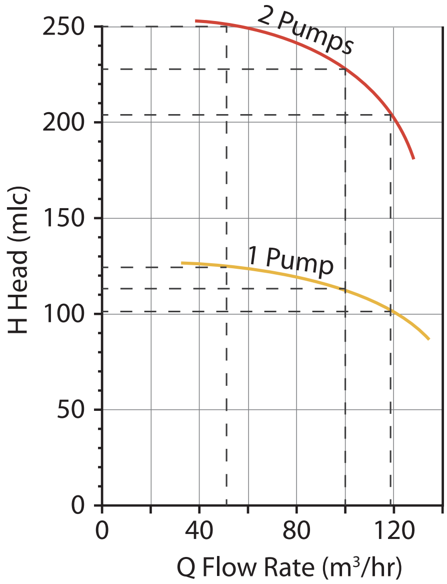


Figure 31.4: *Centrifugal pumps in series – combined characteristics*

These arguments relate only to pump performance. For a full assessment of a tanker's discharge performance the effect of head difference from the cargo tank to the manifold and of pipeline resistance between cargo pump and manifold should be subtracted from pump performance.

The liquid flow rates achieved by any pump or combination of pumps will depend on the back pressure encountered due to static head (difference in liquid levels of receiving tank and tank being discharged) and the resistance to flow in the pipeline.

Remember that the length and diameter of the shore piping on the terminal will create a certain back pressure. This is usually a considerable restriction that limits the pumping capacity of the vessel. The effective discharge speed is significantly influenced.

To determine the flow rate for a particular pipeline set-up, the shore pipeline flow characteristic must be superimposed on the tanker's pumping characteristic. This is dealt with in section 32.7 but note that the system resistance may be steep enough to restrict the flow shown in figures 31.3 and 31.4.

The minimum necessary pumping power should be used to reduce heat input to the cargo and to limit the rise in saturated vapour pressure of the delivered cargo (see section 32.7.2). A rotating pump always emits energy to the cargo, which increases in temperature. This can cause problems with refrigerated cargoes. It is less important with pressurised cargoes.

Deepwell pumps

Deepwell pumps are the most common type of cargo pump for gas carriers. Figure 31.5 shows a typical deepwell pump assembly. The pump is driven electrically or hydraulically (through a sealing arrangement) by a motor that is mounted outside the tank. The drive shaft is held in carbon bearings inside the cargo discharge tube. These bearings are lubricated and cooled by the cargo flow.

The centrifugal impeller is mounted in a small well at the bottom of the cargo tank and frequently comprises two or three stages together with a first stage inducer: this latter is used to minimise the net positive suction head requirement of the pump. Shaft-sealing at the cargo tank dome consists of a double mechanical seal flushed with lubricating oil. This stops cargo leaks to atmosphere. It is important that the motor coupling, thrust bearing and mechanical oil seal are accurately aligned.

The length of the drive shaft can also be a problem, as the longer it gets the more support is needed. Accordingly, it is often found that the largest types of tankers are fitted with submerged pumps.

Submerged motor pumps
Special submersible pumps are only used in large gas tankers. They are electrically driven and are also installed at the bottom of cargo tanks and enable very low pump-down levels to be achieved. Submerged pumps are currently not used in the European inland gas trade.

The pump and electric motor are integrally mounted on the same shaft so eliminating the need for a mechanical seal or coupling. Power is supplied to the motor through specially sheathed cables. Electrical cabling is passed through a hazardous-area junction box in the tank dome and then by flexible cables to the motor terminals. The older mineral insulated copper-sheathed cable used inside cargo tanks has been superseded in modern tankers by flexible stainless steel armoured insulated power cables.

These pumps are cooled and lubricated by cargo flow, so are prone to damage caused by loss of flow. Accordingly, the pump is protected from dry running by safety devices such as an under-current relay, a low discharge pressure switch, or a low tank level switch.

Submerged pumps need to be designed for the particular grades of cargo found on the ship's list of substances to be transported. For example, contrary to the hydrocarbon gases, ammonia is an electric conductor and can also be a particularly corrosive cargo for some materials such as copper wires and electrical insulation. The pump design must take this into account. To preserve the electric motor, pumps used for ammonia have the electric stator enclosed in a can.

Booster pumps
Booster pumps are usually of the centrifugal type. They may be vertically or horizontally mounted on deck in the appropriate discharge line. In these positions, they will be driven by an increased safety (E Exe) electric motor (see section 31.8). The seal-flushing system should be well maintained to ensure continuing reliability. Booster pumps are seldom installed on inland gas tankers.

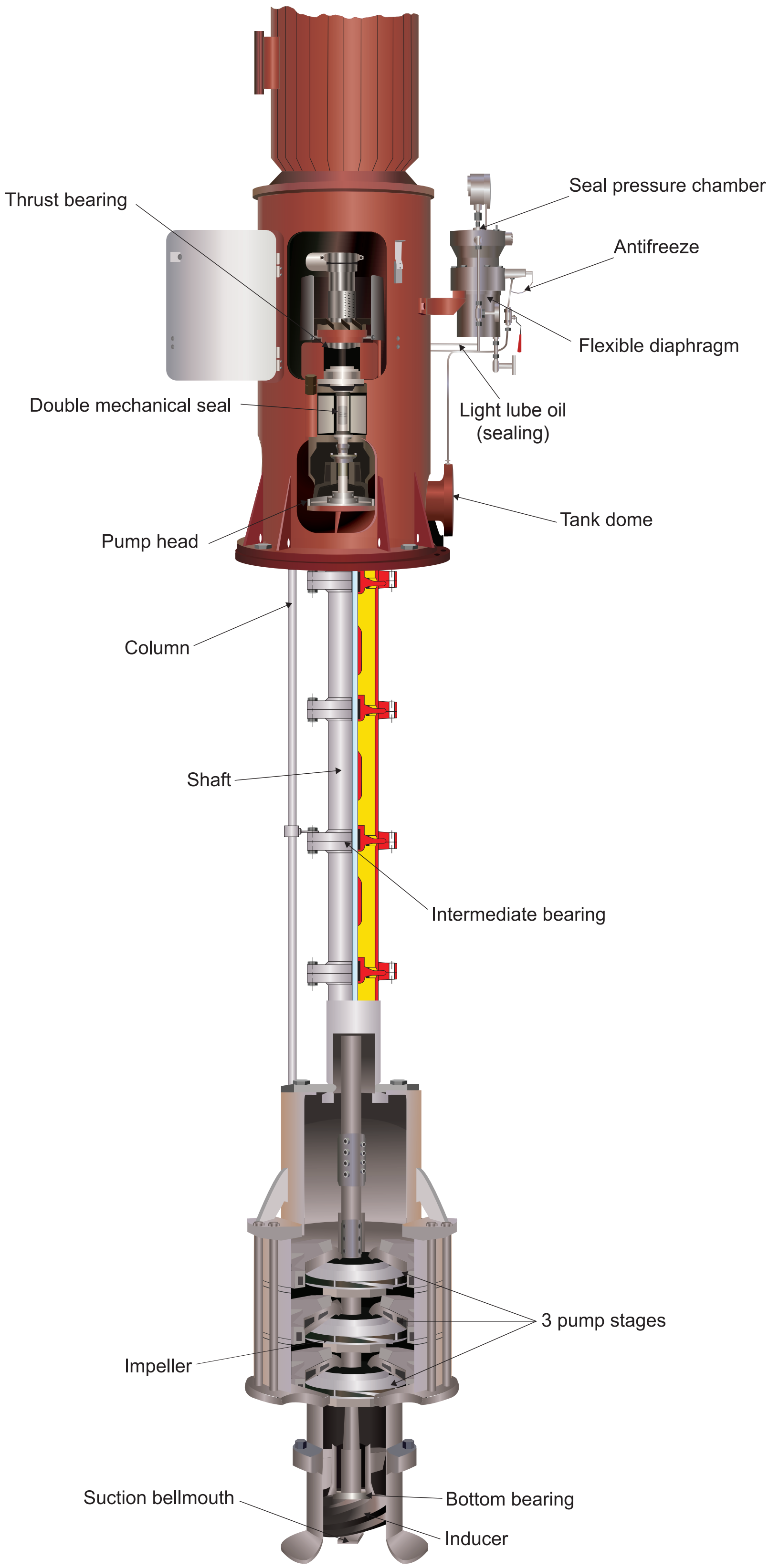


Figure 31.5: *Typical deepwell pump*

Ice prevention at cargo pumps

The formation of ice or hydrates (see section 27.7) may occur in tankers carrying refrigerated or semi-pressurised LPG. Furthermore, hydrates may be transferred from the terminal during loading operations. Hydrates from the shore can be removed by cargo filters in the terminal loading lines.

Hydrate formations may enter cargo pumps, block lubricating passages, unbalance impellers and seize bearings. To prevent such damage, it is common practice to inject a small quantity of freezing-point depressant into the cargo pump to help de-icing.

Commonly used products are methanol, ethanol or propanol. They are normally only necessary with cargoes that are cooled below the solidification point of water.

Because of the danger of contamination to certain LPG cargoes, injecting these products should not normally be allowed without the cargo receivers' agreement.

To prevent freezing-up during the loading of refrigerated liquefied gases, it is recommended to manually rotate the shaft of the pump. This is particularly important if the previous cargo was a non-refrigerated cargo or if the tanks have been open for inspection. During manual rotation the activation switches of the pumps should be secured against operation.

31.3 Cargo heaters

When loading refrigerated cargoes from shore storage, it is usually necessary to heat the cargo to avoid low-temperature embrittlement of the shore tanks and pipelines.

Cargo heaters are normally of the conventional horizontal shell and tube type exchanger. Most often, they are mounted in the open air on the tanker's deck. Harbour water is commonly used as the heating medium and this passes inside the tubes with the cargo passing around the tubes.

The heaters are typically designed to raise the temperature of fully refrigerated propane from -42°C to -5 till 0°C. However, noted that the cargo flow rate at which this temperature rise may be achieved can be significantly reduced in cold water areas. In winter, when water temperatures fall below 5°C, only very slow loading rates may be possible.

Note the requirement for temperature controls and alarms to avoid freezing. This is a very real risk that always has to be guarded against when cargoes with a temperature below freezing point of water are handled with this type of cargo heater.

31.4 Cargo vaporisers

A means of producing cargo vapour from liquid is often required on gas carriers. For example, vapour may be needed to gas-up cargo tanks or to maintain cargo tank pressure during discharge. This latter need will be more obvious in the absence of a vapour-return line from shore. Accordingly, a vaporiser is usually installed on board for these purposes. They are used with either steam, harbour water or electrical elements as the heating source.

31.5 Cargo compressors and associated equipment

The compressor is the heart of the reliquefaction plant. As far as LPG tankers are concerned there are two main types of compressor: the reciprocating type and the screw type.

31.5.1 Reciprocating compressors

Older compressors were sometimes not the oil-free type. This attracted the problems discussed in sections 27.10 and 32.6.1 because many liquefied gases can adversely affect the quality of the lubricating oil used in the machines. In using these older compressors, careful control is required. In particular, sump heating systems are often fitted in order to evaporate any dissolved gases. In addition, changing the lubricating oil between cargoes is usually necessary. Full data on the operation of these compressors should be available from manufacturers' handbooks.

For these reasons, the vast majority of reciprocating cargo compressors now found on board gas carriers are the oil-free type.

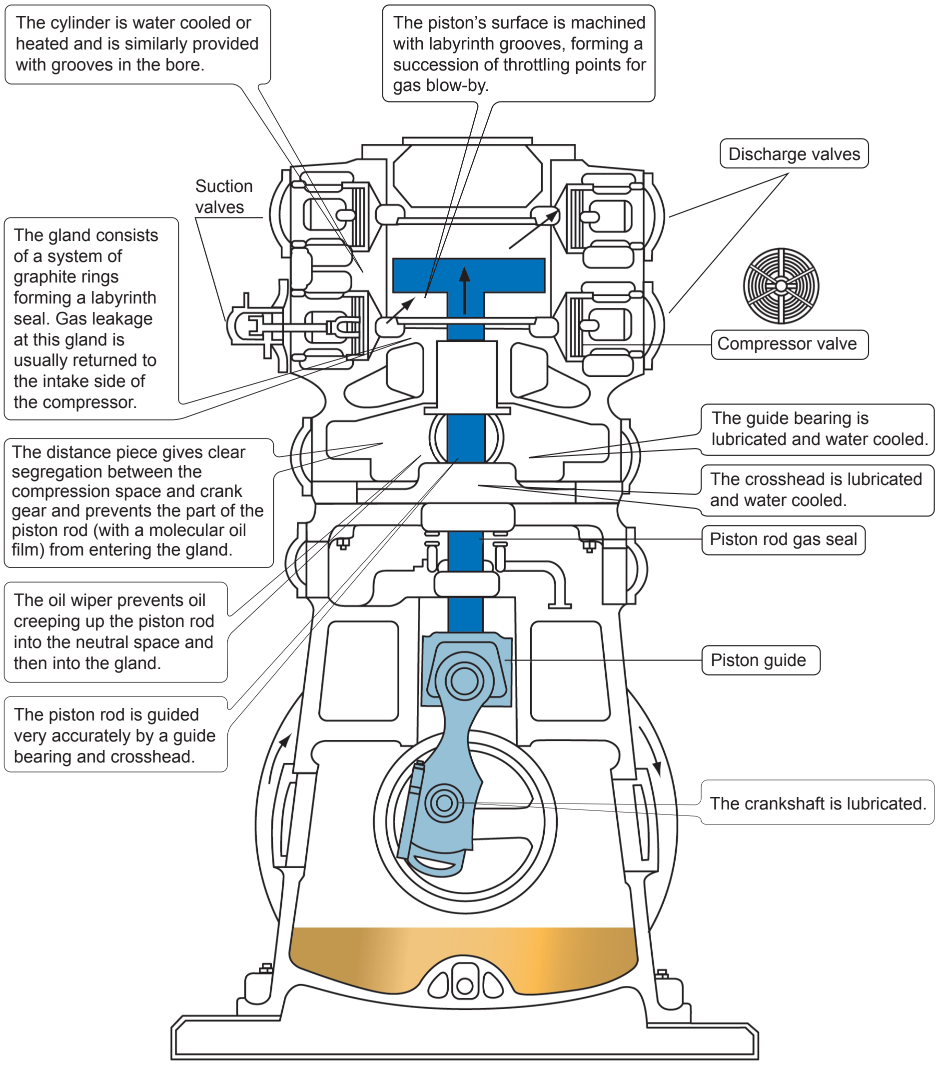


Figure 31.6: *Oil-free compressor*

In the oil-free compressor shown in figure 31.6, sealing between the piston and cylinder wall, and between the piston rod and gland, is achieved by the use of machined labyrinths. Consequently, no lubrication is needed for those spaces in the compressor swept by cargo vapours. The absence of any contact at the seals limits wear, and lubricating oil consumption is minimal. The oil-free side of the compressor and the lubricated crank are separated by oil scraper rings mounted on the piston rod. The rod also carries a ring that prevents any residual oil film from creeping up the rod. The distance between the crank and gland is such that the oily part of the piston rod cannot enter the oil-free gland. Should any gas leak through the gland, it is returned to the suction side. The crankcase and separation space are kept under suction pressure. Where the crankshaft leaves the case, it is fitted with a shaft seal operating in oil.

Although the compressor is oil-free in the compression chamber, it is common practice to change the lubricating oil with each change of cargo. This is to cover the question of compatibility of the lubricating oil grade with the next cargo (see section 32.6.1).

Capacity control of the compressor is achieved by lifting suction valves during the compression stroke. The plate lifters are normally hydraulically operated, with the fluid pressure provided by the lubricating oil pump. When the compressor is shut down, the cargo vapour in the crankcase can condense, causing lubricating problems. To avoid this, provision must be made for crankcase heating when the compressor is idle. When the compressor is running, cooling must be provided for the crankcase, for the crossheads and for the guide bearings. Normally, a closed cycle glycol water system provides the heating (when the compressor is shut down) and cooling (when the compressor is running).

31.5.2 Screw compressors

Screw compressors for use with liquefied gas cargoes can be either dry oil-free or oil-flooded machines. In the dry machines, the screw rotors do not make physical contact but are held in-mesh and driven by external gearing. Due to leaks through the clearances between the rotors, high speeds are necessary to maintain good efficiency (typically 12,000rpm). Figure 31.7 is a diagram of a typical rotor set with the common combination of four and six lobes. The lobes inter-mesh and gas is compressed in the chambers which are reduced in size as the rotors turn. The compressor casing carries the suction and discharge ports.

The oil-flooded machine relies on oil injection into the rotors, which eliminates the need for timing gears. Drive power is transmitted from one rotor to the other by the injected oil. This also acts as a lubricant and coolant. Because the rotors are sealed with oil, gas leakage is much less, so oil-flooded machines can run at lower speeds (3,000rpm). An oil separator on the discharge side of the machine removes oil from the compressed gas.

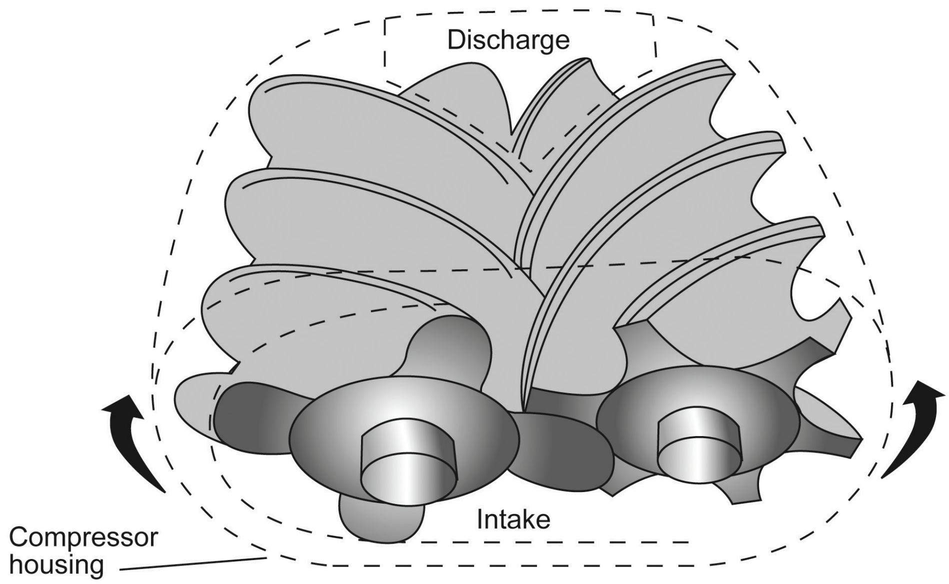


Figure 31.7: *Typical rotor for an oil-free screw compressor*

Capacity control of screw compressors can be achieved in a number of ways. The most common is the use of a sliding valve that effectively reduces the working length of the rotors. This is more efficient than suction throttling. Screw compressors consume more power than reciprocating compressors.

31.5.3 Compressor suction liquid separator

It is necessary to protect cargo vapour compressors against the possibility of liquid being drawn in. Such a situation can seriously damage compressors since liquid is incompressible, so it is normal practice to install a liquid separator on the compressor suction line coming in from the cargo tanks. The purpose of this vessel is to reduce vapour velocity and, as a result, to allow any entrained liquid to be easily removed from the vapour stream. In case of overfilling, the separator is fitted with high-level sensors that set off an alarm and trip the compressor.

31.6 Inert gas and nitrogen systems

As covered in section 27.5, gas carriers use various forms of inert gas and these are:

- Nitrogen from shipboard production systems.
- Pure nitrogen taken from the shore (either by pipeline or road tanker).

31.6.1 Nitrogen production on tankers

The most common system to produce nitrogen on seagoing tankers is an air-separation process. This system works by separating air into its component gases by passing compressed air over hollow-fibre membranes. The membranes divide the air into two streams – one is essentially nitrogen and the other contains oxygen, carbon dioxide plus some trace gases. This system can produce nitrogen of 95 to 99.8% purity. The capacity of these systems depends on the number of membrane modules fitted and depends on inlet air pressure, temperature and the required nitrogen purity. Figure 31.8 shows such a system.

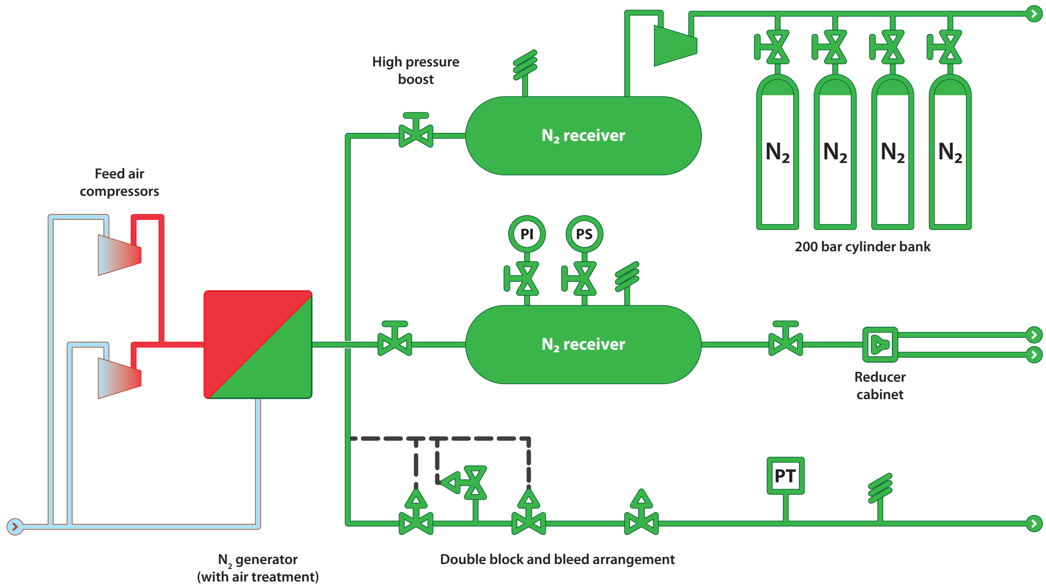


Figure 31.8: *The membrane system for producing nitrogen*

31.6.2 Pure nitrogen from the shore

The quality of inert gas produced by onboard systems is usually inadequate for oxygen-critical cargoes – see the strict in-tank oxygen requirements in table 27.3(b). Bearing in mind the components of the inert gas, this may create restrictions on use if tanks have been previously gas-freed for inspection (which is often necessary when a change in grades is involved). Under these circumstances, and before loading, it is normal for Masters to arrange for cargo tanks to be inerted with pure nitrogen from the shore. This is usually delivered by pipeline, road tanker or barge.

Nitrogen supplied via the piping system and loading arm or hose from shore is always in gaseous form. When delivered via a truck or a barge it is in liquid form. The tanker truck and barge are provided with an evaporator so that the liquid nitrogen can be heated to above 0°C before being fed into the cargo tanks.

When cargo tanks have been opened to the atmosphere for visual inspections at a shipyard, or at other times, it is possible moisture from the air will collect in the individual spaces. This water vapour must be removed from the cargo tank by purging with 'dry' nitrogen. It is important that the temperature of the supplied nitrogen should always be well above 0°C. If the temperature lower than the water, vapour will condensate or freeze on the cargo tank walls. This may cause the next loaded cargo to be off specification (off spec) due to water content.

When purging must be done to a certain dewpoint, it costs more for the nitrogen used.

31.7 Electrical equipment in gas dangerous spaces

Common definitions of safety areas for electrical equipment are:

- **Zone 0:** a flammable mixture continuously present.
- **Zone 1:** flammable mixtures are likely during normal operations.
- **Zone 2:** flammable mixtures are unlikely during normal operations.

Electrical installations on gas carriers are subject to the requirements of the classification society and the relevant regulations. Zones and spaces on tankers are classified as either gas-safe or gas-dangerous, depending on the risk of cargo vapour being present. For example, accommodation and machinery spaces are gas-safe, while compressor rooms, cargo tank areas and holds are gas-dangerous. In gas-dangerous spaces, only approved electrical equipment may be used. This applies to fixed and portable equipment. Several types of electrical equipment are certified as safe for use on gas carriers and are described in the following sections.

Intrinsically safe equipment
Intrinsically safe equipment can be defined as an electrical circuit in which a spark or thermal effect (under normal operation or specified fault conditions) is incapable of causing the ignition of a given explosive mixture.

The limitation of such energy may be achieved by placing a barrier in the electrical supply. This must be positioned in a safe area. Zener barriers are frequently used for this purpose. The voltage is limited by Zener diodes, so the maximum current flow to the hazardous area is restricted by the resistors. The uses of such intrinsically safe systems are normally limited to instrumentation and control circuitry in hazardous areas. Because of the very low energy levels to which they are restricted, intrinsically safe systems cannot be used in high-power circuits, such as actuation of cargo pumps, etc.

Flameproof equipment
A flameproof enclosure can withstand the pressure developed during an internal ignition of a flammable mixture. They are designed so that any flames occurring within the enclosure are cooled to below ignition temperatures before reaching the surrounding atmosphere.

The gap through which hot gases are allowed to escape is critical and great care must be taken in assembling and maintaining flameproof equipment to ensure that these gaps are well maintained. No bolts must be omitted or tightened incorrectly, while the gap must not be reduced by painting, corrosion or other obstructions.

Pressurised or purged equipment
The pressurisation or purging of equipment is a technique used to ensure that an enclosure remains gas-free. In the case of pressurisation, an over-pressure of about 0.5 bar relative to the surrounding atmosphere must be maintained. In the case of a purged enclosure, a continuous supply of purging gas must be provided to the enclosure. Air or inert gas can be used.

Increased safety equipment
The use of increased safety equipment is appropriate for electrically powered light fittings and motors. This equipment has a greater than normal separation between electrical conductors and between electric terminals. Starters are designed to minimise arcing at contactors and to limit the temperature of components. Increased safety motors with flameproof enclosures are frequently used on deck on gas carriers. Here they may be found driving deepwell pumps or booster pumps. In such cases they must be protected by a suitable weatherproof covering. Also see the temperature classification in ADN chapter 3.2, table C, column 15 (temperature class T1 up to T6) and section 3.2.4.3, part G: Determination of temperature class.

31.8 Instrumentation

Instrumentation is an important part of gas tanker equipment and is required for:

- Measuring cargo level (linked with loading computer).
- Pressure.
- Temperature.

- Activation of the emergency shutdown systems.
- Gas detection.

Instrumentation must be carefully selected and be class approved. It should be maintained according to the manufacturer's guidance.

31.8.1 Liquid level instrumentation

The applicable regulations and classification society rules normally require every cargo tank to be fitted with at least one liquid level gauge. Specific types of gauging system are required for certain cargoes.

Classification for gauging systems is:

- Indirect systems – these may be either weighing methods or flow meters.
- Closed devices that do not penetrate the cargo tank – here ultrasonic devices or radio isotope sources may be used.
- Closed devices that penetrate the cargo tank – such as float gauges and radar type gauges.

Float gauges

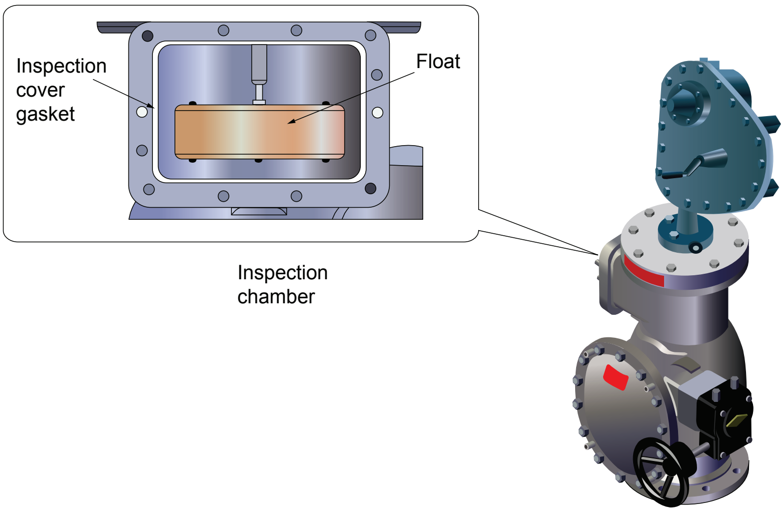


Figure 31.9: *Float level gauge*

The float gauge was widely used on gas carriers but is now being superseded by newer equipment. It consists of a float attached by a tape to an indicating that which can be arranged for local and remote readout. Figure 31.9 shows a typical float gauge installed in a tubular well. Alternatively guide wires may be fitted. Float gauges have gate valves for isolation so that the float can be serviced in a safe atmosphere.

The float must be lifted from the liquid level when not in use. If left down, liquid sloshing, especially in rough conditions, will damage the tape-tensioning device. Float gauges are normally placed in a tank sump or reach to a minimum distance to the tank bottom. In inland tankers the float normally floats on the liquid.

Radar gauges

Another type of tank gauging equipment is designed to operate on the principle of radar. This equipment works at very high frequencies – around 11GHz (11 x 109). Radar type liquid level gauges have now been specially developed for liquefied gases on gas tankers. The equipment provides measurements that meet industry requirements.

These devices are classed as closed devices. This means that when in use no cargo liquids or vapours are released to the atmosphere during level measurement.

31.8.2 Level alarm and automatic shutdown systems

Every cargo tank should be fitted with an independent high-level sensor giving audible and visual alarms. The float, capacitance or ultrasonic sensors may be used for this purpose. The high-high-level alarm – or other independent sensor – is required to automatically stop the flow of cargo to the tank.

During cargo loading, there is a danger of generating a significant surge pressure if the valve stopping the flow closes too quickly against a high loading rate (for more on surge pressure, see sections 31.1.3 and 16.10).

31.8.3 Pressure and temperature monitoring

The applicable relevant regulations should call for pressure monitoring throughout the cargo system. Appropriate positions include cargo tanks, suction and pressure lines of pump and compressor, liquid crossovers and vapour crossovers. Where applicable also on the main cargo lines. Pressure switches are also fitted to various systems to protect personnel and equipment by operating alarms and shutdown systems in case of an emergency.

It is recommended that more than one thermometer be fitted to the cargo tanks to assist with monitoring to prevent undue thermal stresses. The tanker's crew should be aware of the lowest temperatures to which the cargo tanks can be exposed, and these values should be marked on the temperature gauges – especially those at the cargo manifold.

32 Shipboard operations

This chapter looks at the complete cycle of tanker loading and discharging operations, from a gas-free condition until a change of cargo is planned.

When a gas carrier first comes alongside a berth for cargo-handling operations, it is essential that the preliminary procedures be properly completed. In particular, the questions given in the safety checklist should always be addressed. In line with these questions the cargo handling plans should be developed and agreed jointly. Written procedures should also be established for controlling ship/shore cargo flow rates and for procedures covering general emergencies. It is in accordance with these plans that safe operations can be ensured.

32.1 Sequence of operations

Assuming a gas carrier comes directly from a shipyard, the general sequence of cargo handling operations is:

1. Tank inspection
2. Drying
3. Inerting
4. Gassing up
5. Loading
6. Voyage with cargo
7. Discharging
8. Ballast voyage
9. Changing cargo
10. Preparation for tank inspection or dry-docking

Note: Step 4 (gassing up) for certain low-pressure products, such as C4, is often left out.

32.2 Tank inspection, drying and inerting

32.2.1 Tank inspection

Before any cargo operations are carried out, it is essential that cargo tanks are thoroughly inspected for cleanliness, that all loose objects are removed, and that all fittings are properly secured. Any free water must also be removed. Once this inspection has been completed, the cargo tank should be securely closed, and air-drying operations may start.

32.2.2 Drying

When various products are transported pressurised and at a temperature above 0°C, such as butadiene and propylene, extra requirements regarding moisture content are presented.

Whatever method is used for drying, care must be taken to achieve the correct dew point temperature – see table 27.3(b). Malfunction of valves and pumps can be caused due to insufficient drying of the cargo tanks and piping systems. Tank atmosphere drying can be accomplished in several ways. These are described below.

Drying using inert gas from the shore
Drying may be carried out as part of the inerting procedure when taking inert gas (nitrogen) from the shore (see section 31.6). In advance it should be ascertained that all free water has been removed from the cargo tanks and piping systems. When tank walls are wet it is advisable to pre-purge with dry air and to carry out a new tank inspection.

Inerting serves two purposes. To reduce the:

1. Moisture content in the tank atmosphere until the desired dew point.
2. The oxygen content.

If a low dew point is required, the time to reach the dew point can take longer than the time for the required oxygen content.

For various gasses, particularly chemical gases, a much lower oxygen level is required than for LPG. Then purging for the dew point can run roughly equal the purging for oxygen.

For all pressure tanks a leak test must be performed with a certain over-pressure before the actual loading can start.

Drying using inert gas from tanker's plant
Drying and inerting can also be done with the nitrogen generator on board the tanker, if available. Satisfactory drying depends on the specification of the system and its installation. The generator must be of suitable capacity and the nitrogen gas of suitable quality.

32.3.3 Inerting – before loading

Inerting (removal of oxygen) cargo tanks and pipelines is undertaken primarily to ensure a non-flammable condition during subsequent gassing-up with cargo. For this purpose, oxygen concentration must be reduced from 20.9% to a maximum of 5% by volume, though lower values (less than 0.5%) are often preferred – see table 27.3(b).

Another reason for inerting is that for some of the more reactive chemical gases, such as vinyl chloride or butadiene, levels of oxygen as low as 0.1% may be required to avoid a chemical reaction with the available oxygen in the tank atmosphere, which can result in an off-spec cargo. Such low oxygen levels can usually only be achieved by nitrogen inerting provided from the shore (see sections 27.7 and 31.7.2).

There are two ways to inert cargo tanks: displacement or dilution. These procedures are discussed below.

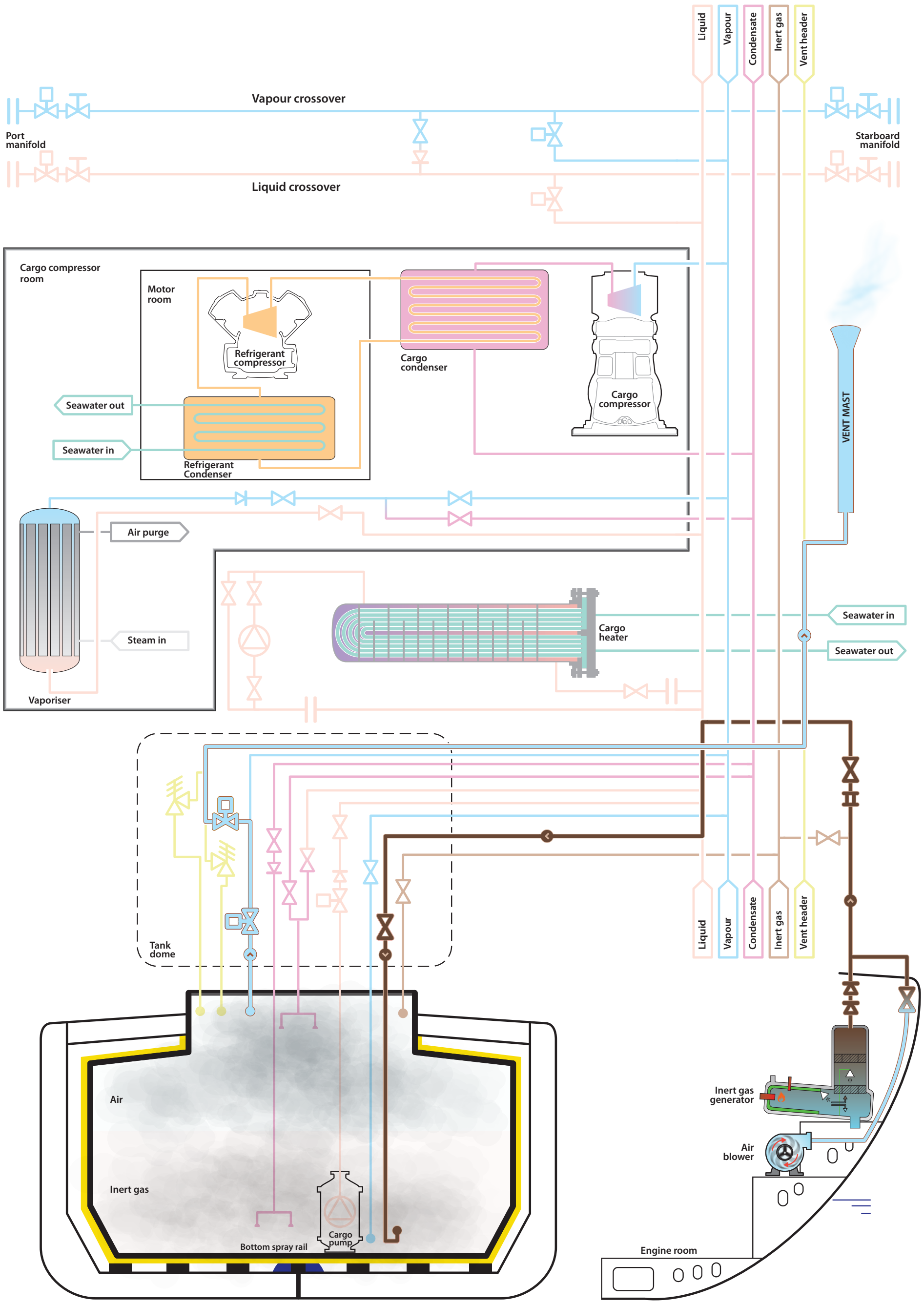


Figure 32.1: *Inerting cargo tanks by the displacement method*

Inerting by displacement

Inerting by displacement relies on stratifying the cargo tank atmosphere based on the difference in vapour densities between the gas entering the tank and the gas already in the tank. The heavier gas (see table 27.5) is introduced beneath the lighter gas at a low velocity to minimize turbulence. If good stratification can be achieved, with little mixing at the interface, then just one tank volume of the incoming inert gas is enough to change the atmosphere.

In practice mixing occurs and it is necessary to use more than one tank-volume of inert gas. This amount may vary by up to four times the tank volume, depending on the relative densities of the gases, together with tank and pipeline configurations. There is little density difference between air and inert gas (nitrogen) (see table 27.4), as nitrogen is slightly lighter than air. These small density differences make inerting by displacement difficult to achieve, and usually the process becomes part displacement and part dilution (discussed below). Depending on the gasses to be removed, purging can also be done 'top in' and 'bottom out' – e.g. during purging cargo tanks from LPG vapours to air.

Inerting by displacement will use the least amount of inert gas and takes the shortest time. However, it is only practical when mixing with the initial tank vapour can be limited. If the tank shape and the position of pipe entries are suitable for displacement, then results will be improved by inerting more than one tank at a time. This should be done with the tanks aligned in parallel. Sharing the inert gas generator output between tanks reduces gas inlet speeds, so limiting vapour mixing at the interface. At the same time the total inert gas flow increases due to the lower overall flow resistance. Tanks inerted in this way should be monitored to ensure equal sharing of the inert gas flow. With this method the inert gas flow must be low in order to prevent mixing in the tank atmosphere.

Inerting by dilution
When inerting a tank by dilution, the incoming inert gas mixes via turbulence with the gas already in the tank. The most used method is pressurisation and relaxing.

Dilution by pressurisation and relaxing
In the case of pressure tanks, inerting by dilution can be done through a process of repeated pressurisation and relaxing. Each repetition brings the tank nearer and nearer to the oxygen concentration of the inert gas. For example, to bring the tank contents to a level of 5% oxygen within a reasonable number of repetitions, inert gas quality of better than 5% oxygen is required. When purging with pure nitrogen this is largely the case. When purging with an onboard inert gas or nitrogen generator this may create a problem.

It has been found that quicker results will be achieved with more repetitions at low pressurisation (1-2 bar) than by fewer repetitions at higher pressurisation.

The optimum arrangement for inerting by dilution will differ from tanker to tanker and may be a matter of experience.

Inert gas – general considerations
Inert gas can be used in different ways to achieve inerted cargo tanks, though no one method is the best since the choice will vary with tanker design and gas density differences. Generally, each individual tanker should establish its favoured procedure based on its piping system and experience. As indicated, the displacement method is best, but its efficiency depends on good stratification between the inert gas and the air or vapours to be expelled. Unless the inert gas entry arrangements and the gas density differences are present, it may be better to choose a dilution method (though its efficiency depends on fast and turbulent entry of the inert gas).

Whichever method is used, it is important to monitor the oxygen concentration in each tank from time to time and from suitable locations, using the vapour-sampling connections provided. To be sure that on the sampling connections the actual tank pressure is measured, properly blow through the sample connections before performing a test. When purging to expel air, the sampling connections can be allowed to blow slowly through continuously. In this way, the progress of inerting can be assessed and assurance eventually given that the cargo tanks and cargo system are adequately inerted.

Nitrogen may be required when preparing tanks to carry chemical gases such as vinyl chloride, ethylene or butadiene. Because of the high cost of nitrogen, the inerting method should be consistent with minimum nitrogen consumption.

Inerting before loading ammonia
Modern practice demands that ships' tanks be inerted with nitrogen before loading ammonia, even though ammonia vapour is not readily ignited.

Inert gas from a combustion-type generator must never be used when preparing tanks for ammonia, as ammonia reacts with the carbon dioxide in inert gas to produce carbamates. Nitrogen needs to be taken from the shore because onboard generators are too small to inert the tanks within an efficient time frame.

The need to inert a ship's tanks before loading ammonia is further underscored by a particular hazard associated with spray loading. Liquid ammonia should never be sprayed into a tank containing air as there is a risk of creating a static charge, which could cause ignition (mixtures of ammonia in air also introduce an additional risk as they can accelerate stress corrosion cracking – see section 27.5).

32.3 Gassing-up

Gassing-up operations are undertaken using cargo vapours supplied from the shore.

Well before a tanker arrives in port with tanks inerted, the Master must consider the following points:

- Is gassing-up allowed alongside the terminal? If so, what is permissible?
- Is a vapour-return facility to a flare available?
- Is liquid or is vapour provided from the terminal for gassing-up?
- Will only one tank be gassed-up and cooled down initially from the shore?
- How much liquid must be taken on board to gas-up and cool-down the remaining tanks?
- Where can the full gassing-up operation be carried out?

Before starting gassing-up operations, the terminal will normally sample tank atmospheres to check that the oxygen is less than 5% for LPG cargoes (some terminals require less than 0.5%) or the much lower concentrations required for chemical gases such as vinyl chloride – see table 27.3(b).

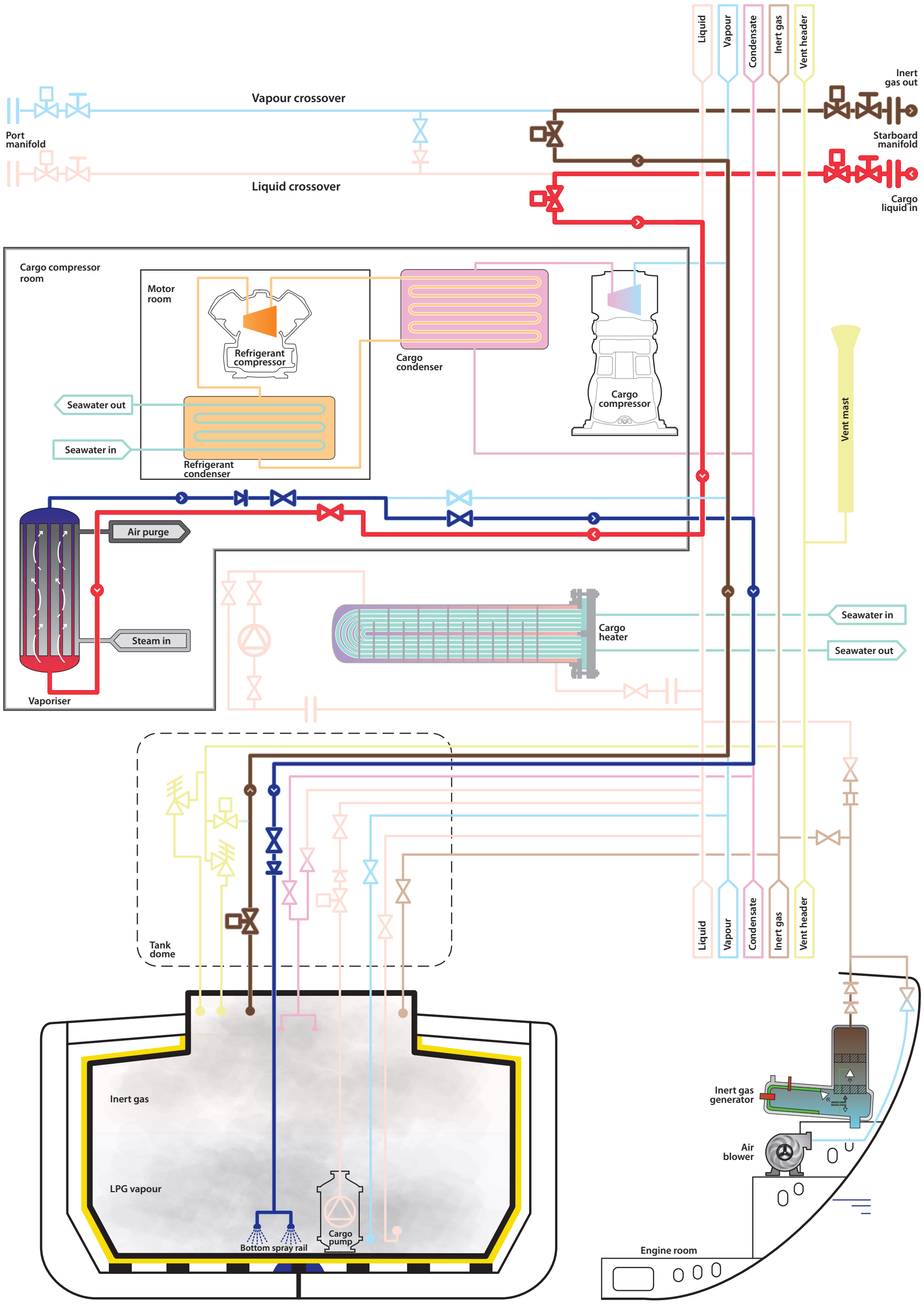


Figure 32.2: *Gassing-up cargo tanks using liquid from shore*

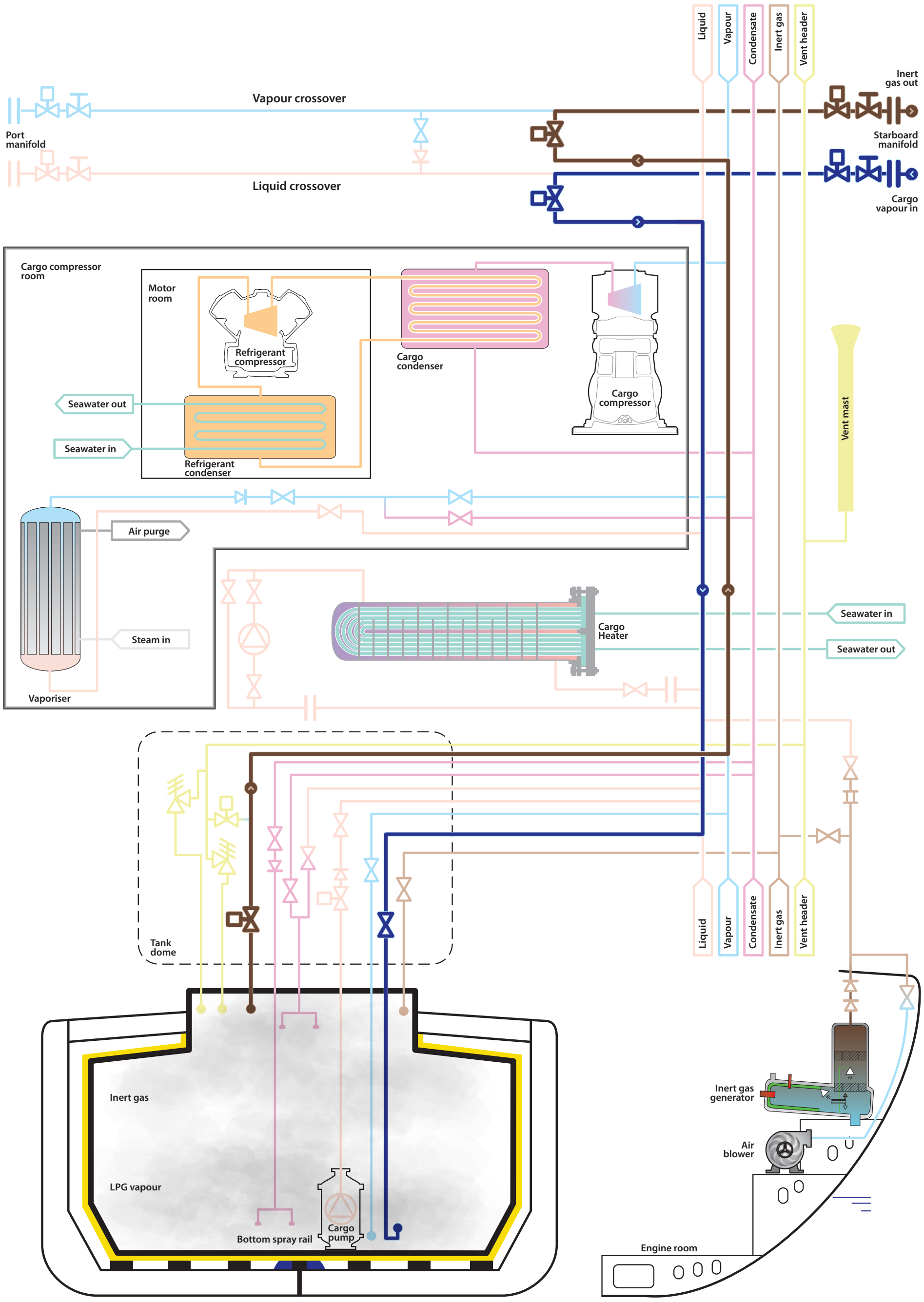


Figure 32.3: *Gassing-up cargo tanks using vapour from shore*

A vapour-return facility, e.g. a flare, must be provided and used throughout the gassing-up operation. In some situations it might be necessary to use the tanker's cargo compressors to maintain the cargo system and tanks in a safe condition. Terminals and port regulations prohibit the venting of cargo vapours to the atmosphere. Venting nitrogen to the atmosphere is normally allowed.

Where a terminal supplies a liquid for gassing-up, it should be loaded at a carefully controlled rate. The liquid may be allowed to vaporise in the ship's tanks. Depending on the boiling point of the product, the pumping of liquid directly in a cargo tank that is under nitrogen can quickly result in very low temperatures. This can suddenly cause local shrinkage stresses in the cargo tank. It can also result in a so-called sub-cooling effect situation.

The correct method is to gas-up the cargo tanks with cargo vapours from the shore or from an onboard evaporator. If vapour is supplied, this can be introduced to the tank at the top or bottom depending on the vapour density (see table 27.5). Figures 32.2 and 32.3 show typical gassing-up operations using liquid from shore and vapour from shore.

If there is no vapour return available from the shore, a method for gassing up with propane (C3) or ammonia (NH_3) is available. It involves selecting one tank and load via the spray line. This will provide a build-up of pressure in the tank. When the working tank pressure is reached, it should then be loaded immediately through the normal main liquid line at maximum capacity. The liquid will boil off until it reaches its partial vapour pressure, because continuously relatively warm product is fed into the tank, the temperature remains within acceptable values. After this action, the vapour pressure in the tank can be fed to the other cargo tanks, until these tanks are also at an acceptable vapour pressure in order to load liquid.

The risk here is a low temperature. Clear agreement with the shore is required that the loading is not interrupted in any case.

This way of work may vary by ship. The responsibility for proper starting procedures and actions remains with the company and the Master.

When a tanker arrives alongside a terminal with tanks containing a cargo vapour that needs to be replaced with the vapour of a different grade, the terminal will normally provide a vapour-return line. The vapours in the cargo tank will dilute until the desired vapour quality is achieved in the tanks.

During gassing-up and loading with the vapour-return, it is very important that all inert gases are discharged as much as possible to the shore. Nitrogen can dissolve in the cargo, especially when the switch from loading via the bottom to loading via the spray line is made too quick – this can result in an off-spec cargo. The lower the temperature, the better nitrogen can dissolve.

32.4 N/A

32.5 Loading

32.5.1 Loading – preliminary procedures

Before loading operations begin, the pre-operational ship/shore procedures must be thoroughly discussed and carried out. Appropriate information exchange is required, and the relevant parts of the safety checklist should be completed. Particular attention should be paid to:

- The setting of cargo tank relief valves and high-pressure alarms.
- Remotely operated valves.
- Compressors and re-liquefaction equipment.
- Gas-detection systems.
- Alarms and controls.
- The maximum loading rates.

This should all be carried out taking into account restrictions in ship/shore systems.

The terminal should provide the necessary information on the cargo, including inhibitor certificates (where inhibited cargoes are loaded (see section 27.6). Any other special precautions for specific cargoes should be made known to tanker personnel. This may include the lower compressor discharge temperatures required for some chemical gas cargoes (see section 32.6). Where fitted, variable setting pressure-relief valves, high-pressure tank alarms and gas-detection sample valves should be correctly set.

The ballast system for gas carriers is totally independent of the cargo system, so deballasting can take place simultaneously with loading, subject to local regulations. Tanker stability and stress are of primary importance during loading. Procedures for these matters are in line with normal tanker practice. Ballasting and deballasting while alongside is prohibited at some terminals owing to stability concerns.

The tanker's safety

Trim, stability and stress

The cargo plan should allow for distribution within the tanker to achieve acceptable structural stress and the required trim to meet safe stability conditions when underway. For these purposes, the weight of the cargo in each tank will need to be known. For tanker-stability purposes, the weight in question is the true weight-in-air.

The weight-in-air of liquefied gases, calculated for cargo-custody purposes, is not exact in that the cargo vapour in these calculations is assumed to be liquid of the same mass as the vapour, so the air buoyancy of the cargo vapour spaces has been neglected. However, for the practical purpose of calculating a tanker's stability, this may be ignored.

As part of the statutory requirements, gas carriers are often provided with stability data, including worked examples showing cargo loaded in a variety of ways. In conjunction with equipment and consumables such as fresh water, spare parts and bunkers on board, provide these stability data (often in the form of a computer program) guidelines to the tanker's crew in order to maintain the ship in a safe and stable condition. Additionally, as part of the requirements to obtain a Certificate of Approval, Ships' Certificate and Class certificate in compliance with the relevant regulations, the stability conditions must be such that, in specified damaged conditions, the tanker will meet certain survival requirements. It is, therefore, essential that all relevant guidance concerning the filling of cargo tanks be observed.

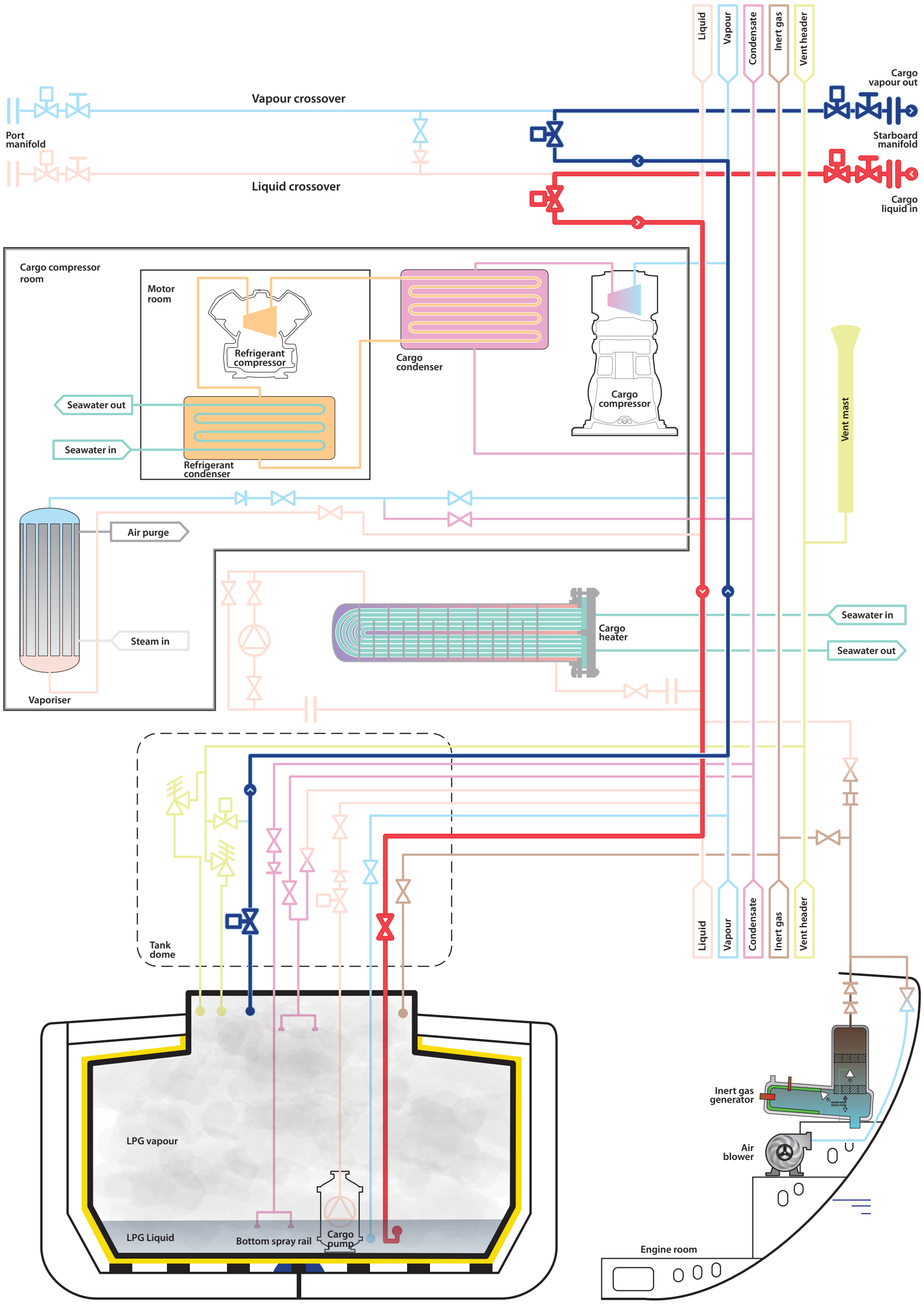


Figure 32.4: *Loading with vapour-return*

32.5.2 Control of vapours during loading

Cargo vapours can be controlled during loading by using a vapour-return line to the shore.

When a vapour-return line is in use during loading, the loading rate is independent of the maximum loading capacity.

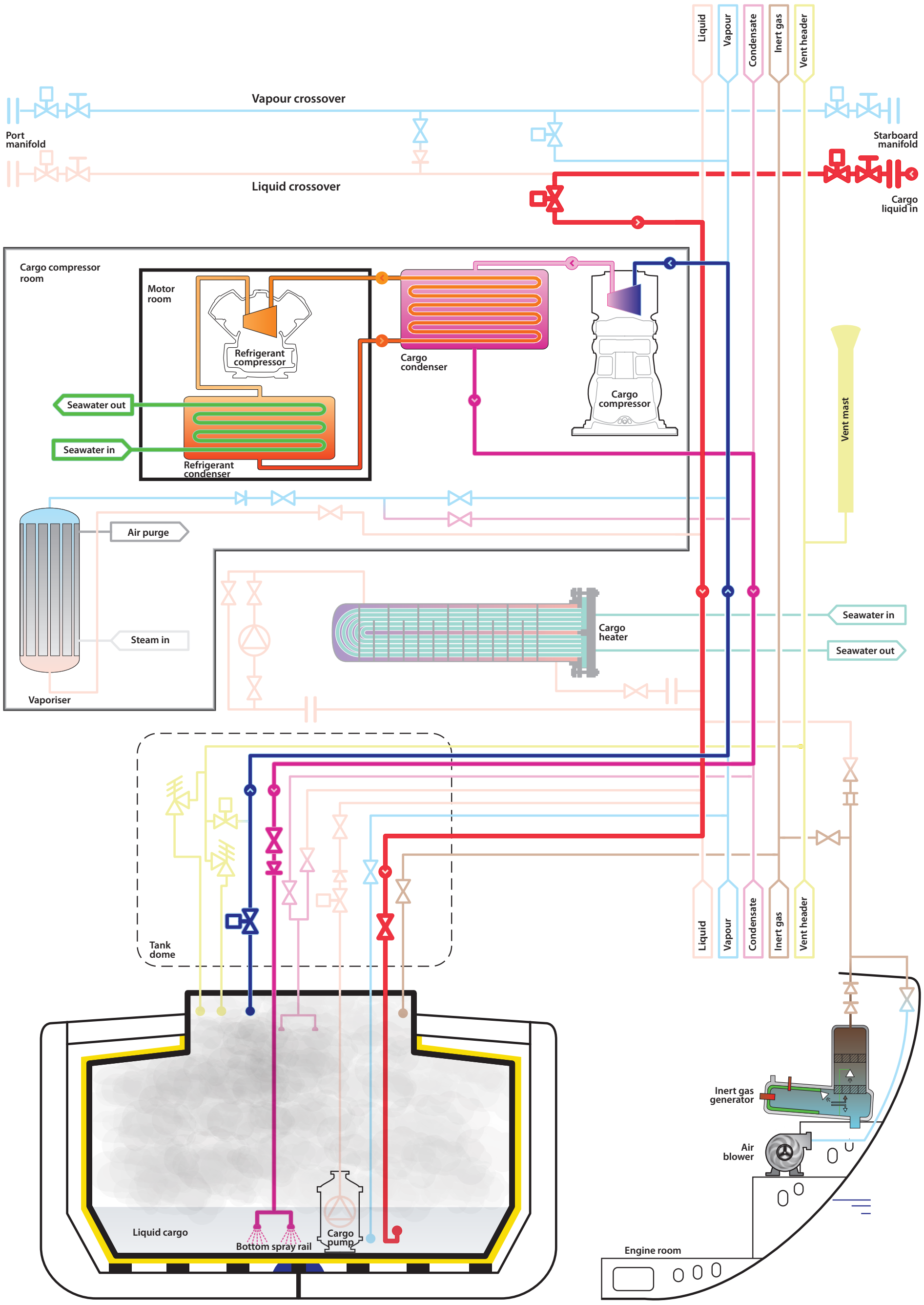


Figure 32.5: *Loading without vapour-return*

For pressurised vessels a vapour-return line is normally not required, unless the tanks are under nitrogen before the loading operation. The loading is normally carried out by the shore pumps, which provide enough pressure to condense the vapour (pressure) continuously in the liquid. However, for security reasons with pressurised vessels, the vapour-return lines are often connected to the shore system.

When using vapour-returns in the LPG trade, terminals can be concerned about the vapour quality returned to the shore, especially during the early stages of loading. Terminal personnel can be concerned about residual nitrogen, which acts as an incondensible during reliquefaction. They may also be concerned about contamination with vapours from previous cargoes. It is difficult to account for the vapour returned to shore, especially if it is flared. This can lead to an overstatement of the Bill of Lading quantity unless credit is given for the returned vapour. For these reasons it is unusual to find LPG terminals accepting return gas other than for safety reasons and then only to a flare.

32.5.3 Loading – early stages

Loading pressurised tankers

Pressurised tankers normally arrive at the terminal with their cargo tanks under the corresponding vapour pressure on the previous cargo, or lower if during the last discharge operation the compressors are used to discharge the vapours to the shore.

Firstly, the tanker requests vapours from the shore to purge any remaining nitrogen or contaminants from the tanks. This also allows the equalisation of tanker and shore pressures. Then the method used is to start loading in one tank at a high-flow rate via the bottom line to avoid local low temperatures.

In this case, local flash-cooling can occur as the liquid is loaded, so it is important to ensure tank or pipeline temperatures are never allowed to fall below design limitations.

Loading pressurised tankers from refrigerated storage

The cargo tanks on fully pressurised tankers are made from carbon steel, which is only suitable for a minimum temperature of between 0°C and -10°C. Given that fully pressurised tankers may not have cargo heaters fitted on board, all heat input must be provided by pumping through heaters fitted on shore.

On a pressurised tanker having loaded a cargo at close to 0°C, the cargo may warm up further by heat radiation from the outside during the voyage in line with ambient conditions. The relevant legislations only allow cargo to be loaded to such a level that the tank-filling limit will never be more than 91% at the highest temperature reached during the voyage. This means that during the pre-loading discussions, tank-filling limits must be established to allow enough room for liquid expansion into the vapour space while on voyage.

Terminal pipeline system and operation

Where a terminal can expect to load fully pressurised tankers not fitted with their own heaters, in-line equipment fitted to terminal pipeline systems is needed. This usually consists of:

- Shore tank.
- Cargo pump.
- Booster pump.
- Cargo heater.

When considering a refrigerated terminal loading a fully pressurised tanker, given that loading temperatures on these tankers are limited to about -10°C to 0°C, loadings can normally be managed by pumping through the refrigerated pipelines rated at 19 bar.

Operating the system takes the following form: first, until back pressure starts to build up from the tanker, loading is carried out by pumping only through the cargo heater then, as the back pressure increases, the booster pump is brought into operation.

At the start of loading, the pressure in a ship's tank should be at least 2 bar. This pressure will limit flashing-off and sub-cooling as the first liquid enters the tank. At this time, in-tank cargo temperatures should be carefully watched. Practical observation is also of value, with ice formation on pipelines acting as a warning that temperatures on board the tanker are falling below safe levels. In such cases, the loading rate must be reduced and the temperature at the end of the cargo heater must be increased.

Small tanker problems at large berths

A primary concern for loading small tankers is that refrigerated storage is most often designed for large ship/shore operations. At the jetty, this means that mooring plans must be properly adapted to accommodate the very different mooring patterns from small tankers and that loading arms or hoses are of a size suited to the operation.

Large loading arms can also introduce difficulties on small tankers. If the berth is in an exposed area, and depending on the conditions, a small tanker may roll and pitch at the berth. The loading arm has to keep pace with these fast movements. Such dynamic forces on the loading arm are not always taken into account. Manufacturers leave this to the operational procedures of the terminal. These movements are often considerably faster than the slow movements (say tidal) that may be accommodated under normal design considerations. Here, the inertia of the loading arm has to be taken into account.

32.5.4 Bulk loading

Depending on the efficiency of the earlier gassing-up operation, significant quantities of incondensable gases may be present in tank atmospheres. When the tank pressure becomes too high these incondensables will have to be vented via the vapour-return to the shore.

During loading, the tank pressures, temperatures, liquid levels and inter barrier spaces should be closely monitored.

Towards the end of loading, transfer rates should be reduced as previously agreed with shore personnel in order to accurately top-off tanks. When loading is completed, the tanker's pipelines should be drained back to the cargo tanks. Remaining liquid residue can be cleared by blowing the line with cargo vapour or nitrogen from the shore. The best practice is to use nitrogen, so that the manifold connections are gas-free and safe during disconnecting.

32.5.5 Maximum tank-filling limits

The goal of maximum filling limits is:

- Economical and safe use of tank capacity.
- To avoid overfilling tanks (in Europe, more than 91% is seen as overfilling, though this can vary by region or legislation).
- To avoid tank failure in the case of fires.

Tanks should be provided with double safety valves, with a manual valve under each safety valve. Both safety valves should be in the open position under normal conditions. There should be means to avoid both valves closing at the same time (e.g. three-way valve).

Short description of the IGC Code regulation:
The large thermal coefficient of expansion of liquefied gas means there needs to be maximum allowable filling limits for cargo tanks in order to avoid overfilling the cargo tanks.

Filling limits differ and depend on product, transport conditions and regions. For particular regions there may be prescribed filling conditions that must be adhered to.

The latest developments for determining filling limits are laid down in the amended chapter 15 of the IGC code.

For the purpose of this chapter the following definitions apply:

1. Reference temperature means the highest temperature that may be reached on termination of loading, during transport, or during unloading, under the ambient design temperature conditions.
2. The maximum filling limit expressed in % means the maximum allowable liquid volume in a cargo tank relative to the tank volume when the liquid cargo has reached the reference temperature.
3. The accepted loading limit expressed in % means the maximum allowable liquid volume relative to the tank volume to which a tank may be loaded to avoid the liquid volume exceeding the allowable maximum filling limit in service.

The administration may allow a higher filling limit than the limit of 98% specified at the reference temperature, taking into account the shape of the tank, arrangements of pressure relief valves, accuracy of level and temperature gauging, and the difference between the loading temperature and the reference temperature, provided the conditions specified in the IGC Code, chapter 8.2.17 are maintained.

The maximum loading limit (LL) to which a cargo tank may be loaded is determined by the following formula:

$$LL = FL \frac{\rho R}{\rho L}$$

where: FL = filling limit as specified
ρR = relative density of the cargo at the reference temperature
ρL = relative density of the cargo at the loading temperature and pressure

Information to be provided to the Master
A list provided by the administration should indicate the maximum allowable tank loading limit (LL) for each tank and for each product that it might carry, for each loading temperature that might apply and for the applicable maximum reference temperature.

The list should also state the pressure that has been set for the pressure relief valves. A copy of the list should be permanently kept on board by the Master.

For European inland gas carriers, the ADN allows a maximum filling limit of 91%.

The use of the above formula requires a special layout of the venting system, which is explained in chapter 8 of the IGC Code.

There are good safety reasons for minimising cargo shut-out. The concept is simple: the fuller the tank, the longer the structure will be able to withstand fire conditions. When exposed to a fire, the tank contents will boil at a constant temperature until the bulk of the liquid has been vented through the relief valve system to the vent mast. After this, the upper regions of the tank become exceedingly hot and eventually fail. However, the greater the mass of liquid inside the tank, the longer the tank can withstand unacceptable external temperatures.

General
Local requirements may have different approaches to setting maximum filling limits, but in any event the temperature influences on liquefied gases should not be ignored.

Example
Case 1 (amended IGC regulation)
A fully pressurised ship loading propane at 5°C.

$$LL = FL \frac{\rho R}{\rho L}$$

Reference temperature as calculated under amended Gas Code 20°C
Density of liquidpropane at 20°C = 500kg/m^3
Loading temperature 5°C
Density of liquid propane at 5°C = 522kg/m^3

$$LL = 98 \times \frac{500}{522} = 93.9\%$$

The tank can be loaded to 93.9% of tank volume.

Case 2 (amended IGC regulation)
A fully pressurised tanker loading propane at -10°C.

Reference temperature as calculated under amended Gas Code 15°C
Density of liquid propane at 15°C = 508kg/m^3
Loading temperature = -10°C
Density of liquid propane at -10°C = 542kg/m^3

$$LL = 98 \times \frac{500}{542} = 91.9\%$$

The tank can be loaded to 91.9% of tank volume.

32.6 The loaded voyage

Prevention of polymerisation

Where butadiene cargoes are being carried, the compressor discharge temperature must not exceed 60°C and the appropriate high-discharge temperature switch must be selected. Similarly, in the case of vinyl chloride, compressor discharge temperatures should be limited to 90°C to prevent polymerisation (see also section 27.6).

Condition inspections

Throughout the loaded voyage, regular checks should be made to ensure there are no defects in cargo equipment and no leaks in nitrogen or air supply lines. Such inspections must comply with all relevant safety procedures for entry into enclosed spaces and due regard must be given to hazardous atmospheres in adjacent spaces.

32.7 Discharging

When a tanker arrives at the discharge terminal, cargo tank pressures and temperatures should be in line with terminal requirements. This will help to ensure maximum discharge rates are achieved.

Before the discharge operation begins, the pre-operational ship/shore (safety checklist) procedures should be carried out along similar lines to the loading operation previously outlined.

The method of discharging the tanker will depend on the type of tanker, cargo specification and terminal storage. Two basic methods may be used:

- Discharge by pressurising the vapour space.
- Discharge with the ships' own cargo pump (the method normally used).

32.7.1 Discharge by pressurising the vapour space

Discharge by pressure using either a shore vapour supply or a vaporiser and compressor on board is only possible where the ship has pressure tanks. It is an inefficient and slow method of discharge and is restricted to small tankers. Using this system, the pressure above the liquid is increased and the liquid is transferred to the terminal.

32.7.2 Discharge by pumps

Starting ship's cargo pumps

A centrifugal pump should always be started against a closed or partially open valve in order to minimise the starting load. Thereafter, the discharge valve should be gradually opened until the pump load is within safe design parameters.

The liquid level, pressure and temperature in the cargo tanks should be monitored during the whole operation. Discharge and ballasting operations should be carefully controlled, bearing in mind tanker stability and hull stress.

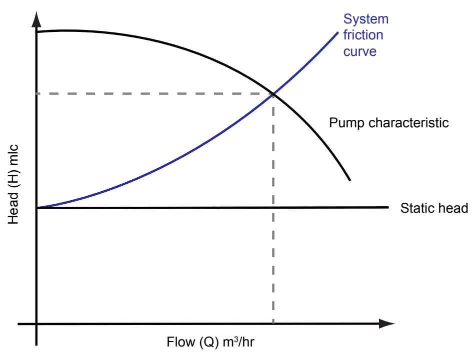
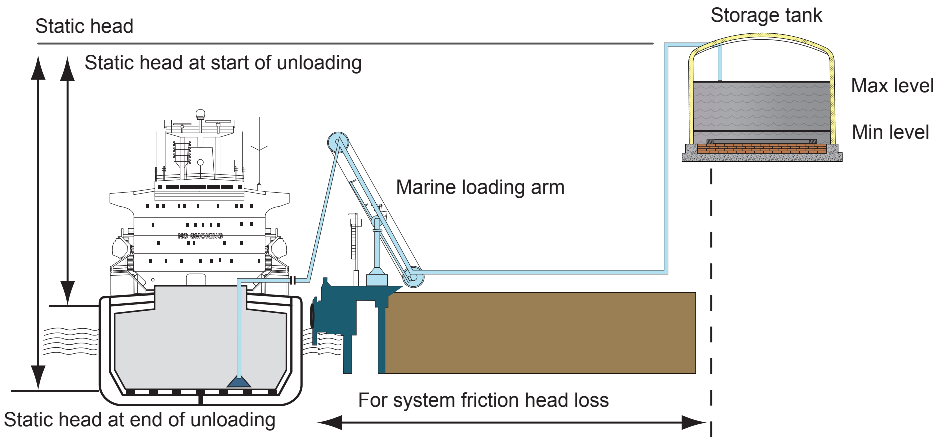


Figure 32.6: *Combined tanker and shore cargo pumping characteristics – single pump*

Discharging by the ship's centrifugal cargo pumps, either alone or in series with booster pumps, is the method adopted by most tankers and an understanding of the centrifugal pump characteristic (as outlined in section 31.2) is essential for efficient cargo discharge. Figure 32.6 shows a cargo pump Q/H curve (flow against head) superimposed on a system resistance curve (or system characteristic). The graph shows the head or back pressure in metres liquid column (mlc) in the terminal pipeline system against flow rate measured in cubic metres per hour (m^3/hr). Increasing the flow rate increases the back pressure. This varies approximately as the square of the flow rate, giving the shape of system characteristic curve as shown. The point where the two curves intersect is the flow rate and head at which the pump will operate.

Some of the above points are further demonstrated by inspection of figure 32.7. This diagram shows a gas carrier alongside a jetty discharging to shore storage set at some elevation. The elevation of the tank introduces the concept of static head – this being the back pressure exerted at the pump even when pumps are not running. It can be seen that the static head changes as the tanker moves up and down with the tide and as the level in the shore tank alters. The diagram also indicates that the friction head loss depends largely on the length of the pipeline system.



For a ship unloading, assuming constant pressures in the ship's tanks and the land storage tank:

- The static discharge head will not vary significantly
- the static suction head will decrease as cargo is discharged (more head required so flow will decrease)
- the friction head will increase with capacity increase.

Figure 32.7: *Illustrations of static head and friction head*

Consider now the situation where pumps are run in parallel, as would be the normal case for a gas carrier discharge. Figure 32.8 shows the pump characteristics using one pump and when using two, three or four similar pumps in parallel. (This family of curves is derived from the principles discussed in section 31.2).

Superimposed on the pump characteristics are a number of system characteristics labelled A, B and C. System characteristic A indicates a small diameter shore pipeline, B a larger diameter pipeline and C a very large diameter pipeline with shore tanks situated nearby. The latter provides the least resistance to cargo flow.

The actual system characteristic applicable at any terminal should be known to shore personnel and they should have such curves available. In preparing such graphs, personnel should note, as mentioned above, that the system characteristic can vary with the size of the chosen pipeline and with variation in the pipe-lengths from the jetty when alternative shore tanks are used. In any case, during the pre-transfer discussions (see section 22.4), such matters should be covered and the optimum transfer rate agreed.

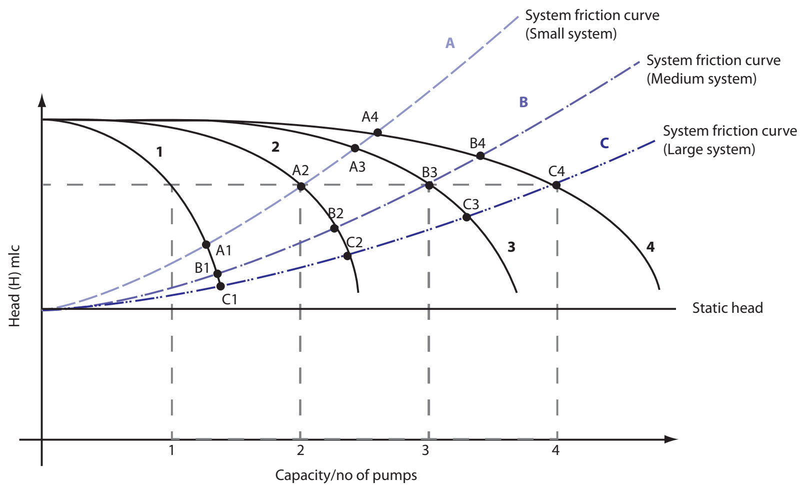


Figure 32.8: *Combined tanker and shore cargo pumping characteristics – parallel pumps*

To clarify some of these issues, two of the system characteristics, as shown in figure 32.8, are covered in detail below.

If a tanker, having the pumping characteristics as shown in figure 32.8 (numbered 1, 2, 3, and 4), is discharging to a terminal presenting only minor restrictions to flow, then the shore system characteristic may be equivalent to C. The operating point of the ship/shore system moves from points C1 through to C4 as the number of cargo pumps in operation is increased from one to four. Under such conditions, the total flow achieved (when using four pumps) is only marginally less than the total theoretical flow (assuming no resistance). With such a shore pipeline system, it is probable that all four pumps (and maybe more) can be run to good effect.

In the case of system characteristic A, where flow restrictions are high, it can be seen how little extra flow is achieved by running more than two pumps. By running three pumps the operating point moves from A2 to A3, achieving some extra throughput. By running four pumps the operating point moves from A3 to A4, achieving an increased flow of virtually zero. In such cases, much of the energy created in the additional pumps is imparted to the cargo. This is converted to heat in the liquid and results in an increase in cargo temperature. This increases flash-gas boil-off as the liquid discharges into shore storage, and this excess must be handled by the shore compressors, which reduces the discharge speed. If the shore compressors are unable to handle the additional flash-gas, the terminal will require a reduction in flow rate to avoid lifting the shore relief valves. The net effect, in restricted circumstances, of running an unnecessary number of pumps can be to decrease rather than to increase the overall discharge rate.

Observing pressure gauges at the manifold will give a good indication if it is worthwhile running, say, four pumps or six pumps. The discharge rate should not be reduced by throttling valves at the tanker's cargo manifold if the shore cannot accept the discharge rate. Throttling in this manner further heats up the cargo. However, those gas carriers with only limited recirculation control may have to use manifold valves to throttle pumps.

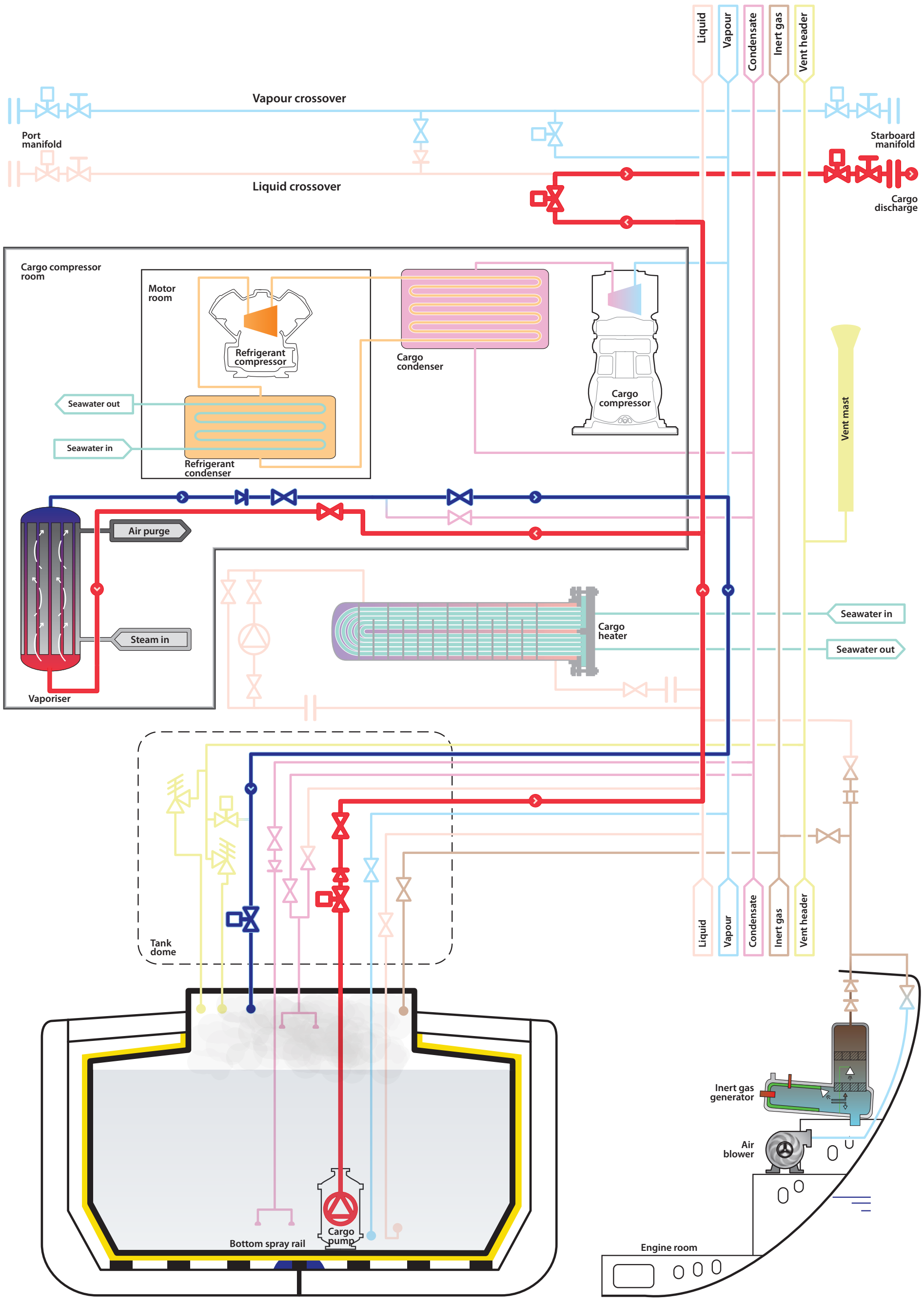


Figure 32.9: *Discharge without vapour return*

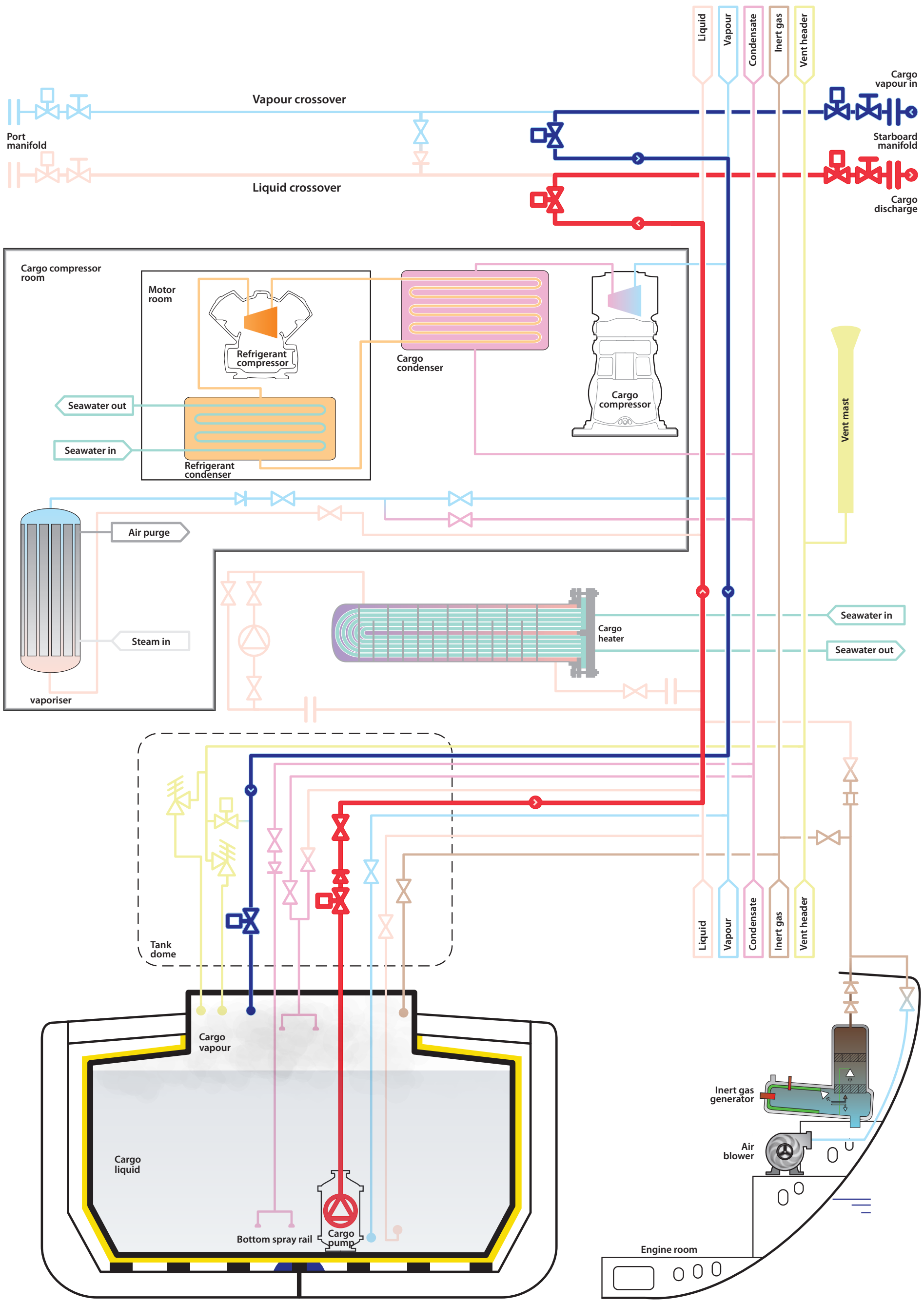


Figure 32.10: *Discharge with vapour return*

As liquid is being pumped from the tanker, tank pressures tend to fall. Boil-off due to heat flow through the tank insulation takes place continuously and this generates vapour within the tank. The boil-off is usually not enough to maintain cargo tank pressures at acceptable levels but this ultimately depends on discharge rate, cargo temperature and ambient temperature. Where vapours produced internally are insufficient to balance the liquid removal rate, it is necessary to add vapour to the tank if discharge is to continue at a constant rate.

32.7.3 Draining tanks and pipelines

It has already been noted in section 31.2 and illustrated in figure 31.2 that to avoid cavitation of a centrifugal pump, the pressure of the liquid at the pump suction needs to exceed the saturated vapour pressure by an amount known as the minimum net positive suction head. The required minimum net positive suction head, expressed as an equivalent head of liquid above the pump suction, may vary from one metre (at maximum pump capacity) to 200 millimetres (at reduced flow). If the vapour space pressure can be increased above the saturated vapour pressure by the supply of extra vapour from the shipboard vaporiser, the onset of cavitation, as the liquid level approaches the bottom of the tank, can be delayed.

Such augmentation of vapour space pressure is usual practice on fully pressurised and semi-pressurised tankers and may also be carefully applied to fully refrigerated cargoes, particularly where maximum cargo out-turn is required in preparation for gas-freeing. Whether this extra vapour pressurisation is used or not, there will be a liquid level at which the pump becomes erratic. Gradual reduction of the flow rate at this point, by careful throttling of the discharge valve, reduces the net positive suction head requirement and permits continued discharge to a lower level. However, remember that a pump discharge valve should not be used for flow control if the pump is operating with a booster pump since the booster pump might cavitate, resulting in damage (see section 32.7.2).

On completion of discharge, liquid cargo must be drained from all deck lines and cargo hoses or hard arms. Such draining can be done from tanker to shore using a cargo compressor. Alternatively, it may be carried out from shore to tanker, normally by blowing the liquid into the ship's tanks using nitrogen injected at the base or apex of the hard arm. Only after depressurising all deck lines and purging with nitrogen should the ship/shore connection be broken.

32.8 The ballast voyage

In general, the quantity retained on board as a heel depends on:

- Commercial agreements.
- The type of gas carrier.
- The duration of the ballast voyage.
- The next loading terminal's requirements.
- The next cargo grade.

If the tanker is proceeding to a loading terminal to load an incompatible product, none of the previous cargo should be retained on board. This avoids contamination of the following cargo and allows the maximum quantity of the new cargo to be loaded (see section 32.9).

32.9 Changing cargo (and preparation for drydock)

Of all the operations undertaken by a gas carrier, the preparation for a change of cargo is the most time consuming. If the next cargo is not compatible with the previous cargo, it is often necessary for the tanks to be gas-freed to allow a visual inspection (see table 27.3(b)). This is commonly the case when loading chemical gases such as vinyl chloride, ethylene, butadiene and propylene oxide.

When a tanker receives voyage orders, a careful check must be made on the compatibility of the next cargo. (It is also necessary to check compatibilities and the tanker's natural ability to segregate if more than one cargo grade is to be carried. On such occasions special attention must be given to the tanker's reliquefaction system.) When changing cargoes there may also be a need to replace the lubricating oil in compressors for certain cargoes – this is discussed in sections 32.6.1 and 31.6.1.

Tables 27.2, 27.3(a) and 27.3(b) provide a guide to the compatibility of gases. The tables also cover cargo compatibility with respect to the construction materials commonly used in cargo-handling systems.

To obtain a gas-free condition, the full process is shown below. However, depending on the grade switch, it may not be necessary to include all these steps:

1. Make the tank liquid free.
2. Warm the tank with hot cargo vapours (if necessary).
3. Inert the tank.
4. Ventilate with air (only when the tank temperature and the temperature of tank walls are above the ambient temperature).

These procedures are preliminary to tank entry for inspection or when gas-freeing the tanker for drydock.

32.9.1 Removal of remaining liquid

Depending on cargo tank design, residual liquid can be removed by pressurisation or normal stripping.

The first operation to be carried out is the removal of all cargo liquid remaining in the tanks or in any other part of the cargo system. Enhanced evaporation in a non-saturated atmosphere means residual liquid can become super-cooled to a temperature that could result in brittle fracture of the tank. This will occur less with C4 cargoes but may play a role with C3 cargoes.

When all cargo tank liquid has been removed, the tanks can be inerted either with inert gas from the tanker's supply or from the shore, as required by the next cargo. Alternatively, gassing-up using vapour from the next cargo may be carried out – but this is increasingly unusual (see sections 32.2.3 and 32.3 for more detail of the procedure).

Liquid stripping for pressurised tanks
For tankers having pressure tanks a cargo stripping line is often provided (see figure 31.1).

By pressurising the cargo tanks on these tankers (using the cargo compressor or nitrogen), residual liquid can be lifted from the tank sump into the stripping line and to deck level. It may then be stored temporarily in a chosen cargo tank for returning to the shore. This draining should continue until all liquid cargo is removed from the cargo tanks, as checked through the bottom sampling line (this is only possible when there is still left enough pressure in the cargo tanks). The compressor pressure necessary to remove residual liquid will depend on the specific gravity of the cargo and the depth of the tank (see figure 32.11).

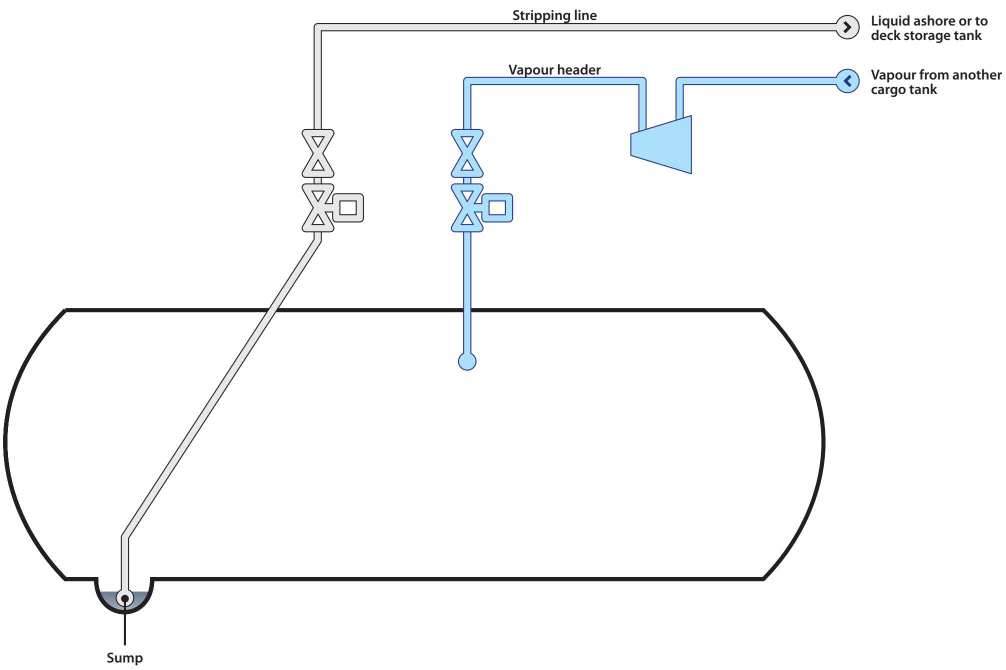


Figure 32.11: *Removal of cargo liquid residue by pressurisation*

32.9.2 Inerting – after discharge

Removal of cargo vapours with inert gas (nitrogen) is carried out to reduce gas concentrations to a level where aeration can take place without the tank atmosphere passing through the flammable envelope (see figure 27.20). The level to which the hydrocarbon vapour must be reduced varies according to the product. In general, when inerting in this way, it is necessary to reduce the hydrocarbon content in the inert atmosphere to about 2% by volume before air blowing can begin.

In the past, some grade-changing operations involved replacing existing tank vapours with the vapours of the next cargo to be loaded. However, this is now seldom done. As shown in table 27.3(b), this method can only ever be appropriate when switching to compatible grades and when air is not to be introduced into the tank.

Once the cargo system has been satisfactorily freed of liquid and warmed up, inerting operations may start. This involves replacing the vapour atmosphere with inert gas or nitrogen. The need to inert will depend on:

- A desire to gain tank entry for inspection.
- Last cargo.
- Next cargo.
- Charter party terms.
- Requirements of the loading terminal
- Requirements of the receiving terminal.
- Permissable cargo admixture.

Where tanks must be opened for internal inspection, inerting is always necessary. This is to reduce the content of flammable gases within tank atmospheres to the safe level required before blowing through with fresh air. This safe level will correspond to a point below the critical dilution line (see figure 27.20) as found on a graph for the product in question. The procedure for inerting after cargo discharge is similar to that described in section 32.2.3.

32.9.3 Aerating

After the preceding procedures have been addressed, the cargo tanks can be ventilated with air. The air is supplied using compressors or air blowers and air dryers in the inert gas plant. This should continue until the oxygen content of the whole tank is at 20.9% and hydrocarbon levels are at 0% of the LFL. To ensure uniformity in the tank atmosphere, various levels and positions in the tank should be monitored before tank entry. Figure 32.12 shows a pipeline set up for aerating tanks.

Note that ventilation with air should only take place once the ship's tanks are warmed to ambient conditions. If the tank is still cold when air is allowed inside, any moisture in the air will condense on tank surfaces. This can cause serious problems when preparing the tank for new cargoes. If condensation is allowed to form, its removal can be a protracted and costly operation.

Ventilating an atmosphere with hydrocarbon vapors of less than 2% can be regarded as safe. But one should always comply with local legislation. Ventilating/aerating of cargo vapours is increasingly restricted by legal requirements.

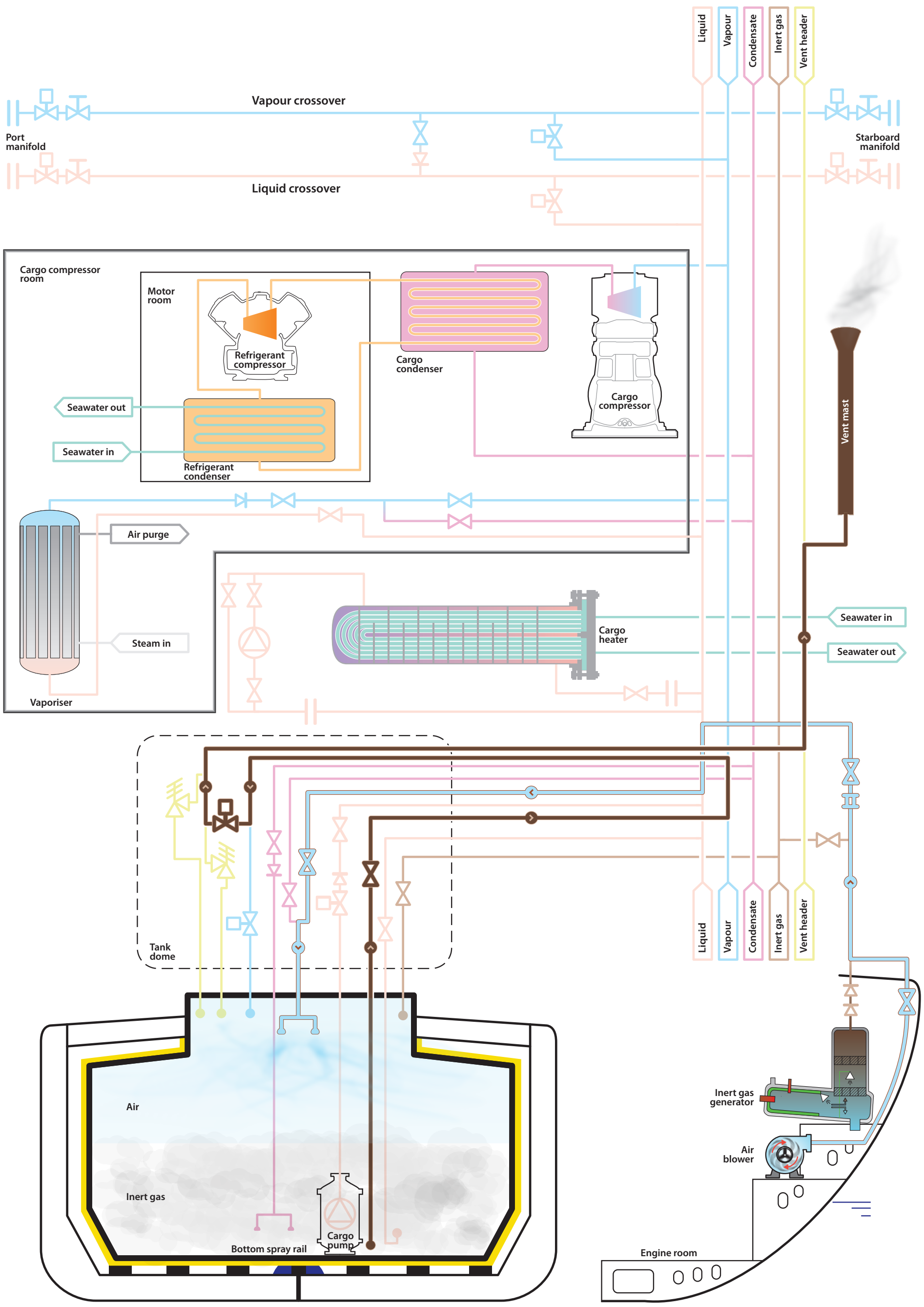


Figure 32.12: *Aeration of cargo tanks*

32.9.4 Ammonia – special procedures

Certain cargoes present particular difficulties when trying to remove all traces of the product. Ammonia is one such case. When a tanker is switching from ammonia to LPG, virtually all traces of vapours must be removed from the system. Before loading the next cargo, an allowable concentration of ammonia vapour in a tank atmosphere is usually quoted at less than 20ppm by volume. This results in a time-consuming operation, covered in more detail below.

The first operation when switching from ammonia is to remove all liquid ammonia from the system. This is important as ammonia, when evaporating to air, is particularly likely to reach super-cooled conditions. Unless all liquid is removed, dangerously low liquid temperatures can result and tank fractures could ensue. Confirmation that all liquid has been removed can be established by carefully observing tank temperature read-outs during warming-up.

Once cargo tank temperatures have been warmed to substantially above the dew point of the air, the ammonia vapours are usually dispersed by blowing warm fresh air through the system. (For ammonia the inert gas plant must not be used due to the formation of ammonia carbamates when ammonia is in contact with carbon dioxide.) The continued use of warm dry air should avoid water vapour condensation, so limiting seeps of ammonia into porous tank surfaces. The ventilation of tanks and the cargo system at the highest practical temperature is advantageous as this encourages release of ammonia from rusty surfaces (ammonia is released ten times faster at 45°C than at 0°C).

Washing with fresh water to remove ammonia is sometimes carried out. This can be most effective as ammonia is highly water soluble. However, note the following points:

- The benefit of water washing is limited to certain types of tank (e.g. it is not always practical for large fully refrigerated tankers with prismatic tanks).
- When switching from ammonia to LPG, water can hold ammonia in solution, which this can be a contaminant for future cargoes. Accordingly, water washing is only recommended for cargo tanks that are completely clean, rust-free and have minimum internal structure, so allowing full and effective drainage.
- All traces of water must be removed at the end of washing to prevent the formation of ice or hydrates.
- The high solubility of ammonia in water (300:1) can lead to dangerous vacuum conditions being created within a tank. So it is essential to ensure adequate air or nitrogen entry into the cargo tank during the water washing process.

After water washing, it is essential that all water residue is removed using either fixed or portable pumps. Subsequently, tanks and pipelines must be thoroughly dried before further preparations for cargo loading. To maintain maximum dryness, it is important to continue ventilating the tanks using air with a dew point lower than the tank atmosphere for the reasons discussed above.

32.10 Ship-to-ship transfer

In recent years, the transfer of liquefied gas cargoes from one tanker to another has become a common practice. Detailed recommendations for the safe conduct of such operations are given in the (local) Ship-to-Ship Transfer Guide (Liquefied Gases). Before such operations are arranged, it is recommended that this publication should be consulted and its procedures adopted. Many port authorities require special permission for ship-to-ship transfer.

Note that during ship-to-ship transfer from seagoing vessels the cargo on board can be (semi) refrigerated. One ship will then heat the cargo via a heat exchanger to approximately 0°C. Good temperature control on board is required.

32.11 Conclusion

This completes the cycle of gas carrier operations. It is important for every tanker to have its own detailed operational procedures clearly listed. What can be done on one tanker may not be possible or even desirable on another. However, the basic principles of cargo handling for liquefied gas remain the same for al gas carriers. A safe operation is invariably also an efficient operation. If in doubt about the safety of any operation, the tanker's crew and terminal personnel are recommended to seek further advice.

33 Types of gas carriers

This chapter provides an overview of the several gas tanker types and cargo tank constructions. Note that apart from the written standards there are some aspects of gas carrier construction that are covered by the additional requirements of experienced shipowners.

33.1 Types of gas carriers

General

A feature almost unique to the gas carrier is that the cargo is kept under positive pressure. All connections and appendages should be closed hermetically This means that only cargo liquid and cargo vapour are present in the cargo tank and flammable atmospheres cannot develop. All gas carriers also use closed cargo systems when loading or discharging, with no venting of vapour being allowed to the atmosphere.

Gas carriers must comply with the standards set by the relevant legislation or national rules, and with all safety and pollution requirements common to other tankers. The safety features inherent in design requirements have helped considerably in the safety of these tankers. Equipment requirements for gas carriers include temperature and pressure monitoring, gas-detection and cargo tank liquid-level indicators, all of which are provided with alarms and ancillary instrumentation. The variation of equipment as fitted can make the gas carrier one of the most sophisticated and safest tankers afloat today.

Inland gas tankers

At present only pressurised liquefied gas is transported in the inland gas trade in Europe. The most common maximum working pressure is 15.8 bar. The pressure tanks on board range in capacity from 380 to 550m^3. The gas carriers carry propane, butane and chemical gases at ambient temperature, so they are equipped with a number of horizontal cylindrical pressure tanks.

The transport of liquefied gases on the waterways is a high-tech industry with a large fleet of tankers, a network of export and import terminals and a lot of experience with the various people involved.

Seagoing gas tankers (for information)

Seagoing gas tankers can vary widely. The type of tanks include:

- Pressure tanks, with similar pressure as in the inland trade.
- Semi-refrigerated pressure tanks with a maximum pressure of 5 to 7 bar. These vessels are usually equipped with tank material suitable to -50°C. They have compressors with refrigeration units that can cool cargo, e.g. propane or propylene. By cooling the product, the vapour pressure drops and the cargo tanks can be built lighter. These tankers have cylindrical, spherical or bi-lobe shaped cargo tanks, that can transport cargoes at temperatures up to -50°C. Semi-refrigerated tankers can load and discharge their products at terminals that have refrigerated or pressurised tanks.
- Fully refrigerated tanker tanks. These tanks can have an over-pressure up to 0.40 to 0.5 bar. The tanks are almost square and so can bear little pressure. The advantage is that it allows a large volume to be loaded. These vessels have a tank volume of about 30,00 to 100,000m^3.

Fully refrigerated tankers are built to carry liquefied gases at low temperatures and atmospheric pressure between terminals equipped with fully refrigerated storage tanks. Prismatic tanks enable the tanker’s cargo carrying capacity to be maximised, making the fully refrigerated tanker highly suitable for carrying large volumes of cargo such as LPG, ammonia and vinyl chloride over long distances.

Liquefied natural gas carriers

Liquified natural gas is carried at its boiling point, -162°C. Liquified natural gas containment systems have developed considerably. The carriers are fitted with independent cargo tanks or with membrane tanks.

The concept of the membrane containment system is based on a very thin primary barrier (0.7 to 1.5mm thick) that is supported through the insulation. Membrane containment systems must always be provided with a secondary barrier to ensure the integrity of the total system in the event of primary barrier leak. The special feature of these tankers is that they use the cargo and cargo vapours (boil off) for their own propulsion.

33.2 Cargo containment systems

A cargo containment system is the entire system for storing cargo, including, if present:

- A primary barrier (the cargo tanks).
- A secondary barrier (if any).
- Associated thermal insulation.
- Inter-barrier spaces.
- Adjacent structures, if necessary, to support these elements.

33.2.1 Independent tanks

Gas tanks are independent structures and are completely self-supporting. They are not part of the hull structure of the tanker and so do not contribute to the robustness of the hull of a tanker.

33.2.2 Membrane tanks

The concept of the membrane tank is based on a thinner barrier that is supported by primary insulation. These tanks are not self-supporting. Membrane tanks may be used only with a secondary barrier. This secondary barrier ensures the integrity of the entire system in the event of a leak in the primary barrier.

33.2.3 Semi-membrane tanks

The semi-membrane concept is a variation of the membrane tank system. The primary barrier is much thicker than than in the membrane system, having flat sides and large radiused corners. The tank is self-supporting when empty but not in the loaded condition. The system has been adopted for use in LPG tankers, and several Japanese-built fully refrigerated LPG carriers have been delivered to this design.

33.3 Construction material and insulation

33.3.1 Construction materials

The choice of cargo tank materials is dictated by the minimum service temperature and, to a lesser degree, by compatibility with the cargoes carried. The most important property to consider in the selection of cargo tank materials is the low-temperature toughness. This is vital as most metals and alloys (except aluminium) become brittle below a certain temperature.

Treatment of structural carbon steels can be used to achieve low-temperature characteristics and the Gas Codes specify low-temperature limits for varying grades of steel down to -50°C. Refer to the Gas Codes and classification society rules for details on the various grades of steel.

According to the Gas Codes, tankers carrying fully refrigerated LPG cargoes may have tanks capable of withstanding temperatures down to -50°C. Usually, the final temperature is chosen by the shipowner, depending on the cargoes expected to be carried. This is often determined by the boiling point of liquid propylene at atmospheric pressure, meaning cargo tank temperature limitations are frequently set at about -50°C. To achieve this service temperature, steels such as fully killed, fine-grain carbon-manganese, sometimes alloyed with 0.5% nickel, are used.

Where a tanker has been designed specifically to carry fully refrigerated ethylene (with a boiling point at atmospheric pressure of -104°C) or LNG (atmospheric boiling point of 162°C), nickel-alloyed steels, stainless steels (such as Invar) or aluminium must be used for the tank construction.

33.3.2 Tank insulation

Thermal insulation must be fitted to refrigerated cargo tanks to:

- Minimise heat flow into cargo tanks and so reduce boil-off.
- Protect the tanker structure around the cargo tanks from the effects of low temperatures.

Insulation materials for use on gas carriers should have these main characteristics:

- Low thermal conductivity.
- Ability to bear loads.
- Ability to withstand mechanical damage.
- Lightweight.
- Unaffected by cargo liquid or vapour.

The vapour-sealing property of the insulation system, to prevent ingress of water or water vapour, is important. Not only can moisture result in loss of insulation efficiency but progressive condensation and freezing can cause extensive damage to the insulation. This means that humidity conditions must be kept as low as possible in hold spaces. One method to protect the insulation is to provide a foil skin acting as a vapour barrier to surround the system.

Appendix 1: Tanker-Shore Safety Checklist

European Regional Legislation	Question #	Part A. Bulk Liquid General – Physical Checks				
		Bulk Liquid – General	**Tanker**	**Terminal**	**Code**	**Remarks**
	1	There is safe access between the tanker and shore.			R	
L	L1	The fendering arrangements are assessed as satisfactory. The fender pennants are in order.				
B 3	2	The tanker is securely moored, considering the local conditions.			R	
B 11	3	The agreed ship/shore communication system is operative.			A R	
L	4	Emergency towing-off pennants are correctly rigged and positioned, if required by terminal.			R	
B 14	5	The tanker's fire hoses and fire-fighting equipment are positioned and ready for immediate use.			R	
	6	The terminal's fire-fighting equipment is positioned and ready for immediate use.			R	
B 6.1	7	The tanker's cargo hoses and/or the terminal arms or hoses, pipelines and manifolds are in good condition, properly rigged and appropriate for the service intended.			R	
B 6.1	7.1	All reducers are approved and compatible with cargo lines and the type of cargo.				
B 6.2	7.2	All connection flanges are fitted with the appropriate gaskets.				
B 6.3	7.3	All flange bolts are properly tightened.				
B 6.4	7.4	The loading arms are free to move in all directions and/or the hoses have enough room for easy movement.				
B 14	7.5	All valves are checked and in the right position.				
B 5	7.6	Adequate lighting is ensured at the cargo transfer area and emergency escape route.				
	8	This line has been intentionally left blank.				
L	9	The cargo transfer system is sufficiently isolated and drained to allow safe removal of blank flanges before connection.				
B 8	10	Scuppers and save-alls on board are effectively plugged and drip trays are in position and empty.			R	
L	11	Scupper plugs temporarily removed will be monitored constantly.			R	
	12	Shore spill-containment and sumps are correctly managed.			R	
B 7	13	The tanker's unused cargo, bunker and vapour return connections are properly secured. All connected flanges are fitted with the appropriate gaskets.				

European Regional Legislation	Question #	Part A. Bulk Liquid General – Physical Checks				
		Bulk Liquid – General	**Tanker**	**Terminal**	**Code**	**Remarks**
	14	The terminal's unused cargo, bunker and vapour return connections are properly secured. All connected flanges are fitted with the appropriate gaskets.				
B 18	15	All sighting, ullaging and sampling ports of the cargo, ballast or bunker tanks have been closed or protected by flame arrestors in good condition, if required.				
B 9	16	Sea and overboard discharge valves are closed and visibly secured when not in use. The removable parts between ballast and overboard discharge lines and cargo lines are removed.				
B 14	17.1	All external doors, ports and windows in the accommodation, stores and machinery spaces are closed. Engine room vents may be open.			R	
B 14	17.2	The LPG domestic installation is isolated at the main stop valve.				
L	18	The tanker's emergency fire control plans are available.				Location:

		If the tanker is fitted with an inert gas system (IGS), or is required to be fitted with one, the following points should be physically checked:				
		Inert Gas System				
L	19	IGS pressure and oxygen content-measuring equipment are in good working order.			R	
L	20	All cargo tank atmospheres are at positive pressure with oxygen content of 8% or less by volume.			P R	
L	20L	All inerted tanks are marked or labelled with a warning sign.				

European Regional Legislation	Question #	Part BA. Bulk Liquid General – Verbal Verification				
		Bulk Liquid – General	**Tanker**	**Terminal**	**Code**	**Remarks**
L	21	The tanker is ready to move under its own power. A dumb barge without its own propulsion should be able to move with the help of a designated tug at short notice.			P R	
B 10	22	There is an effective deck watch in attendance on board and adequate supervision of operations on the tanker and ashore.			R	
L	22L	On the tanker and the shore, a competent person is appointed who is responsible for the planned cargo-handling.				
L	23	There are sufficient personnel on board and ashore to deal with an emergency.			R	
B 15.1	24.1	The procedures for cargo, bunker and ballast-handling have been agreed.			A R	
B 15.2	24.2	The outlet pressure of the cargo pump of the tanker is regulated to take account of the admissible working pressure of the equipment of the terminal			A R	
	24.3	The outlet pressure of the shore's cargo pump is regulated to take account of the admissible working pressure of the equipment on the tanker.			A R	
B 13	25	The emergency signal and shutdown procedure to be used by the tanker and shore have been explained and understood.			A	
B 2	26	Safety Data Sheets (SDS), or equivalent, for the cargo transfer have been exchanged where requested.			P R	
B1	26L	The tanker is approved to transport the product to be loaded.				
L	27	The hazards associated with toxic substances in the cargo being handled have been identified and understood.				Hydrogen sulphide content: Benzene content:
	28	An international shore fire connection has been provided, if required by legislation.				
L	29	The agreed tank venting system will be used.			A R	Method:
	30.1	The requirements for closed operations have been agreed.			R	
B 12.1	30.2	The tanker's vapour-return connection, if required, is connected by a vapour-return line to the vapour-return connection to the shore.			R	
B 12.3	30.3	If protection against explosions is required, the vapour-return line is equipped with a flame arrestor and/or detonation protection.			R	
B 12.2	31	The operation of the P/V system has been verified. The delivering tanker or shore guarantees that the pumping rate does not exceed the maximum working pressure agreed. Agreed max pumping rate: ....(m^3/h) Agreed max pressure: ....(kPa)			R	

European Regional Legislation	Question #	Part BA. Bulk Liquid General – Verbal Verification				
		Bulk Liquid – General	**Tanker**	**Terminal**	**Code**	**Remarks**
L	32	Where a vapour-return line is connected, operating parameters have been agreed.			A R	
B16+17	33	Independent high-level alarms and/or emergency stops, if fitted, are operational and have been tested.			A R	
L	34	Adequate electrical insulation is in place in the tanker/shore cargo and, if applicable, vapour-return line connections. The insulating means is installed either aboard or ashore: ....(state where).			A R	
	35	Shore lines are fitted with a non-return valve, or procedures to avoid back-filling have been discussed.			P R	
B 14	36	Smoking requirements have been agreed and are being observed.			A R	
B 14	37	Naked light regulations have been agreed and are being observed.			A R	
L	38	Portable electronic (e.g. communication) devices requirements are observed.			A R	
L	39	Hand torches (flashlights) are of an approved type.				
L	40	Fixed VHF/UHF transceivers and AIS equipment are on the correct power mode or switched off.				
L	41	Portable VHF/UHF transceivers are an approved type.				
B 14	42	The tanker's main radio transmitter aerials are earthed, and radars are disconnected/switched off.				
B 14	43	Electric cables to portable electrical equipment within the hazardous area are disconnected from power.				
L	44	Window-type air conditioning units are disconnected, if applicable.				
L	45	Positive pressure is maintained inside the accommodation and/or wheelhouse, if applicable.				
L	46	Measures have been taken to ensure sufficient mechanical ventilation in the pumproom, if applicable.			R	
B 4	47	There is provision for emergency escape.				
L	48	The weather, maximum wind and swell criteria for operations have been agreed. Stop cargo operations at: .... Disconnect at: .... Unmoor at:			A	
L	49	Security protocols have been agreed between the ship security officer and the port facility security officer, if appropriate.			A	

European Regional Legislation	Question #	Part BA. Bulk Liquid General – Verbal Verification				
		Bulk Liquid – General	**Tanker**	**Terminal**	**Code**	**Remarks**
L	50	Where appropriate, procedures have been agreed for receiving nitrogen supplied from shore, either for inerting or purging cargo tanks or for line clearing into the tanker.			A P	

		If the tanker is fitted with an IGS, or is required to be fitted with one, the following statements should be addressed:				
		Inert Gas System				
L	51	The IGS is fully operational and in good working order.			P	
L	52	Deck seals, or equivalent, are in good working order.			R	
L	53	Liquid levels in pressure/vacuum breakers are correct, if applicable.			R	
L	54	The fixed and portable oxygen analysers have been calibrated and are working properly.			R	
L	55	All the individual tank inert gas valves (if fitted) are correctly set and locked.			R	
L	56	All personnel in charge of cargo operations are aware that should the inert gas plant fail, discharge operations should stop and the terminal be advised.				

		If the tanker is fitted with a crude oil washing system and intends to crude oil wash, the following statements should be addressed:				
		Crude Oil Washing				
L	57	N/A				
L	58	N/A				

		If the tanker is planning to tank clean alongside, the following statements should be addressed:				
		Tank Cleaning				
L	59	Tank-cleaning operations are planned during the tanker's stay alongside the shore installation.	Yes/No*	Yes/No*		
L	60	If 'yes', the procedures and approvals for tank-cleaning have been agreed.				
L	61	Permission has been granted for gas-freeing operations by the competent authority.	Yes/No*	Yes/No*		

* Delete as appropriate

European Regional Legislation	Question #	Part C. Bulk Chemicals – Verbal Verification				
		Bulk Liquid Chemicals	**Tanker**	**Terminal**	**Code**	**Remarks**
L	1	SDS, or equivalent, are available, giving the necessary data for the safe handling of the cargo.				
L	2	A manufacturer's inhibition certificate, where applicable, has been provided.			P	
L	3	Sufficient protective clothing and equipment (including self-contained breathing apparatus) are ready for immediate use and suitable for the product being handled.				
L	4	Countermeasures in the event of accidental personal contact with the cargo have been agreed.				
L	5	The cargo-handling rate is compatible with the automatic shutdown system, if in use.			A	
L	6	Cargo system gauges and alarms are correctly set and in good order.				
L	7	Portable vapour-detection instruments are readily available for the products being handled.				
L	8	Information on fire-fighting equipment and procedures has been exchanged.				
L	9	Transfer hoses and gaskets are of suitable material, resistant to the action of the products being handled.				
L	10	Cargo-handling is being performed with the permanent installed pipeline system.			P	
	11	Where appropriate, procedures have been agreed for receiving nitrogen supplied from shore, either for inerting or purging cargo tanks, or for line-clearing into the tanker.			A P	
L	12	If required, the cargo deck water spray system is ready for immediate use.				

European Regional Legislation	Question #	Part D. Bulk Liquefied Gases – Verbal Verification				
		Bulk Liquefied Gases	**Tanker**	**Terminal**	**Code**	**Remarks**
L	1	SDS, or equivalent, are available giving the necessary data for the safe handling of the cargo.				
L	2	A manufacturer's inhibition certificate, where applicable, has been provided.			P	
L	3	The cargo deck water spray system is ready for immediate use.				
L	4	Sufficient protective clothing and equipment (including self-contained breathing apparatus) are ready for immediate use and suitable for the products being handled.				
L	5	Hold and inter-barrier spaces are properly inerted or filled with dry air, as required.				
L	6	All remote-control valves are in working order.				
L	7	The required cargo pumps and compressors are in good order, and the maximum working pressures have been agreed between tanker and shore.			A	
L	8	Re-liquefaction or boil-off control equipment is in good order.				
L	9	The gas-detection equipment has been properly set for the cargo, is calibrated, has been tested and inspected, and is in good order.				
L	10	Cargo system gauges and alarms are correctly set and in good order.				
L	11	Emergency shutdown systems have been tested and are working properly.				
L	12	Tanker and shore have informed each other of the closing rate of emergency shutdown valves, automatic valves or similar devices.			A	Ship: Shore:
L	13	Information has been exchanged between tanker and shore on the maximum/minimum temperatures/pressures of the cargo to be handled.			A	
L	14	Cargo tanks are protected against inadvertent over-filling at all times while any cargo operations are in progress.				
L	15	The compressor room is properly ventilated, the electrical motor room is properly pressurised and the alarm system is working.				
L	16	Cargo tank relief valves are set correctly, and actual relief valve settings are clearly and visibly displayed (record settings below).				
L	17	The operating parameters (opening pressure) of the pressure valves (MARVS) of the tanker have been considered and agreed.				

European Regional Legislation	Question #	Part D. Bulk Liquefied Gases – Verbal Verification				
		Bulk Liquefied Gases	**Tanker**	**Terminal**	**Code**	**Remarks**
B 19	18	When transporting refrigerated liquefied gases, the holding time has been determined, and is known and documented.			A	Only if the vessel is to be loaded.
L	19	The (port) authorities have been notified prior to cargo handling, if required.			P	

	Remarks
	Cargo tank relief valve settings:

Operational Arrangements

Inland tanker: .... Shore: ....

Date: .... Time: .... Location: ....

The following cargo or ballasting operations will be carried out at the above-mentioned location:

					Stop by:		Inland tanker						Shore				
Product	Quantity (m^3)	Actual temperature (°C)	Starting time	Completion time	Inland tanker 1	Shore tanker 2	Tank	Tank capacity	Manifold connection	Max load/unload rate	Max pressure	Loading*/unloading*	Tank	Tank capacity	Line	Max rate	Max pressure

* Delete where not applicable

Responsible officer inland tanker: Responsible terminal operator:

....

Declaration

We, the undersigned, have checked the above items in Parts A and B and, where appropriate, Part C or D, in accordance with the instructions, and have satisfied ourselves that the entries we have made are correct.

We have also made arrangements to carry out repetitive checks as necessary and agreed that those items coded R in the checklist should be re-checked at intervals not exceeding .... hours.

If, to our knowledge, the status of any item changes, we will immediately inform the other party.

For inland tanker	For shore
Name:	Name: ....
Rank:	Position or title: ....
Signature:	Signature: ....
Date:	Date: ....
Time:	Time: ....

Record of repetitive checks:

Date:								
Time:								
Initials for tanker:								
Initials for shore:								

Appendix 2: Seagoing*-Inland* Tanker/Inland Tanker Safety Checklist

Name of seagoing*/inland* tanker 1: ....

Date of arrival: .... Time of arrival: ....

Name of inland tanker 2: ....

Date of arrival: .... Time of arrival: ....

Location: .... Port: ....

* Delete where not applicable

Regional Legislation		**Part A. Bulk Liquid General – Physical Checks**					
		Bulk Liquid – General	**Seagoing Tanker**	**Inland Tanker 1**	**Inland Tanker 2**	**Code**	**Remarks**
	1	There is safe access between the (seagoing) tanker and inland tanker.				R	
L	L1	The fendering arrangements are assessed as satisfactory. The fender pennants are in order.				R	
B 3	2	The tanker is securely moored, considering the local conditions.				R	
B 11	3	The agreed inter-ship communication system is operative.				A R	VHF channel: Communication system: Back up system:
L	4	Emergency towing-off pennants are correctly rigged and positioned, if required by terminal.				R	
B 14	5	The tanker's fire hoses and fire-fighting equipment are positioned and ready for immediate use.				R	
B 6.1	7	The tanker's cargo hoses, pipelines and manifolds are in good condition, properly rigged and appropriate for the service intended.				R	
B 6.1	7.1	All reducers are approved and compatible with cargo lines and the type of cargo.					
B 6.2	7.2	All connection flanges are fitted with the appropriate gaskets.					
B 6.3	7.3	All flange bolts are properly tightened.					
B 6.4	7.4	The hoses have enough room for easy movement.					
B 14	7.5	All valves are checked and in the right position.					
B 5	7.6	Adequate lighting is ensured at the cargo transfer area and emergency escape route.					
	8	This line has been intentionally left blank.					
L	9	The cargo transfer system is sufficiently isolated and drained to allow safe removal of blank flanges before connection.					
B 8	10	Scuppers and 'save alls' on board are effectively plugged and drip trays are in position and empty.				R	
L	11	Scupper plugs temporarily removed will be monitored constantly.				R	
	12	This line has been intentionally left blank.					
B 7	13	The tanker's unused cargo and bunker/ vapour-return connections are properly secured.					
	14	This line has been intentionally left blank.					

Regional Legislation		Part A. Bulk Liquid General – Physical Checks					
		Bulk Liquid – General	**Seagoing Tanker**	**Inland Tanker 1**	**Inland Tanker 2**	**Code**	**Remarks**
B 18	15	If required, all sighting, ullaging and sampling ports of the cargo, ballast or bunker tanks have been closed or protected by flame arrestors in good condition.					
B 9	16	Sea and overboard discharge valves are closed and visibly secured when not in use. The removable parts between ballast and overboard discharge lines and cargo lines are removed.					
B 14	17.1	All external doors, ports and windows in the accommodation, stores and machinery spaces are closed. Engine room vents may be open.				R	
B 14	17.2	The LPG domestic installation is isolated at the main stop valve.					
L	18	The tanker's emergency fire control plans are available.					Locations:

		If the tanker(s) is fitted with an inert gas system (IGS), or is required to be fitted with one, the following points should be physically checked:					
		Inert Gas System					
L	19	IGS pressure and oxygen content-measuring equipment recorders are in good working order.				R	
L	20	All cargo tank atmospheres are at positive pressure with oxygen content of 8% or less by volume.				P R	
L	20L	All inerted tanks are marked or labelled with a warning sign.					

Regional Legislation		Part B. Bulk Liquid General – Verbal Verification					
		Bulk Liquid – General	**Seagoing Tanker**	**Inland Tanker 1**	**Inland Tanker 2**	**Code**	**Remarks**
L	21	The tankers are ready to move under their own power. A dumb barge without its own propulsion should be able to move with the help of a designated tug at short notice.				P R	
B 10	22	There is an effective deck watch in attendance on board and adequate supervision of operations on both tankers.				R	
L	22L	On each tanker a competent person is appointed who is responsible for the planned cargo-handling.					
L	23	There are sufficient personnel on board both tankers to deal with an emergency.				R	
B 15.1	24.1	The procedures for cargo, bunker and ballast-handling have been agreed.				A R	
B 15.2	24.2	The outlet pressure of the cargo pump of the other tanker is regulated to take account of the admissible working pressure of the equipment on board the tanker.				A R	
B 13	25	The emergency signal and shutdown procedures to be used by both tankers have been explained and understood.				A	
B 2	26	Material Safety Data Sheets (MSDS), or equivalent, for the cargo transfer have been exchanged where requested.				P + R	
B1	26L	The tanker is approved to transport the product to be loaded.					
L	27	The hazards associated with toxic substances in the cargo being handled have been identified and understood.					H2S content: Benzene content:
	28	An international shore fire connection has been provided.					
L	29	The agreed tank-venting system will be used.				A R	Method:
	30.1	The requirements for closed operations have been agreed.				R	
B 12.1	30.2	The tanker's vapour-return connection, if required, is connected by a vapour-return line to the vapour-return connection of the other tanker.				R	
B 12.3	30.3	If protection against explosions is required, the vapour-return line is equipped with a flame arrestor and/or detonation protection.				R	
B 12.2	31	The operation of the P/V system has been verified. The delivering tanker guarantees that the pumping rate does not exceed the maximum working pressure agreed.				R	Agreed max pumping rate: (m^3/h) Agreed max pressure: (kPa)
L	32	Where a vapour-return line is connected, operating parameters have been agreed.				A R	

Regional Legislation		Part B. Bulk Liquid General – Verbal Verification					
		Bulk Liquid – General	**Seagoing Tanker**	**Inland Tanker 1**	**Inland Tanker 2**	**Code**	**Remarks**
B 16+17	33	Independent high-level alarms and/or emergency stops, if fitted, are operational and have been tested.				A R	
L	34	Adequate electrical insulation is in place in the tanker/tanker cargo and vapour-return (if applicable) line connections. The insulating means is installed only on board .... (name tanker).				A R	
	35	This line has been intentionally left blank.					
B 14	36	Smoking requirements have been agreed and are being observed.				A R	
B 14	37	Naked light regulations have been agreed and are being observed.				A R	
L	38	Portable electronic (e.g. communication) device requirements are observed.				A R	
L	39	Hand torches (flashlights) are an approved type.					
L	40	Fixed VHF/UHF transceivers and AIS equipment are on the correct power mode or switched off.					
L	41	Portable VHF/UHF transceivers are an approved type.					
B 14	42	The tankers' main radio transmitter aerials are earthed, and radars are disconnected/switched off.					
B 14	43	Electric cables to portable electrical equipment within the hazardous area are disconnected from power.					
L	44	Window-type air conditioning units are disconnected, if applicable.					
L	45	Positive pressure is maintained inside the accommodation and/or wheelhouse, if applicable.					
L	46	Measures have been taken to ensure sufficient mechanical ventilation in the pumproom, if applicable.				R	
B 4	47	Provision for emergency escape or emergency boarding is positioned ready for use.					
L	48	The weather, maximum wind and swell criteria for operations have been agreed. Stop cargo operations at: .... Disconnect at: .... Unmoor at:				A	
L	49	Security protocols have been agreed between the tankers' security responsible persons/officers, if appropriate.				A	

Regional Legislation		Part B. Bulk Liquid General – Verbal Verification					
		Bulk Liquid – General	**Seagoing Tanker**	**Inland Tanker 1**	**Inland Tanker 2**	**Code**	**Remarks**
L	49L	Security protocols have been agreed for the crew of one tanker to board the other tanker. The location of the security protocol for boarding tanker is:					
L	50	Where appropriate, procedures have been agreed for receiving nitrogen, either for inerting or purging tanker's tanks or for line clearing.				A P	

		If the tanker(s) is fitted with an IGS, or is required to be fitted with one, the following statements should be addressed:					
		Inert Gas System					
L	51	The IGS is fully operational and in good working order, if applicable.				P	
L	52	Deck seals, or equivalent, are in good working order, if applicable.				R	
L	53	Liquid levels in pressure/vacuum breakers are correct, if applicable.				R	
L	54	The fixed and portable oxygen analysers have been calibrated and are working properly.				R	
L	55	All the individual tank IGS valves (if fitted) are correctly set and locked.				R	
L	56	All personnel in charge of cargo operations are aware that should the inert gas plant fail, discharge operations should stop and the other tanker should be advised.					

		If the tanker is fitted with a crude oil washing system, and intends to crude oil wash, the following statements should be addressed:					
		Crude Oil Washing					
L	57	N/A					
L	58	N/A					

		If the tanker is planning to tank clean alongside, the following statements should be addressed:					
		Tank Cleaning					
L	59	Tank cleaning operations are planned during the tanker's stay alongside the other tanker.	Yes/No*	Yes/No*	Yes/No*		
L	60	If 'yes' the procedures and approvals for tank cleaning have been agreed.					
L	61	Permission has been granted for gas-freeing operations by the competent authority.	Yes/No*	Yes/No*	Yes/No*		

*Delete as appropriate.

Regional Legislation		Part C. Bulk Chemicals – Verbal Verification					
		Bulk Liquid Chemicals	**Seagoing Tanker**	**Inland Tanker 1**	**Inland Tanker 2**	**Code**	**Remarks**
L	1	MSDS, or equivalent, are available giving the necessary data for the safe handling of the cargo.					
L	2	A manufacturer's inhibition certificate, where applicable, has been provided.				P	
L	3	Sufficient protective clothing and equipment (including self-contained breathing apparatus) are ready for immediate use and suitable for the product being handled, if applicable.					
L	4	Countermeasures in the event of accidental personal contact with the cargo have been agreed.					
L	5	The cargo-handling rate is compatible with the automatic shutdown system, if in use.				A	
L	6	Cargo system gauges and alarms are correctly set and in good order.					
L	7	Portable vapour-detection instruments are readily available for the products being handled.					
L	8	Information on fire-fighting equipment and procedures has been exchanged.					
L	9	Transfer hoses and gaskets are of suitable material, resistant to the action of the products being handled.					
L	10	Cargo-handling is being performed with the permanent installed pipeline system.				P	
	11	This line has been intentionally left blank.					
L	12	If required, the cargo deck water spray system is ready for immediate use.					

Regional Legislation		Part D. Bulk Liquefied Gases – Verbal Verification					
		Bulk Liquefied Gases	**Seagoing Tanker**	**Inland Tanker 1**	**Inland Tanker 2**	**Code**	**Remarks**
L	1	MSDS, or equivalent, are available giving the necessary data for the safe handling of the cargo.					
L	2	A manufacturer's inhibition certificate, where applicable, has been provided.				P	
L	3	The cargo deck water spray system is ready for immediate use.					
L	4	Sufficient protective clothing and equipment (including self-contained breathing apparatus) are ready for immediate use and suitable for the products being handled, if applicable.					
L	5	Hold and inter-barrier spaces are properly inerted or filled with dry air, as required.					
L	6	All remote-control valves are in working order.					
L	7	The required cargo pumps and compressors are in order and the maximum working pressures have been agreed between the two tankers.				A	
L	8	Re-liquefaction or boil-off control equipment is in good order, if applicable.					
L	9	The gas-detection equipment has been properly set for the cargo, is calibrated, has been tested and inspected and is in good order.					
L	10	Cargo system gauges and alarms are correctly set and in good order.					
L	11	Emergency shutdown systems have been tested and are working properly.					
L	12	Both tankers have informed each other of the closing rate of emergency shutdown valves, automatic valves or similar devices.				A	Tanker 1: Tanker 2:
L	13	Information has been exchanged between the tankers on the maximum/minimum temperatures/pressures of the cargo to be handled.				A	
L	14	Cargo tanks are protected against inadvertent over-filling at all times while any cargo operations are in progress.					
L	15	The compressor room is properly ventilated, the electrical motor room is properly pressurised, and the alarm system is working, if applicable.					
L	16	Cargo tank relief valves are set correctly, and actual relief valve settings are clearly and visibly displayed (record settings below).					

Regional Legislation		Part D. Bulk Liquefied Gases – Verbal Verification					
		Bulk Liquefied Gases	Seagoing Tanker	Inland Tanker 1	Inland Tanker 2	Code	Remarks
L	17	The operating parameters (opening pressure) of the pressure valves (MARVS) of both tankers have been considered and agreed.					
B 19	20a	When transporting refrigerated liquefied gases, the holding time has been determined, and is known and documented.				A	Only for the vessel to be loaded
L	18	The (port) authorities have been notified prior to cargo handling, if required.				P	
L	19	If required by the (port) authorities, an external co-ordinator has been appointed and is on board as co-ordinator responsible for the planned cargo handling between the two tankers.				P	Name of external co-ordinator: Company:

	Remarks
	Pressure relief valve settings:

Operational Arrangements

Seagoing*/inland* tanker 1: .... Inland tanker 2: ....

Date: .... Time: .... Location: ....

The following cargo or ballasting operations will be carried out at the above-mentioned location:

					Stop by:		Seagoing*/inland* tanker 1						Inland tanker 2				
Product	Quantity (m3)	Actual temperature (°C)	Starting time	Completion time	Seagoing* / inland* tanker 1	Inland tanker 2	Tank	Tank capacity	Manifold connection	Max load/unload rate	Max pressure	Loading*/unloading*	Tank	Tank capacity	Line	Max rate	Max pressure

* Delete where not applicable

Responsible officer seagoing*/inland* tanker 1: Responsible officer inland tanker 2:

....

Declaration

We, the undersigned, have checked the above items in Parts A and B and, where appropriate, Part C or D, in accordance with the instructions, and have satisfied ourselves that the entries we have made are correct.

We have also made arrangements to carry out repetitive checks as necessary and agreed that those items coded R in the checklist should be re-checked at intervals not exceeding .... hours.

If, to our knowledge, the status of any item changes, we will immediately inform the other party.

For the seagoing*/inland* tanker 1	For the inland tanker 2
Name:	Name: ....
Rank:	Rank: ....
Signature:	Signature: ....
Date:	Date: ....
Time:	Time: ....

Record of repetitive checks:

Date:								
Time:								
Initials for the seagoing*/ inland* tanker 1:								
Initials for the inland tanker 2:								

* Delete where not applicable

Appendix 3: Hazardous Disposal Safety Checklist

Name of seagoing vessel: ....

Name of tanker: ....

Name of receiving terminal: ....

Port: .... Berth: ....

Date of disposal: .... Time of arrival of tanker: ....

Disposal of:	Quantity (m^3)	UN number	Hazardous components	Class	Legal waste code	Remarks
Bilge water						
Engine room sludge						
Washing waters/slops						
Dirty ballast						
Others						

	Operational arrangements					
Liquid waste:	**Tank N° tanker**	**Tank N° terminal**	**Available tank capacity (m^3)**	**Max pumping rate in m^3/h**	**Max. pressure (kPa)**	**Remarks**
Bilge water						
Engine room sludge						
Washing waters/slops						
Dirty ballast						
Others						

To be used in combination with either Appendix 1 Tanker-Shore Safety Checklist or Appendix 2 Seagoing-Inland Tanker/Inland Tanker Safety Checklist

Appendix 4: Non-Hazardous Disposal Safety Checklist

Name of seagoing vessel: ....

Name of tanker: ....

Name of receiving terminal: ....

Port: .... Berth: ....

Date of disposal: .... Time of arrival of tanker: ....

Disposal of:	Quantity (m^3)	Specification	Legal code	Remarks
Bilge water				
Engine room sludge				
Washing waters/slops				
Dirty ballast				
Others				

	Operational arrangements					
Liquid waste:	Tank n° tanker	Tank n° terminal	Available tank capacity (m^3)	Max pumping rate in m^3/h	Max. Pressure (kPa)	Remarks
Bilge water						
Engine room sludge						
Washing waters/slops						
Dirty ballast						
Others						

ISGINTT ref.		Tanker	Receiving tanker	Terminal	Code	Remarks
1	There is safe access between the two tankers/ shore.				R	
L1	The fendering arrangements are assessed as satisfactory. The fender pennants are in order.				R	
2	The tanker is securely moored, considering the local conditions.				R	
3	The agreed inter-ship/shore communication is operative.				A + R	
9	The cargo transfer system is sufficiently isolated and drained to allow safe removal of blank flanges before connection.					
10	Scuppers and save-alls are effectively plugged, and drip trays are in position and empty.				R	
11	Scupper plugs removed temporarily will be monitored constantly.				R	
13	The tanker's unused cargo and bunker connections are properly secured. All connected flanges are fitted with the appropriate gaskets.					
14	The terminal's unused cargo and bunker/ vapour return connections are properly secured.					
16	Sea and overboard discharge valves are closed and visibly secured when not in use. The removable parts between ballast and overboard discharge lines and cargo lines are removed.					
22	There is an effective deck watch in attendance on board and adequate supervision of operations on the tanker and ashore.				R	
23	There are sufficient personnel on board and ashore to deal with an emergency.				R	
25	The emergency signal and shutdown procedure to be used by the tankers and/or shore have been explained and understood.				A	
26L	The tanker is approved to transport the liquid waste to be loaded.					
33	Independent high-level alarms and/or emergency stops, if fitted, are operational and have been tested.				A + R	
36	Smoking requirements have been agreed and are being observed. No smoking is allowed on board the tankers.				A + R	
48	The weather, maximum wind and swell criteria for operations have been agreed. Stop cargo operations at: .... Disconnect at: .... Unmoor at:				A	

ISGINTT ref.		Tanker	Receiving tanker	Terminal	Code	Remarks
59	Tank-cleaning operations are planned during the tanker's stay alongside the shore installation.	Yes/No	Yes/No	Yes/No		
60	If 'yes', the procedures and approvals for tank-cleaning have been agreed.					
C 9	Transfer hoses and gaskets are of suitable material, resistant to the liquid waste being handled and properly rigged.					
legal	*The procedures for the disposal have been agreed and in line with local legislation.*					

Checked, filled in and signed for the seagoing tanker/tanker

Name: ....

Rank: ....

Signature: ....

Date: ....

Time: ....

Checked, filled in and signed for the tanker/terminal

Name: ....

Rank: ....

Signature: ....

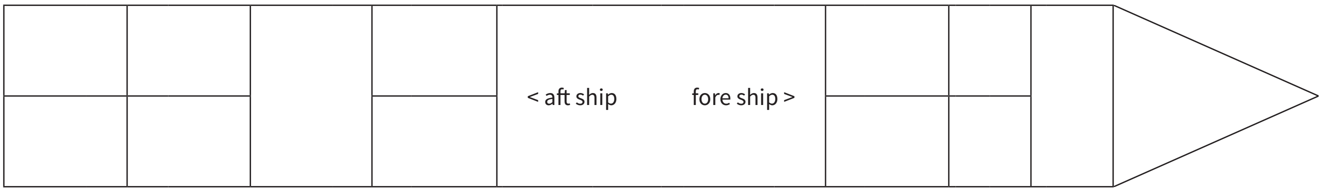
Date: ....

Time: ....

Appendix 5: Bunkering Safety Checklist for Bunker Delivery to Inland Ships

Port/Navigation at (*)		Date	
Time connected		Time start pumping	
Time disconnected		Time stop pumping	

Number bunker tank	1	2	3	4	5
Grade					
Tank capacity (at 97%)	ℓ	ℓ	ℓ	ℓ	ℓ
Content of tank before bunkering	- ℓ	- ℓ	- ℓ	- ℓ	- ℓ
Capacity available for bunkering	ℓ	ℓ	ℓ	ℓ	ℓ
Agreed bunker quantity	ℓ	ℓ	ℓ	ℓ	ℓ
Start pumping rate in: ℓ/min | m^3/h | tons/h (*)					
Max pumping rate in: ℓ/min | m^3/h | tons/h (*)					
Name of responsible person during receiving operations					
Name of responsible person during delivering operations					
Bunker tank contents are checked during operations at intervals of:				Every .... minutes	



			Yes	No
1	(*)	Is the receiving ship securely moored and sufficient fendering in place?		
2	(*)	Is the delivering ship securely moored and sufficient fendering in place?		
3	(*)	If bunkering during navigation has a safe sailing speed been agreed?		
4		Are all of the bunker hoses in good condition and appropriate for the service intended?		
5		Have effective communications been established between both parties?		
6		Is there an effective watch on both ships?		
7		Is enough lighting in place to monitor the delivery?		
8		Are the smoking and open fire restrictions being observed?		
9		Has an emergency stop procedure been agreed?		
10	(**)	Will a bunker overfill protection system be used?		
11	(*)	Has the filler pipe been connected properly and checked for tightness?		
12	(*)	If using a nozzle that cannot be fully connected, is the nozzle inserted far enough into the filling pipe opening and is the hose securely fastened to the receiving ship?		
13		Are the bunker hoses rigged within their limits of torsion and pulling, and is the radius of bending of the hoses above their minimum?		

14	(*)	Are spill containment arrangements in place? (Drip tray, scupper plugs, spill rail, etc.)		
15		Is clean-up equipment available?		

Ticking or initialing the appropriate boxes and signing this checklist confirms the acceptance of obligations.		
Receiving ship	Delivering bunker jetty / station/ship/truck (*)	
Master's name	Representative name	
Signature	Signature	

(*) = delete where not applicable (**) = mandatory when available ℓ = litres

In general, bunkering may only take place if the questions 4 to 9, 13 and 15 are answered with 'yes'.

Appendix 6: Bunkering Safety Checklist for Bunker Delivery to Maritime Ships

(Chapter 25.4.3 ISGOTT)

Port: .... Date: ....

Ship: .... Barge: ....

Master: .... Master: ....

1. Bunkers to be transferred

Grade	Tonnes	Volume at loading temp	Loading temperature	Maximum transfer rate	Maximum line pressure
Fuel oil					
Gas oil/diesel					
Lub. oil in bulk					

2. Bunker tanks to be loaded

Tank No	Grade	Volume of tank at .... %	Vol. of oil in tank before loading	Available volume	Volume to be loaded	Total volumes grade

3. Checks by barge before berthing

	Bunkering	Ship	Barge	Code	Remarks
1	The barge has obtained the necessary permissions to go alongside the receiving ship.				
2	The fenders have been checked, are in good order and there is no possibility of metal-to-metal contact.			R	
3	Adequate electrical insulation is in place in the barge-to-ship connection. (34)				
4	All bunker hoses are in good condition and are appropriate for the service intended. (7)				

4. Checks before transfer

	Bunkering	Ship	Barge	Code	Remarks
5	The barge is securely moored. (2)				
6	There is a safe means of access between the ship and barge. (1)				
7	Effective communications have been established between responsible officers. (3)			A R	(VHF/UHF Ch ....) Primary system: Backup system: Emergency stop signal:
8	There is an effective watch on board the barge and on the ship receiving bunkers. (22)				
9	Fire hoses and fire-fighting equipment on board the barge and ship are ready for immediate use. (5)				
10	All scuppers are effectively plugged. Temporarily removed scupper plugs will be monitored at all times. Drip trays are in position on decks around connections and bunker tank vents. (10) (11)			R	
11	Initial line-up has been checked and unused bunker connections are blanked and fully bolted. (13)				
12	The transfer hose is properly rigged and fully bolted and secured to manifolds on ship and barge. (7)				
13	Overboard valves connected to the cargo system, engine room bilges and bunker lines are closed and sealed. (16)				
14	All cargo and bunker tank hatch lids are closed. (15)				
15	Bunker tank contents will be monitored at regular intervals.			A R	At intervals not exceeding ....…… minutes
16	There is a supply of oil spill clean-up material readily available for immediate use.				
17	The main radio transmitter aerials are earthed, and radars are switched off. (42)				
18	Fixed VHF/UHF transceivers and AIS equipment are on the correct power mode or switched off. (40)				
19	Smoking rooms have been identified and smoking restrictions are being observed. (36)			A R	Nominated smoking rooms Tanker: Barge:
20	Naked light regulations are being observed. (37)			R	
21	All external doors and ports in the accommodation are closed. (17)			R	
22	Safety Data Sheets (SDS) for the bunker transfer have been exchanged where requested. (26)			R	
23	The hazards associated with toxic substances in the bunkers being handled have been identified and understood. (27)			R	Hydrogen sulphide content... Benzene content...
24	Bunkering operation emergency stop is operational				

Declaration

We have checked, where appropriate jointly, the items of the checklist in accordance with the instructions and have satisfied ourselves that the entries we have made are correct to the best of our knowledge.

We have also made arrangements to carry out repetitive checks as necessary and agreed that those items coded R in the checklist should be re-checked at intervals not exceeding .... hours.

If, to our knowledge, the status of any item changes, we will immediately inform the other party.

For ship	For barge
Name:	Name: ....
Rank:	Position or title: ....
Signature:	Signature: ....
Date:	Date: ....
Time:	Time: ....

Record of repetitive checks:

Date:								
Time:								
Initials for ship:								
Initials for barge:								

Appendix 7: Guidelines for Completing the Safety Checklists

Coding of items

The letters A, P or R in the 'Code' column indicates the following:

A (Agreement). An agreement or procedure that should be identified in the 'Remarks' column of the checklist or communicated in some other mutually acceptable form.

P (Permission). In the case of a negative answer to the statements coded P, operations should not be conducted without the written permission from the appropriate authority.

R (Re-check). Items to be re-checked at appropriate intervals, as agreed between both parties, at periods stated in the declaration.

The joint declaration should not be signed until both parties have checked and accepted their assigned responsibilities and accountabilities.

The numbers and the letters in the first column indicate:

Number. That the provision in question is based on the recommendations from ISGOTT/ISGINTT. The number corresponds with the relevant item in the ISGOTT checklist.

B number. That the provision in question is based on those in the ADN (Annexed Regulations to the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways) relating to the transfer of cargo from ship to shore. The B number corresponds with the relevant item in the ADN checklist.

L (legislation). That the provisions in question are related to regional legislation and/or requirements.

Checklists

1 Tanker-Shore Safety Checklist (Appendix 1)

2 Seagoing-Inland Tanker/Inland Tanker Safety Checklist (Appendix 2)

3 Hazardous Disposal Safety Checklist (Appendix 3)

4 Non-hazardous Disposal Safety Checklist (Appendix 4)

Guidelines for Completing the Safety Checklists			Appendix			
		Part A. Bulk Liquid General – Physical Checks	**1**	**2**	**3**	**4**
	1	**There is safe access between the tanker(s) and/or shore.** The access should be positioned as far away from the manifolds as practicable. The means of access to the tanker should be safe and may consist of an appropriate gangway or accommodation ladder with a properly secured safety net fitted to it if practically possible. Particular attention to safe access should be given where the difference in level between the point of access on the tanker and the jetty and/or quay is large or is likely to become large. When terminal access facilities are not available and a tanker's gangway is used, there should be an adequate landing area on the berth to provide the gangway with a sufficient clear run of space and to maintain safe and convenient access to the tanker at all states of tide and changes in the tanker's freeboard. Near the access ashore, appropriate life-saving equipment should be provided by the terminal. A lifebuoy should be available on board the tanker preferably near the gangway or accommodation ladder. The access should be safely and properly illuminated during darkness. Persons who have no legitimate business on board or who do not have the Captain's permission should be refused access to the tanker. The terminal should control access to the jetty or berth in agreement with the tanker.	x	x	x	x
	1L	**The fendering arrangements are assessed as satisfactory.**	x	x	x	x
	2	**The tanker is securely moored, considering the local conditions.** Tankers should remain adequately secured in their moorings. Alongside tankers, piers or quays, ranging of the tanker should be prevented by keeping all mooring lines taut. Attention should be given to the movement of the tanker caused by wind, currents, tides or passing tankers and the operation in progress. Wire ropes and fibre ropes should not be used together in the same direction (i.e. as breast lines, spring lines, head or stern lines) because of the difference in their elastic properties. If synthetic ropes are used, at least two steel cables should be used in the opposite direction to prevent the barge from going adrift. Once moored, tankers fitted with automatic tension winches should not use such winches in the automatic mode. Means should be provided to enable quick and safe release of the tanker in case of an emergency. In ports where anchors must be used, special consideration should be given to this matter. Irrespective of the mooring method, the emergency release operation should be agreed, taking into account the possible risks involved. Electric cables and hose assemblies should not be compressed, folded or subject to tensile strain. Anchors not in use should be properly secured.	x	x	x	x
	3	**The agreed inter-ship or tanker/shore communication system is operative.** Communication should be maintained in the most efficient way between the Responsible Person(s) on duty on the tanker(s) and/or the Terminal Representative. When telephones are used, the telephone on board and/or ashore should be continuously manned by a person who can immediately contact his respective supervisor. The supervisor should also have a facility to override all calls. When radio systems are used, the units should preferably be portable and carried by the supervisor or a person who can get in touch with his respective supervisor immediately. Where fixed systems are used, the guidelines for telephones should apply. The selected primary and back-up systems of communication should be recorded on the checklist, and information on telephone numbers and/or channels to be used should be exchanged and recorded. The telephone and portable radio systems should comply with the appropriate safety requirements.	x	x	x	x

Guidelines for Completing the Safety Checklists			Appendix			
		Part A. Bulk Liquid General – Physical Checks	**1**	**2**	**3**	**4**
	4	**Emergency towing-off pennants are correctly rigged and positioned.** Unless advised to the contrary, emergency towing-off pennants (fire wires) could be positioned on both the off-shore bow and quarter of the tanker. There are various methods for rigging emergency towing-off pennants currently in use. Some terminals may require a particular method to be used and the tanker should be advised accordingly.	x	x	x	
	5	**The tanker's fire hoses and fire-fighting equipment are positioned and ready for immediate use.** See question 6 below.	x	x	x	
	6	**The terminal's fire-fighting equipment is positioned and ready for immediate use.** Fire-fighting equipment on board and on the jetty should be correctly positioned and ready for immediate use. Adequate units of fixed or portable equipment should be stationed to cover the tanker's cargo deck and the jetty area, having due regard to the presence of the tanker and nearby shore tanks. The shore and tanker's fire-main systems should be pressurised or be capable of being pressurised at short notice. The tanker and shore should ensure that their fire-main systems can be inter-connected in a quick and easy way utilising, if necessary, the international shore fire connection (see question 28).	x		x	
	7	**The tanker's cargo hoses and/or the terminal arms or hoses, pipelines and manifolds are in good condition, properly rigged and appropriate for the service intended.**	x	x	x	
	7.1	**All reducers are approved and compatible with cargo lines and the type of cargo.**	x	x	x	
	7.2	**All connection flanges are fitted with the appropriate gaskets.**	x	x	x	
	7.3	**All flange bolts are properly tightened.**	x	x	x	
	7.4	**The loading arms are free to move in all directions and/or the hoses have enough room for easy movement.**	x	x	x	
	7.5	**All valves are checked and in the right position.**	x	x	x	
	7.6	**Adequate lighting is ensured at the cargo transfer area and emergency escape route.** Hoses should be in a good condition and properly fitted and rigged to prevent strain and stress beyond design limitations. All flange connections and reducers should be fully bolted and have the proper gasket. Any other types of connections should be properly secured. Hoses, pipelines and metal arms should be constructed of a material suitable for the substance to be handled, taking into account its temperature and the maximum operating pressure. Cargo hoses should be indelibly marked to allow the identification of the products they are suitable for, specified maximum working pressure, the test pressure and last date of testing at this pressure. If to be used at temperatures other than ambient, maximum and minimum service temperatures should be marked.	x	x	x	
	8	**N/A – question is included in question 7.**				
	9	**The cargo transfer system is sufficiently isolated , drained and depressurised to allow safe removal of blank flanges prior to connection.** A positive means of confirming that both tanker and/or shore cargo systems are isolated , drained and depressurised should be in place and used to confirm that it is safe to remove blank flanges prior to connection. The means should protect against pollution caused by unexpected and uncontrolled release of product from the cargo system and injury to personnel caused by pressure in the system suddenly being released in an uncontrolled manner.	x	x	x	x

Guidelines for Completing the Safety Checklists			Appendix			
		Part A. Bulk Liquid General – Physical Checks	**1**	**2**	**3**	**4**
	10	**Scuppers and save-alls on board are effectively plugged and drip trays are in position and empty.** Where applicable, all scuppers on board should be properly plugged during the operations. Accumulation of water should be visually checked for oil sheen and drained off periodically through absorbent materials. The effectiveness of scupper plugs needs to be ensured and they should be replaced immediately after the water has been run off. The tanker's manifolds should ideally be provided with fixed drip trays in accordance with OCIMF recommendations, where applicable. In the absence of fixed containment, portable drip trays should be used. All drip trays should be emptied in an appropriate manner whenever necessary but always after completion of the specific operation. When only corrosive liquids or refrigerated gases are being handled, the scuppers may be kept open, provided that an ample supply of water or, when prohibited, other adequate means according the related SDS, is available at all times in the vicinity of the manifolds.	x	x	x	x
	11	**Scupper plugs temporarily removed will be monitored constantly.** Scuppers that are temporarily unplugged, e.g. to drain clean rainwater from the cargo deck, must be constantly and closely monitored. The scupper must be re-sealed immediately in the event of a deck oil spill or any other incident that has the potential to cause pollution.	x	x	x	x
	12	**Shore spill containment and sumps are correctly managed.** Shore containment facilities, such as bund walls, drip trays and sump tanks, should be properly maintained, having been sized for an appropriate containment volume following a realistic risk assessment. Jetty manifolds should ideally be provided with fixed drip trays. In their absence, portable drip trays should be used. Spill or slop transfer facilities should be well maintained and, if not an automatic system, should be readily available to deal with spilled product or rainwater.	x			
	13	**The tanker's unused cargo, bunker and vapour-return connections are properly secured. All connected flanges are fitted with the appropriate gaskets.** Unused cargo and bunker/vapour return connections should be closed and blanked. Blank flanges should be fully bolted and other types of fittings, if used, properly secured.	x	x	x	x
	14	**The terminal's unused cargo, bunker and vapour-return connections are properly secured. All connected flanges are fitted with the appropriate gaskets.** Unused cargo and bunker connections should be closed and blanked. Blank flanges should be fully bolted and other types of fittings, if used, properly secured.	x		x	x
	15	**If required, all sighting, ullaging and sampling ports of the cargo, ballast or bunker tanks have been closed or protected by flame arrestors in good condition.** Apart from the openings in use for tank venting (see question 29), all openings to cargo, ballast and bunker tanks should be closed and gas tight. Tankers not equipped for closed loading may use the open tank lid venting, ullaging and sampling method, subject to agreed control. Except on gas tankers, ullaging and sampling points may be opened for the short periods necessary for ullaging and sampling. These activities should be conducted taking account of the controls necessary to avoid electrostatic discharge. (See also section 3.2) Closed ullaging and sampling systems should be used where required by international, national or local regulations and agreements.	x	x	x	
	16	**Sea and overboard discharge valves, when not in use, are closed and visibly secured. The removable parts between ballast and overboard discharge lines and cargo lines are removed.** Experience shows the importance of this item in pollution avoidance on tankers where cargo lines and ballast systems are interconnected. Remote operating controls for such valves should be identified in order to avoid inadvertent opening. If appropriate, the security of the valves in question should be checked visually.	x	x	x	x

Guidelines for Completing the Safety Checklists			Appendix			
		Part A. Bulk Liquid General – Physical Checks	1	2	3	4
	17.1	**All external doors, ports and windows in the accommodation, stores and machinery spaces are closed. Engine room vents may be open.** External doors, windows and portholes in the accommodation should be closed during cargo operations. These doors should be clearly marked as to be closed during such operations, but at no time should they be locked. This requirement does not prevent reasonable access to spaces during operations, but doors should not be left open when unattended. Engine room vents may be left open. However, consideration should be given to closing them where such action would not adversely affect the safe and efficient operation of the engine room spaces served.	x	x	x	
	17.2	**The LPG domestic installation is isolated at the main stop valve.**	x	x	x	
	18	**The tanker's emergency fire control plans are available.** A set of fire control plans should be available at a prominently marked location for the assistance of shoreside fire-fighting personnel. A crew list should also be included in this enclosure.	x	x	x	

		If the tanker is fitted with an Inert Gas System (IGS), or is required to be fitted with one, the following points should be physically checked:				
		Inert Gas System (see section 7.1)				
	19	**IGS pressure and oxygen contents measuring equipment are in good working order.** If required, fixed or portable IGS pressure and oxygen-content recorders/ instruments should be switched on, tested as per the manufacturer's instructions, and operating correctly.	x	x	x	
	20	**All cargo tank atmospheres are at positive pressure with oxygen content of 8% or less by volume.** Before starting cargo operations, each cargo tank atmosphere should be checked to verify an oxygen content of 8% or less by volume. Inerted cargo tanks should be kept at a positive pressure at all times.	x	x	x	
	20L	**All inerted tanks are marked or labelled with a warning sign.** For example: 	x	x	x	

Guidelines for Completing the Safety Checklist			Appendix			
		Part B. Bulk Liquid General – Verbal Verification	**1**	**2**	**3**	**4**
	21	**The tanker is ready to move under its own power. A dumb barge without its own propulsion should be able to move with the help of a designated tug at short notice.** The tanker should be able to move under its own power at short notice, unless permission to immobilise the tanker has been granted by the port authority and the Terminal Representative. Certain conditions may have to be met for permission to be granted.	x	x	x	
	22	**There is an effective deck watch in attendance on board and adequate supervision of operations on the tankers and/or ashore.** The operation should be under constant control and supervision on the tankers and/or in the terminal. Supervision should be aimed at preventing the development of hazardous situations. However, if such a situation arises, the controlling personnel should have adequate knowledge and the means available to take corrective action. The controlling personnel on the tankers and/or in the terminal should maintain effective communications with their respective supervisors. All personnel connected with the operations should be familiar with the dangers of the substances handled and should wear appropriate protective clothing and equipment.	x	x	x	x
	22L	**On the tanker(s) and/or the shore, a competent person is appointed who is responsible for the planned cargo handling.**	x	x	x	
	23	**There are sufficient personnel on board and ashore to deal with an emergency.** At all times during the tanker's stay at the terminal or alongside the other tanker, a sufficient number of personnel should be present on board the tankers and/or in the shore installation to deal with an emergency.	x	x	x	x
	24.1	**The procedures for cargo, bunker and ballast-handling have been agreed.**	x	x	x	
	24.2	**The outlet pressure of the cargo pump of the tanker is regulated to take account of the admissible working pressure of the equipment ashore or on board the other tanker.** The procedures for the intended operation should be pre-planned. They should be discussed and agreed upon by the Responsible Persons and/or Terminal Representative before the start of the operations. Agreed arrangements should be formally recorded and signed by the Responsible Persons and/or Terminal Representative. Any change in the agreed procedure that could affect the operation should be discussed by both parties and agreed upon. After both parties have reached agreement, substantial changes should be laid down in writing as soon as possible and in sufficient time before the change in procedure takes place. In any case, the change should be laid down in writing within the working period of those supervisors on board and ashore in whose working period agreement on the change was reached. The properties of the substances handled, the equipment of tanker and/or shore installation, and the ability of the tanker's crew and shore personnel to execute the necessary operations and to sufficiently control the operations are factors that should be taken into account when ascertaining the possibility of handling a number of substances concurrently. The initial and maximum loading rates, topping-off rates and normal stopping times should be agreed, having regard to: • The nature of the cargo to be handled. • The arrangement and capacity of the tanker's cargo lines and gas venting systems. • The maximum allowable pressure and flow rate in the tanker/shore hoses and loading arms. • Precautions to avoid accumulation of static electricity. • Any other flow control limitations. A record to this effect should be formally made as above.	x	x	x	
	24.3	**The outlet pressure of the shore's cargo pump or the other tanker is regulated to take account of the admissible working pressure of the equipment on board the tanker.** See 24.2	x		x	

Guidelines for Completing the Safety Checklist			Appendix			
		Part B. Bulk Liquid General – Verbal Verification	**1**	**2**	**3**	**4**
	25	**The emergency signal and shutdown procedure to be used by the tanker and shore have been explained and understood.** The agreed signal to be used in the event of an emergency on shore or on board should be clearly understood by shore and/or tanker personnel. An emergency shutdown procedure should be agreed between tankers and/or shore, formally recorded and signed by the Responsible Officer and Terminal Representative. The agreement should state the circumstances in which operations have to be stopped immediately. Due regard should be given to the possible introduction of dangers associated with the emergency shutdown procedure.	x	x	x	x
	26	**Safety Data Sheets (SDS), or equivalent, for the cargo transfer have been exchanged where requested.** An SDS should be available on request to the receiver from the terminal or tankers supplying the product. As a minimum, such information sheets should provide the constituents of the product by chemical name, name in common usage, UN number (if applicable) and the maximum concentration of any toxic components, expressed as a percentage by volume or as ppm.	x	x	x	
	26L	**The tanker is approved to transport the product to be loaded.** The barges substance list issued by the classification society that classified the barge (see ADN 1.16.1.2.5) must be checked by a representative of the filler and the Master (or a mandated person). The substance list must be verified by the information provided by the consignor (ADN 1.4.2.1).	x	x	x	x
	27	**The hazards associated with toxic substances in the cargo being handled have been identified and understood.** Many tanker cargoes contain components that are known to be hazardous to human health. To minimise the impact on personnel, information on cargo constituents should be available during the cargo transfer to enable the adoption of proper precautions. In addition, some port states require such information to be readily available during cargo transfer and in the event of an accidental spill. This is particularly relevant to cargoes that could contain H2S, benzene, lead or other additives.	x	x	x	
	28	**An international shore fire connection has been provided.** If required, the connection must meet the standard requirements and, if not actually connected before operations start, should be readily available for use in an emergency.	x	x	x	
	29	**The agreed tank venting system will be used.** Agreement should be reached and recorded as to the venting system to be used for the operation, taking into account the nature of the cargo and local, national or international regulations and agreements. There are four basic systems for venting tanks: 1. Open to atmosphere via open ullage ports, protected by suitable flame screens. 2. Fixed venting systems, including inert gas systems. 3. To shore through a vapour collection system (see question 32 below). 4. Open to atmosphere (for products without a dangerous goods classification or separately listed in national or international legislation).	x	x	x	
	30.1	**The requirements for closed operations have been agreed.** It is a requirement of many terminals that, when the tanker is ballasting into cargo tanks, loading or discharging, it operates without recourse to opening ullage and sighting ports. In these cases, tankers will require the means to enable closed monitoring of tank contents, either by a fixed gauging system or by using portable equipment passed through a vapour lock, and preferably backed up by an independent overfill alarm system.	x	x	x	
	30.2	**The tanker's vapour-return connection, if required, is connected, by means of a vapour-return line to the vapour-return connection to the shore or the other tanker.**	x	x	x	
	30.3	**If protection against explosions is required, the vapour-return line is equipped with a flame arrestor and/or detonation protection.**	x	x	x	

Guidelines for Completing the Safety Checklist			Appendix			
		Part B. Bulk Liquid General – Verbal Verification	**1**	**2**	**3**	**4**
	31	**The operation of the P/V system has been verified. The delivering tanker or shore guarantees that the pumping rate does not exceed the maximum working pressure agreed.** The operation of the P/V valves and/or high-velocity vents should be checked using the testing facility provided by the manufacturer. Furthermore, it is imperative that an adequate check is made, visually or otherwise, to ensure that the check lift is actually operating the valve. On occasion, a seized or stiff vent has caused the check lift drive pin to shear and the tanker's crew to assume, with disastrous consequences, that the vent was operational.	x	x	x	
	32	**Where a vapour-return line is connected, operating parameters have been agreed.** Where required, a vapour-return line will be used to return hazardous vapours from the cargo tanks to shore or cargo tank to tank. In case of flammable vapours, the vapour-return line should be incorporated with a flame arrestor capable of withstanding a detonation/deflagration. The maximum and minimum operating pressures and any other constraints associated with the operation of the vapour-return system should be discussed and agreed by tankers and/or shore personnel.	x	x	x	
	33	**Independent high-level alarms and/or emergency stops, if fitted, are operational and have been tested.** Owing to the increasing reliance placed on gauging systems for closed cargo operations, it is important that such systems are fully operational and that backup is provided in the form of an independent overfill alarm arrangement. The alarm should provide audible and visual indication and should be set at a level that will enable operations to be shut down before the tank is overfilled. Under normal operations, the cargo tank should not be filled higher than the setting for the overfill alarm. Individual overfill alarms should be tested at the tank to ensure their proper operation before loading starts unless the system is provided with an electronic self-testing capability that monitors the condition of the alarm circuitry and sensor, and that confirms the instrument set point.	x	x	x	x
	34	**Adequate electrical insulation is in place in the tanker/shore cargo and vapour-return line connection (if applicable) or between the tankers.** Unless measures are taken to break the continuous electrical path between tankers and/or shore pipework provided by the tanker/shore or tanker/tanker hoses or metallic arms, stray electric currents, mainly from corrosion-prevention systems, can cause electric sparks at the flange faces when hoses are being connected and disconnected. The passage of these currents is usually prevented by an insulating flange inserted at each jetty manifold outlet or incorporated in the construction of metallic arms. Alternatively, the electrical discontinuity may be provided by the inclusion of one length of electrically discontinuous hose in each hose string. It should be ascertained that the means of electrical discontinuity is in good condition and is not being by-passed by contact with an electrically conductive material.	x	x	x	
	35	**Shore lines are fitted with a non-return valve, or procedures to avoid back-filling have been discussed.** To avoid cargo running back when discharge from a tanker is stopped because of operational needs or excessive back pressure, the terminal should confirm that it has a positive system that will prevent unintended flow from the shore facility onto the tanker. Alternatively, a procedure should be agreed that will protect the tanker.	x		x	
	36	**Smoking requirements are being observed and have been agreed.** No smoking is allowed on board the tankers. No smoking is allowed on the jetty and the adjacent area, except in buildings and places specified by the Terminal Representative in consultation with the Captain. Buildings, places and rooms designated as areas where smoking is permitted should be clearly marked as such.	x	x	x	x

Guidelines for Completing the Safety Checklist			Appendix			
		Part B. Bulk Liquid General – Verbal Verification	**1**	**2**	**3**	**4**
	37	**Naked light regulations have been agreed and are being observed.** A naked light or open fire comprises the following: flame, spark formation, naked electric light or any surface with a temperature that is equal to or higher than the auto-ignition temperature of the products handled in the operation. The use of naked lights or open fires on board the tanker, , should be prohibited, unless all applicable regulations have been met and agreement reached by the port authority, Terminal Representative and the Captain.	x	x	x	
	38	**Portable electronic (e.g. communication) device requirements are being observed.** Tanker/shore telephones should comply with the requirements for explosion-proof construction, except when placed and used in a safe space in the accommodation. Mobile telephones and pagers should not be used in hazardous areas unless approved for such use by a competent authority.	x	x	x	
	39	**Hand torches (flashlights) are an approved type.** Battery operated hand torches (flashlights) should be of a safe type, approved by a competent authority. Damaged units, even though they may be capable of operation, should not be used.	x	x	x	
	40	**Fixed VHF/UHF transceivers and AIS equipment are on the correct power mode or switched off.** Fixed VHF/UHF and AIS equipment should be switched off or on low power (one watt or less) unless the Captain, in consultation with the Terminal Representative, has established the conditions under which the installation may be used safely.	x	x	x	
	41	**Portable VHF/UHF transceivers are of an approved type.** Portable VHF/UHF sets should be of a safe type, approved by a competent authority.	x	x	x	
	42	**The tanker's main radio transmitter aerials are earthed, and radars are disconnected/switched off.** The tanker's main radio station should not be used during the tanker's stay in port, except for receiving purposes. The main transmitting aerials should be disconnected and earthed. Satellite communications equipment may be used normally, unless advised otherwise. The tanker's radar installation should not be used.	x	x	x	
	43	**Electric cables to portable electrical equipment within the hazardous area are disconnected from power.** The use of portable electrical equipment on wandering leads should be prohibited in hazardous zones during cargo operations, and the equipment preferably removed from the hazardous zone. Telephone cables in use in the tanker/shore communication system should preferably be routed outside the hazardous zone. Wherever this is not feasible, the cable should be so positioned and protected that no danger arises from its use.	x	x	x	
	44	**Window-type air conditioning units are disconnected.** Window-type air conditioning units should be disconnected from their power supply.	x	x	x	
	45	**Positive pressure is maintained inside the accommodation and/or wheelhouse.** A positive pressure should be maintained inside the accommodation/wheelhouse when possible, and procedures or systems should be in place to prevent flammable or toxic vapours from entering accommodation spaces. This can be achieved by air conditioning or similar systems, which draw clean air from non-hazardous locations protected by inlet gas and low-pressure alarm systems.	x	x	x	
	46	**Measures have been taken to ensure sufficient mechanical ventilation in the pumproom.** Pumprooms should be mechanically ventilated. The ventilation system, which maintains a safe atmosphere throughout the pumproom, should be kept running throughout cargo-handling operations. If fitted, the gas-detection system should be functioning correctly.	x	x	x	

Guidelines for Completing the Safety Checklist			Appendix			
		Part B. Bulk Liquid General – Verbal Verification	**1**	**2**	**3**	**4**
	47	**There is provision for emergency escape or for emergency boarding ready for use.** It must be possible to board or escape from the vessel at any time. In addition to the means of access referred to in question 1, a safe and quick emergency escape route should be available on board and ashore. Ideally, a jetty should provide secondary means of escape from the tanker in case the normal access is unusable in an emergency. If the jetty configuration renders such secondary escape by gangway impossible, other means should be considered such as: • Preparing the ship's (free-fall) lifeboat for immediate lowering. • Rigging the ship's accommodation ladder on the side away from the jetty. National and/or international legislation may impose different or more stringent requirements.	x	x	x	
	48	**The weather, maximum wind and swell criteria for operations have been agreed.** Numerous factors will help determine whether cargo or ballast operations should be discontinued. Discussion between the terminal and/or the tanker should identify limiting factors, which could include: • Wind speed and direction and the effect on hard arms. • Wind speed and direction and the effect on mooring integrity. • Wind speed and direction and the effect on gangways. • At exposed terminals, swell effects on moorings or gangway safety. Such limitations should be clearly understood by both parties. The criteria for stopping cargo, disconnecting hoses or arms and vacating the berth should be written in the 'Remarks' column of the checklist.	x	x	x	x
	49	**Security protocols have been agreed between the tanker(s) security responsible person/officer and/or the port facility security officer, if appropriate.** In states that are signatories to SOLAS, the ISPS Code requires that the tanker(s) security responsible person/officer and/or the port facility security officer co-ordinate the implementation of their respective security plans with each other.	x	x	x	
	49L	**Security protocols have been agreed for the crew of one tanker to board the other tanker.** The location of the security protocol for boarding tanker is:		x	x	
	50	**Where appropriate, procedures have been agreed for receiving nitrogen supplied from shore, either for inerting or purging the tanker's tanks, or for line clearing into the tanker.** Tanker and shore should agree in writing on the inert gas supply, specifying the volume required, and the flow rate in cubic metres per minute. The sequence of opening valves before beginning the operation and after completion should be agreed, so that the tanker remains in control of the flow. Attention should be given to the adequacy of open vents on a tank in order to avoid the possibility of over-pressurisation. The tank pressure should be closely monitored throughout the operation. The tanker's agreement should be sought when the terminal wishes to use compressed nitrogen (or air) as a propellant, either for pigging to clear shore lines into the tanker or to press cargo out of shore containment. The tanker should be informed of the pressure to be used and the possibility of receiving gas into a cargo tank.	x	x	x	
		Inert Gas System (see section 7.1)				
	51	**The IGS is fully operational and in good working order.** The IGS should be in safe working condition with particular reference to all interlocking trips and associated alarms, deck seal, non-return valve, pressure regulating control system, main deck inert gas line pressure indicator, individual tank inert gas valves (when fitted) and deck pressure/vacuum breaker. Individual tank inert gas valves (if fitted) should have easily identified and fully functioning open/close position indicators.	x	x	x	
	52	**Deck seals, or equivalent, are in good working order.** It is essential that the deck seal arrangements are in a safe condition. In particular, the water supply arrangements to the seal and the proper functioning of associated alarms should be checked.	x	x	x	

Guidelines for Completing the Safety Checklist			Appendix			
		Part B. Bulk Liquid General – Verbal Verification	**1**	**2**	**3**	**4**
	53	**Liquid levels in pressure/vacuum breakers are correct, if applicable.** Checks should be made to ensure that the liquid level in the pressure/vacuum breaker complies with manufacturer's recommendations.	x	x	x	
	54	**The fixed and portable oxygen analysers have been calibrated and are working properly.** All fixed and portable oxygen analysers should be tested and checked as required by the operator and/or manufacturer's instructions and should be operating correctly. The in-line oxygen analyser/recorder and sufficient portable oxygen analysers should be working properly. The calibration certificate should show that its validity is as required by the tanker's SMS.	x	x	x	
	55	**All the individual tank inert gas valves (if fitted) are correctly set and locked.** For loading and discharge operations alike, it is normal and safe to keep all individual tank inert gas supply valves (if fitted) open in order to prevent inadvertent under or over-pressurisation. In this mode of operation, each tank pressure will be the same as the deck main inert gas pressure and thus the pressure/vacuum breaker will act as a safety valve in case of excessive over or under-pressure. If individual tank inert gas supply valves are closed for reasons of potential vapour contamination or de-pressurisation for gauging, etc, then the status of the valve should be clearly indicated to all those involved in cargo operations. Each individual tank inert gas valve should be fitted with a locking device under the control of a responsible officer.	x	x	x	
	56	**All personnel in charge of cargo operations are aware that should the inert gas plant fail, discharge operations should stop and the terminal and/or the other tanker be advised.** In the case of failure of the inert gas plant, the cargo discharge, de-ballasting and tank-cleaning operations should cease and the terminal be advised. Under no circumstances should the tanker's personnel allow the atmosphere in any tank to fall below atmospheric pressure.	x	x	x	
		Crude Oil Washing				
	57	N/A				
	58	N/A				
		Tank Cleaning				
	59	**Tank cleaning operations are planned during the tanker's stay alongside the other tanker/shore installation.** During the pre-transfer discussion between the responsible person/officer and/or terminal representative, it should be established whether any tank cleaning operations are planned while the tanker is alongside and the checklist should be annotated accordingly.	x	x	x	x
	60	**If 'yes', the procedures and approvals for tank cleaning have been agreed.** It should be confirmed that all necessary approvals that may be required to enable tank cleaning to be undertaken alongside have been obtained in line with local legislation and regulations from relevant authorities. The method of tank cleaning to be used should be agreed, together with the scope of the operation.	x	x	x	x
	61	**Permission has been granted for gas-freeing operations by the competent authority.** It should be confirmed that all necessary approvals that may be required to enable gas-freeing to be undertaken alongside have been obtained in line with local legislation and regulations from the relevant authorities.	x	x	x	

Guidelines for Completing the Safety Checklist			Appendix			
		Part C. Bulk Liquid Chemicals – Verbal Verification	**1**	**2**	**3**	**4**
	1	**Safety Data Sheets, or equivalent, are available giving the necessary data for the safe handling of the cargo.** Information on the product to be handled should be available on board the tanker and ashore, and should include: • A full description of the physical and chemical properties, including reactivity, necessary for the safe containment and transfer of the cargo. • Action to be taken in the event of spills or leaks. • Countermeasures against accidental personal contact. • Fire-fighting procedures and fire-fighting media.	x	x	x	
	2	**A manufacturer's inhibition certificate, where applicable, has been provided.** Where cargoes are required to be stabilised or inhibited in order to be handled, tankers should be provided with a certificate from the manufacturer stating: • Name and amount of inhibitor added. • Date inhibitor was added and the normal duration of its effectiveness. • Any temperature limitations affecting the inhibitor. • The action to be taken should the length of the voyage exceed the effective lifetime of the inhibitor. The document should be on board before departure.	x	x	x	
	3	**Sufficient protective clothing and equipment (including self-contained breathing apparatus) are ready for immediate use and suitable for the product being handled.** Protective equipment (including self-contained breathing apparatus and protective clothing) appropriate to the specific dangers of the product handled should be readily available in sufficient quantities for operational personnel on board and ashore.	x	x	x	
	4	**Countermeasures in the event of accidental personal contact with the cargo have been agreed.** Sufficient and suitable means should be available to neutralise the effects and remove small quantities of spilled products. Should personal contact occur, to limit the consequences it is important that sufficient and suitable countermeasures are undertaken. The SDS should contain information on how to handle such contact. It should refer to the special properties of the cargo, and personnel should be aware of the procedures to follow. A suitable safety shower and eye-rinsing equipment should be fitted and ready for instant use in the immediate vicinity of places on board or ashore where operations regularly take place.	x	x	x	
	5	**The cargo-handling rate is compatible with the automatic shutdown system, if in use.** Automatic shutdown valves may be fitted on the tanker(s) and/or ashore. The action of these is automatically initiated, e.g. by a certain level being reached in the tanker(s) or shore tank being filled. Where such systems are used, the cargo handling rate should be established to prevent pressure surges from the automatic closure of valves causing damage to tanker or shore line systems. Alternative means, such as a re-circulation system and buffer tanks, may be fitted to relieve the pressure surge created. A written agreement should be made between the responsible person/officer and terminal representative indicating whether the cargo handling rate will be adjusted or alternative systems will be used.	x	x	x	
	6	**Cargo system gauges and alarms are correctly set and in good order.** Tankers and shore cargo system gauges and alarms should be checked regularly to ensure they are in good working order. In cases where it is possible to set alarms to different levels, the alarm should be set to the required level.	x	x	x	

Guidelines for Completing the Safety Checklist			Appendix			
		Part C. Bulk Liquid Chemicals – Verbal Verification	**1**	**2**	**3**	**4**
	7	**Portable vapour-detection instruments are readily available for the products being handled.** The equipment provided should be capable of measuring flammable and/or toxic levels, where appropriate. Suitable equipment should be available for operational testing of those instruments capable of measuring flammability. Operational testing should be carried out before using the equipment. Calibration should be carried out in accordance with the SMS.	x	x	x	
	8	**Information on fire-fighting equipment and procedures has been exchanged.** Information should be exchanged on the availability of fire-fighting equipment and the procedures to be followed in the event of a fire on board or ashore. Special attention should be given to any products that are being handled that may be water reactive or require specialised fire-fighting procedures.	x	x	x	
	9	**Transfer hoses and gaskets are of suitable material, resistant to the action of the products being handled.** Each transfer hose should be indelibly marked to allow the identification of the products for which it is suitable, its specified maximum working pressure, the test pressure and last date of testing at this pressure, and, if used at temperatures other than ambient, its maximum and minimum service temperatures.	x	x	x	x
	10	**Cargo handling is performed with the permanent installed pipeline system.** All cargo transfer should be through permanently installed pipeline systems on board and ashore. Should it be necessary for specific operational reasons to use portable cargo lines on board or ashore, care should be taken to ensure that these lines are correctly positioned and assembled to minimise any additional risks associated with their use. Where necessary, the electrical continuity of these lines should be checked, and their length be kept as short as possible. The use of non-permanent transfer equipment inside tanks is not generally permitted unless specific approvals have been obtained. Whenever cargo hoses are used to make connections within the tanker(s) and/or shore permanent pipeline system, these connections should be properly secured, kept as short as possible and be electrically continuous to the tanker(s) and/or shore pipeline respectively. Any hoses used must be suitable for the service and be properly tested, marked and certified.	x	x	x	
	11	**Where appropriate, procedures have been agreed for receiving nitrogen supplied from shore, either for inerting or purging tanker's tanks, or for line clearing into the tanker.** Tanker(s) and/or shore should agree in writing on the nitrogen supply, specifying the volume required and the flow rate in cubic metres per minute. The sequence of opening valves before beginning the operation and after completion should be agreed, so that the tanker(s) remains in control of the flow. Attention should be given to the adequacy of open vents on a tank in order to avoid the possibility of over-pressurisation. The tank pressure should be closely monitored throughout the operation. The tanker's agreement should be sought when the terminal/discharging tanker wishes to use compressed nitrogen (or air) for line clearing. The (receiving) tanker should be informed of the pressure to be used and the possibility of receiving gas into a cargo tank.	x		x	
	12	**If required, the cargo deck water spray system is ready for immediate use.** A good working water spray can be used to avoid increasing the cargo deck temperature by radiation.	x	x	x	

Guidelines for completing the safety checklist			**Appendix**			
		Part D. Bulk Liquefied Gases – Verbal Verification	**1**	**2**	**3**	**4**
	1	**Safety Data Sheets, or equivalent, are available giving the necessary data for the safe handling of the cargo.** Information on each product to be handled should be available on board the tanker(s) and/or ashore before and during the operation. Cargo information, in a written format, should include: • A full description of the physical and chemical properties necessary for the safe containment of the cargo. • Action to be taken in the event of spills or leaks. • Countermeasures against accidental personal contact. • Fire-fighting procedures and fire-fighting media. • Any special equipment needed for the safe handling of the particular cargoes. • Minimum allowable inner-hull steel temperatures. • Emergency procedures.	x	x	x	
	2	**A manufacturer's inhibition certificate, where applicable, has been provided.** Where cargoes are required to be stabilised or inhibited in order to be handled, tankers should be provided with a certificate from the manufacturer stating: • Name and amount of inhibitor added. • Date inhibitor was added and the normal duration of its effectiveness. • Any temperature limitations affecting the inhibitor. • The action to be taken should the length of the voyage exceed the effective lifetime of the inhibitor. The document should be on board before departure.	x	x	x	
	3	**The cargo deck water spray system is ready for immediate use.** In cases where flammable or toxic products are handled, water spray systems should be tested regularly. Details of the last tests should be exchanged. During operations, the systems should be kept ready for immediate use.	x	x	x	
	4	**Sufficient protective clothing and equipment (including self-contained breathing apparatus) are ready for immediate use and suitable for the products being handled.** Suitable protective equipment, including self-contained breathing apparatus, eye protection and protective clothing appropriate to the specific dangers of the product handled should be available in sufficient quantities for operational personnel on board and ashore. Storage places for this equipment should be protected from the weather and be clearly marked. All personnel directly involved in the operation should use this equipment and clothing whenever the situation requires. Personnel required to use breathing apparatus during operations should be trained in its safe use. Untrained personnel and personnel with facial hair should not be selected for operations involving the use of breathing apparatus.	x	x	x	
	5	**Hold and inter-barrier spaces are properly inerted or filled with dry air, as required.** The spaces that are required to be inerted by the IMO Gas Carrier Codes should be checked by the tanker's crew before arrival.	x	x	x	
	6	**All remote-control valves are in working order.** All tanker(s) and/or shore cargo system remote-control valves and their position-indicating systems should be tested regularly. Details of the last tests should be exchanged.	x	x	x	
	7	**The required cargo pumps and compressors are in good order, and the maximum working pressures have been agreed between (the two) tanker(s) and/or shore.** Agreement in writing should be reached on the maximum allowable working pressure in the cargo line system during operations.	x	x	x	
	8	**Re-liquefaction or boil-off control equipment is in good order.** It should be verified that re-liquefaction and boil-off control systems, if required, are functioning correctly before starting operations.	x	x	x	

Guidelines for completing the safety checklist			Appendix			
		Part D. Bulk Liquefied Gases – Verbal Verification	1	2	3	4
	9	**The gas-detection equipment has been properly set for the cargo, is calibrated, has been tested and inspected, and is in good order.** Suitable gas should be available to enable operational testing of gas-detection equipment. Fixed gas-detection equipment should be tested for the product to be handled before the start of operations. The alarm function should have been tested and the details of the last test should be exchanged. Portable gas-detection instruments, suitable for the products handled, capable of measuring flammable and/or toxic levels, should be available. Portable instruments capable of measuring in the flammable range should be operationally tested for the product to be handled before operations start. Calibration of instruments should be carried out in accordance with the SMS.	x	x	x	
	10	**Cargo system gauges and alarms are correctly set and in good order.** Tanker(s) and/or shore cargo system gauges should be checked regularly to ensure that they are in good working order. In cases where it is possible to set alarms to different levels, the alarm should be set to the required level.	x	x	x	
	11	**Emergency shutdown systems have been tested and are working properly.** Where possible, tanker(s) and/or shore emergency shutdown systems should be tested before starting cargo transfer.	x	x	x	
	12	**The tanker(s) and/or shore have informed each other of the closing rate of emergency shutdown valves, automatic valves or similar devices.** Automatic shutdown valves may be fitted in the tanker(s) and/or the shore systems. Among other parameters, the action of these valves can be automatically initiated by a certain level being reached in the tank being loaded, either on board or ashore. The closing rate of any automatic valves should be known, and this information should be exchanged. Where automatic valves are fitted and used, the cargo-handling rate should be adjusted so that a pressure surge evolving from the automatic closure of any such valve does not exceed the safe working pressure of either the tanker(s) and/or shore pipeline systems. Alternatively, means may be fitted to relieve the pressure surge created, such as re-circulation systems and buffer tanks. A written agreement should be made between the responsible person(s)/officer(s) and/or terminal representative indicating whether the cargo-handling rate will be adjusted or alternative systems will be used. The safe cargo handling rate should be noted in the agreement.	x	x	x	
	13	**Information has been exchanged between tanker(s) and/or shore on the maximum/minimum temperatures/pressures of the cargo to be handled.** Before operations start, information should be exchanged between the responsible person(s)/officer and terminal representatives on cargo temperature/pressure requirements. This information should be in writing.	x	x	x	
	14	**Cargo tanks are protected against inadvertent overfilling at all times while any cargo operations are in progress.** Automatic shutdown systems are normally designed to close the liquid valves, and if discharging to trip the cargo pumps should the liquid level in any tank rise above the maximum permitted level. This level must be accurately set and the operation of the device should be tested at regular intervals. If tanker(s) and/or shore shutdown systems are to be inter-connected, their operation must be checked before cargo transfer begins.	x	x	x	
	15	**The compressor room is properly ventilated, the electrical motor room is properly pressurised and the alarm system is working.** Fans should be run for at least 10 minutes before cargo operations start and then continuously during cargo operations. Audible and visual alarms, provided at airlocks associated with compressor/motor rooms, should be tested regularly.	x	x	x	

Guidelines for completing the safety checklist			Appendix			
		Part D. Bulk Liquefied Gases – Verbal Verification	**1**	**2**	**3**	**4**
	16	**Cargo tank relief valves are set correctly, and actual relief valve settings are clearly and visibly displayed.** In cases where cargo tanks are permitted to have more than one relief valve setting, it should be verified that the relief valve is set as required by the cargo to be handled and that the actual setting of the relief valve is clearly and visibly displayed on board the tanker(s). Relief valve settings should be recorded in the checklist.	x	x	x	
	17	**The operating parameter (opening pressure) of the pressure valve (MARV) of the tanker has been considered and agreed.** This is the abbreviation for the Maximum Allowable Relief Valve setting on a tanker's cargo tank – as stated on the tanker's certificate of fitness/approval.	x	x	x	
	18	**When transporting refrigerated liquefied gases, the holding time has been determined, and is known and documented.** If liquefied gas is transferred, this item needs to be filled before loading Unless the temperature of the cargo is controlled guaranteeing the use of the maximal boil-off in any service conditions, the holding time has to be determined by the Captain or another person on his behalf before loading, and validated by the Captain or another person on his behalf during loading and shall be documented on board.				
	19	**The (port) authorities have been notified prior to cargo handling, if required.**	x	x	x	
	20	**If required by the (port) authorities, an external co-ordinator has been appointed and is on board as co-ordinator responsible for the planned cargo handling between the two tankers.**		x	x	

CCNR
CENTRAL COMMISSION
FOR THE NAVIGATION OF THE RHINE

OCIMF

Our vision
A global marine industry that causes no harm to people or the environment

Oil Companies
International Marine Forum
29 Queen Anne's Gate
London
SW1H 9BU
United Kingdom

T +44 (0)20 7654 1200
E enquiries@ocimf.org

ocimf.org

Central Commission for the
Navigation of the Rhine (CCNR)
Palais du Rhin
2, Place de la République – CS10023
67082 Strasbourg Cedex
France

T +33 (0)3 88 52 20 10
E ccnr@ccr-zkr.org

ccr-zkr.org