RECORD OF CHANGES
REVISED 01.08.05

DATE	CIRCULAR LETTER	REV. NO.	CORRECTIONS
01.08.05		0	Complete Manual Reissued

PREAMBLE

This manual should be read in conjunction with the following:

1. Company Safety Manual
2. Company Emergency and Contingency Manual.
3. ICS Tanker Safety Guide
4. Liquefied Gas Handling Principles by SIGTTO
5. Review of LPG Cargo Quantity Calculations by SIGTTO
6. Ship-To-Ship Transfer Guide (Liquefied Gases)
7. ICS / OCIMF /SIGTTO Guide to Contingency Planning for Gas Carrier Alongside and Within Port Limits
8. ICS / OCIMF / SIGTTO Guide for Contingency Planning and Crew Response Guide for Gas Carrier Damage at Sea and In Port Approaches.
9. SIGTTO Guide lines on Maintenance of Pressure Relief Valves on Board Gas Carriers.
10. BCH 24/15, Amendments and Interpretations of the GC and IGC Codes, Regarding Filling Limits.
11. SIGTTO Recommendations and Guidelines for Ship / Shore Linked ESD of Cargo Transfer.
12. SIGTTO Guidelines on the Ship-Board Odourization of LPG.
13. Liquefied Gas Handling Principles on Ship's and in Terminals.
14. OCIMF Mooring Equipment Guidelines.
15. OCIMF Effective Mooring.
16. ISGOTT – International Safety Guide for Oil Tankers and Terminals.

LIST OF CONTENTS

1. INTRODUCTION

1.1 PURPOSE

This Manual is issued to assist all personnel involved in the operation of LPG Carriers to carry out their duties in a safe and efficient manner.

1.2 SCOPE

If any conflict is found between the requirements of this and any other instructions, the Master shall consult the Company for instructions on how to resolve the conflict.

1.3 RESPONSIBILITY

The Master is responsible for implementing the requirements of these Instructions on board. He shall normally appoint the Chief Officer as Cargo Officer to deal with all matters relating to cargo operations.

1.4 DOCUMENTATION AND REPORTING

The Master shall ensure that full and accurate documenting and reporting is carried out in accordance with the requirements of Company Stationery Manual CS 209 and that orderly and accessible storage of documents, records and reports is maintained in accordance with the requirements of the shipboard Safety Management System.

1.5 COMMERCIAL RESPONSIBILITIES

In normal circumstances, there will be no conflict between the SMS and the commercial operation of the ship.

In using the SMS, the Master shall take equal account of the requirements of Owners and Charterers, particularly with regard to preparing cargo spaces for cargo, maximising cargo intake, the correct loading, storage, segregation, care and discharge of cargo and the successful conduct of the voyage.

The SMS shall take precedence if a conflict arises, and the Master shall promptly inform the Company Management Office if this happens.

1.6 LIQUID CARGO

LPG cargoes shall be carried in accordance with the Regulations, Certificate of Fitness and Codes applicable to the ship and flag and the nature of the cargo.

Before accepting a LPG cargo, the Master shall satisfy himself that his ship is capable of safely loading, carrying, and discharging the proposed cargo, and if in any doubt he shall consult the Company.

1.6.1 CARGO RELATED PUBLICATIONS

All Deck Officers shall be instructed by the Master to make themselves familiar with the contents of the cargo-related publications on board appropriate to the ship type.

2. COMPANY LIQUID CARGO STANDING ORDERS (APPENDIX 1)

The Master shall appoint a Deck Officer (normally the Chief Officer) as the Cargo Officer in charge of all cargo, ballast and tank cleaning (grade change) operations and shall instruct this Officer regarding the operational circumstances in which the Master shall be called or consulted.

The duties of the Cargo Officer are to plan, organise, control and supervise all deck, tank and pumproom (Compressor room) aspects of the appropriate operations and to liaise with the Chief Engineer to ensure timely availability of systems.

A Deck Watch shall be on duty to assist during all cargo, ballast and tank cleaning operations and the Cargo Officer shall organise other Deck Officers and Ratings into these Watches.

The strength of a Deck Watch may vary from time at the discretion of the Master but, when operating alongside a terminal or other ship, a Watch shall consist of at least:

- The Cargo Officer
- The Deck Officer
- The Gas Engineer
- Two ratings (one stationed at the Cargo manifold at all times during cargo operation)

The rotation of Deck Watch Personnel shall be so organized as to ensure that they receive adequate rest periods. Watch-keeping schedule must be documented and posted up for reference)(El: 6b-2-1/6b-2-2) Since there is only one Gas Engineer available it is essential that his is adequately rested during his time on duty and these shall be arranged at times of low operational activity. It may also be necessary for the Cargo Officer to take rest periods during this time on duty.

The prepared loading / discharge plan must include a bar chart showing the planned progress of the operation. The Cargo Officer shall fully brief the Watch Officers of the planned operation and make full use of the Watch Officer to control and supervise the routine aspects of the operation. However the Cargo Officer shall personally:

- Check cargo loading arm/ hose connections before commencing to load or discharge. The supervision of the loading arm / hose connection and carrying out the leak test to be done by the Gas Engineer and Duty officer.

- Supervise and check all pipeline valve and blanking device settings during lining up and closing down procedures.

- Supervise the commencement and completion of loading and discharging of cargo or ballast in cargo tanks.

- Supervise the topping off of all cargo tanks whether loading cargo or ballast.
- Check the cargo manifold draining arrangement/system.
- Before he leaves the deck/CCR for any length of time the Cargo Officer shall give clear written instructions to the Watch Officer regarding the continuance of current operations and the time or circumstances when he is to be called.

When the Cargo Officer is absent from the deck/CCR the Watch Officer shall assume responsibility for continuing all planned operations as outlined in the 'standing orders for cargo operations' and written instructions. He shall control and supervise all routine aspects of monitoring tanks, pumps and equipment in use as well as the general ship keeping requirements of moorings, gangway, draught, etc. He may regulate tank valves and pump controls in progressing the planned operation but he shall not depart from the plan without direct instructions from the Cargo Officer. He shall call the Cargo Officer immediately if any emergency arises or any unforeseen circumstance becomes apparent. In an emergency he shall not hesitate to stop all operations if he considers that the circumstances require such action.

During cargo operations, the Deck Watch should take regular rounds and cross-check and report status of liquid and vapour lines, vent lines and vents, valves and overboard discharges to the Watch Officer. These rounds should be carried out along with the items marked as "R" in the ship-shore safety checklist (Appendix II) at the agreed intervals and recorded.

The Watch Officer shall record the events of the operations as they occur in the Cargo Logbook and maintain records of all the parameters monitored.

Cargo Officer should issue Supplementary Standing orders for Deck Officers, Gas Engineer and to Deck Crew on Cargo watches as appropriate.

A copy of these Standing Orders shall be displayed at the Cargo Control Station. A further copy shall be inserted in the Master's Night Order Book and each Deck Officer shall sign that he has read and fully understands these Standing Orders before participating in his first Deck Watch on any ship.

3. GENERAL PRACTICES

3.1 RECORDING OF OPERATIONS

A comprehensive detailed record of all events during operations shall be kept by noting events as they occur in a Cargo Log Book at the control station. Only significant events recorded in the Cargo Log Book shall be transferred to and noted in the **Deck Log Book**.

No detailed list of the events to be recorded in the Cargo Log Book is given here and Masters and Officers shall use their own judgement in this matter. However, the object of this record is, if necessary, to reconstruct the method and sequence of events of an operation and to this end full, relevant details shall be recorded. An entry for Ship / shore safety checklists agreement and for further safety checks on deck should be made in Cargo log book.

In addition to the recording of events, a record of the operating conditions of relevant machinery, equipment and systems in use shall be maintained at the control station.

This data need not be entered directly into the Cargo Log Book but may be recorded on company Gas forms. Where online gauging of tank contents is not fitted the loading computer should be regularly updated for stress monitoring. (El: 6a-3-1)

The following items, as appropriate to the particular operation, shall be recorded at least once per hour:

- The ullages or soundings of all cargo and ballast tanks being worked
- The cargo tank loading or discharge rate calculated from cargo tank ullage readings
- If time and circumstances permit, the ballast loading or discharge rate calculated from the ballast tank soundings.
- Pump performance gauge readings.
- The cargo manifold pressure gauge and temperature gauge readings
- Ship's draught gauge readings
- The cargo tank pressures and temperatures

When continuous recording equipment is in use, a hand written time reference mark shall be made on the print-out paper at the commencement and completion of operations.

3.2 SYSTEMS, MACHINERY AND EQUIPMENT

The Shipbuilder's and Manufacturer's Instruction Manuals for relevant systems, machinery and equipment shall be readily available in an appropriate location for all Officers involved in cargo operations.

These Officers are to familiarise themselves with the operation of the relevant items and to instruct ratings in the correct use of equipment as necessary.

All systems, machinery and equipment shall be operated within the Shipbuilder's or Manufacturer's design limitations and their specified routine tests and checks during start-up and operation shall be carried out

3.3 STANDARD OPERATIONAL TESTS

In addition to the routine tests during operation specified by the Shipbuilder or Manufacturer the following tests shall be carried out:

- The operation of standby power packs for remote control systems shall be tested on each occasion before the system is put into operation
- The accuracy of a remote level gauge in each cargo tank shall be proved at least once during the loading or discharging operation in that tank - this shall be done as soon as convenient by comparing the remote reading with a local reading.
- High and high – high level alarms shall be tested prior arrival and always in use as independent monitoring in addition to the primary gauging system.(el: 6a-2-4).
- Regular comparison checks should be carried out between the tank vapour space local gauge and any remote read outs and recorded.
- .Operational accuracy shall be tested of loading computer quarterly using class approved test data. (el: 6a-2-3)
- Leak testing of the cargo system prior cargo operations to check system integrity

3.4 PIPING SYSTEMS

It is essential that all Deck Officers take the first opportunity to commit to memory the arrangements of all cargo, ballast, and inert gas piping systems so that they may deal immediately with any emergency situation that may arise
during operations.

Diagrams of the cargo, ballast, and inert gas systems shall be prominently displayed at the Control Station. During normal operations these diagrams shall be consulted before setting pipelines or altering valve settings.

3.5 SETTING LINES

The initial lining up of piping systems and any subsequent alterations of valve settings for cargo/ballast operations shall be directly supervised by the Cargo Officer. The individual requirements of each operation and the facilities provided by the ship's systems will determine the line-up to be adopted and the Cargo Officer shall prepare a programme for the operation to make full and efficient use of the available facilities.

While it is not possible to detail a line setting procedure, which will suit all ships on all occasions, any prepared programme shall include the following general rules of good practice:

- all valves in the cargo related piping systems and ballast systems shall be CLOSED at all times except when they are required to be OPEN for operational reasons - this basic must be followed without qualification and valves, which are OPEN, shall be CLOSED as soon as operational requirements permit

- blanking devices including spool pieces and elbow connections in piping systems shall have a normally OPEN or normally CLOSED designation - when these are changed from their normal positions for operational reasons, they shall be returned to their normal position as soon as circumstances permit

- manifold blanks with gaskets shall always be secured with ALL bolts in place in the CLOSED position except when a blank has to be removed for operational reasons. When closed, the bolts should extend at least by two full threads after the nut.

- when lining up for transfer operations the manifold valves shall not be OPENED until cargo arms are connected and shall be CLOSED before the arms are disconnected - the settings of manifold valves shall not be altered during cargo transfer operations without the agreement of the transfer terminal representative - where manifold valves are fitted with locking devices, these shall always be used

- when working parcel cargoes, which require segregation, the valves providing the necessary separation shall be lashed in the CLOSED position.

- where, due to the remote operation of a valve, it is impractical to lash it in the CLOSED position then the appropriate valve operating position on the control console shall be temporarily labelled "TO REMAIN CLOSED"

- setting of valves and isolating devices shall be progressed in a logical sequence to obtain the required line up but tank suction valves, ship's side valves, manifold valves and pump suction and discharge valves as appropriate shall not be opened until the operation is about to commence before opening these valves and after completion of the setting of all other individual valves, the whole piping system shall be checked to ensure that it is correctly lined up.

3.6 OPERATION OF VALVES

Changing the condition of a valve setting shall always be done at a slow rate. Rapid OPENING or CLOSING of a valve can result in a system pressure surge which could cause damage to piping, valves, pumps and other system components.

Valves shall never be CLOSED against the flow of liquid unless other valve settings permit the flow to be diverted to another tank or open discharge line.

3.7 ENGINE ROOM MANNING

The engine room must be manned at all times during cargo and ballast transfer operations, and whenever the inert gas plant is in operation.

3.8 DISCOVERY AND REPORTING OF DEFECTS

Defects discovered in cargo equipment or machinery are to be reported to the Chief Engineer. Where such a defect may constitute a safety hazard or considerably reduce the efficiency of an operation the Master is also to be informed immediately.

3.9 ROUTINE SOUNDING AND TESTING OF TANKS AND SPACES

The routine sounding of segregated ballast tanks and void spaces is to be carried out to detect any water leakage to void spaces, which can damage the tank insulation and affect the stability of vessel.

If leakage is detected the Master must take action to control the situation and advise the Company of the circumstances and the action taken.

The atmosphere in all ballast tanks should be tested weekly and recorded. Cargo handling Spaces, Void spaces, Accommodation area and Engine room are regularly monitored by Fixed Gas detection system. The Fixed Gas Detector should be checked daily for operational condition and regularly calibrated as per maker’s instruction. The Fixed Gas detector readings should be recorded on daily basis. These records should be kept to demonstrate the levels and any apparent trends or changes in level.

If hydrocarbon gas is detected the cause is to be investigated and action taken to render the space gas free. The Master is to report the circumstances and action being taken to the Company as soon as possible.

3.10 MANHOLES, ACCESSES AND OPENINGS

A record is to be maintained of the opening and closing of manhole covers to all ballast tanks and of all other accesses and openings which are within the cargo tank area and below the upper deck.

The Chief Officer must personally supervise the closing of any access which has been opened in a cargo tank. He must personally check the condition and the quantity used of all gaskets, studs, washers, nuts and other securing devices to ensure that the opening is closed tightly.

The Chief Officer may delegate the supervision of the closing of other manholes or accesses to a responsible crew member provided the Officer receives a verbal report from the crew member that the access has been properly closed.

3.11 MOORINGS

The use of polypropylene ropes is no longer acceptable in the oil and gas industry. Where soft ropes are supplied, these must be constructed of a polyester/polypropylene mixture. Moorings of different material or lengths should not be used in the same service.
When an Optimoor profile has been created for a vessel at a particular berth and this profile cannot be adhered to, the facts of the case must be reported to the company.

Masters must ensure that at all berths the mooring pattern could not constitute “mixed moorings” as described in the OCIMF Mooring Equipment Guidelines, OCIMF Effective Mooring and ISGOTT. If the shore insist on a mixed mooring pattern, the Master must issue a letter of protest and inform AESM.

On vessels on frequent scheduled voyages and fitted with wire mooring ropes, the wires will be renewed at each special survey and turned end-for-end at intermediate docking. Synthetic pennants will be renewed at each docking. One spare wire and one spare pennant should be on board.
If mooring tails are fitted to wires, connecting links are usually either Tonsberg or Mandal Shackles. Tonsberg have a straight pin, and tail should be connected to it; Mandal has a curved roller and the wire should be connected to it.

Mooring Tails to meet OCIMF guidelines: If mooring wire tails are used they should be of a material with high breaking strength such as braided or plaited (not three strand construction) nylon. The size of rope selected should be capable of easy handling, while at the same time being of sufficient quality to ensure that the tail has a dry breaking strength at least 25% greater than the associated wire. Dry nylon rope is slightly stronger than polyester, but wet Nylon loses strength much faster under cyclic loading than polyester, and for this reason nylon tails should have at least 37% more strength than the associated wire to allow for the reduction in wet strength. Polypropylene rope should not be used for mooring wire tails.

Mooring lines should be reeled so that the pull is against the fixed pin of the brake strap rather than the floating end. Reeling in the contrary direction can seriously reduce the brake holding capacity.

Winch brakes should be tested at intervals not exceeding 12 months. A record of regular maintenance and inspections and tests, test certificates of each item of the mooring system should be maintained on board.
While alongside self-tensioning winches should not be used in automatic mode.
Mooring winch brake design capacity is the percentage of the minimum breaking load of a new mooring rope or wire it carries, at which the winch brake is designed to render.

Winch brakes will normally be designed to hold 80% of the line's minimum breaking load and will be set in service to hold 60% of the mooring line's minimum breaking load. Brake holding capacity may be expressed either in tonnes or as a percentage of a line's minimum breaking load. The primary brake should be set to hold 60% of the mooring line's minimum breaking load. Since brakes may deteriorate in service, it is recommended that new equipment be designed to hold 80%of the line's minimum breaking load, but have the capability to be adjusted down to 60%.

Specifications should be available on the winch drum to show the design holding capacity and the torque required on the hand wheel or lever to achieve this. If mooring lines are utilized that have a minimum breaking load in excess of that for which the winch was originally designed, the brakes should be set to render at 60% of the minimum breaking load of the mooring line for which the winch was designed.

FIRE WIRES: OCIMF recommendation- wires of 6 x 36 construction with an independent wire rope core. For ships over 20,000 DWT the wire's diameter should be at least 28mm with a length of at least 45m. The Fire wires to be rigged as per Port / Terminal regulations.

EMERGENCY TOWING ARRANGEMENT (ETA): To be readily available for deployment fore and aft. The information to be posted on bridge. The aft ETA should be pre-rigged and capable of being deployed in a controlled manner in harbour conditions by one person within 15 minutes. The forward ETA should be capable of being deployed in harbour conditions in not more than one hour. ETA's should be clearly marked to facilitate safe and effective use even in darkness and poor visibility.

4. SOURCES OF IGNITION

The relevant sections of ISGOTT shall be consulted.

4.1 STATIC ELECTRICITY

All materials, whether solid, liquid or vapour, can generate and return a static charge to some extent. The level of charge depends on the electrical resistance of the material; if it is high, a charge can be built up. On board it is possible for a static charge to build up in the cargo system on materials with low resistance, e.g. pipework that are electrically insulated from each other.

In an un-bonded system or in a system in which the bonding has been removed or damaged static electricity can be generated by:

- flow of liquid through pipes and valves
- flow of liquid/vapour mixtures through spray nozzles
- flow of vapour containing foreign particles, e.g. rust, through piping

A sufficiently large potential difference between the piping system and the hull may result in a discharge of static electricity, which may cause a spark which could result in the ignition of a flammable gas/air mixture.

To minimise the risks of static discharges the cargo system must be properly bonded through to the hull. This will normally be done by the fitting of bonding straps at each flange in the cargo pipework and on the mounting of pumps and valves.

The bonding straps may be made from steel, copper or other conducting material. Copper bonding straps, particularly the type made up by woven strands can deteriorate over time, with the result that the strap either disintegrates or fails to conduct.

ALL BONDING ARRANGEMENTS ON BOARD MUST BE THE SUBJECT OF REGULAR INSPECTIONS WITH RECORDS OF THE INSPECTIONS MAINTAINED.

When maintenance work is carried out on the cargo system, checks must be made to ensure that the bonding arrangements have been reinstated correctly.

4.2 ELECTRICAL SPARKS

Sparks created by the operation of electrical switches or controllers or by the short circulating of live wires will normally have sufficient energy to ignite an explosive gas/air mixture.

To prevent the possibility of electrical equipment creating a source of ignition only approved electrical equipment may be used in gas hazardous operation areas.

4.3 MECHANICAL SPARKS

Hammering with metal on metal may cause sparks with sufficient energy to create a source of ignition. These sparks are tiny particles torn off the metal and made very hot by the energy of impact. The energy within any spark depends upon the nature of the metals concerned. Base metals, such as aluminium, can create very high energy sparks when brought into contact with a rusty surface. These base metals have a very high affinity to oxygen and when in the presence of oxides of iron or lead may create a source of ignition by the liberating heat in a combustion process.

This type of ignition source may occur when for instance an aluminium gangway is drawn over a steel deck, which in places is starting to rust. The heat liberated due to friction between the two surfaces may be sufficient to ignite stray particles consisting of a mixture of for instance aluminium and iron oxide. The sparks formed are known as hot sparks, and due to the liberated combustion heat, their energy content may be very high.

So called "spark free" tools are available, but in use these tools may, and often do, create sparks with sufficient energy to act as a source of ignition. **The use of such tools is therefore not permitted.**

4.4 ELECTRICAL STORMS (LIGHTNING)

Cargo operations or the venting of flammable cargo vapours shall be stopped during electrical storms in the immediate vicinity of the ship.

5. PORTABLE GAS DETECTORS

Portable gas detectors and Oxygen detectors of self aspirating type should be used by any personnel entering enclosed spaces or hazardous area. For determining flammable limits and health hazards each LPG carrier shall carry at least two combustible gas indicators for detecting concentrations of hydrocarbon gas in air. Each of these indicators shall have dual scale calibrations from zero to 100% L.F.L. and from zero to 10% L.F.L.

At least two Tankscopes should be carried on each tanker.

For determining the oxygen content of enclosed spaces each vessel shall carry at least two portable oxygen analysers with a scale reading from 0-21% oxygen by volume.

On every tanker a Multigas detector shall be carried (Draeger or equivalent). At least 10 tubes each shall be carried for measuring VCM Butadiene, Ammonia and Hydrogen Sulphide. Where a particular cargo has to be tested for toxic or flammable gas other than those mentioned above, the Master shall liaise with the Company to ensure timely receipt of a suitable instrument and/or tubes.

Note: Hydrogen Sulphide tubes are supplied for the testing of bunker tank atmospheres as there have been cases where bunker tanks have indicated dangerous levels of hydrogen sulphide (H2S).

Additionally two personal gas detection meters and two personal oxygen meters should be available on board for enclosed space entry. A Multi Gas personal detector measuring H2S, CO, O2 and HC will be an ideal instrument for making enclosed space entry (For e.g. Rekin Keiki GX-2001).

All personnel required to use gas detection equipment shall understand the operation principles used by the detector. The manufacturer's instruction handbook must be available for each unit.

6. PROPERTIES AND HAZARDS OF LIQUEFIED GASES

6.1 DESCRIPTION

Liquefied Gases are mixtures of low-molecular weight hydrocarbons; transported as bulk liquids on specialized constructed vessels referred to as Gas Carriers.

Liquefied Gases are divided into three main categories:

1. LPG or Liquefied Petroleum Gases;
2. LNG or Liquefied Natural Gas;
3. Liquefied Chemical Gases

6.2 COMPOSITION

6.2.1 LIQUEFIED PETROLEUM GASES (LPG)

LPG is generally defined as propane, butane and propane/ butane mixtures in the liquid state. These are colourless, non-corrosive, non-toxic but highly flammable.

6.2.2 LIQUEFIED NATURAL GAS (LNG)

LNG is the product of liquefaction of a naturally occurring mixture of hydrocarbons obtained in petroleum bearing regions. Its composition varies from field to field, but generally contains 65% to 100% methane, 0% to 16% ethane, any balance being propane, butane, pentane, nitrogen and carbon dioxide.

LNG is clean odourless liquid. LNG is non- corrosive. It does not react chemically with common materials found on LNG ships. It does not react with Air, Salt water and Fresh water.

6.2.3 Liquefied Chemical Gases

For the purpose of this manual, the chemical gases considered are those transported in bulk on gas carriers which when liquefied possess similar physical properties to LPG.

The most important of those products are anhydrous ammonia, ethylene, butadiene and vinyl chloride monomer.

6.3 PROPERTIES

Substances, which under ambient conditions are gaseous, are transported as liquid to reduce the required container volume.

In case of methane, liquefaction of gas to LNG reduces the volume by a factor of 600. Whereas in the case of LPG, liquefaction reduces the volume by a factor of roughly 250.

Liquefaction under atmospheric pressure requires temperature reduction to the liquid's boiling point.

When transported at low temperature, heat transfer from surroundings will cause some liquid to vaporize. This vapour can either be condensed and returned to the tank or burnt as fuel. Some substances can be transported at ambient temperatures under pressure, in which case there will not be any boil off.

6.4 HAZARDS

The major hazards of liquefied gases derive from their flammability and their low temperatures. Some chemical gases may also be toxic and corrosive. Most vapor clouds are also heavier than air and so tend to remain at ground level.

6.4.1 FLAMMABILITY

In a liquefied gas fire only the vapour burns, not the liquid itself. Thus the major danger is the ignition of the vapour cloud. The flammable vapour can ignite only when mixed with air in certain proportions. Combustion cannot occur when there is too little or too much vapour.

6.4.2 EXPLOSIVITY

In confined spaces an ignition of vapours or liquefied gases can develop into a violent explosion. Even in unconfined spaces, it may be possible for the speed of flame travel through a large vapour cloud to be at a rate sufficient to cause blast damage in the vicinity.

6.4.3 FLAMELESS EXPLOSION

An explosion like event known as flameless explosion' or 'rapid phase transition (RPT)' may occur if very cold liquefied gas strikes water.

Generally this is not considered a major hazard, as energy release is limited and the possibility of large volumes of liquefied gas reaching the necessary critical conditions is remote.

6.4.4 HEALTH HAZARDS

Health hazards include toxicity, asphyxia, anaesthesia and frost bite.

6.4.4.1 Toxicity

Some cargoes are toxic because their chemical properties can cause temporary or permanent health damage with symptoms such as irritation, tissue damage or impairment of faculties. Skin or skin-wound contact or inhalation may cause this effect. In some cases the effect is cumulative. Contact with cargo liquid or vapour should be avoided. Protective clothing should be worn as necessary and breathing apparatus worn if there is a danger of inhaling toxic vapour.

6.4.4.2 Asphyxia

Asphyxia occurs when the blood oxygen level is insufficient to supply oxygen to the brain. The person affected may experience headache, dizziness and inability to concentrate, followed by loss of consciousness. If any vapour is present in sufficient concentration to exclude oxygen, it may cause asphyxiation whether the vapour is toxic or not.

Care should be taken to avoid asphyxiation by use of vapour and oxygen detecting equipment and breathing apparatus as necessary.

6.4.4.3 Anaesthesia

Certain vapours can produce loss of consciousness because of their effects upon the nervous system (anaesthesia). The unconscious person may react to sensory stimuli, but can only be roused with great difficulty.

Care should be taken to avoid breathing anaesthetic vapour by the use of cargo vapour detection equipment and breathing apparatus as necessary.

6.4.4.4 Frostbite

Direct contact with cold liquid or vapour, or uninsulated pipes and equipment can cause cold burns, or ‘frostbite’ which may permanently damage certain organs (e.g. lungs)

Protective clothing should be worn as necessary to avoid frostbite and contact should be avoided with cold cargo liquid or vapour or equipment.

6.5 REACTIVITY

6.5.1 REACTION WITH WATER - HYDRATE FORMATION

Some hydrocarbon cargoes may combine with water under certain conditions to produce a substance known as 'hydrate'. Crystals of hydrates resembles crushed ice or slush. The water for hydrate formation can come from purge vapours with an incorrect dewpoint, water in the cargo system or water dissolved in the cargo. Care should be taken to ensure that the dewpoint of any purge vapour used is suitable for the cargo concerned, and that water is excluded from the cargo system.

Hydrates can cause pumps to seize, and can also block pump inlets. Care should be taken to ensure prevention of hydrate formation.

It is emphasized that nothing whatsoever should be added to any cargo without the shipper's permission. Antifreeze should not be used with cargoes as Ethylene or Inhibited cargoes (VCM or Butadiene) as in case of inhibited cargoes the antifreeze could affect the inhibitor. Vapour return during discharging should generally be avoided. In case vapour return to ships tank is to be received, obtain certificate of analysis from Shore for the vapour being returned to the ships tanks and issue a letter of protest for possible cargo contamination

6.5.2 SELF REACTION

The most common form is polymerisation. In general, cargoes, which may self-react, are inhibited before shipment and an inhibitor certificate is provided to the ship. If an addition of inhibitors is necessary, such addition should be in accordance with shipper's instructions.

The inhibitor may not boil off with the cargo and it is possible for reliquefaction systems to contain uninhibited cargo the system should be drained or purged with inhibited cargo when shut down.

Many inhibitors are much more soluble in water than in the cargo, and care should be taken to exclude water from the system; otherwise the concentration of inhibitor in the cargo could be considerably reduced.

Similarly the inhibitor may be very soluble in antifreeze additives if these form a separate phase and shipper's instructions on use of antifreeze should be observed. If the ship is anchored in still conditions the cargo should be circulated daily to ensure a uniform concentration of inhibitor.

There are no inhibitors available for certain cargoes that can self react (e.g. ethylene oxide) and these have to be carried under an inert gas blanket. Care should be taken to ensure that a positive pressure of inert gas is maintained at all times and that the oxygen concentration never exceeds 0.2% by volume.

6.5.3 REACTION WITH OTHER CARGOES

Certain cargoes can react dangerously with one another and these should be prevented from mixing, and effectively segregated. SIGTTO Chemical compatibility chart should be consulted. Incase reaction will occur between two chemicals or gases, double separation in stowage and transfer of cargo should be provided which will include the segregation of venting system.

Data sheets for both cargoes should be consulted, to establish whether or not these particular cargoes would react dangerously. Cargo should not be loaded till sufficient information is available to establish the possibilities of reaction and office should be informed.

6.5.4 REACTION WITH OTHER MATERIALS

Data Sheets give a list of materials, which should not be allowed to come into contact with the cargo. Care should be taken to ensure that no incompatible materials are used. (E.g. gaskets, seals. components of cargo equipment etc..)

Reaction can occur between cargo and purge vapours of poor quality (e.g. inert gas with high CO2 content can cause carbarmate formation with ammonia). Reaction can also occur between compressor lubricating oils and some cargoes, which can cause blockage and damage.

6.6 CORROSIVITY

The cargo and inhibitors may be corrosive. Care should be taken to ensure that unsuitable materials are not introduced into the cargo system. All precautions specific to the cargo should be strictly observed.

Corrosive liquid can also attack human tissue and care should be taken to avoid contact. Instructions about the use of protective clothing should be observed.

6.7 VAPOUR CHARACTERISTICS

A characteristic of liquefied gases is the large quantity of vapour readily produced by a small volume of liquid. If possible, the venting of cargo vapour should be avoided. If necessary, it should be done with care and in full knowledge of potential hazards. In most areas the venting of flammable or toxic vapour is forbidden, and any such local regulation should be observed.

No venting must be done during thunderstorms or lightning.

6.8 LOW TEMPERATURE EFFECTS

Liquefied gas cargoes are often shipped at low temperatures and this can present a hazard to personnel and to ship's equipment or systems. It is very essential that temperature-sensing equipment is well maintained and calibrated.

6.8.1 BRITTLE FRACTURE

Care should be taken to prevent cold cargo from coming into contact with normal shipbuilding steels, the resultant rapid cooling would make the metal brittle and would cause stress due to contraction. In this condition the metal would not be able to withstand the combined static, dynamic and thermal stresses and it would crack.

6.8.2 SPILLAGE

Care should be taken to prevent spillage of low temperature cargo because of the hazard to personnel and the danger of brittle fracture. If spillage does occur, first isolate the source and then disperse the spilt liquid. Breathing apparatus may have to be used, because of the presence of vapour. If there is a danger of brittle fracture, a water spray could be used both to vaporize the liquid and to keep the steel warm.

If the spillage is contained in a drip tray, the contents should be covered or protected to prevent accidental contact and allowed to evaporate unless the drip tray is fitted with a drain when the liquid should be drained off. Liquefied gases quickly reach equilibrium and visible boiling ceases; this quiescent liquid could be mistaken for water and carelessness could be dangerous. Water should never be sprayed onto the contents of a drip tray.

Suitable drip trays should always be used beneath manifold connections. Care should be taken to ensure that unused manifold connections are isolated and blanked (flange surface of the blanks should be cleaned and free of frost). Accidents have occurred because cargo has escaped past incorrectly fitted blanks.

If liquefied gases spill on to the sea, large quantities of vapour will be generated by the heating effect of the water. This vapour may create a fire or health hazard, or both. Great care should be taken to ensure that such spillage does not occur, especially when disconnecting cargo hoses.

6.8.3 COOLDOWN

Cargo systems are designed to withstand a certain service temperature. The stress and thermal shock caused by an over-rapid cooldown of the system could cause brittle fracture. Cooldown operations should be carried out carefully in accordance with the cooldown rate (Deg C / Hr) as per instructions in the ship-specific gas-operating manual. As a thumb rule usually it is about 8 degrees Celsius per hour.

6.8.4 COLD SPOTS

The cargo containment insulation prevents adjacent ship steel from falling below permitted levels. 'Cold spots' and icing on this steel indicates local breakdown of the insulation regular checks should be made to see if such breakdowns have occurred. If cold spots are found, the steel temperature should be maintained using water either by direct hosing, or if this is ineffective, by filling the adjacent water ballast space alternatively if a heating system is fitted this should be used in preference.

6.8.5 ICE FORMATION

Low cargo temperatures can freeze water in the system. The effects of ice formation are similar to those of hydrates and anti-freeze can be used to prevent ice formation. General precautions given for hydrates apply. Control air piping on deck should be protected from icing from surrounding cargo piping as any moisture content in it will freeze and cause shut down.

6.8.6 ROLL OVER

If the cargo is stored for any length of time and the boil-off is removed to maintain tank pressure, the evaporation will cause a slight increase in density and reduction of temperature near the liquid surface, which will create a marginally higher temperature and lower density at the tank bottom.

This unstable equilibrium will exist until some disturbance occurs, such as the addition of new liquid. Spontaneous mixing will then take place with the violent evolution of large quantities of vapour. It results in a rapid vapour generation and significant rise in tank pressure.

This phenomenon is called 'roll over'. It may happen on ships that have been in still water for some time. Under such circumstances tank contents should be circulated daily by cargo pumps to prevent roll over occurring.

Roll over can also occur if the same or compatible cargoes of different densities are put into the same tank, for example:

- If tank pressure is maintained by boil-off reliquefaction, the condensate return may be of slightly different temperature (and density) from the bulk liquid.

- If condensate from two or more cargoes is returned to one tank. In such circumstances, roll over may be prevented by returning condensate to the top of the tank if it has higher density than the bulk cargo, and to the bottom of the tank if its density is less.

- Roll over may also occur when two part cargoes are loaded into the same tank (e.g. propane and butane). In this case there will be a large boil-off due to the temperature difference between the two, up to 3% of the total liquid volume. For this reason, such a practice is considered unsafe unless a thorough thermodynamic analysis of the process is carried out, and loading done under strictly controlled conditions.

6.9 PRESSURE

It is very important that pressure sensors are well maintained and accurately calibrated. All pressure sensors should be calibrated using a reference pressure gauge annually and record maintained. Reference pressure gauge should be calibrated ashore annually by a competent body and certified.

6.9.1 HIGH AND LOW PRESSURE EFFECTS

As pressures either above or below the design range can cause damage, it should always be kept within the specific maximum and minimum values.

Cargo trapped in a closed system (e.g. between closed valves) can cause changes in pressure. Cold liquid can heat up and cause the pressure to rise and warm vapour (especially butane and butadiene) can condense and reduce pressure. Care should be taken to ensure that cold liquid does not remain in a closed system and the necessary precautions concerning cargo vapour should be taken.

6.9.2 PRESSURE SURGE

High surge pressures (shock pressures or 'liquid hammers') can be created if valves are opened or shut too quickly, and the pressure surges may be high enough to cause hose or pipeline failure. The closing rate of remotely controlled valves should be checked periodically under actual operating conditions and adjusted if necessary; as valves often have torque characteristics, which change with change of temperature.

Automatic shut-off valves operated by level sensors may cause pressure surges; these valves have been known to shut prematurely because of a fault or power failure and it is important that the system is well maintained and properly adjusted. Cargo tank filling valves should be tested weekly and a record of test should be maintained.

The following precautions should be taken to avoid pressure surges during cargo transfer:

1. During cargo operations, valves should be set to the positions required before transfer begins. While cargo is being transferred, valves in the liquid system should never be operated or shut suddenly. Manual valves

that do not have to be used during normal operations may be lashed, but should never be locked in case they have to be used in an emergency.

2. All liquid lines should be drained after use to prevent liquid being trapped between valves in a deck line and becoming warm and in such cases the valve should be opened very carefully to equalize the pressures slowly.

3. During loading, when flow is diverted from one tank to another, the valves on the tank about to receive cargo should be fully opened before closing the valves on the tank being isolated.

4. During discharge, cargo flow should be controlled by the pump's discharge valves or by the valves on the tank dome, to minimize pressure effects.

For detailed guidance on pressure surges, refer to ISGOTT.

6.9.3 PRESSURIZED SYSTEMS

In pressurized systems, with the cargo at ambient temperature, there is normally no external frosting to indicate the presence of liquid or vapour anywhere in the system. Checks should be made for the presence of high-pressure vapour or liquid by gauges and test cocks before opening valves etc.

It is possible for vapour trapped in a system to condense in cold weather, causing a slight reduction in pressure. If the cargo is inhibited, the recondensed liquid will be uninhibited and the precautions given for reactive cargoes should be observed.

6.9.4 RECIPROCATING MACHINERY

If vapour trapped in a reciprocating compressor condenses, it can dilute the lubricating oil in the crankcase, which could cause bearing failure, over-heating or possibly an explosion. The crankcase heating equipment should be used to reduce the possibility of cargo condensing and should be operated before starting the compressor. Liquid condensed in the compressor may also cause mechanical damage.

6.9.5 CARGO OPERATIONS

Cargo operations such as cooldown, warm-up, loading and discharging may affect pressures in hold or inter-barrier spaces; climatic changes and variation in temperature can also affect pressures.

Pressure in cargo tanks, holds or inter-barrier spaces should be closely monitored, especially during cargo operations and the equipment provided should be used to make necessary adjustments. Particular care is necessary with membrane or semi-membrane systems, which are vulnerable to damage from vacuum or incorrect differential pressures because of the thin barrier metals.

6.9.6 LIQUID GAS SAMPLES

Liquid gas samples should not be placed in containers that cannot withstand the pressure created by the sample at the highest ambient temperature expected. Sufficient space should be left in the container to ensure that it does not become liquid full at the highest temperature anticipated.

6.9.7 SLOSHING

Cargoes may be carried safely within the range of filling levels specified for a particular system. Guidance should be sought from the approved stability booklet and Loading manual. Partial loading of cargo tanks may not be permitted due to possibility of damage caused by significant acceleration loads.

6.9.8 PRESSURE RELIEF VALVES

Pressure relief valves depend on accurate setting of opening and closing pressures for effective operation. Liquid on the outlet side of these valves can disturb the set pressure and prevent pressure relief. Any collected liquid should be drained off carefully and regularly.

6.9.9 HEAT EXCHANGERS

A pressure differential should be maintained on heat exchangers so that leakage can only occur into the cargo side of the system, thus preventing cargo vapour from entering an otherwise safe system. Any leakage should be drained off as necessary.

6.10 SATURATED VAPOUR PRESSURE

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.

The pressure exerted by a saturated vapour at a particular temperature is called the **saturated vapour pressure** of that substance at that temperature.

For further information, refer to SIGTTO Liquefied Gas Handling Principles.

7. GENERAL PRECUATIONS

This chapter gives general precautions, which should be observed irrespective of the type of cargo carried; precautions concerning particular cargoes are given in other chapters and are additional to those given in this chapter.

(1) The Master and all those concerned should use the ICS data sheets and any other relevant information to acquaint themselves with the characteristics of each cargo to be loaded. If information necessary for safe carriage is not available, loading should be refused loading should also be refused if a cargo is to be inhibited but no certificate giving details of the inhibitor is made available. Special note should be made of any contaminants that may be present in the cargo, e.g. water.

(2) Moorings should be properly tended so as to keep the vessel securely berthed as excessive movement could cause damage to hoses or loading arms.

(3) Emergency towing off wires (Fire wires) should be properly rigged and ready for immediate use at all times.

(4) Safe access should be provided to and away from the manifold area. Safety nets should be used where appropriate.

(5) Means of access and all working areas should be well lit during darkness.

(6) No unauthorized persons should be allowed on board. Access should also be denied to persons smoking, intoxicated or under the influence of drugs.

(7) Permanent notices should be conspicuously displayed indicating where smoking and naked lights are prohibited and where ventilation is necessary before entering.

(8) Temporary Notices should be displayed near points of access to the ship stating :

- Unauthorised persons are not allowed to board;
- Visitors are required to show identification;
- Mobile phones and other electronic equipment must be switched off;
- Smoking and naked lights are prohibited;
- Lighters and matches are prohibited to be carried on board. ***(VIQ* 5.23)**

In addition, if the cargo presents a health hazard,

"HAZARDOUS LIQUEFIED GAS"

should be displayed.

(9) No craft should be allowed to come alongside during operations involving venting of cargo vapour. Regulations against smoking and naked lights should be strictly enforced on any craft permitted alongside and on shore if applicable.

(10) If there is little wind movement, vapour may persist on deck. Vapour may also collect on the lee side of superstructures. In such situations, it may be necessary to stop cargo operations, specially during grade change operations.

(11) In cold weather, there is a risk of equipment freezing up. Particular attention should be paid to relief valves and cooling water systems; heating systems should be used if fitted. Water collected on the discharge side of the relief valves should be drained off. Cooling water should be dosed with antifreeze, or drained as necessary. If a system is drained, this action should be logged and the system refilled before subsequent use. Water in fire main or spray systems should be circulated continuously or drained if there is a risk of freezing. Motor room vent should be cleared of snow as it may lead to depressurising of motor room and cause shut down of cargo operation.

Cold weather can cause cargo vapour trapped in rotating equipment (e.g. in a cargo compressor) to condense, enter the crankcase and dilute the lubricating oil and cause damage. Crankcase heaters should be used. Pneumatic valves and control systems can be frozen up in cold weather if the control air supply is damp.

(12) Cargo vapour if required, should be vented to the atmosphere with extreme caution, taking into account all regulations and weather conditions.

(13) All doors portholes and other openings in superstructures should be kept closed at all times. Air conditioning intakes must be set to ensure that the atmospheric pressure inside the accommodation is always greater than that of the external atmosphere. Air conditioning systems must not be set to 100% recirculation as this will cause the pressure of the internal atmosphere to fall to less than that of the external atmosphere due to extraction fans operating in sanitary spaces and galleys. Externally located air conditioning units, such as window or split air conditioning types, should not be operated during cargo operations unless they are either located in safe areas or are certified as safe for use in the presence of flammable vapours. Air lock doors should be opened only when necessary because loss of pressure between the doors could cause equipment to shut down.

(14) Boiler tubes, uptakes, exhaust manifolds and combustion equipment should be maintained in a good condition as a precaution against funnel fires and sparks. If the funnel emits sparks or the up take is on fire, cargo operations should be stopped. At sea, the course should be altered soonest to prevent sparks falling on the tank deck. Soot blowing should not be carried out in port. At sea this should be done only if soot will be blown clear of the tank deck. **[Inform the OOW before soot blowing].**

(15) Oil spillage and leakage should be avoided in the engine room and compressor room & Motor room and the floor plates should be kept clean. In no case should any oil or fuel come in contact with hot surfaces. Flammable liquids for cleaning etc., should be kept in closed, unbreakable and correctly labelled containers in a suitable compartment when not in use and handled with all care.

(16) Care should be taken to ensure that cargo vapour does not enter the engine or boiler room or electric motor room from any source. Diesel engines are liable to overspeed and destroy themselves if flammable vapour is present in the air supply, even at concentrations well below LFL.

(17) Galley personnel should be made aware of the potential dangers from galley fires and all necessary safeguards should be taken. Oily rags and fat should not be allowed to accumulate and the trunking of extractor fans should be kept clean.

(18) Gas detectors are fitted at high and low levels, and relevant detectors should be used for the cargo carried. Compressor room fans should be started at least ten minutes before cargo operations begin and kept running throughout the operation and also if cargo leakage is suspected. Ventilation and lighting systems should be maintained carefully and design features should not be impaired in anyway. Care should be taken to ensure that gas tight bulkhead gland seals and air lock doors function correctly and are maintained properly.

(19) The ship should be at all times adequately stable and in good trim to allow for departure at short notice in an emergency. The ship's Loading and Stability Booklet should be complied with. Hull stresses should be kept within permissible limits.

(20) While berthed, the ship should always be ready to move under her own power at short notice. Immobilization should only be undertaken with prior written agreement of the terminal and if necessary from the local port authority.

(21) All applicable pollution regulations should be complied with. Fire fighting appliances should be in readiness, tested regularly and available for immediate use.

(22) Items such as mobile telephones and radio pagers should only be used in a safe area, such as within the ship's accommodation.

(23) All helicopter operations should be carried out as per the advice contained in ICS Guide to Helicopter / Ship operations. Helicopter operations must not be permitted over the tank deck unless all other operations have been suspended.

(24) Operational abnormalities in any of the ship's system should be recorded and informed to all concerned. Routine records for all systems and operations should be maintained diligently.

They are to be switched off whilst outside the accommodation and on the tank deck.

8. FIRE HAZARDS AND PRECAUTIONS

Cargo vapours in flammable concentrations should be expected in areas such as cargo tanks, cargo machinery spaces and, at times, on deck. Sources of ignition are present in spaces such as accommodation, galley and the engine room, and it is essential to prevent cargo vapour entering these spaces.

8.1 SMOKING

Smoking should be permitted only under controlled conditions at times and in places specified by the Master. In the designated smoking room, all ports should be kept closed and doors into passageways should be kept closed except when in use. Only closed self-extinguishing type ashtrays should be used. Matches and lighters should not be carried about on deck. Smoking must be strictly prohibited on board any gas carrier while at a berth except in designated smoking areas. During grade change operations smoking to be completely prohibited in all parts of the vessel.

8.2 PORTABLE ELECTRICAL EQUIPMENT

Portable electrical equipment (self-contained or on extension cables) should not be used inside cargo tanks, compressor room, motor rooms or adjacent spaces unless:

(1) The compartment over which, or within which, the equipment and/ or extension cable is to be used is free of flammable vapour throughout the period during which the equipment is in use.

(2) Adjacent compartments are also free of flammable vapour, or have been made safe by inerting or completely filling with water.

(3) All connections with other compartments that are not free of flammable vapour are closed and will remain so.

(4) The equipment circuit and extension cable is intrinsically safe.

(5) The equipment is connected within an approved explosion proof housing. Flexible cable used should be of a type approved for extra hard usage has an earth conductor, and should be permanently attached to the explosion proof housing in an approved manner.

(6) Air driven lamps of an approved type may be used in non gas-free atmospheres. Although, to avoid the accumulation of static electricity on the lamp, it should be either earthed or the hose should have a resistance low enough to allow static dissipation.

(7) Only approved safety torches or hand lamps should be used.

Portable domestic radios, electronic calculators, tape recorders, and other non-approved battery powered equipment should not be used on the tank deck or wherever flammable vapour may be encountered.(Repeated)

(9) All portable electrical equipment should be carefully examined for possible defects before use. Special care should be taken to ensure that insulation is undamaged, that cables are securely attached and remain so while the equipment is in use. When berthed, the ship may come within a shore hazardous zone. The precautions relating to the use of electrical equipment within that zone should then be observed on board the ship.

8.3 COMMUNICATION EQUIPMENT

When berthed the ship's normal communication equipment should not be used unless certified safe or the terminal has given specific approval. This applies to telephones, loudhailers, searchlights, etc.

Main radio transmitters should not be used during cargo operations if the aerial is above deck. This is not applicable to permanently and correctly installed VHF equipment.

When berthed, the ship's main transmitting aerials are to be earthed. If required to operate the ship's radio in port for maintenance etc., the agreement of the terminal should be sought. Work permits will have to be issued and to ensure safety; operations will have to be carried out at low power using a dummy aerial load, or transmitting only when no cargo operations are in progress. Globe E mail HF mail service should be in sleep mode at berth and only satellite link for mail should be established.

The terminal should be consulted before radar scanners or satellite communication terminals are used, because they may include non-approved equipment (e.g. drive motors), although the radiation itself is not considered an ignition hazard.

8.4 HOT WORK, HAMMERING, CHIPPING AND POWER TOOLS

Hot work should only be carried out on board in accordance with ISGOTT and Company guidelines. If for any reason, hot work is to be carried out outside the designated area in the machinery space, The Master must obtain the Company's approval for the work, in accordance with Company standing instructions.

Before any power tool is used and before hot work, hammering, chipping or sandblasting is undertaken, the area to be treated should be examined carefully to ensure that the work can be safely undertaken. The following points should be kept in mind:

(1) The area is free of flammable vapour (flammable gas concentration in the areas should be zero, but never exceeding 1% LFL). !!

(2) There is no cargo impregnated scale or other material in the area likely to give off vapour which is flammable, or harmful or both.

(3) There is no flammable liquid in adjacent spaces, which might catch fire by the transmission of heat through the bulkhead or deck.

(4) No flammable vapour can be introduced through common vent lines.

(5) All combustible material such as insulation should be removed or protected from heat.

(6) No flammable vapour or liquid should be released while hot work is in progress.

(7) If carrying out work in an enclosed space, the oxygen content should be normal at 21%.

(8) Adequate fire extinguishing equipment is ready for immediate use.

(9) Approved hot work permit systems are being followed.

(10) Continuous atmosphere monitoring is carried out in the work area.

(11) The use of non-sparking tools is not recommended, as particles of steel or rust may be embedded in the soft metal of such tools and make them capable of creating sparks. However, some Terminals specifically demand that only these tools are used.

(12) Aluminium equipment should not be dragged or rubbed across steel since it may leave a smear. If a heavy smear of aluminium on rusty steel is struck, it is possible to cause an incendiary spark.

8.5 SHIP-SHORE BONDING

Cargo hose strings and loading arms should be fitted with an insulating flange or a length of non-conducting hose to ensure electrical discontinuity between ship and shore. Insulating flanges or length of non-conducting hose, when installed should not be short-circuited, for example, by direct contact with the jetty structure, hose handling equipment, or metal gangways. Insulating flanges should be visually inspected periodically to ensure that the insulation is clean and in good condition. Resistance across it should be measured to confirm.

Cargo hoses with internal bonding between the end flanges should be checked for electrical continuity before they are taken into service and at regular intervals thereafter.

While some national and local regulations still require mandatory connection of a bonding cable, it should be noted that the IMO ‘Recommendations on the Safe Transport of Dangerous Cargoes and Related Activities in Port Areas’ (1995) urge port authorities to discourage the use of ship/shore bonding cables and to adopt the recommendation concerning the use of an insulating flange or a single length of non-conducting hose. Insulating flanges should be designed to avoid accidental short circuiting.

If shore authorities require a bonding cable, the connection to the ship should be checked to see that it is mechanically and electrically sound. Connection should not be made or broken during cargo operations.

Switching off the ship's cathodic protection system is not a substitute for an insulating flange or a length of non-conducting hose. Ship's systems may be switched off, if the terminal has neither insulating flange nor a cathodic protecting system.

8.6 AUTO IGNITION

Immediate steps should be taken to remedy any leakage, which may result in the liquid coming in contact with hot surfaces. Care should also be taken to avoid rags or other materials soaked in oil or chemical from coming in contact with hot surfaces.

8.7 SPONTANEOUS COMBUSTION

Cotton waste and similar absorbent materials should not be stowed near oil, paints etc. nor allowed to come in contact with cargo for instance, while taking it on board. They should not be left lying on the jetty, on deck, on equipment, and on or around pipelines, due to the danger of spontaneous combustion. These materials if they become damp, should be dried before stowing or destroyed.

8.8 STATIC ELECTRICITY

The cargo system of a gas carrier is electrically bonded to the ship's hull to prevent a charge build up and it is essential that these bonding connections be maintained in an efficient condition. Danger of ignition by static electricity is reduced if the system is correctly bonded or if flammable mixtures are not formed.

Due to the risk of static electricity, neither steam nor CO^2 should be injected into a tank, compartment or pipe system, which contains a flammable mixture.

8.9 FIRE FIGHTING AND FIRE PROTECTION EQUIPMENT

Fire fighting appliances should be kept in good order, tested regularly and be available for immediate use at all times.

Prior to cargo transfer, the ship's fire fighting system should be made ready. Two fire hoses should be uncoiled and kept forward and aft of the manifold ready for immediate use, the fire main should be pressurized. The water spray system should be set to protect the manifold and should be tested. Fixed DCP monitors should be made ready and, if remotely activated, should be adjusted to protect the manifold before operations commence. A portable DCP extinguisher should be placed conveniently for use near the manifold and hoses from fixed dry powder stations should be uncoiled and kept ready for immediate use.

Additional protective clothing should be kept near the Cargo Manifold in case of certain hazardous cargoes (e.g. Ammonia, VCM)

Flame arrestors and screens, if fitted, should be maintained in good condition and replaced if they become defective. Flame screen for specified cargoes (Propylene oxide, Isoprene) if available should be regularly inspected.
If inert gas is used in the cargo system (e.g. tank holds or inter-barrier spaces) the gas in each space should be checked regularly to ensure that the oxygen concentration is maintained at the required level and that the pressure is above atmospheric. Instrumentation and equipment used in the system should be maintained in good condition. Inert gas for fire fighting purposes should not be used for cargo service.

Inerting will not prevent external fire if flammable liquid or vapour escapes due to leakage, overflow, burst hose or collision damage. An inert gas/ cargo vapour mixture may become flammable should it escape to atmosphere.

9. CARGO OPERATIONS

9.1 INTRODUCTION

This chapter outlines the range of cargo operations normally carried out on LPG Carriers and general safety precautions to be observed in connection with these operations. Procedures outlined below should be considered as general, due to the considerable variety in design of cargo containment and cargo handling systems. Specific instructions should be prepared for each particular ship and individual operation, the ship-specific cargo operation manual should be consulted.

9.2 COMMISSIONING THE CARGO SYSTEM

Before a ship is commissioned to carry liquefied gas, it is essential that all parts of the cargo system are clean and dry.

Cargo tanks should be clean and inspected at all levels to ensure that any accumulations of rust, water and possible loose objects have been removed. Manhole gaskets should be checked for possible damage and covers properly tightened down.

Pipelines, valves and pumps are to be completely dried out and if necessary, treated with antifreeze. The piping system should be thoroughly blown through with adequate quantities of compressed air, making full use of the system's drains. Special attention should be paid to body cavities of valves and convolutions of expansion bellows.

The E.S.D. system should be made ready. The operation of all actuated valve cutouts on compressors and pumps checked.

The final adjustment and testing of some control equipment in connection with cargo refrigeration plant can only be carried out with cargo on board. Pipe supports should be checked especially where expansion bellows are fitted.

9.3 GENERAL CYCLE OF CARGO OPERATIONS

The sequence of cargo handling operations for any LPG carrier, which comes directly from the builder or dry-dock, is as follows:

(1) Drying - To remove moisture from cargo tanks and pipework in order to reduce the dewpoint and minimize potential ice formation problems.

(2) Inerting - To reduce the oxygen content in the cargo system and so prevent a flammable atmosphere in the subsequent gassing up operations.

(3) Purging (or gassing up) - To replace the inert gas in the cargo tanks, etc. with the vapour of the cargo to be loaded.

(4) Cooldown - To reduce the temperature of the cargo tank prior to loading in order to minimize thermal stresses and excessive vaporization.

(5) Loading - which may involve cooling the product below delivered temperature.

(6) Cargo Conditioning at sea

(7) Discharge - which may involve heating refrigerated cargoes for discharge into pressurized storage.

(8) Ballast passage - which may involve preparing the cargo tanks for a change of cargo.

(9) Changing cargo - which may involve gas freeing, inerting and re-gassing up.

9.3.1 DRYING

Drying of the cargo handling system of any refrigerated ship is a necessary procedure, which must be undertaken as part of the general commissioning and preparation of any such vessel to carry liquefied gas. The amount of water vapour in the empty air-filled cargo tanks may be very high depending on the ambient conditions and this water and water vapour if not removed can cause problems of icing and hydrate formation throughout the system.

Drying is most commonly carried out by means of an air drier. Fresh air from atmosphere is taken through blower or compressor and then passed to a refrigerated drier, normally cooled by R22. The air is cooled and therefore saturated at a lower dewpoint. The dewpoint can be further reduced by down stream silica gel drying. Thereafter, the air may be warmed back to ambient temperature by means of an air heater and then sent to the cargo tank. This process is continued for all tanks and the pipework system until the dewpoint of the air is lower than the envisaged cargo carriage temperature. Drying operation is very common during carriage of Ammonia.

Drying can also be accomplished simultaneously with the inerting operation either using nitrogen from shore or alternatively with an inert gas generator on board fitted with both refrigerated and silica gel drying facilities to achieve a dewpoint of minus 50^{o}C at atmospheric pressure.

9.3.2 INERTING

Inerting of the cargo tanks and pipework system is undertaken to ensure that a non-flammable condition exists while gassing up with the vapour of the cargo to be loaded. For this purpose, a reduction of oxygen concentration below 0.5% by volume is generally adequate, although lower values are usually obtainable and preferred. When oxygen levels as low as 0.1% are required to avoid chemical reaction with incoming gassing-up vapour, it can only be provided by a nitrogen inerting system.

There are two procedures, which can be used for inerting cargo tanks: displacement or dilution. Whichever method is used, it is important to monitor the oxygen concentration in each tank from time to time and at as many locations as possible using the vapour sampling connections provided.

Inert gas from a combustion type generator must never be used in preparation for carrying ammonia because of the reaction of ammonia vapour with the CO2 content of such inert gas to form carbamates.

9.3.2.1 Inerting by Displacement

This relies on stratification in the cargo tank as a result of the difference in vapour densities between the gas entering the tanks and the gas already in the tank. The heavier gas is introduced beneath the lighter gas, and at a low velocity to minimize turbulence. Perfect stratification is very difficult to achieve and in general $1^1/_4$ to 4 times the tank volume of inert gas is required to completely displace the air, depending upon relative densities, tank and piping configurations. Most hydrocarbons are heavier than inert gas, whereas ammonia is lighter than air. Nitrogen and inert gas have almost equal densities but nitrogen is heavier at low temperatures. The amount of inert gas used is considerably lower than the other methods, but the vapour has to be introduced at a controlled rate to prevent turbulence. This method can be used for all types of tanks, but is most efficient for those with the least internal structure.

9.3.2.2 Inerting by Dilution

In the dilution method the incoming gas mixes with the gas already in the tank. The dilution method can be carried out in several different ways.

Dilution by Repeated Pressurization

With type C pressure tanks, the dilution can be achieved by a process of repeated pressurization of the tank with inert gas using a cargo compressor and followed by release of the compressed contents to atmosphere. Each repetition will bring the tank contents nearer and nearer to the oxygen concentration level of the injected inert gas. Quicker results will be achieved by more numerous repetitions each at lower pressurization levels, than by few repetitions using higher pressurization levels which the tank and compressor may be capable of.

Continuous Dilution

This is the only process available for type A tanks, which have a very small pressure or vacuum capability. For a true dilution process, it is necessary to introduce the inert gas at high speed through the vapour connections and vent the diluted contents via the bottom loading lines. Care should be taken to ensure continuous good quality inert gas at the maximum output conditions of the inert gas generator.

Where a number of tanks are to be inerted, it may be possible to achieve a reduction in the total quantity of inert gas consumed and time taken, by inerting two or more tanks in series. This provides a ready way for inerting pipework and equipment at the same time.

9.3.3 PURGING (OR GASSING UP)

Nitrogen or CO2, the main constituents of inert gas cannot be condensed by ship's reliquefaction plant.

To avoid incondensable gases during reliquifying of Cargo, it may be desirable to replace the atmosphere in the tanks by cargo vapour. This may become necessary when the tanks are filled with inert gas or Nitrogen, or dry air when ammonia is to be carried.

Purging the inert gas out of the cargo tanks with cargo vapour is necessary so that the reliquefaction plant can operate continuously and efficiently. Basic principles discussed previously for inerting apply equally to purging.

PURGING AT SEA USING LIQUID FROM DECK STORAGE TANKS

This is only applicable to the large fully refrigerated or semi-refrigerated vessels, which are equipped with deck storage tanks.

Liquid or vapour as required can be taken into the cargo tanks to achieve the necessary cargo concentration.

PURGING ALONGSIDE

The 'gassing up' operation may also be undertaken using cargo supplied from ashore. This facility exists only at certain terminals and the majority of terminals do not permit venting of hydrocarbon vapours alongside, as it presents a hazard.

If no facilities (vapour return etc.) are available for the ship to purge alongside, it is common practice for the ship to prepare one cargo tank and to take sufficient liquid on board, so that the vessel can leave the berth, purge and cooldown the remaining cargo tanks using this liquid and then return ready for loading.

9.3.4 COOLING DOWN

To prevent undue thermal stresses and excessive tank pressure during loading the cargo system must be gradually cooled down. Cooldown consists of introducing cargo liquid into a tank at a low and carefully controlled rate.

The rates at which cargo tanks can be cooled without creating undue thermal stresses depend on the design of the containment system and are typically 10 8 oC per hour. Reference should always be made to the ship-operating manual to determine maximum allowable cooldown rates.

The procedure is for cargo liquid from shore or from deck storage tanks to be gradually introduced into the tanks either through spray lines, if fitted, or via the cargo loading lines. The vapour produced by the rapid evaporation of this liquid can be sent ashore through a vapour return line or handled in the ship's reliquefaction plant. If vapour is being handled in the ship's reliquefaction plant, a closewatch should be kept on compressor discharge temperatures and the incondensible gases vented from the top of the reliquefaction condenser as required.

As the cargo containment system cools down, the thermal contraction of the tank and drop in surrounding temperature together tend to cause a pressure drop in the void spaces. Normally pressure control systems supplying air or inert gas will maintain these pressures, but a watch should be kept on them as the cooldown proceeds.

Cooldown should continue until liquid begins to form in the bottom of the cargo tanks. This can be seen from the sensors. The actual temperature gradient depends on the size of the cargo tanks, position of sprays etc.

Generally, problems encountered during cooldown operations result from inadequate drying or from inadequate purging of inert gas. In the former case, ice or hydrates may form and ice-up valves, pump shafts, etc. Methanol can be added as antifreeze provided the intended cargo permits this. Deepwell pump shaft should be regularly turned by hand to keep them free during the cooldown period.

Once the cargo tanks have been cooled down, cargo pipework and equipment not already cooled can be cooled down.

Precautions must be taken on a semi-refrigerated ship, to avoid subjecting the steel to lower temperatures, than those which the cargo tank has been designed for. It is necessary always to maintain a pressure within the cargo tank at least equal to the Saturated Vapour Pressure (S.V.P.) corresponding to the minimum allowable steel temperature.

Cargo planning:
A detailed cargo plan should be prepared prior arrival to the port. Company has standard forms for cargo planning which involves ship / shore information exchange, Emergency preparedness in port, cargo quantities, stability conditions at different stages of operation and specific instructions by Chief officer for the operation.
Cargo plan should cover the following at all stages of cargo operation:

- Quantity and grade of each parcel;
- Density, temperature and other relevant conditions, including the reference temperature, which determines the filling limits;
- A plan of the distribution, quantities, innages, lines and pumps to be used;
- Transfer rates and maximum allowable pressures;
- Critical stages of the operation;
- Notice of rate change;
- Stability and stress information;
- Drafts and trims;
- Emergency stop procedures;
- Action to be taken in the event of a spill;
- Flammability and toxicity with references to cargo data sheets;
- Ballast operations;
- Protective equipment requirements;
- Hazards of the particular cargoes.
- And, as required, requirements for:
- Cargo pollution category;
- Cooling requirements including rates of cool-down;
- Use of the cargo heater or vapouriser;
- Heel requirements after discharge;
- Under keel clearance limitations;

9.3.5 LOADING

Before loading operations begin pre-operational ship / shore procedures must be thoroughly discussed, appropriate information exchanged and relevant ship/ shore safety checklist completed. Particular attention should be paid to the condition of tank relief valves, remotely operated valves, reliquefaction plant, gas detection systems, alarm and controls (e.g. high level and pressure alarms and shutdowns). Cargo should not be loaded until all required information on cargo properties has been obtained.

Cargo loading can be carried out using a vapour return line, the ship's reliquefaction plant or both. The cargo is led into the cargo tank via the filling lines, which usually terminate close to the tank bottom. If the tank has been cooled down, it is normal to bypass some of the incoming liquid through the tank sprays, if fitted, to reduce the temperature gradient from the top to the bottom of tanks, and to even out the rate of boil off.

On fully pressurized or semi-refrigerated ships, the vapour pressure created during loading can be reduced by spray loading, provided the cargo temperature will give a saturation pressure which is safely below the relief valve set pressure.

The initial stages of loading are critical. Ship's tank pressures must be regularly observed and on no account should relief valves be allowed to lift. Loading rates should be reduced and if necessary stopped when difficulties are experienced in maintaining acceptable tank pressures. Reliquefaction plant should be in operation before commencement of loading operation. Depending on the purging operation, significant quantities of incondensible gas may be present and if no vapour return is provided, these incondensables will have to be vented to the atmosphere via the purge condenser where fitted or alternatively from the top of the cargo condenser. Care must be taken when venting incondensables to minimize venting of cargo vapours to the atmosphere.

A close watch should be kept on the vessel's cargo tank pressures, temperatures, liquid levels, inter-barrier space pressures, etc. throughout the loading operation. If large quantities of vapour are being generated, the bubbles created will increase the liquid volume. Accurate level monitoring then can be achieved by suspending temporarily the vapour removal to allow the liquid level to stabilize.

Towards the end of the loading operations; the loading rate should be reduced to an appropriate level as previously agreed with shore staff in order to accurately 'top-off' tanks (topping up and stopping levels of cargo tanks to be supervised and checked by two officers) On completion of loading, all cargo lines should be drained back to the cargo tanks. Once liquid has been cleared and lines depressurised, manifold valves should be closed and cargo hose disconnected from the manifold flanges.

The relief valves of some vessels have dual settings to allow higher tank pressures during the loading operation. If relief valve settings are to be changed, by changing the pilot spring this can only be carried out with the prior permission of the Master then it must be logged down in Deck Log Book and the current settings prominently displayed. The relief valve pressure must not be set above the MARVS and harbour setting must be reset to sea setting before the ship goes to sea.

De-ballasting can take place simultaneously with loading subject to local regulations. Stability and stresses are of primary importance during loading and deballasting and procedures should be in accordance with correct tanker practices.

Membrane tanks have special loading conditions imposed for permitted liquid levels in order to minimize sloshing.

THE CHANGING OF THE SET PRESSURE SHOULD BE CARRIED OUT UNDER THE SUPERVISION OF THE MASTER IN ACCORDANCE WITH PROCEDURES APPROVED BY THE ADMINISTRATION AND SPECIFIED IN THE SHIP'S OPERATING MANUAL. TERMINAL REQUIREMENTS MUST ALSO BE TAKEN INTO ACCOUNT WHEN SETTINGS ARE CHANGED (VIQ 8.82)

9.3.5.1 FILLING LIMITS AND OVERFILL PROTECTION CARGO TANK FILLING LIMITS:

<u>THE PRESENT LEGAL SITUATION</u>

No cargo tank should have a higher filling limit than 98% at the reference temperature with some exceptions that are given in IGC 15.1.3.

Loading limit means the extent, expressed as a percentage of the tank volume to which a cargo tank can be loaded. This is generally ascertained by the following formula:

$LL = FL\ (D_R/D_L)$

Where

LL= ***loading limit expressed as a percent age which means the maximum allowable liquid volume relative to the tank volume to which the tank can be loaded.***

FL= ***filling limit, this will generally be 98% unless there are considerations as per IGC 15.1.3***
D_R= ***relative density of the cargo at the reference temperature.***

D_L= ***relative density of the cargo at the loading temperature and pressure.***

This is a familiar formula and curves generated on this formula are usually supplied on board. However, the IMO has modified the definition of reference temperature in its 1994 amendments to all the three gas codes in paragraph 15.1.5. This change is applicable only to type C tanks. This consideration does not apply to products that require type 1G ships.

The administration may now allow type C tanks to be loaded according with this amended formula provided the tank vent system has been approved in accordance with IGC 8.2.18. In the revised formula, "D_R" is defined as:

"Relative density of cargo at

Reference temperature means:

- The temperature corresponding to the vapour pressure of the cargo at the set pressure of the pressure relief valves when no cargo vapour pressure/temperature control is provided;
- The temperature of the cargo upon termination loading, during transportation, or at unloading, whichever is the greatest, when a cargo vapour pressure/temperature control is provided. (VIQ 8.3/8.21)

IGC 8.2.18 requires that the owner demonstrate the adequacy of the venting system to handle a two-phase flow.

CONSEQUENCE

Because of these amendments, ships which have a type C tank can now load a much larger amount of cargo. Apart from commercial gains, this is actually beneficial in a fire situation. SIGTTO and IACS have demonstrated that the upper tank body can withstand a fire without rupturing for a longer duration under such loading.

CERTIFICATION

In order to take advantage of this amendment the venting system of the cargo system needs approval. Once approved, the administration will issue a permanent certificate to that effect. The Master will retain on board the original certificate.

THE ISOTHERMAL METHOD

The isothermal method is probably the easiest way to determine the maximum temperature expected en route. The intended track of the vessel should be laid on routing charts, which are overlaid with surface and air temperature isothermals. From this, the maximum temperature that can be expected en route can be read off. The Master should also consult the relevant pilot books to confirm the maximum temperature expected en route.

A full tank of cargo may never reach this maximum temperature. The tank has to remain for some time in that environment to reach thermal equilibrium with the surroundings.

In the smaller pressurized ships, where this amendment is particularly relevant, a full tank of cargo will warm-up typically by 1^o to 2^o C per day, provided the cargo temperature is not very different from the ambient temperature. However the Master will have to decide this on the basis of the accumulated experience on board. The Master should note the tank conditions and the sea and air temperatures in a booklet for every voyage to help him assess the expected temperature rise in the tanks.

Many environmental factors like wind, cloud cover, state of sea also affect the expected temperature rise. Such conditions can be recorded in the same booklet.

This is at best an approximate method as it is impossible to factor all the variables in. In assessing the maximum temperature the cargo may reach en route the master must follow prudent seamanship.

OVERFLOW CONTROL

All cargo tanks and pressure tanks of volume more than 200-m^3 are fitted with a high liquid level alarm giving an audible and visible alarm when activated. Another sensor operating independently of this alarm should automatically actuate a shutoff valve, which will avoid surge along the cargo piping and prevent the tank from being overfilled. The latter is generally called the high-high alarm.

If the high level alarm is actuated by an independent sensor, then the high-high alarm may be actuated by the level gauge, or vice versa. The IGC code does not specify the actual settings of these alarms.

The following are recommended settings for these alarms:

- 95% for the high level alarm
- 98.5% for the high- high level alarm and shut off.

BYPASSING THE LEVEL ALARMS

It is not permitted to bypass the level alarms other than in extraordinary circumstances. In any event, only the Master is allowed to bypass the high-high level alarm. The Master must develop on board written instructions, for bypassing the cargo system alarms, and in particular the level alarms. These instructions must be posted near the position from where such overriding is possible.

9.3.6 CARGO CONDITIONING

The term cargo conditioning refers to the maintaining during sea passages:

- Cargo quantity without undue loss;
- Cargo tank pressure within design limits, and

- Maintaining or altering cargo temperature as required.

This is achieved on LPG ships by reliquefying the boil-off and returning it to the tanks.

Frequently, it is necessary to reduce the temperature of an LPG cargo on passage. Depending on the cargo and reliquefaction plant capacity, it can often take several days to cool the cargo by even 0.5oC.

Heavy weather sometimes presents problems in which there is a risk of slugs of liquid being carried over to the compressor. For this reason, it is preferable not to run compressors in very heavy weather, if it can be avoided. Condensables may be vented off as necessary at such times to minimize compressor discharge pressure and temperatures.

Full reliquefaction capacity should be run on each tank separately and condensate return from the cargo condenser should be returned through a bottom connection to ensure circulation of tank contents. After the cargo has been cooled, the reliquefaction plant capacity can be reduced to a level sufficient to balance the heat flow through the tank insulation.

If the reliquefaction plant is being run on more than one tank simultaneously, it is essential to ensure that condensate returns are carefully controlled in order to avoid overfilling.

Where butadiene cargoes are being carried, the compressor discharge must not exceed 60oC. Similarly, in the case of VCM, compressor discharge temperatures should be limited to 90oC to prevent polymerisation. Vapours of certain cargoes (e.g. ethylene oxide, propylene oxide) cannot be compressed. Such cargoes can be refrigerated by indirect cooling, and cargo compressors normally have to be isolated or blanked off.

Throughout the loaded passage, regular checks should be made to ensure that there are no defects in cargo equipment and no leaks anywhere. If two or more cargoes are carried simultaneously, they should be kept separate throughout all cargo operations and particular care is required with incompatible cargoes.

OPERATION OF RELIQUEFACTION PLANT

For general guidance on safe procedures for reliquefaction and boil-off control, please refer to Chapter 16, section 16.9. Detailed instructions for the ship will depend upon the particular system fitted and reference should always be made to the ship-specific cargo operation gas manual.

9.3.7 CARGO DISCHARGE

Prior to the vessel's arrival at the reception terminal, cargo tank temperatures and pressures should be at values appropriate to terminal requirements. Before the discharge operation begins, pre-operational ship / shore information should be exchanged and ship /shore safety checklist filled.

The method of discharging the cargo will depend on the type of ship, cargo specifications and terminal storage facilities.

Three basic methods are used:

- Vapour pressure, with or without booster pumps.
- Centrifugal cargo pumps with or without a booster pump in series,
- Centrifugal cargo pumps through a cargo heater and a booster pump.

DISCHARGE BY VAPOUR PRESSURE

This is applicable where type - 'C' tanks are fitted and there are no cargo pumps. The vapour pressure above the liquid is increased (by a vaporizer and compressor) and the liquid transferred ashore by this increased pressure. When there are no cargo pumps, there is generally a booster pump fitted.

DISCHARGE BY CENTRIFUGAL PUMPS WITH OR WITHOUT BOOSTER PUMPS

Discharging by centrifugal cargo pumps either alone or in series with booster pumps is the method most commonly adopted and a good understanding of centrifugal pump characteristics is essential for efficient cargo discharge. The discharge rate should not be reduced by throttling of valves at the cross over if the shore cannot accept the discharge rate, as throttling in this manner heats up the cargo. Cargo pump discharge may be throttled when used in conjunction with a booster pump in order to reduce the outlet pressure from the booster pump.

Control of flow supply by throttling the main pump discharge may cause loss of booster pump suction. Hence a judicious control of flow should be affected by throttling the booster pump discharge or the main pump re-circulation or a combination of both.

As liquid is being discharged from the tank, tank pressures will tend to fall. Boil-off due to heat flow through the tank insulation takes place continuously and this generates vapour within the tank, which may or may not be enough to maintain cargo tank pressures at acceptable levels. Where vapours produced internally are insufficient to balance the discharge rate, it is necessary to add vapour to the tank either by a vapour return line or by a cargo vaporizer on board.

DISCHARGE BY CENTRIFUGAL PUMPS VIA CARGO HEATER AND BOOSTER PUMP

Where cargo is being transferred from a refrigerated ship into pressurized storage, it will be necessary to warm the cargo on discharge, which means running the cargo booster pump and cargo heater in series with the main cargo pump. This operation will involve higher line and manifold pressures, thereby requiring extra caution. The pumps usually have significantly different capacities and the total flow may have to be regulated on the booster pump outlet to prevent this pump from running dry. To operate the booster pump and heater, it is necessary to first establish seawater flow through the heater. Thereafter the pump and heater may be slowly cooled down prior to operation by carefully bleeding in liquid from the main cargo pump discharge. Once cooled down, the discharge valve can be opened until the desired outlet temperature is reached. Cargo heating always entails a risk of freezing of heater circulating water. Seawater inlet and outlet temperatures should be monitored. Seawater temperature from the heater outlet must not be allowed to fall below the maker's recommended limit. Sea water flow switch and Low temperature cutout should be tested prior use of Heater.

GENERAL CONSIDERATIONS

In order to avoid cavitation or gassing up of cargo pumps, pressure at the pump suction requires to exceed the S.V.P. of the liquid by an amount termed the NPSH (Net Positive Suction Head). The onset of cavitation as the liquid level approaches the bottom of the tank can be delayed by increasing the vapour space pressure above the S.V.P. by supply of extra vapour from shore vapour return or shipboard vaporizer. Such augmentation of vapour space pressure is usual practice on fully pressurized and semi-pressurized ships and may also be used for fully refrigerated cargoes particularly where maximum possible cargo out-turn is required in preparation for subsequent gas freeing of the tank. Gradual reduction of flow rate, when the tank comes to stripping level will reduce NPSH requirement and permit continued discharge to a lower level. Deepwell or submersible pumps should not be used for flow control if the pump is operating in series with a booster pump, as there is a likelihood that the booster pump would cavitate with possible damage.

Centrifugal pumps should always be started against a closed, or partially open, discharge valve in order to minimize the starting load, thereafter the discharge valve should be gradually opened until the pump load is within its safe design parameters. As discharging is in progress, the liquid level in the cargo tanks should be monitored and discharge / ballasting operation controlled for ship stability / stress. Removal of liquid from cargo tanks may cause changes in inter-barrier space pressures and these should be monitored throughout the discharge.

On completion of cargo discharge liquid must be drained from all deck lines, cargo hoses or hardarms, which can be done either from ship to shore using a cargo compressor or from shore to ship, normally by blowing liquid into the ship's tank using nitrogen injected at the base of the hardarm. Only after depressurising all deck lines should the hoses be disconnected.

BALLAST PASSAGE

On refrigerated ships, it is a normal practice to retain some product on board after discharge (called heel). This is used to maintain the tanks at reduced temperature during the ballast voyage.

CHANGING CARGO

Before changing cargoes or gas freeing, it is essential to remove all cargo liquid remaining in the tanks, piping, reliquefaction plant or any other part of the cargo system. Depending upon their design, the liquid can be removed from the cargo tanks by pressurizing, normal stripping or with type 'A' tanks, heating the tanks with warm gas from the compressor. Some ships are fitted with heating coils for this purpose. When all liquid has been removed the tanks can be purged either with inert gas from the ship's supply or from shore, or by using the vapour of the next cargo.

Ammonia is a special case since it is extremely difficult, if not impossible to remove all traces of the product by purging alone. Furthermore, the ship's own inert gas may not be suitable because or the risk of carbamate formation. For removal of all traces of ammonia, freshwater was resorted to earlier, but because of precautions required to be taken and difficulty in removing the water / water vapour from the system, it has been generally stopped.

A careful check must be made of the compatibility of successive cargoes and this is particularly important if more than one cargo is carried simultaneously - when special attention should be paid to the reliquefaction system.

****** Refer to appendixes 5 and 6 for more detailed description.***

GAS FREEING, INERTING AND AERATION

Gas freeing, purging and aeration are essential preliminaries for the inspection of tanks in service or for entering dry dock.

9.3.8 LIQUID FREEING

Before commencement of gas freeing or purging, all liquid must be removed. For type ‘C’ cargo tanks, a stripping line is often provided. By pressurizing the cargo tanks using the cargo compressor, residual liquid can be removed through the stripping line and collected into one tank for returning ashore where permissible or into a deck tank provided for this purpose. This draining and stripping should continue until all liquid is removed from the cargo tanks as checked through the bottom sampling line. The pressure necessary in the tanks to remove residual liquid will depend on the specific gravity of the cargo, and on the height of cargo tank and dome.

For vessels with tanks other than type ‘C’, liquid freeing is not possible by pressurization. Instead, hot gas vaporization must be carried out either using puddle heating coils where fitted or by supplying hot gas to the bottom of the cargo tanks directly. Vapour is taken from the tanks and passed through the compressor, whereby the increased temperature evaporates the residual liquid. Where puddle-heating coils are fitted, the liquid puddle evaporates and the vapour in the coil condenses. Condensate can then be put ashore or into deck storage. Where hot gas is introduced directly into the bottom of the tank, the liquid puddles are boiled off and vapour is normally vented, when the ship is at sea or condensed in the reliquefaction plant and put ashore, overboard or to deck storage.

When all tanks have been satisfactorily liquid freed, all pipes, vessels, heat exchangers etc. must be blown free of liquid and drained through drain valves where appropriate.

Prior to the disposal of cargo liquid overside the following procedures shall be complied with :

- Fire-fighting equipment to be checked and ready for immediate use
- Gas detection system to be checked and in full operation
- Fire pump running and the deck main pressurised
- Master informed and his agreement obtained
- Liquid is to be disposed off from the manifold area only
- The discharge hose must be clear of the water and the ship’s side protected by a water curtain
- Consideration shall be given to the possibility of wind eddies carrying gas up onto the after deck in way of the accommodation, and machinery space intake.
- Experience indicates that liquid disposal at slow speed substantially reduces the effect “eddies”.
- All other ships must be given a wide berth, and due consideration must be given to possible dangerous gases being carried by the wind into the vicinity of the other ships.

- An Officer shall monitor the atmosphere around accommodation decks using a combustible gas indicator. Should any gas reading be registered all disposal operations must be stopped.
- Disposal of cargo over side is prohibited when :
- Electrical storms (lightning) are in the vicinity
- Whilst the ship is at anchor or in restricted waters

In cases of emergency should the Master consider that disposal of cargo liquid is necessary while the ship is at an anchorage due considerations shall be given to additional safety measures, such as operating bridge front sprays. Wind direction and the proximity of any craft shall be considered. The Ship Manager shall be informed.

9.3.9 PURGING

Once the cargo system has been satisfactorily liquid freed, purging can commence. Purging involves replacement of the atmosphere within a tank by another cargo vapour or by inert gas or nitrogen, which will depend upon the type of cargo to be loaded and the specific requirement for presentation at the loading terminal and subsequent discharge terminal in terms of permissible cargo contamination levels.

Where tanks must be opened for internal inspection, purging with inert gas or nitrogen is always necessary to reduce hydrocarbon concentrations within the tank to the relatively low safe levels required before admitting fresh air. Carrying out purging is identical to the primary inerting operation. Care must be exercised when venting hydrocarbon or toxic vapour to atmosphere especially in still air conditions.

In order to achieve maximum dryness after purging it is important (a) to ventilate the tanks with air having a dewpoint lower than the tank temperature, and (b) to ventilate the tanks and cargo system at the highest practicable temperature.

9.3.10 WARMING UP AND AERATION OF CARGO TANKS

When cargo tanks have to be provided with a fresh air atmosphere for inspection or dry dock, it may be necessary to warm up the cargo tank by circulating hot gas throughout the system before inerting takes place. If warming up to ambient temperatures is not carried out, freezing of moisture and CO_2 in the inert gas will result, and also greater volumes of inert gas will be required at low temperatures.

Once the tanks have been warmed and hydrocarbon concentration reduced below the flammable limit by addition of inert gas, the tanks can be ventilated with fresh air by compressors or blowers, until the oxygen content in the tank is 21% all over.

9.3.11 SAMPLING

Sampling of cargo is routinely carried out by a terminal representative prior to commencement of discharge. Sampling is carried out for two basic reasons:

(1) To establish safe conditions before cargo transfer.

(2) To establish that the cargo is within commercially agreed specification at the various points of cargo transfer.

This could be a hazardous situation as the terminal representative or Surveyor will not generally be familiar with the layout of the shipboard piping. Hence a competent officer thoroughly familiar with the pipeline layout of the vessel must always accompany the terminal representative.

It is generally accepted that sampling will always be associated with a certain amount of disposal of vapour to the atmosphere for sample point purging and cylinder ullaging. The following safeguards should be followed:

1. In all cases venting, purging or ullaging of sample containers must be carried out in a safe area with due regard to prevailing wind and weather conditions.

2. When the sample being taken might have an irritant hazard in addition to flammable hazards, then means should be provided to absorb or disperse the material in a safe area. For example in the case of ammonia, a hose could be provided to carry the vapour to a water surface or spray area.

   When the sample might have toxic rates for instance VCM or butadiene, then means should be provided to avoid release of the material to the atmosphere. In this case a closed loop system may be provided or obtained by connecting the outlet valve of the sampling container to a vapour sample connection point or vent system.

3. Certain cargoes are required to be carried under a nitrogen pad (propylene oxide, ethylene oxide or mixtures of them); product samples are therefore drawn only from the tank bottom or liquid space. The vapour space is sampled to ensure adequate nitrogen content.

The other hazard associated with sampling is accidental loosening of the sampling connection. This would not normally occur at the designated sampling points as safeguards have been incorporated at the design stage. However, from time to time, sampling is done from screwed down connections on the cargo piping. This is done particularly from a partly empty tank. In order to guard against this the flanged area of such connections should be temporarily secured with a length of rubber gasket and seizing wire. **Do not attempt to secure these by a tack weld**. The heat of the welding will definitely damage any Teflon seating in way of these connections and destroy their gas tight integrity.

A peculiar problem is associated with bottom sampling. This must always be done from the designated sampling point. Do not try to draw a sample from the sump drains. The content of the sump drain is never a representative sample of the cargo. It contains traces of many previous cargoes and water. In order to obtain a representative sample the entire length of the drain lines must be adequately vented. This problem can easily be avoided by drawing the sample from the designated sampling points. Cargoes have in the past been rejected because of this.

9.4 DRYDOCKING AND REFIT PERIODS.

Before work begins, or in some yards before the vessel enters the yard, during dry-docking or refit periods, all systems that contain flammable, toxic or inert gas should be gas freed.

9.4.1 CARGO TANKS AND HOLD OR INTER-BARRIER SPACE

A Gas free Certificate from port authorities is necessary before attempting entry into any enclosed space.

Pockets of cargo vapour may have collected in inter-barrier spaces or insulation. Cargo vapour trapped in insulation and inter-barrier spaces could be released gradually with increased temperatures. Therefore, it is essential that adequate ventilation is provided and that the atmosphere is monitored periodically. Insulation spaces should be kept as dry and moisture free as possible to prevent deterioration of the insulation.

Special attention should be paid to membrane systems when work is undertaken. Differential pressures should be maintained when ventilating inter-barrier spaces. If work inside the tank is necessary, the membranes should be protected and a careful inspection carried out after completion of the work to ensure that the membrane has not been damaged or ruptured.

Before cargo tanks and other enclosed spaces are closed up, careful checks should be made to ensure that all tools and equipment have been removed, all fixtures are secure, contaminants such as rust or water have been removed, and if necessary, antifreeze added if permissible. If should also be confirmed that valves, pumps and level gauges are free to operate.

9.4.2 INSTRUMENTATION

All cargo system instrumentation should be checked for integrity. Instruments and their control, sensing and sampling lines should be carefully protected from mechanical damage. If necessary, pressure gauges, thermometers and other delicate equipment should be removed and stored in a safe place during repair work.

Ship’s plans and specifications should be clearly amended to indicate any modification made to systems and circuitry.

9.4.3 MATERIAL AND PROCEDURES USED IN REPAIRS

All parts and materials used for repair or replacement anywhere in the cargo system should be compatible with the cargoes to be carried and able to withstand the full range of temperatures and pressures anticipated.

Welding within the cargo system should only be carried out using the appropriate special procedures and by qualified personnel. If pressure testing of part of the system is to be carried out, care should be taken to ensure that other parts are effectively isolated and due considerations given to the safety of personnel in the vicinity.

9.4.4 HOTWORK

Hot work should not be permitted unless the immediate vicinity and adjacent compartments are certificated gas free.

Adequate ventilation should always be provided and special care taken when hot work is undertaken near combustible materials, which should be either removed or protected against heat. Material such as polyurethane, polystyrene, etc. produce toxic and asphyxiating vapour if they catch fire. Hot work should only be undertaken near such material provided suitable fire fighting and escape apparatus is immediately available.

Emergency exits should be provided for any enclosed space in which hot work is being carried out. The number of people allowed in restricted areas (e.g. cargo tanks, hold spaces, inter-barrier spaces) should be limited so that at any time, it can be checked how many are in the space.

All equipment that is to be opened up for repair or maintenance should be checked internally for the presence of flammable, toxic or inert gas and should be purged if necessary before proceeding with hot work.

9.4.5 RECOMMISSIONING

All equipment and systems should be thoroughly checked for integrity, cleanliness, operation, calibration and freedom of movement (as appropriate) before re-commissioning into cargo service.

9.5 SUB-COOLING

9.5.1 GENERAL

Certain cargoes can cooldown inadvertently. This can happen in both refrigerated as well as in pressurized carriage. In case of refrigerated carriage, this happens with butane and in case of pressurized carriage this happens with propane. Both situations are considered separately below.

9.5.2 SUB-COOLING OF BUTANE

This situation is typical to refrigerated carriage. Cold butane does not generate much vapour. Sometimes at terminals located in hot climates, ethane chillers are used with commercial butane to chill the cargo to -6^{o}C. This can lead to a critical situation with the pressure dropping to the low-pressure alarm levels when air might be drawn into the tanks.

In case this happens the following may be considered.

1. Inject inert gas into the tank to raise the tank pressure.

2. Inject propane vapour into the tank, if you have propane in any cargo tank.

3. On one occasion, the ship's crew filled the manifold crossover-line to half depth with liquid butane by running the cargo pump for a moment. You can easily judge the depth of liquid in the line, from the extent of frosting. They then used the flash-off vapour from this line to supply vapour to the tank to pressurize the tank.

4. The best solution would be to load butane at -2^{o}C or so instead of at -6^{o}C and avoid this problem altogether.

9.5.3 SUB-COOLING OF PROPANE

This problem is typically associated with pressurized ships. Once a cargo of butane is discharged, the tank pressure is fairly low, about 1 bar or less. If the next cargo is propane, and if propane liquid is directly put in the tank, this liquid will flash off. The latent heat of evaporation will be supplied by the tank structure. This will lead to cooling down of the tank below the minimum design temperature (typically 0^{o} C).

1. The best way to tackle this problem would be to pressurize one tank with propane vapour obtained by vaporizing the cargo in the cargo heater. Once the tank pressure has built up to about 4 bar, direct liquid loading can now be started in this tank. Vapour from this tank now can be used to pressurize the other cargo tanks. When these tanks also come up to this pressure, direct liquid loading can be started.

2. In cold climates with the seawater temperature around 6^{o} C or less the above method cannot be used. In this case, the only solution is to load the cargo very slowly and stop loading altogether when the temperature starts to drop. The cargo in the tank will now flash off and slowly raise the tank pressure. This process should be continued until the tank pressure is in the region of about 4 bar. Now you can begin to load at full rate into the cargo tank.

9.6 HANDLING LPG MIXTURES

9.6.1 GENERAL

Sometimes vessels are required to load a mixture of propane and butane. Usually the shippers specify the percentage mix. Individual grades are then loaded separately in the cargo tank, one after the other. The products are then mixed on board. Some of the larger gas carriers discharge LPG mix, typically in an STS operation. Both scenarios will be considered separately.

9.6.2 LOADING

The usual practice is for an independent surveyor to be appointed by the shipper to oversee the loading. The surveyor will advise the chief officer as to the amount of each parcel to be loaded to arrive at the specified percentage mix. Basis this, the chief officer will work out the sounding at which one parcel will be shut out and load the other product. The surveyor will advise the chief officer as to the final density of the mix. Using this, the chief officer will be able to work out the final sounding to which the tank will be topped off. There is a problem in this area. The mix will not attain this density homogeneously. This problem is particularly acute in small, pressurized ships where the loading line terminates at the bottom, without branching off in the form of a bottom line. However, in practice, this does not give rise to any major problem. The error involved normally stays within the limits of tolerance built into the specifications of the cargo.

9.6.3 PRECAUTIONS

The main problem with the mixtures is that, a large volume of gas may evolve when the second product is mixed with the cargo. This would be associated with a sharp rise in tank pressure. This problem is most acute when propane is mixed with butane, provided both were supplied from a pressurized storage. The situation is reversed, in case the supply was from refrigerated storage.

Mixing propane with butane will anyway increase the vapour pressure of the product. This rise associated with the temporary rise may well cause the tank pressure to shoot up very rapidly. Hence for semi refrigerated ships the reliquefaction plant should be run before the mixing is started.

9.6.4 MIXING

In general, the vessel will need to mix the cargo on-board. Re-circulating the cargo using the cargo pumps does this. The following precautions apply:

1. Monitor the tank level in all the tanks while mixing the cargo. In case the level in some other tank is increasing, stop the pump immediately. Check the line up and valves. If the lining up is correct, obviously some valve is not holding. You may generally find a problem with the non-return valves. Address this problem before continuing with further mixing.

2. Re-circulation will warm up the cargo. Monitor the tank parameters including the volume expansion of the cargo. On semi-refrigerated ships, if possible the reliquefaction plant should now be used. On some ships, this may not be possible due to the configuration of the cargo lines. If you note a sharp rise in tank pressure, stop the mixing and address the pressure rise before attempting mixing again.

9.6.5 DISCHARGING

Larger gas carriers that discharge propane and butane separately into smaller barges or shuttle vessels typically carry out these operations. In this case usually, refrigerated cargo is discharged into pressurized tanks. Usual mix ratio of propane and butane is 30:70 in summer. In winter, this ratio could be 40:60 or even 50:50. The shipper would advise the vessel as to their normal requirement. In this connection, follow the following precautions:

1. Discharge butane first and propane after that. This is to prevent a high tank pressure during topping off in the shuttle vessel.

2. On nearing the completion of propane discharge, the tank pressure in the shuttle vessel is very high. Reducing the propane temperature to below zero can reduce this.

3. Because of the high tank pressure in the shuttle vessels on completion of cargo, you must stop the booster and cargo pump and close the manifold valve simultaneously. Otherwise, cargo from the shuttle vessel may flow back from the shuttle vessel to the larger vessel. This will raise the safety relief valve on the inlet end of the booster pump. Consequently, cargo vapour will be released to the atmosphere.

4. At times the larger vessel may be required to odorize the cargo. In this connection, refer to chapter 13.

5. There may be a considerable difference in cargo figures if propane and butane are not loaded in the correct proportion. Most of the shuttle vessels engaged in such operations have two tanks. Sometimes they may take more of one grade in one tank than in the other. This changes the required proportion leading to the difference in figures.

9.6.6 CARGO CALCULATIONS

The COSTALD equation is the acknowledged way of obtaining the density of a mixture of LPG liquids. Refer to the following SIGTTO publications for a detailed description of this method.

A review of LPG cargo quantity calculations.

Quantity calculations, LPG and Chemical Gases.

In actual practice, this is not always the case. More often than not, the density of the mix is worked out using weighted averages. This is wrong in principle. X-litres of one liquid when added to Y-litres of another will not produce a solution of (X+Y) litres. Such mixing is always accompanied by shrinkage in volume. In other words, the volume of the mix will always be less than (X+Y) litres. Get the density of the mix in writing from the appointed surveyor for calculating the cargo.

10. CARGO EQUIPMENT

10.1 GENERAL

Equipment on gas carriers is precision made and should be operated in accordance with maker's instructions. It should not be operated outside its specified limits.

10.2 OPERATIONAL PRECAUTIONS

10.2.1 MAINTENANCE

Any defect can impair operation and present a hazard to personnel, equipment or the ship. Equipment should be carefully maintained and the following precautions observed:

1. Personnel who are familiar with the equipment should undertake maintenance and maker's instructions should be followed.

2. Equipment, which has been exposed to cargo liquid or vapour internally, should be drained, depressurised and purged thoroughly before dismantling.

3. All sensing and control piping should be leak proof, especially if the ship operates under vacuum.

4. All instruments used to calibrate equipment should be accurate, the composition and concentration of any gas samples used for calibrations should be accurate. Calibration should be recorded on or near the equipment.

5. All maintenance work should be recorded. A log of equipment readings should be kept.

6. Suspected leaks from piping and equipment should be investigated using safe means, such as portable detectors or soapy water.

7. AS PER VIQ 8.122 *Each hose should be stencilled or otherwise marked with its specified maximum working pressure and, if used in other than the ambient temperature services, its maximum or minimum service temperature, or both. The specified maximum working pressure should be not less than 10 bar gauge (For hoses delivered after 1st July 2002).*

   Each hose should also be marked with the test date and be individually numbered for identification.

10.2.2 ACTION IN THE EVENT OF DEFECT

1. A suitable entry should be made in the Log and personnel concerned informed.

2. The defect should be rectified as soon as possible.

3. The back up or the duplicate system should be activated; this may involve manual operation.

4. All sensing and control piping to the defective equipment should be isolated to prevent leakage or malfunction of other equipment.

5. Care is necessary when testing circuits with high voltage test equipment; low voltage circuits may be permanently damaged and sparks may be created.

6. If any alarm malfunctions, immediate investigation is necessary and appropriate action should be taken.

10.3 PLANT AND EQUIPMENT PRECAUTIONS

Equipment should be operated in accordance with the instructions for the particular ship, maker's instructions and the cargo properties.

10.4 PUMPS

1. Before starting, check (manually if possible) that the pump is free to turn and dose with antifreeze if necessary. If the pump is submersible, check electrical resistance.
2. Start-up in accordance with instructions, pay special attention to pump priming, and discharge valve settings.
3. After starting, valves should be opened slowly, flash gas vented, cavitation avoided and discharge pressure maintained above manifold pressure by throttling to avoid running dry.
4. While stripping tanks, discharge valves should be throttled to maintain suction and improve drainage. Maker's instructions should be followed.
5. During maintenance, particular care should be taken to keep filters clean and to the condition of seal bearings and pressurizing circuits.

10.4.1 DEEP WELL PUMPS

These are single stage or multi-stage centrifugal pumps with deck mounted motors driving impellers near the tank bottom. The motor may be electric or hydraulic. The impeller casing is supported by the discharge tube, which is flange connected to the tank dome. The drive shaft runs inside the discharge tube and is lubricated by the cargo.

Particular attention is drawn to the following points:

1. Pumps should not be allowed to cavitate.
2. Flameproof electric motors are generally only drip proof and waterproof covers should be fitted when not in use.
3. Thrust bearings are susceptible to indentation (or ‘brinelling’) when stopped and subject to shipboard vibration because of the heavy weight they have to support. When not in use the pump shaft should be turned at frequent intervals to vary the bearing surfaces.
4. After overhauling of pumps, care should be taken to ensure that sufficient clearance has been left between the bell mouth and the tank bottom to enable adequate cargo flow and to prevent mechanical interference when cooled down.
5. Shaft intermediate bearings are lubricated by the cargo and passages in the bearing housing should be kept clear.
6. Liquid seals at the upper end of the pump discharge should be kept in good condition to prevent cargo leakage and leakage of the pressurizing liquid into the cargo.
7. Local start / stop switches should be properly maintained.
8. If required, an antifreeze should be injected to prevent freezing of any water collected in bearings, shaft sleeves, impeller’s etc., as freezing could cause pumps to seize, with consequent damage to motors.

10.4.2 FIXED SUBMERGED PUMPS

These are fixed vertical combined pump and electrical motor assemblies mounted on seating in the bottom of the tank. Power is supplied through stainless steel sheathed cables, which terminate in a junction box at the tank dome. Motors are normally fitted with low liquid level shut down devices to prevent them running dry.

Particular attention should be paid to the following points:

1. Cables should be checked for insulation resistance before the pump is started.
2. Heaters should be used when tanks are gas freed to prevent condensation.
3. When re-assembling pumps, the discharge piping should be prevented from imposing stresses on the pump.
4. Since bearings are lubricated by cargo, lubricating passages should be kept clear. Filters should be cleaned regularly.
5. Cable connections at the pump should be assembled using new compression washers and pressure or vacuum tested.
6. Stainless steel sheathing should be checked for cracks and chafing, sharp bends and kinks should be avoided.
7. Before the tank is closed, the pump should be turned by hand to ensure freedom of rotation.
8. Local start / stop switches should be properly maintained.
9. Antifreeze should be injected to prevent freezing of any water, if necessary, to avoid causing damage to pumps / motors.
10. N2 blowthrough of the cargo pumps before cargo discharge and after cargo loading.

10.4.3 SUBMERGED PUMPS CAPABLE OF BEING REMOVED

These are identical to the fixed submerged pumps but are located within a tube, which acts as a support and discharge pipe and is provided with a foot valve so the pump can be removed while the tank still contains cargo. When the liquid and vapour contents of the tube are purged with inert gas, the pump can be raised slightly to close the foot valve. The pump can then be removed in stages.

Precautions given for submerged cargo pumps should be observed. Additionally, manufacturer's instructions for installation and removal should be closely followed.

10.4.4 DECK MOUNTED PUMPS

These are normally horizontally mounted motor driven centrifugal pumps. They are generally used as maintenance pumps, booster pumps, heater supply pumps, deck storage, tank, supply pumps etc.

Particular attention should be paid to the following points:

1. Precautions mentioned for deepwell pumps should be observed.
2. Pumps should be primed and the cargo tank sufficiently pressurized to provide an adequate liquid suction head.
3. Seals and gas tight bulkhead seals (if fitted) should be carefully maintained.
4. Motor/pump alignment should be correct to prevent coupling damage. All clearances and tolerances specified by the maker should be observed.

10.4.5 HOLD OR INTER-BARRIER SPACE PUMPS

These may by submerged pumps (in which case the precautions given for them should be observed) or they might be ejectors working on the venturi principle.

Motor driven pumps should be checked frequently for freedom of rotation as condensation might collect in bearings, unless the atmosphere in the space is kept dry.

10.5 VAPOUR PUMPS AND COMPRESSORS

There are different types of compressors, which might be encountered like conventional reciprocation compressors, conventional oil free compressor, stirring cycle compressor, centrifugal compressor, Rootes-type compressors and screw compressors. Only general precautions required will be mentioned, for more details, maker's instructions and maintenance manual should be consulted.

General precautions require:

1. Before starting, check that no liquid has condensed in the machine, heating systems are operating as required, filters are clean and cut outs set to correct values.
2. After starting; open suction valves slowly to prevent liquid carry over. The lubricating oil should be clean and oil separators working properly. Check for signs of leakage especially on the discharge side and pressures should be monitored carefully.
3. If changing cargoes, it may be necessary to change the grade of lubricating oil (e.g. after ammonia, butadiene or VCM cargoes). Even pistons might have to be changed for certain cargoes.
4. Gas tight bulkhead seals should be kept in good condition.
5. During maintenance, particular attention should be paid to cutouts, bulkhead glands, and crankcase seals, suction filters, relief valves and associated piping.
6. Careful routine maintenance should be carried out on automatic loading devices. Pressure and temperature switches should be checked and calibrated as a routine.
7. Cooling systems should be inhibited to prevent corrosion or freezing.

8. All electrical installations and equipment should be properly maintained; electrical resistance of motors should be checked regularly.
9. Compressor crankcases should be isolated, when pressure testing pipelines, unless they can withstand the test pressure.
10. Damage may be caused by surges (in centrifugal compressors). Automatic surge controls should be kept in working order and calibrated after maintenance according to manufacturer's instructions.
11. Equipment should be operated within design limits and according to maker's instructions.

10.6 HEAT EXCHANGERS

Heat exchangers may be fitted for any of the following purposes:

- as vaporizers (for cargo or nitrogen liquid to vapour),
- as heaters (for liquid or vapour),
- as condensers (for cargo or refrigerant gas),
- as driers (for inert gas, cargo vapour, compressed air),
- as inter-coolers (in refrigeration plants),
- as coolers (for water, lubricating oil).

Attention should be paid to the following:

1. Hot and cold phase flow should be established in the correct sequence. Seawater heated cargo vaporizers or cargo heaters can be blocked and damaged if excess cargo flow freezes the water.
2. The non-hazardous medium should be kept at a higher pressure than the cargo phase, or cargo could leak into an otherwise safe system.
3. Pressure testing and checks for leaks should be carried out regularly.
4. Instrumentation and associated equipment should be correctly functioning.
5. The cooling system should be kept clear, as fouling could cause loss of efficiency and cause a hazard due to overheating.

10.7 RELIEF DEVICES

10.7.1 GENERAL

The following devices may be fitted to allow the escape of liquid or vapour:

- bursting discs
- deadweight relief valves
- spring loaded relief valves
- pilot operated relief valves.

10.7.2 COMMON PRECAUTIONS

1. Both sides of any relief devices should be kept free of obstruction and water, oil, polymers, etc., should not be allowed to collect. Even a small head of water can easily alter the set point of pressure valves. Means of drainage are usually provided which should be kept clear and used frequently.
2. If valves have more than one setting, changes should be made under the supervision of the Master and in accordance with specified procedures. Changes should be recorded in the logbook and an appropriate sign posted at the valve and in the CCR, stating the set pressure.
3. Relief valves should never be used as control valves by temporarily altering the set point.
4. If the valve can be operated manually, operating personnel should be familiar with the operation and operating gear should be kept clean, lubricated and free from paint or rust.
5. Routine checks should be made of set points, blow down characteristics and tightness of sealing.

10.7.3 SPRING LOADED AND PILOT OPERATED RELIEF VALVES

The following precautions should be taken:

1. Care should be taken to prevent damage to needle valves, thin spindles and other delicate components on re-assembly.
2. Small bore pipes, passages and sensing connections should be clear and unobstructed.
3. All setting devices should be securely locked in position to prevent alteration by vibration, shock or tampering.

10.7.4 DEADWEIGHT RELIEF VALVES

These only operate at an accurate set pressure when upright and are usually used as a back up to spring loaded or pilot operated relief valves.

10.7.5 BURSTING DISCS

The following precautions should be observed:

1. Discs should be inspected frequently for deterioration, corrosion etc., which may affect the set point.
2. Gaskets should be fitted on both sides of the disc, but should not reduce the effective diameter.
3. If a disc fractures,
    - The cause should be investigated.
    - The replacement disc should be checked for correct set pressure and compatibility specification, and should be fitted correctly.
4. SIGTTO guidelines on maintenance of pressure relief valves should be consulted and maintenance scheduled accordingly.

10.8 VALVES

All valves in the cargo system should be treated as precision equipment and should be inspected and maintained to ensure safe and efficient operation. It is important to keep valves tight and functioning properly.

The following precautions should be observed:

1. Lines should be set correctly before commencement of cargo operations. Portable handles should be kept readily available near all manual valves for use in an emergency.
2. Control valves should be checked frequently for correct operation over their entire range. Good quality calibration equipment should be used to simulate pressure/ temperature signals.
3. Actuating systems, whether remote or local should be free to operate.
4. Pneumatic signal lines to actuators should be leak tight and the air supply should be dry and oil free.
5. Leaks from joints, glands etc., should be repaired as soon as possible; leakage can be suppressed temporarily using a wet bandage.
6. When valves are removed for maintenance, the flanges should be blanked, or joined with a spool piece. All concerned personnel should be informed and the necessary entry made in the cargo log.

7. Material used in maintenance should be suitable for the cargo.
8. Ball and gate valve body cavities are normally provided with some means of pressure relief when used with cargoes below minus 50oC, as at these temperatures the PTFE seats become rigid and cannot flex to relieve pressure. In Case of Ball Valve generally a hole is drilled between the cavity and one side of the valve, or a pressure valve relieving to the appropriate side is fitted. This arrangement should be kept clear and in good working order.
9. Before the valve is replaced, it should be thoroughly dried out to prevent ice or hydrate formation.

10.9 FILTERS AND STRAINERS

Filters should be kept working correctly to protect plant and equipment from contamination. Gradual blockage will affect performance and operating conditions, and may damage the equipment.

Attention should be paid to the following:

1. Filters should be fitted the right way. If they are fitted the wrong way, the filter can collapse and block the line.
2. If differential pressure gauging equipment across a filter is provided, it should be monitored and properly maintained.
3. Inspection of filters should be carried out regularly and the system should not be operated without a filter / strainer.

10.10 EXPANSION BELLOWS

Bellows may be used to accommodate thermal contraction and expansion in various applications such as pipelines, heat exchangers, bulkhead seals, valve spindle seals and automatic controls.

When used properly, bellows are very durable, but easily damaged though and for this reason expansion loops and offsets may be used instead.

If bellows are fitted, the following precautions should be observed:

1. Bellows should never be subjected to unnecessary shocks and efforts should be made to protect the bellows from internal and external damage.
2. Bellows should be drained of water or dosed with antifreeze, if permissible, before low temperature service.
3. Internal and external inspection of bellows should be carried out regularly for cracks, corrosion, cleanliness etc.

4. When bellows are stored, they should be properly protected against over-extension, compression, misalignment and mechanical damage.

10.11 FLAME SCREENS

If fitted, they should be cleaned frequently and inspected regularly, and they should never be painted. Flame screens should not be confused with ordinary Protection screens. As per IGC code Cargo tank outlets should be provided with readily renewable and effective flame screens or safety heads of an approved type when carrying a cargo referenced in column ‘i’ of Chapter 19 - (Diethyl ether, Ethylene oxide-Propylene oxide mixtures with an E-o content of not more than 30%, Isoprene, Isopropylamine, Monoethylamine, Pentanes, Pentene, Propylene oxide, Vinyl ethyl ether and Vinylidene chloride).

Due attention should be paid in the design of flame screens and vent heads to the possibility of the blockage of these devices by the freezing of cargo vapour or by icing up in adverse weather conditions. Ordinary protection screens should be fitted after the removal of flame screens.

10.12 VENT STACKS

Discharges from relief valves and purge systems are carried to atmosphere through vent masts, the outlets of which are designed to promote vapour dispersal and reduce the risk of

The following precautions should be taken:

1. Vent systems should be kept clear, water should be drained off regularly from the stack and relief valves. Drains should be kept closed when not in use.
2. Cargo liquid should never be vented through vent masts as this would over pressurize the system and cause rupture.

10.13 HOSES

The cargo hose is the weakest link in the cargo transfer system and should be treated with great care. The following precautions should be taken:

1. Hoses should be certified for the cargo service pressure and temperature required.
2. Material from which the hose is constructed should be compatible with the cargo.
3. Hoses should be well supported to prevent excessive movement, chafing or crushing.
4. Hoses should not be subjected to pressure surges.
5. Hoses to be inspected prior each use. Regular inspection of hoses should be carried out for damage and they should be replaced if there is any evidence of internal / external deterioration or sign of leakage.

6. Hoses to be pressure tested annually to the designed working pressure. Routine pressure testing should be carried out and recorded.
7. Ends of hoses stored on the open deck should be sealed to prevent ingress of water.

10.14 PIPELINE SUPPORTS

The following precautions should be taken:

1. Excessively corroded components should be replaced.
2. All supports should be correctly assembled and securing devices locked.
3. If relative movement is to be provided, all moving surfaces should be clean and, if necessary, lubricated.
4. All supports should be in position and properly assembled before cargo operations begin.

10.15 TANK INSULATION

The following precautions should be observed:

1. All insulation should be protected against deterioration or mechanical damage, as damaged insulation would increase cargo boil-off.
2. Insulation boundaries should be adequately vapour / water sealed to prevent corrosion of the material beneath it.
3. Insulation can be damaged or dissolved by cargo, antifreeze etc., compatibility should be checked and contact avoided.
4. Insulation materials are easily damaged by high temperatures and should not be subjected to them.
5. During maintenance, care should be taken to exclude moisture, which may be absorbed by the insulation and could reduce its effectiveness.
6. Insulation materials should be regarded as flammable and protected against flames, sparks etc. The material may also be toxic and cause allergy and personnel working with it may require protection.

10.16 BONDING CONNECTIONS

The following precautions should be taken:

1. All bonding connections should make good electrical contact. Surfaces in contact should be free from paint, oil, salt or rust, and be tightly bolted or clipped.

2. The bond itself should be in good condition and not corroded. Solid strip connections should be used which are more durable than wires. Bonds should not be painted over.
3. Ship-shore bonding wires should always be connected before the hoses and not disconnected until after the hoses have been disconnected.
4. If insulating flanges are used, there should be no bonding across them; this can be done inadvertently by metal connection between ship and shore (e.g. wires, gangways, and ladders).

10.17 INERT GAS SYSTEMS

The maintenance hazard associated with inert gas is asphyxiation of personnel due to lack of oxygen. Inert gas plant is often situated in the Engine room and great care should be taken to ensure that cargo vapour does not flow back down inert gas lines. Any temporary connection between the inert gas plant and the cargo system should be disconnected and tightly blanked after use.

The following precautions should be taken:

1. Inert gas equipment may not be required very often but should be tested frequently to prevent deterioration, so that faults can be identified and rectified before the plant is required to be used.
2. Before starting up, the plant should be in good condition, non return valves should seat properly, fuel supply adjustment should be correct, dryers should be free from clogging and fans should be functioning correctly.
3. The scrubber water supply should be started before combustion begins.
4. Combustion conditions should be adjusted until the gas produced is of good quality. The quality of the gas produced should be monitored while the plant is in use.

10.18 SCRUBBERS

These are used to dissolve out unwanted contaminants from a mixture. The scrubbing liquid used is seawater and the most common application is the removal of sulphur dioxide and solid combustible products in the production of inert gas.

The following precautions should be taken:

1. Water should be flowing before the gas flow is started to prevent overheating or damage to internal anti-corrosion coatings.
2. Water flow should be controlled within design limits.
3. Internal components should be inspected regularly for corrosion and security of fitting.

4. There should be no fouling of components in the flow path, as this will cause a high-pressure drop across the unit.

10.19 BOOSTER PUMPS

10.19.1 GENERAL

Booster pumps are centrifugal type pumps. They are used to increase the flow rate against shore backpressure. They are used generally in series with the main cargo pumps. The main cargo pump provides liquid to the inlet of the booster. In some old ships, the cargo would be supplied to the inlet of the booster by pressurizing the tanks with cargo vapour. In fact, this was standard operating practice. However, nowadays it is unusual to find such systems as the primary cargo discharging system. This practice may still be used as an emergency backup to the main discharging system.

The following safeties are usually incorporated in the booster pump:

1. Pump sealing failure.
2. Winding temperature.
3. Under-current protection.
4. Low-pressure differential across the pump.
5. Two phase running overload.

10.19.2 MOUNTING

Booster pumps can be vertically or horizontally mounted. They can be located on the cargo deck or in the compressor room. They are driven by electric motors.
For pumps located on deck the motor will be of “intrinsically safe type”. For such mounting ensure that a weatherproof covering additionally protects the motor when not in use.

For pumps located in the compressor room the motor would be located in the electric motor room. The connecting shaft penetrates the bulkhead. There would be seals to keep the bulkhead gas tight. These seals must be inspected and kept in good working order. For oil seals lookout for any leakage. **Remember if the oil can get out then the gas can get in.**

10.19.3 SUPPLY

The booster pump must never be starved of cargo. It is not enough to maintain the recommended pressure at the pump inlet. You must consider the designed capacity of the booster pump and the cargo pump feeding the booster. The capacity of the feeder pump must be significantly larger than the capacity of the booster pump.

If the throughput of the cargo pump is only marginally more than that of the booster, then at least two cargo pumps must be used to feed the booster.

The booster pumps should be stopped before starting stripping of the tanks.

When not in use, turn the booster pumps by hand as a daily routine.

10.19.4 REFRIGERATED CARGOES

Booster pumps that are designed to handle refrigerated cargoes are made of cryogenic material. It is important to ensure that such pumps are not subjected to sudden thermal stresses. On starting the cargo, the booster pumps should be cooled down before starting them. To do this, cargo should be allowed to flow through the booster pump without starting the pump. The pump will be started only when the pump and the pipeline have cooled down.

In case refrigerated cargo is to be discharged to pressurized storage, the cargo pumps are run in series with boosters and the cargo heater.

Following are the purposes for which the booster pump and heater combination is used:

1. To discharge to pressurized storage from a refrigerated storage.
- Warm discharge with booster pump and cargo heater.
- Cold discharge with booster pump with the heater bypassed.

2. The cargo heater can also be used as a vaporizer during:
- Gassing up
- Discharging
- To handle low pressure in cargo tanks due to sub-cooled cargo.

The following precautions must be taken to protect the cargo heater:

1. In case of very low temperatures at the outlet of the heater, do not hesitate to activate the ESD.
2. In case of prolonged inactivity of the cargo heaters, rinse the seawater side of the heater with fresh water.

3. When two or more booster pumps are running in parallel, procedures must be in place to protect reverse turning of the booster due to accidental stopping of that pump.

10.19.5 SHIP T0 SHIP TRANSFER

In case of STS operations, in particular while discharging propane to fully pressurized shuttle vessels, the tank pressures in these shuttle vessels can be very high (about 10 to 15 kg/cm^2). There is a definite possibility of a backflow, of the tank vapour of the shuttle vessel, into the tanks of own vessel.

This high pressure may lift the suction side safety valve of the booster pump, which are typically set at 10 kg/cm^2.
To avoid this, stop the cargo pump, the booster pump and shut the manifold valve simultaneously.

10.20 EMERGENCY SHUTDOWN SYSTEM - ESDS

All liquefied gas carriers are provided with an emergency shut down system such that, by the operation of a push button or the opening of a control valve, cargo valves will close, pumping equipment will shut down and the control is such as to minimize the risk of any pressure surge
The instrumentation, control process and power actuators necessary to fulfil these functions are therefore of paramount importance and any maintenance is only to be undertaken by competent personnel.
Automatic shut down systems require particular attention. They are normally designed to shut the tank loading valves if the liquid level rises above the pre-set and there is a danger of the tank being overfilled. Care should be taken to ensure that the activation point is accurately set and if possible the operation of the device is regularly tested.

The precise timing and rate of closure of the cargo valves must be known, reliable and reproducible in order that shore personnel may be advised of the closing times and in liaison with the ship’s officers, agree an acceptable cargo transfer rate.

The system must be closed down within 30 seconds from activation and to reduce possible pressure surge, the last 20% of valve closure must take at least 6 seconds.

All tests and closure times are to be recorded.

Following any maintenance to the ESD system and prior to each cargo transfer operation the system is to be tested.

When the ship is fitted with an ESDS extension pennant, this must be provided to the shore during every cargo transfer operation.

On ships where the ship and shore emergency shut down system may be directly linked; the system must be in place and tested prior to commencement of any cargo transfer operation.

The control system is provided with fusible elements designed to melt at temperatures between 98 deg C and 104 deg C, which will cause the emergency shutdown, valves to close in the event of fire. Locations for such fusible elements include the tank domes and loading stations. Emergency shutdown valves should be of fail- closed (closed on loss of power) type and be capable of local manual closing operation.

11. INSTRUMENTATION

11.1 LIQUID LEVEL GAUGES

Level gauges are important because gas carrier cargo systems are closed and levels cannot be sounded. They may be linked to high level alarms to give warning of the tank being overfilled, and shutdown systems to prevent overfilling the cargo tanks. The accuracy required of a gas carrier level gauge is higher than those of other tankers because of the value of the cargo. Hence gauges are generally sophisticated and require careful maintenance.

11.1.1 FLOAT GAUGES

These consist of a float, which can rise vertically, floating on the liquid. A tape attaches it to an indicating device, which can be connected to a remote read out.

Particular attention is drawn to the following:

(1) Floats should be brought up to the stowage position manually when at sea; otherwise if the float is left 'down' at sea it will most certainly be damaged.

(2) Local and remote readings should be compared frequently to determine discrepancies. Corrections should be applied for float correction, expansion or contraction of tape and ship's trim and heel.

(3) Free vertical movement should be ensured for the tape. All parts on the float gauge should be securely locked in position, especially the tape-to-float and tape-to-reel attachments.

(4) Manufacturer's instructions should be complied with when assembling/ disassembling float gauges.

11.1.2 DIFFERENTIAL PRESSURE GAUGES

These are non-mechanical instruments, which work on the pressure difference between liquid and vapour within the tank.

Particular attention should be paid to the following:

(1) If tank contents are flammable or toxic, the signal lines are normally purged continually with inert gas; the flow rate should be adjusted to prevent false readings or leakage of cargo vapour into the safe areas.

(2) Manometer type displays are liquid filled and rely on liquid density to ensure accurate reading. The liquid should be compatible with the cargo concerned. Generally a pad of inert fluid (e.g. silicone) is used to separate incompatible liquids and vapours (e.g. mercury and ammonia).

(3) When more than one tank is monitored by a single instrument, the switching valve should be kept functional to prevent cross-connection and false readings.

(4) Small bore sensing pipes should be checked frequently. If blocked, erroneous readings will be indicated.

11.1.3 SLIP TUBE AND FIXED TUBE GAUGES

The tube penetrates the tank and has a valve at the top. When the valve is opened, a restricted amount of cargo is emitted. If the open end of the tube is in the vapour phase, vapour comes from the valve and if it is in the liquid phase, a fine spray is emitted. Generally, a fixed-tube is fitted which indicates that the liquid has reached a certain level. If it is a calibrated pipe, which can be raised or lowered vertically through a gland to determine the liquid level, this pipe is called a slip tube. These are easy to use and require minimum of maintenance. Due to the escape of cargo when taking readings, slip tubes are not allowed on vessel's carrying toxic cargoes. Many European ports do not allow the use of Slip tubes and other means of gauging system should be used.

The following precautions should be taken:

(1) The spray from the valve should be directed away from personnel and protective clothing should be worn.

(2) The slip tube gland should not be slackened excessively, otherwise the tank pressure may cause the slip tube to be pressed up with great force.

(3) Sources of ignition should be avoided in the area.

(4) Gas expansion through the valve can cause freezing and it may be necessary to use an anti-freeze to prevent this or to free the valve.

(5) The valves should be protected from damage and care taken to avoid the orifice being blocked by paint, salt, rust, etc.

(6) Pressure in the tank may cause a slip-tube to be pressed up with great force. Personnel should not stand directly in the path of the tube. <u>Use a stopper to prevent the tube from being pressed out completely</u>.

(7) If you are using slip tubes for gauging, then stow and lock the tube after taking the ullage. Do not keep the valve of the tube open permanently to monitor ullage continuously.

DO NOT USE SLIP TUBES FOR GAUGING AS FAR AS POSSIBLE. USE SLIP TUBES IF AND ONLY IF NO OTHER MEANS OF GAUGING IS AVAILABLE.

11.1.4 NITROGEN BUBBLE GAUGES

This type of gauge measures the pressure necessary to displace the liquid from a small bore sensing pipe mounted in the tank. The level of the liquid in the sensing pipe is the same as the level of the liquid in the tank. Nitrogen is introduced into the pipe at a pressure just sufficient to displace the liquid, which is indicated by nitrogen bubbles escaping. The necessary pressure depends on the cargo density and the liquid level. If the cargo density is known, the liquid level can be worked out directly' if not, then it is possible to calculate the cargo density if two gauges are fitted, one at the bottom of the tank and one at a known height above it - the density can be worked out by the difference in pressures. Readouts are either of a manometer type or dial-type.

The following precautions should be taken:

(1) Flow rate in the system should be low to avoid backpressure, which would give inaccurate readings.

(2) All joints should be checked regularly as leaks in the sensing pipes will cause inaccuracy.

11.1.5 CAPACITANCE PROBES

This type of gauge employs a fixed electronic sensor electrically insulated from the tank, which detects the change in capacitance between vapour and liquid. Readout is usually by means of a digital or a lamp display. Capacitance probes have no moving parts and are very simple.

The following care should be taken:

1. Probes should be kept clean, as dirt, rust, etc., will cause inaccurate readings.
2. Water should be kept out of the probe and the electrical circuits, as water has a very high electric constant and the slightest trace will cause inaccuracy.

11.1.6 ULTRASONIC GAUGES

These work on the same principle as an echo sounder. Particular care is necessary with the delicate transmitters and receivers, and with the calibration of this type of gauge.

11.1.7 RADIOACTIVE GAUGES

A radioactive source is placed on one side of the tank and a detector on the other, and the absorption of the radiation by the tank contents is measured. Difference in absorption between liquid and vapour phases allows the liquid level to be measured.

RADAR LEVEL GAUGES

The radar gauge transmits microwaves towards the surface of the liquid. The microwave signal has a continuously varying frequency around 10 GHz. When the signal has travelled down the to the liquid surface and back to the antenna, it is mixed with the signal that is being transmitted at that moment. The frequency of the transmitted signal has changed slightly during the time it takes for the echo signal to travel down to the surface and back again. When mixing the transmitted and the received signal the result is a signal with low frequency proportional to the distance to the surface. This signal provides a measured value with high accuracy. The method is called FMCW-method (Frequency Modulated Continuous Wave).

11.2 LEVEL ALARMS AND AUTOMATIC SHUT DOWN SYSTEMS.

Floats operating a switch device activate these, or capacitance probes, ultrasonic or radio active sources, or pump motor currents or temperature sensitive devices.

The set point may be affected by the cargo properties (e.g. density, dielectric constant etc.) and if necessary adjustments should be made in accordance with manufacturer’s instructions.

Particular care should be taken to ensure that the activation point is accurately set and the operation of the device is checked by simulation regularly.

If the ship and shore shutdown circuits can be linked, their operation should be checked before cargo transfer begins, otherwise the terminal should be informed of the closing rate of the ship’s valves.

Cargo monitoring instruments and control safety devices can be overridden by a key and a written procedure detailing how and by whom the system may be overridden should be posted close to the keys.

11.3 PRESSURE INDICATING DEVICES

Pressure gauges are fitted at various points in and around the gas carrier's cargo system in accordance with the requirements of the IGC Code. Pressure gauges can be linked to shutdown or alarm systems. It is important to ensure that gauges are working correctly and that pressure in the system is kept within design limits.

16.3.1. MANOMETERS

The manometer is a very simple and reliable instrument. However, the following precautions should be taken:

(1) Liquid should be compatible with the vapour with which it is in contact, if not, a different liquid or an inert pad should be used.

(2) The liquid should have a suitable density to provide accurate readings.

(3) The liquid and vapour should be compatible with the material of the tube.

(4) The liquid should be free from trapped vapour otherwise readings will be inaccurate.

(5) The system should not be used unless the inert gas flow is within designed limits.

16.3.2. BOURDON TUBES

The following precautions should be taken:

(1) The gauge should not be used beyond 75% of its maximum reading, if the pressure is continuous, or 60% if it is fluctuating.

(2) Compressed air or inert gas supplies to pressure transmitters should be clean, dry and oil free. Bourdon tubes may be damaged by excessive pressure pulsation, which can be eliminated by use of a flow restrictor.

(3) Before a new gauge is fitted, the materials of construction should be checked for compatibility with the cargo.

16.3.3. COMMON PRECAUTIONS

(1) The construction material should be compatible with the cargo.

(2) No pressure gauge should be subjected to violent pressure changes.

(3) All instruments should be calibrated regularly with accurate and certified test equipment.

(4) If the cargo can form polymers (e.g. butadiene) sensor leads should be arranged to drain back into the system or tank to prevent polymer formation and subsequent blockage. Lines and sensor chambers should be flushed.

(5) Sensor lines disconnected during maintenance should be temporarily blanked.

11.4 TEMPERATURE MONITORS

Temperature sensors are fitted in accordance with the IGC code so that the temperatures of both the cargo and the structure around the cargo system can be monitored. It is very important to be able to monitor temperatures in the cargo system during cool down and warm-up operations to ensure unsafe thermal stresses are avoided. There are different types of thermometers, Liquid-vapour thermometers, Liquid filled thermometers, Bi-metallic thermometers, Thermo-couples and Resistance thermometers.

The following common precautions should be taken:

(1) Thermometers used should be suitable for the complete range of temperatures expected.

(2) The sensor should make good thermal contact with the material whose temperature is to be measured.

(3) Thermometers, especially those with capillary tubes, are easily damaged, and they should be handled with care and protected from mechanical damage.

(4) When a thermometer is removed, care should be taken to prevent the removal of its pocket, also care should be taken when fitting the thermometer back.

(5) Electrical connections to the sensor should be clean, tight and correct.

(6) On multi-point recording and alarm or shutdown circuits, it is essential to check that inputs are connected to the correct destinations.

11.5 PRESSURE AND TEMPERATURE SWITCHES

These are fitted to activate alarms or to operate shutdown equipment. Various types may be encountered and each has to be operated and maintained according to manufacturer's instructions. However, the following general precautions should be observed:

(1) The device should be correctly calibrated over its full range using accurate test instruments.

(2) If the set point of the device is fixed, it should be locked to prevent disturbance from vibration or tampering.

(3) No changes should be made to the set points, if adjustable, unless full implications are understood and these adjustments, if done, should be carried out under the direction of a responsible person and proper records maintained.

(4) Shut-off cocks, when fitted, should be open during normal operation.

11.6 VAPOUR DETECTION EQUIPMENT

Vapour detection equipment is required by IGC Codes for the following reasons:

(1) Detection of cargo vapour in air, inert gas or vapour of another cargo.

(2) Concentrations of gas in or near the flammable range.

(3) Concentrations of oxygen in inert gas, cargo vapour or enclosed spaces.

This equipment can be fixed or portable. There are several types like infrared detectors, thermal conductivity meters, combustible gas detectors, tankscopes, chemical absorption indicators and oxygen indicators. All personnel should fully understand the purpose and limitations of vapour detection equipment, whether fixed or portable.

The following common precautions should be taken:

(1) The maker's handbook should be consulted before use or calibration.

(2) Zero setting should be checked regularly and reset if necessary before the instrument is calibrated. Pure nitrogen should be used if possible, when carrying out zero settings.

(3) The instrument should be calibrated frequently throughout its operating range. Concentration and composition of the span gas should be accurately known. Recalibration should be logged on or near the instrument. Supplies of span gas should be replenished as necessary.

(4) When oxygen detectors are calibrated, it is essential to use clean and uncontaminated air.

(5) Tubes or liquids for equipment using chemical absorption or reaction principles have a limited shelf life and they should be replaced before it is exceeded.

(6) All sample lines should be clean, unobstructed, leak tight and connected to the correct points.

(7) If upper and lower sample points are provided, the correct one should be used for the relative density of the cargo carried and care should be taken to change sample points when changing cargoes, if this is necessary.

(8) Due precautions should be taken when using portable detectors while taking readings.

(9) Portable sensing equipment should not be used in flammable atmospheres, unless it is intrinsically safe.

(10) Pumps, filters, flame screens and other components should be well maintained to ensure accurate readings.

(11) Catalytic filament elements should not be exposed to water or oil vapour.

(12) Remote and local readouts should be checked to ensure accuracy.

(13) Calibration of most fixed instruments depends on flow rate and fluctuations can cause inaccuracy flow should be kept steady and flows from each point should be balanced.

(14) Battery voltage of portable instruments should be checked frequently to ensure accurate readings.

11.7 EQUIPMENT ALARM AND SHUTDOWN CIRCUITS

The safe operation of plant and systems depends on the correct operation of these circuits. Design and purpose of these circuits vary widely, but they are normally electric or electronic, though some may be hydraulic.

The following precautions should be observed:

(1) Test facilities, if provided, should be used before cargo operations.

(2) Wiring inside and outside should be checked for chafing, condensation, insulation deterioration, bad connections etc.

(3) The accuracy of all inputs to alarm circuits should be checked.

(4) When an alarm is activated, the reason should be investigated and necessary remedial action taken.

11.8 FLAME FAILURE DEVICES

These are fitted to the combustion control systems of inert gas generators and dual fuel boilers. Following precautions should be taken:

(1) Sensitivity is normally adjustable and should be checked by simulation.

(2) The instrument should be correctly directed at the flame and sight ports kept clean.

(3) Photoelectric cells should be replaced as per maker's recommendation as they have a limited life.

11.9 RELIQUEFACTION PLANT OPERATIONS

Reference should always be made to the ship-specific Gas Manual. Before reliquefaction operations begin, the following general precautions should be taken:

(1) Compressor oil levels should be correct and the oil should be suitable for the cargo carried.

(2) Lines and valves should be correctly set. Compressor discharge valves should always be open before starting. However, it is normal to open compressor suction, lubricating oil separator and compressor hot gas bypass valves after starting.

(3) Crankcase heating system to be activated when necessary.

(4) Full sea water supply to appropriate condensers to be established.

(5) Glycol plant is running.

(6) Variable capacity compressors are set to manual operation at minimum capacity.

16.9.1 CARGO RELIQUEFACTION PLANT OPERATIONS

Before starting and when running the reliquefaction plant, the following precautions should be taken:

(1) Cargo compressor discharge valves are open, and crankcase heaters activated.

(2) Compressor should be cranked manually

(3) The suction side liquid separator checked and drained of any liquid. The suction valve is opened slowly after starting the compressor. If ‘compressor hammer’ is heard the machine should be stopped.

(4) Crankcase oil levels and pressures are within manufacturer’s limits.

(5) Suction and discharge pressures are correct

(6) While operating the plant, conditions should be checked frequently to ensure that the designed efficiency levels are met.

(7) If condensate is being returned to more than one tank simultaneously; it should be ensured tanks are not overfilled.

16.9.2 R22 SYSTEM OPERATION

The cascade system uses a refrigerant such as R22 to condense cargo vapours. The single-stage compression of cargo vapour is identical to the single-stage direct cycle, but the cargo condenser is cooled using R22 instead of sea water. The cargo, in condensing, evaporates the liquid R22 and the R22 vapours are then taken through a conventional R22 closed refrigeration cycle condensing against sea water – hence the term cascade. The cascade cycle is used for fully refrigerated cargoes and plan capacities are not so affected by sea water temperature changes as are other reliquefaction cycles.

If R22 cascade type system is used, the R22 cycle should be started first. The following precautions should be taken:

(1) R22 liquid separator is not flooded.

(2) Compressor should be cranked manually

(3) R22 compressor discharge valve is open

(4) Machine should be started and suction valve opened slowly. If ‘compressor hammer’ is heard, the machine should be stopped.

(5) R22 compressor oil level and crankcase pressures are kept within the manufacturer’s limits.

(6) R22 system should be put on automatic control after normal conditions have been established.

(7) During reliquefaction, R22 liquid level devices should be checked regularly for correct operation.

(8) As an auxiliary function of the R22 system, superheated R22 vapour from the R22 compressor can be passed through a heating coil in the tank sumps to vaporize cargo remaining at the end of discharge. Care should be taken with this system to avoid R22 vapour condensing in the heating coil because it is very difficult to clear these coils of R22 condensate.

16.9.3 COMPLETION OF RELIQUEFACTION OPERATIONS

The following precautions should be observed:

(1) The cargo compressor is stopped and suction valve closed.

(2) The expansion valve by-pass is opened to permit the condenser pressure to clear the condensate lines to the cargo tanks.

(3) Collect R-22 gas in the receiver before stopping compressor

(4) R22 compressor is stopped and oil separator return to the crankcase is closed.

(5) All cargo valves are shut. Compressor discharge and suction valves are closed to prevent condensate collecting in the cylinders or crankcase.

(6) Sea water supply to the condenser and glycol circulation in the system should be either stopped or left running, in accordance with instructions.

(7) That no cargo liquid remains in the system, as it can heat up and lift the relief valves. Butadiene condensate is not inhibited and may polymerise, causing blockage.

16.9.3.1. GLYCOL SYSTEMS

Where the use of cooling coils is essential for certain cargoes, a mixture of ethylene glycol and water is normally used. For ships carrying cargo down to minus 55°C, a 60% volume mixture of glycol and freshwater should be adequate for all purposes. If the glycol percentage is more than 60%, the additional glycol will not have practical advantages. However, it has been observed that the use of glycol in warm weather conditions can lead to sludge generation. Chemical treatment of the cooling water may be considered in consultation with the office.

16.9.3.2. ALCOHOL INJECTION

If water vapour is mixed with cargo vapour in a reliquefaction cycle, ice may form at the expansion valve. Blockage of the condensate return may occur suddenly, or the ice may build up on the pipewall over a period and be evident by a gradually diminishing condensate flow and a condensate build up in the receiver. Automatic expansion valves are usually provided with a manual by-pass valve to avoid shutting down of the plant in the event of blockage.

To prevent or reduce ice-formation, some reliquefaction plants are equipped with an alcohol injection system up-stream of the expansion valve. If the ice does not clear rapidly by using this, it can be assumed that the ice build-up is extensive. The plant must then be shut down or operated on the by-pass, and the alcohol pressure maintained against the ice until the blockage clears. As the ice clears, alcohol will mix with the water and lower its freezing point.

See also Section 25.5

16.9.3.3. INCONDENSABLE GASES

If the presence of incondensables is suspected, they should be vented to the atmosphere if local regulations permit.

Some systems also provide an alternative incondensable return line to the cargo tank.

Venting of incondensables should be continued during the reliquefaction operation until the condensing pressure stabilizes close to the correct theoretical value.

If venting of incondensables over a fairly long period does not succeed in reducing the condensing pressure to the anticipated value, the high pressure can be attributed to components of the cargo and accepted, provided pressures are within the designed limits of the plant.

To ensure that essential minor components (e.g. ethane) of some cargoes are not treated as incondensables and blown to atmosphere, the S.V.P. in relation to the anticipated condensing temperature of the cargo should be noted from the appropriate Mollier or vapour pressure diagram before reliquefaction operations commence.

12. GAS FREEING, TANK ENTRY & HOT WORK

12.1 GAS FREEING

The gas freeing operations of cargo tanks are to be carried out in accordance with the procedures detailed in the vessel's **Inert Gas System Operation and Maintenance Manual and Cargo Manual.**

The gas freeing operations are to be carried out in accordance with the appropriate recommendations of **ISGOTT**. If portable fans are used for gas freeing, injector nozzles and/or flexible ducting are not to be used until the hydrocarbon gas concentration is less than 1% of the lower flammable limit.

When the gas freeing of any tank for entry is completed the tank access hatch and as many other tank openings as possible should be left open to promote continued natural ventilation.

12.2 GAS FREEING FOR ENTRY

Spaces which are to be gas freed for entry shall be ventilated until tests in a still atmosphere give hydrocarbon gas readings of ZERO percentage L.F.L. and oxygen content readings of 21% oxygen by volume.

When gas freeing of any bunker tank is required it is to be carried out after the completion of water washing of the tank and after all portable equipment has been removed from the tank.

Failure to obtain a ZERO percent L.F.L. reading after adequate ventilation in an oil tank may be indicative that further washing is required to remove oil residues.

12.3 ENTRY TO AND WORKING IN CARGO TANKS

All entry to and work in cargo tanks is to be done under the direct supervision of the Officer in Charge and in accordance with the appropriate recommendations of **SIGTTO Liquefied Gas Handling Principles** and an **Enclosed Space entry permit** should be used. The Officer in-charge should ensure that each person entering an enclosed space carries an ELSA set. While working inside the enclosed space, these ELSA sets should always be kept ready at hand for immediate use. Personal oxygen and gas monitors must also be carried into such spaces to continuously monitor the atmosphere in the vicinity where the persons are working.

Immediately before any subsequent entry to a gas free tank is made the Officer in Charge must satisfy himself that the tank is safe for entry and for the intended work by representative sampling of the tank's atmosphere.

In general, all entry to and work in tanks is to be carried out during daylight hours only. In exceptional circumstances such operations may be carried out during darkness provided adequate, appropriate lighting can be maintained.

12.4 EMERGENCY ENTRY AND WORK IN GAS FREE SPACES

Entry to and work in a non gas free tank or space must be directly authorised by the technical management office.

If such entry is required to carry out essential work the operation is to be organised by the Officer in Charge using the full resources of the vessel's Emergency Team. During such operations the appropriate recommendations of **ISGOTT** must be strictly observed.

12.5 ENTRY TO BALLAST TANKS AND OTHER ENCLOSED SPACES

All ballast tanks and other spaces in the cargo tank area are to be proved to be free of hydrocarbon gas and inert gas, and **Enclosed Space Entry Permit** issued before any entry is permitted.

Initial entry for further testing of the tank atmosphere should be made by a responsible Officer wearing an emergency escape apparatus after completion of the **Enclosed Space Entry Permit.**

12.6 INSPECTION AFTER COMPLETION OF WORK INSIDE TANKS

When any work has been carried out inside a cargo, ballast or bunker tank, the tank is to be thoroughly inspected by a responsible Officer when all work has been completed. This inspection is to ensure that tools, equipment and materials, including debris, have been removed and that no obvious damage has occurred to tank fittings or coatings.

12.7 HOT WORK

Hot work is any work involving welding or burning, and other work including certain drilling and grinding operations, electrical work and the use of non-intrinsically safe electrical equipment, which might produce an incendive spark.

Hot work outside the main machinery spaces (and in the main machinery spaces 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. Hot work should only be carried out outside the main machinery spaces if no other viable means of repair exists. Alternatives to be considered include cold work, or removal of the work piece to the main machinery spaces.

Hot work outside the main machinery spaces workshop is permitted only in accordance with prevailing national or international regulations and/or port/terminal requirements and is subject to the restrictions of a shipboard hot work permit procedure.

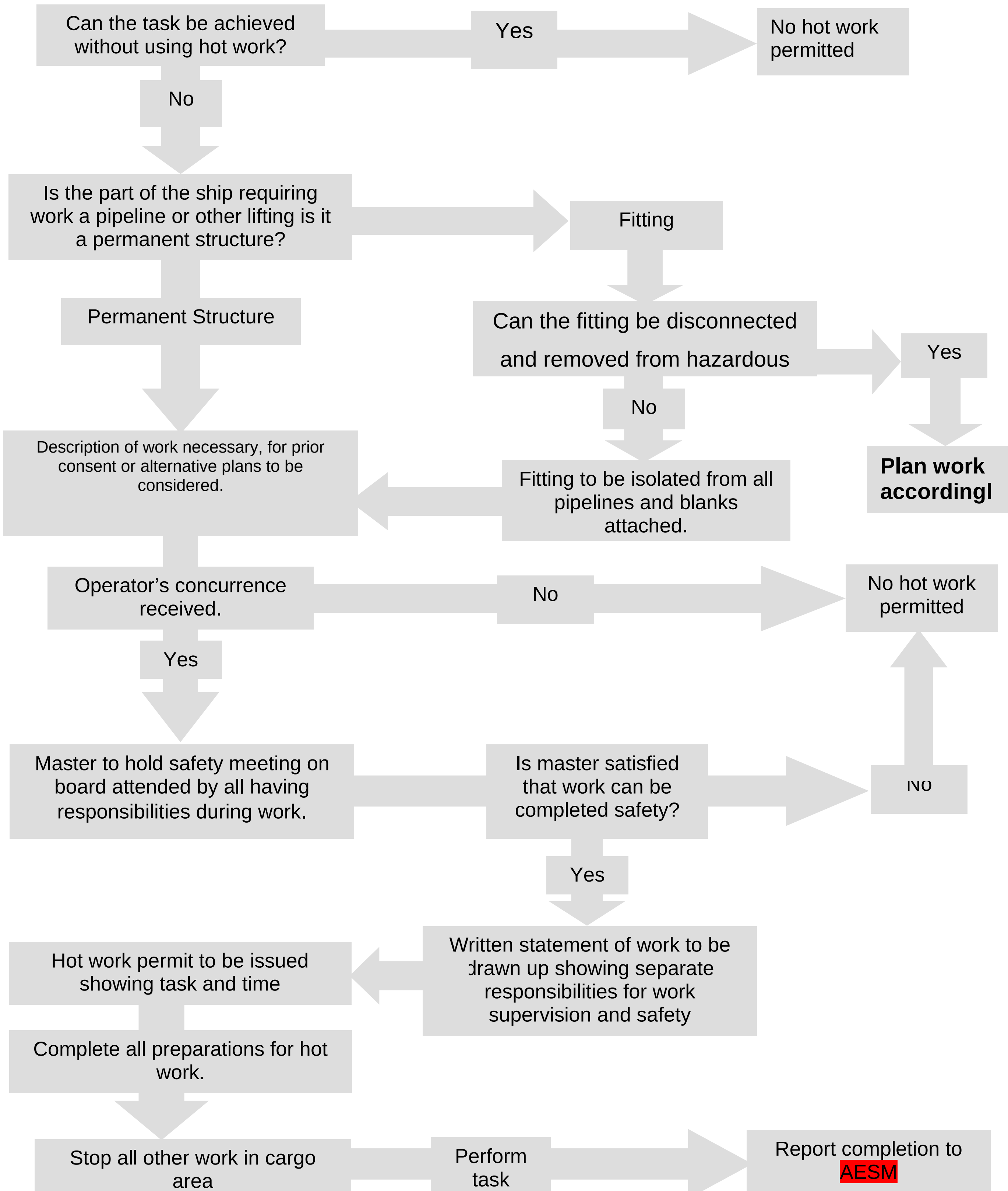
Hot work in areas outside the designated area in the main machinery space should not be proceeded with until the Master has informed our office of the details of work proposed, and a procedure has been discussed and agreed with the superintendent in charge. This should be done in all cases without exception unless for some reason the work is very urgent and time does not permit contacting the office. In this case, the master should decide if the proposed work can be carried out safely and the extent of precautions required.

Before any hot work is started, a safety meeting should be held by the master, at which the planned work and safety precautions should be carefully reviewed. The meeting should be attended by at least all those who will have responsibilities in connection with the work. An agreed plan for the work and related safety precautions should be made. The plan must designate one officer who is responsible for the supervision of the work and another who is responsible for safety precautions.

All personnel involved in the preparations and hot work operation must be briefed and instructed in their role. A written hot work permit should be issued for each intended task. The permit should specify the duration of validity.

A flow chart for guidance is given as follows:. The flow chart assumes the work is considered necessary for safety or operational capability of the ship, and that it cannot be deferred until the next planned visit to a repair yard.

Hot work for which a hot work permit is required should be prohibited during cargo, ballast, tank cleaning, and gas freeing, purging or inerting operations.


Can the task be achieved without using hot work?
Yes
No hot work permitted
No
Is the part of the ship requiring work a pipeline or other lifting is it a permanent structure?
Fitting
Permanent Structure
Can the fitting be disconnected and removed from hazardous
Yes
No
Plan work accordingl
Description of work necessary, for prior consent or alternative plans to be considered.
Fitting to be isolated from all pipelines and blanks attached.
Operator's concurrence received.
No
No hot work permitted
Yes
Master to hold safety meeting on board attended by all having responsibilities during work.
Is master satisfied that work can be completed safety?
No
Yes
Hot work permit to be issued showing task and time
Written statement of work to be drawn up showing separate responsibilities for work supervision and safety
Complete all preparations for hot work.
Stop all other work in cargo area
Perform task
Report completion to AESM

13. EMERGENCY PROCEDURES

Emergency procedures should be pre-planned and exercised during drills, if they are to succeed. In any emergency procedural plan, the first steps should be:

- raising the alarm
- locating and assessing the incident, and the possible dangers
- organizing manpower and equipment

The detailed circumstances of an actual emergency will differ in many cases from those encountered during pre-planning. However, pre-planning is still essential to ensure that basic action can be taken quickly and decisions on how to tackle any additional problems can be made in an orderly manner. Therefore, standard emergency procedures should be developed on each ship based on advice given in the relevant company manuals.

Preliminary action in any emergency procedure should be: raising the alarm, assembling and crew check.

13.1 FIRE

Detailed notes on fighting fire in the cargo area (given in Chapter 19) and for fighting those in the engine room and accommodation (as given in ECM manual 205, section 8) should be followed.

13.2 COLLISION

Action as indicated in ECM Manual 205, section 9.2 should be undertaken immediately. Additionally, the following should be considered:

(1) Issue protective clothing and escape sets.

(2) Implement initial fire fighting measures and activate water spray protection.

(3) Launch boats for survivors, taking into account the potential hazard from unignited gas.

(4) Mount large scale fire fighting, if necessary.

(5) Assess hull damage and stability.

(6) Assess effects on cargo system.

(7) Strict control of all ignition sources should be exercised if liquefied gas has escaped from a cargo tank ruptured by collision.

(8) The ship should be manoeuvred with respect to the prevailing wind so that any vapour cloud will drift clear of the accommodation space and machinery air intakes. If this is not practicable because of an inability to manoeuvre and if significant flammable or toxic vapour clouds appear to be enveloping the ship's accommodation, all accommodation and machinery space ventilation should be stopped.

(9) Any other action, considered necessary by the Master.

13.3 GROUNDING

Action indicated in ECM Manual 205, section 9.4 should be undertaken immediately. Additionally the following should be considered:

(1) Assess hull damage and stability.

(2) Assess effects on cargo system.

(3) Jettison cargo, if situation demands.

(4) Clear boats for launching.

(5) Any other action, considered necessary by the Master.

13.4 WATER LEAKAGE INTO HOLD OR INTER-BARRIER SPACE

If water rises into a hold or inter-barrier space, it may damage the insulation and result in a rise of cargo temperature and pressure. It will also adversely affect the stability of vessel due to increase of large free surface area. These spaces should be regularly checked for water leakage, if leakage occurs, the water should be pumped out.

13.5 CARGO SPILLAGE (HOSE BURST OR PIPEWORK FRACTURE)

The following action should be taken immediately.

(1) All cargo operations should be stopped, the ESD should be activated and all valves closed.

(2) Alarm sounded, accommodation access doors shut and all ventilation (except closed-circuit systems) shut down.

(3) Smoking and naked lights prohibited anywhere on the ship, and electrical switches used as little as possible.

(4) Appropriate fire fighting equipment should be deployed and breathing apparatus sets assembled for immediately use. The emergency squad should wear breathing apparatus and protective clothing.

(5) If liquid spillage occurs, fire hoses or water sprays should be played along the deck to disperse the liquid overboard and to maintain steel temperatures so that brittle fracture is avoided. Water spray from hoses can also be used to deflect a gas cloud.

13.6 TANK LEAKAGE

Cargo tank leakage can be detected by gas detection equipment and constant monitoring will give information on the change of vapour concentration. The rate of change of reading will indicate the magnitude of the leak along with constant monitoring of hold or inter-barrier space pressure and temperature. All cargo tank leakage should be considered serious and reported immediately. Specific instructions should be followed, and additionally the following should be considered:

(1) The pumping of liquid in hold or inter-barrier spaces into an undamaged tank with compatible cargo and sufficient ullage.

(2) The use of a steel heating system if necessary to avoid fracture.

(3) The use of reliquefaction plant to reduce the tank pressure, where applicable. However, care should be taken to avoid drawing air into the tank thereby creating a flammable mixture.

13.7 EMERGENCY DISCHARGE OF CARGO AT SEA

If any tank develops a serious defect at sea, as much as possible of the cargo remaining in it and that which has leaked into the hold or inter-barrier space should be transferred to any other tank with space available and containing compatible cargo. In certain cases, it may be necessary to discharge the remainder overboard, taking into account trim and stress considerations and local circumstances.

If cargo must be discharged, the stern line, if fitted, should be used. If not, a long extension piece of suitable material, angled downward and fitted at the end with a reducer should be connected to the manifold.

If emergency cargo discharge has to be undertaken, precautions given in para 18.5 should be observed and additionally, the following should be considered:

(1) Radio warning to all ships in the vicinity

(2) Heading the ship so that the wind direction is the same as that of the discharge, if possible.

(3) Use of the highest possible pumping rate to get the cargo as far from the ship as possible.

(4) Any other ship specific precautions as required.

13.8 ACCIDENT INVOLVING PERSONNEL

If personnel are affected by or come into contact with the cargo, emergency action as described in the data sheet for that cargo should be taken.

If personnel are overcome in an enclosed space, the man standing by should raise the alarm and assemble the rescue team. The agreed rescue plan should be implemented.

13.9 UNCONTROLLED VENTING

The following actions should be taken:

(1) If alongside, inform the terminal and follow emergency procedures agreed between ship and shore. Activate the ESD system.

(2) At sea, manoeuvre the vessel to ensure a safe dispersal of the vapour cloud away from the accommodation space.

(3) Muster crew (with lifejackets and escape sets), close accommodation access doors and all ventilation (except closed circuit systems) to be shut down.

(4) Activate water spray systems.

(5) Smoking and naked lights to be prohibited anywhere on the ship and all electrical circuits on deck to be isolated.

(6) Appropriate fire fighting equipment should be deployed and any other necessary actions should be undertaken.

13.10 TOXIC GAS RELEASE AT SEA

The following action should be taken in case of accidental release of toxic gases at sea:

(1) Operate the ESD system.

(2) Sound general alarm.

(3) Seal and isolate the accommodation (Close all natural vents).

(4) Change the air conditioner to recirculation.

(5) Inform the coastal state.

(6) Inform AESM.

(7) Do not go out on cargo decks without protective gear suitable for the specific toxic gas that was released.

(8) Continuously monitor the accommodation, machinery spaces and the outside decks for toxic gases until the emergency is over.

13.11 TOXIC GAS RELEASE ALONGSIDE

The following action should be taken in case of accidental release of toxic gases while alongside a terminal:

(1) Operate the ESD system.

(2) Sound the general alarm.

(3) Inform the terminal.

(4) Seal and isolate the accommodation.

(5) Change the air conditioning uptake to recirculation if it is not already on recirculation.

(6) Do not go out on the cargo decks without suitable protective clothing.

(7) Inform AESM.

(8) Follow any specific advice from the terminal.

(9) Continuously monitor the accommodation, machinery spaces and outside decks for toxic gases until the emergency is over.

14. FIRE FIGHTING

If fire occurs, the action taken in the first few minutes is vital. Immediately the alarm should be raised and the emergency plan implemented. Guidelines given in ECM manual 205, section 8; should be referred to for fighting fire in accommodation, machinery space, enclosed spaces and electrical fires. In this chapter, instructions are limited to fighting liquefied gas fires.

14.1 LIQUEFIED GAS FIRE FIGHTING GENERAL CONSIDERATIONS:

The most important consideration in fighting a liquefied gas fire is the large quantity of vapour given off by the liquid and the considerable heat generated by the flames. In the event of fire every effort should be made to isolate the source. The ESD should be activated, dry powder or water sprays used on local fires, which prevent access to valves. The source of fuel should always be shut off before flames are extinguished to prevent a potentially flammable gas cloud forming and being reignited downwind or by surfaces heated in the original fire. If the fuel source cannot be isolated, it is safer to let the fire burn while continuing to cool the area.

Low expansion foam or water is not used for liquefied gas fires because water will increase the rate of vaporization. Dry powder is therefore used and since it does not have any cooling effect, it is essential to use water spray systems or fire hoses with nozzles after the flames are out. Since the capacity of the dry powder system fitted is limited, it is very important to use it carefully so as not to waste a large portion of the powder.

A large quantity of flammable material is used in the insulation of cargo tanks, and cargo handling systems. Care should be taken to protect personnel from the rapid spread of fire, asphyxiation and toxic products of combustion. Risk of fires in insulation is greatest when the vessel is undergoing repairs or refit, at which time insulation spaces are not inerted and sources of ignition such as welding and burning are likely to be present.

14.2 NATURE OF LIQUEFIED GAS FIRES

Cargo and stored product fires may be broadly categorized as follows:

(1) Pressure fires from liquid or vapour leaks at pump glands, pipe flanges, relief valves or vent headers.

(2) Fires from confined liquid pools

(3) Fires from unconfined spillage, and

(4) Fires in confined spaces.

14.3 PRESSURE FIRES

Leaks from pump glands, pipe flanges, relief valves, masthead vent header, etc., will initially produce vapour and / or possibly liquid which will rapidly vaporize and will not ignite spontaneously. The ESD should be activated, and if a gas cloud occurs, initial effort should be directed using water sprays to deflect the cloud away from any potential ignition source and to protect the equipment with water spray against heat damage should ignition occur. If ignition does occur, it will probably flash back to the source of leakage, giving a jet or torch fire. Hence, it is essential to isolate the source of leakage first.

Pressures will persist in a closed pipeline until all the liquid trapped within it has been expelled either as liquid or vapour through the leak. In such a case, it may be sensible to allow the fire to burn out while protecting surroundings by the use of copious amounts of cooling water rather than extinguish the fire and risk a further vapour cloud and flash back re-ignition. In case of a vent mast fire, inject inert gas into the vent if possible and spray the masthead with water.

14.4 POOL FIRES

Prompt initiation of the ESD will do much to limit the amount of liquid spilled and because of the ship's deck, with its camber and open scuppers, liquid spillage will quickly pass over the ship's side and the size and duration of pool fires would be limited. The ignition of the resulting vapour cloud will burn like petrol, with tall flames and some black smoke. It is important to remember that the addition of water will increase the rate of vaporization and intensify the fire. When using water to disperse spilled liquid or to prevent possible brittle fracture, the water should, wherever possible, be introduced a little at a time. Jets of water should never be directed onto burning liquid, as this will cause a violent increase in flame.
When contained in drip trays, the cold liquid may also be spilled onto the deck and water-jet should therefore be avoided. It is essential when fighting a liquefied gas fire to wear full protective clothing and take advantage of water spray protection.

14.5 FIRES IN ENCLOSED SPACES

Leaking gases may form a flammable mixture within an enclosed space, which may cause an explosion if a source of ignition is present. Closing openings where possible and shutting down mechanical ventilation should minimize the supply of oxygen to the space. Enclosed spaces containing cargo related plant such as compressors, heat exchangers, or pumps will normally be provided with fixed and remotely activated fire suppressant systems (CO_2 or Halon). These systems should be immediately effective provided no major damage to the enclosure has occurred due to the ignition of vapour. If possible, adjacent spaces should be kept smoke-free and patrolled regularly so that boundary cooling can be carried out, as necessary.

15. PERSONAL PROTECTION AND FIRST AID

15.1 PROTECTIVE CLOTHING

Protective clothing should be worn during cargo operations due to hazards associated with the cargo. The suits, gloves, boots, goggles, face shields, etc., used should be suitable for the cargo being handled. Many plastics become brittle and crack when subjected to low temperatures, or can be dissolved by the cargo. Clothing made of PVC or similar type of material is less susceptible to absorption, and should be worn when exposure to vapour or liquid emissions is involved.

In particular, gloves should be worn when handling cold equipment, valves or slip tubes. Face protection should be worn when there is danger of liquid emission (e.g. dismantling cargo equipment, using slip tubes, sampling) and respiratory protection should be provided for cargo operations involving toxic or asphyxiating gases. Cargo vapour may be absorbed into clothing in sufficient quantities to create a hazard if taken into accommodation, galley, smoke rooms, etc.

15.2 DECONTAMINATION WATER SPRAYS AND SHOWERS

Full use should be made of changing rooms between deck areas and accommodation, and of the showers, which may be provided in these compartments or on the deck adjacent to accommodation entrances. Personal hygiene is very important when the cargo is toxic and personnel involved in cargo operations should always wash their hands thoroughly before eating and should not wear or bring contaminated clothes into the accommodation.

15.3 BREATHING APPARATUS

Breathing apparatus should be used as necessary by personnel engaged in cargo operations involving toxic cargoes, by fire fighters and when entering an unsafe space.

Precautions on use of breathing apparatus should be taken before using such equipment in enclosed spaces.

Escape sets should not be used for purposes other than for emergency escape.

15.4 CANISTER OR FILTER TYPE RESPIRATORS

"CANISTER OR FILTER TYPE RESPIRATORS SHOULD NEVER BE USED IN ENCLOSED SPACES WHERE THE OXYGEN CONTENT OF THE ATMOSPHERE MAY BY INSUFFICIENT TO SUSTAIN LIFE."

This type of respirator may be used for handling toxic cargoes like VCM or butadiene during normal operations, where exposure to the cargo vapour may be probable. An example could be during connection or disconnection of the manifolds. Such equipment must not be used for escaping from a hazardous atmosphere or fire fighting. Canisters are available for absorption of a variety of different vapours, but the following precautions should be taken:

(1) The type of canister should be correct for the cargo concerned

(2) Canisters should not be opened to the atmosphere until needed for use because they may gradually become saturated and ineffective.

(3) Canisters have a limited life and unless it is confidently known how much of the canister's life remains, it should be discarded and destroyed after use.

The IGC recommends that filter type respirators be replaced by lightweight CABA type escape sets

15.5 FIRST AID

During accidents involving cargo, first aid procedures as given in data sheets are to be followed. In the event of cargo liquid entering the eye, the correct treatment is to flood the eye with clean fresh or salt water and to continue washing for at least 15 minutes. If cargo liquid comes into contact with the skin, the affected area should be washed and any affected clothing removed. If frostbite has occurred, this should be treated by immersion in warm water.

If exposed to cargo vapour, personnel should be advised to vacate the area. Emergency treatment if required should be:

(1) Remove victim to fresh air and

(2) Give artificial resuscitation if breathing is weak or irregular, or has stopped.

15.6 RESUSCITATION

Responsible persons should be instructed in the use of resuscitation apparatus. This apparatus should NOT normally be kept locked up. The operating instructions provided with the apparatus should be clearly displayed.

Contents of oxygen or compressed air cylinders should be checked at regular intervals and replaced or recharged if partially consumed. Resuscitation equipment should not be taken into an enclosed space containing flammable cargo vapour unless the equipment is approved.

15.7 FROSTBITE

If frostbite of the skin has occurred, the victim should handled gently and bending of joints should be avoided. Further reference should be made to the ‘The Ship Master’s Medical Guide’ or the ‘International Medical Guide for Ships’.

15.8 CASUALTIES IN CONFINED SPACES

If an accident occurs in a confined space and a person is overcome by gas or lack of oxygen, the first action is to raise the alarm. No rescue should be attempted without taking proper precautions.

Though speed is vital, breathing apparatus and a manned lifeline must always be used in rescue operations to avoid the risk of rescuers becoming casualties themselves when they enter the space. The rescuer should never remove his facemask to provide air to the person being rescued, as this could only present a hazard to the rescuer, making him a potential victim.

16. SHIP TO SHIP OPERATION

STS operation in general should be carried out in accordance with ICS / OCIMF Ship to Ship Transfer Guide (Liquefied Gases). Checklists in Appendix 1 are to be used as guidelines.

The following precautions should be taken:

(1) Satisfactory communication should be established between both the vessels. Communication channels should be kept open during approach, mooring, transfer and unmooring operations.

(2) Vessel's particulars should be exchanged between both parties, along with details / transfer rates of cargo to be transferred.

(3) Ship-to-Ship operation should only take place if both Masters are satisfied that weather conditions are suitable for berthing and cargo transfer.

(4) Navigation warnings should be broadcast to all ships in the vicinity advising them of the STS operation and requesting for a wide berth. On completion of the operation, the navigational warning should be cancelled.

(5) Pre-mooring preparation should be carried out, this should include testing of cargo equipment and safety inspections.

(6) Fenders should be rigged and positioned taking into consideration the length of each ship, parallel midbody distance and position of manifolds. In general, one primary fender should be rigged on each end of the parallel body of the shuttle-vessel, with another two or three fenders somewhere in between. Secondary fenders made of pneumatic foam or hollow cylindrical rubber should be used on the bow and quarter of the shuttle-vessel. Fenders should be checked by the mooring master and master of the vessel prior to the operation.

(7) Mooring lines should be prepared and kept flaked ready for immediate use. An adequate number of messenger lines, stoppers and portable fenders should be kept ready.

(8) No gear such as derricks should protrude beyond the ship's side. Both ships should be upright and excessive trim avoided. Care should be taken with suitable handling of ballast / cargo that excessive changes in freeboard are avoided.

(9) It is normal practice that the manoeuvring ship approaches and berths with her port side to the starboard side of the other, whether underway or at anchor. Rapid and efficient mooring operations are essential for safe berthing. The STS operation is carried out in different ways for example, with both ships underway, constant heading ship at anchor and drifting transfer. In all above methods, the following points should be kept in mind:

- Wind and sea should be ahead or nearly ahead.
- The angle of approach should not be excessive.
- The effects of interaction should be anticipated when manoeuvring at close quarters.
- The Masters of both ships should be prepared to abort the operation if necessary. The decision should be taken in ample time while the situation is still under control.

(10) After the ship's are moored, the following arrangements should be made:

- Both ships should be prepared to disconnect and unmoor at short notice.
- Continuous power for the winches should be available.
- Extra lines and axes should be placed fore and aft on both ships.
- Flanges between hoses and manifolds should be properly connected and fully bolted, using bolts and nuts of suitable material and length.

(11) Prior to carrying out transfer operations, a safety checklist should be completed.

(12) After completion of transfer, the following operations should be carried out.

- All hoses should be purged into one or other ship prior to disconnecting.
- Manifolds must be securely blanked.
- Side of transfer to be cleared of obstructions.
- The method of disengagement and of letting go moorings agreed.
- Messengers, rope stoppers etc. should be kept ready at stations.

(13) Moorings should only be cast off after timing and sequences have been agreed.

(14) In general, while unmooring, lines should be singled up fore and aft, after which the remaining forward moorings should be cast off allowing the bows to swing away from the constant heading ship to a suitable angle, at which time the remaining after moorings are let go and the manoeuvring vessel moves clear.

(15) The Crew should be made fully aware of emergency signals, procedures and actions and every effort should be made to hold an emergency drill prior to commencement of operations.

(16) During transfer operations the following action should be considered in the event of any emergency arising during the operation.

- All transfer to be stopped and crew alerted on both vessels.
- Hoses purged and disconnected.
- Engines kept ready for immediate use and mooring gangs sent to stations.
- Additionally, emergency procedures described in ICS Tanker Safety Guide (Liquefied Gas) should be referred to.

(17) Risk assessment should be carried out by the master in consultation with the office for the planned STS operation. Following factors should be taken into account:
STS should be carried out in sheltered waters and berthing / unberthing should be done in day light only.

Weather conditions / predictions should be checked from different weather stations and a weather criteria should be set up. Operation should be aborted well in time before weather deteriorates to cause damage to vessel.

Certified hose should be used for operation and the hose should be pressure tested using Nitrogen or compressed air before the operation. Pressure test and continuity test records should be maintained.

17. LPG CARGO CALCULATIONS

LPG cargo quantity calculations, though more complicated than other petroleum cargo measurements are quite logical, when the principles are fully understood. Because of the high value involved in the transportation of LPG cargoes, it is essential that cargo calculations are carried out as accurately as possible.

When making tank measurements, any error in liquid level or liquid density will be directly reflected in the cargo measurement. An error of 1 kg /m3 on liquid density represents 0.2% on cargo quantity. Liquid density is often taken without question as correct but the basis of the liquid should always be known, this is especially so when loading propane / butane mixture. Temperature is also very important with the liquid temperature used in calculations being the average taken at several points in the liquid. An error of 1^{o}C in liquid temperature represents about 0.3% on cargo measurement. Pressure is much less significant with 1 bar representing 0.01% on total cargo.

Wherever possible, checks on the consistency of data should be made. It is possible to calculate the vapour pressure of an LPG from knowledge of its density, or composition and temperature. Any discrepancy between this vapour pressure and the measured tank pressure points to an inconsistency of the measurements.

22.1 CALCULATION PROCEDURES

GENERAL

- Account must be taken of product on board before loading or left on board after discharge.
- Account must be taken of vapour quantity in all calculations.
- Mass of liquid or vapour is determined essentially by multiplying the volume (V_t), at a stated temperature (t) by the density (D_t) at the same temperature. It is essential that both volume and density should be at the same temperature.
- The result of (V_t x D_t) is mass and may be converted to weight-in-air by an appropriate conversion factor found in published tables.

22.2 CALCULATION FORMAT USING STANDARD TEMPERATURE OF 15°C AND S.I. UNITS

LIQUID CALCULATION

Corrected liquid level [(1)]	'**a**' mtrs
Mean liquid temperature	deg Celsius
Density of liquid at 15°C (as given by shore)	'**b**' kg/m^3
Liquid volume at calibration temperature	'**c**' cu.mtrs
Shrinkage factor (liquid)	'**d**'
Liquid volume at observed temperature	(**c** x **d**) = **e** cu.mtrs
VCF to 15°C	**f**
Liquid volume at 15°C	(**e** x **f**) = **g** cu.mtrs
Mass of liquid at 15°C	(**g** x **b**) = h kgm

VAPOUR CALCULATION

Mean vapour temperature	deg. Celsius
Observed vapour pressure	Bars
Molecular weight	kg/k.mol
Tank volume (100%)	**i** cu.mtr
Vapour volume at calibration temperature	(**i - c**) = **j** cu.mtrs
Shrinkage factor (vapour)	'**k**'
Vapour volume at observed temperature	(**j** x **k**) = **l** cu.mtrs
Vapour density [(2)]	**m** kg/m^3
Mass of vapour	(**l** x **m**) = **n** kgm
TOTAL MASS	(**h** + **n**) = **o** kgm
WEIGHT IN AIR	(**o** x appropriate conversion factor)

After necessary corrections for trim, list, tape and float corrections.
Vapour density at observed temperature (*By Ideal Gas Laws*) =

288		Absolute Obs. Vapour Pressure		Molecular Wt
(273 – Vap. Temp.)	x	1.013	x	23.645 (Gas Constant)

22.3 DETERMINING LIQUID DENSITY OF A MIXTURE WHEN THE DENSITY OF THE MIXTURE IS NOT GIVEN

Generally, when molecules of one pure liquid are mixed with the molecules of another, the molecules of the mixture tend to pack more closely together than those of the components when existing singly, as a result of which the volume of the mixture will be less that the combined volume of the components. This volumetric shrinkage, as it is termed results in the density of the mixture being higher than the density, which would be calculated by the addition of the masses and volumes of the component.

Truly speaking, the Costald Equation should be used to predict densities, because it takes into account the effects of volumetric shrinkage, which is not taken into account in the Francis formula. However, since the Costald equation is less easy to understand and there is no major accuracy improvement between the Costald equation and the Francis formula within the temperature range (minus 60^{o}C to plus 30^{o}C), it is much better to use Francis formula.

For details of using the Francis formula or the Costald equation “Review of LPG Cargo Calculations” published by SIGTTO should be referred to.

22.4 TO CALCULATE THE SVP OF A MIXTURE OF PRODUCTS AT A GIVEN TEMPERATURE

1) Divide the component ‘weights’ of the mixture by their respective molecular weights
2) Add the results, together and then divide each individual result by the sum of all the results. This gives the Mol. Fraction.
3) Multipy the SVP of each product at the temperature concerned by its Mol. Fraction. This gives the ’partial pressure’ exerted by each product.
4) Add the partial pressures and by Dalton’s Law of partial pressures, the sum of the partial pressures is the total absolute SVP exerted by the mixture.

18. PRECAUTIONS WITH HANDLING TOXIC CARGOES

18.1 GENERAL

Some gas cargoes are toxic and can cause a temporary or permanent health hazard, such as irritation, tissue damage or impairment of faculties. Such hazards may result from skin or open wound contact, inhalation, or ingestion. These effects could be acute or chronic or both. 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 carcinogen. Butadiene is suspected of having similar effects**.

(2) Narcotics: Narcosis results in ill effects to the nervous system. Sensations are blunted. Prolonged exposure will result in loss of consciousness. All hydrocarbon gases have this effect to some extent.

(3) Corrosion/ irritation of the skin, lungs, throats and eyes.

18.1.1 THRESHOLD LIMIT VALUES (TLV)

As a guide to permissible vapour concentration in air, various government authorities publish these values. They 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). There are following three categories of TLV, which describe the concentration in air to which it is believed personnel may be exposed without adverse effect.

(1) TLV-TWA: this is known as the time weighted average. It is the concentration of vapour-in-air, which may be experienced for an eight-hour day or forty-hour week, throughout a person’s working life. It is the most commonly quoted TLV.

(2) TLV-STEL: this is known as the short-term exposure limit. It is the maximum concentration of vapour-in-air allowable for a period 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 the TWA but is not listed for all cargoes.

(3) TLV-C: this is known as the ceiling concentration. This can never be exceeded. Fast acting toxic cargoes ammonia or chlorine have to be ascribed such a value.

Treat with respect any cargo with a low TLV.

18.1.2 GAS CODE

The following cargoes are listed in the IGC code as toxic:

Acetaldehyde, ammonia, butadiene, chlorine, diethyl ether, dimethylamine, ethyl chloride, ethylene oxide, ethylene oxide and propylene oxide mix, isopropylamine, methyl bromide, methyl chloride, monoethylamine, propylene oxide, sulphur dioxide, vinyl chloride, vinyl ethyl ether, vinylidene chloride.

Some of these cargoes are covered by the IBC code as well. Of these, vinyl chloride and butadiene are generally encountered in our fleet.

It is important to realize that the code lists only the main hazards. All gas cargoes have some detrimental effect on human health. The toxic hazards of some of the cargoes come to light at a much later date. The TLV values are reduced periodically.

You must take all precautions in avoiding direct contact with any of the cargoes carried, as far as practicable, even if they are not listed as toxic in the IGC code.

18.1.3 MATERIAL DATA SHEET

Before handling any cargo, it is essential to consult the material data sheet of the cargo. Apart from the “material data sheets” incorporated in the Tanker Safety Guide, check any additional information provided by the shipper or the terminal.

18.1.4 MEDICAL FIRST AID GUIDE (MFAG)

Before loading any cargo, particularly those that are toxic consult the medical first aid guide and ensure that recommended antidotes are on board.

18.2 EMERGENCY PROCEDURES

Emergency procedures including health data and action in case of accidental contact must be prominently displayed for the particular cargo carried.

Instead of posting up the MSD’s of all the cargoes listed in the certificate of fitness, the material data sheet of the cargo being carried should be posted up in a conspicuous places (CCR, Notice boards and Bridge), the chief officer should carry out training sessions regarding the emergency procedures and hazards associated with the cargo, for the entire crew, at every change of cargo.

18.3 MANIFOLD CONNECTION AND DISCONNECTION

This is the most critical period as far as human exposure to the cargo is concerned. During this period, a certain amount of contact with the cargo is inevitable. Personnel protective equipment as listed in the material data sheets must be worn.

18.4 RESPIRATORY PROTECTION

In case respiratory protection is required, then the ideal is to use gas masks with the relevant filter. They are light and do not interfere with normal work. Remember that they can be used only in the open air as they only filter the air. They do not provide an independent source of breathable air. They must not be used in enclosed spaces. Refer to section 20.4 for general precautions for this type of equipment. **Escape sets must not be used for this purpose.** Apart from their limited duration of use, they are not usually fitted with the alarms associated with a compressed air breathing apparatus. They are only used for the purpose of escape and not for regular cargo operations.

18.5 TANK GAUGING

Use of slip tubes is prohibited with toxic cargoes. Only indirect or closed methods are allowed.

18.6 GAS DETECTION

In general, our ships are fitted with a permanent sampling system for flammable vapours in the spaces required under the IGC code. We usually have hand-held equipment for detecting toxic vapours. This is generally allowed in all cases excepting for chlorine, methyl bromide and sulphur dioxide where permanent toxic gas detection systems must be fitted in the required spaces.

The legal requirement is, **if the required spaces are checked for toxic gases using portable equipment before man entry is made, the spaces must be checked at thirty-minute intervals during the period they remain inside.**

Hold and inter-barrier spaces should be provided with a permanently installed piping system for obtaining gas samples from these spaces. Gas from these spaces should be analyzed by means of portable (or fixed, if fitted) equipment **at intervals not exceeding four hours** and in any event before personnel enter the spaces and at least at thirty-minute interval while they remain inside.

18.7 SOME SPECIFIC CARGOES

We will describe below precautions with **VCM** and **Butadiene** as the two most common toxic cargoes encountered in our fleet. The following are in addition to what is described above which will apply in full in each of the cases described below.

18.7.1 BUTADIENE

Many special requirements apply to the carriage of this cargo. This cargo is now considered toxic and may cause liver disorders like jaundice, it may also cause damage to the liver. This substance is suspected of being carcinogenic to humans. The cargo has a TLV of 10 PPM. The odour threshold is 1000 PPM, this means the cargo can be detected by smell at concentrations 100 times the TLV. Do not depend on smell for detecting dangerous concentrations of this cargo. **By the time you smell it is a hundred times more concentrated than the permitted concentration.**

Butadiene also forms peroxides in contact with air, which leads to polymerisation. This poses extreme explosion hazards. Polymerisation can generate sufficient heat to cause uncontrollable vehement explosion. Hence this cargo is always carried inhibited.

Both hazards of this cargo are considered below.

18.7.1.1 TOXICITY

Butadiene was declared toxic in the 1996 amendments to the IGC code. Before that, it was considered as flammable only. This illustrates the point made in the paragraph headed gas code. The IGC code, at present, still permits restricted gauging of this cargo. It is strongly recommended that slip tubes should not be used for ullaging and only closed or indirect methods of tank gauging are used. All other precautions regarding toxic cargo must be followed.

While any venting etc. of this cargo is done, even at sea, the accommodation must be hermetically sealed and the air conditioner put on re-circulation. The accommodation must be regularly checked for the presence of gas. Suitable equipment must be used which can detect the presence of butadiene in concentrations as low as 10 PPM and lower.

If you can smell the cargo, the situation may already be dangerous.

All watertight doors, gastight doors, ventilators and other openings in the accommodation must be tested and proven gastight before handling this cargo.

While connecting and disconnecting manifolds, the following personnel protective equipment should be used:

(1) Breathing apparatus or air filtration masks.

(2) Protective clothing covering all parts of the body.

(3) Chemical resistant gloves.

(4) Boots.

(5) Goggles or other eye protection.

Ensure the gas tightness of the connection with Draeger type equipment and not only with soap solution.

Check the integrity of the piping system at the flanges using similar equipment.

18.7.1.2 INHIBITION

This cargo is always carried inhibited.
Do not commence loading or gassing up until you get a proper inhibitor certificate from the shippers. Ensure that the expiry date of the inhibitor is appropriate for the contemplated voyage. Typically, the inhibitor should not expire within six months of loading the cargo. In case of language difficulties, do not hesitate to suggest the correct wording for this certificate. A suggested format is provided below:

The tank atmosphere must not contain more than 0.2% oxygen. A positive pressure must be maintained in the tanks with an inert gas blanket with oxygen content less than 0.2%. Maintaining positive pressure is particularly relevant to refrigerated cargoes.

For butadiene cargo, the compressor discharge temperature must not exceed 60^{o}C.

See over page for a sample information form.

LIQUIFIED GAS- INHIBITOR INFORMATION FORM
<u>To be completed before loading an inhibited cargo</u>

SHIP………………………………….. DATE………………………….

PORT & BERTH……………………. TIME………………………….

1. CORRECT TECHNICAL NAME OF THE 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 18.1.2)

FOR SHIP……………………………. FOR SHORE………………………….
(SIGNED) (SIGNED)

<u>Inhibitor Information Form</u>

Butidiene is usually inhibited with about 100 PPM tertiary butyl catechol. Which does not boil off with the cargo. Hence the condensate from the reliquifaction plant is uninhibited. This recondensed cargo should not be allowed to form stagnant pockets of uninhibited liquid.

Although butadiene does not react with water <u>the inhibitor may be removed by water</u> thereby presenting a hazard. Ensure the cargo is loaded in a dry tank.

If the ship is to carry consecutive loads of this cargo with ballast passages in between, all uninhibited liquids should be removed prior to starting the ballast voyage. Refer to IGC code 17.4.2 and 17.4.3 for more information about this.

Remember that inhibitors themselves are toxic in nature. Hence if any inhibitor is placed on board, which is unusual, then material data sheet, antidotes and emergency procedures for them should be available.

18.7.2 VINYL CHLORIDE MONOMER (VCM)

The TLV of VCM is only 2 PPM. Its odour threshold is 250 PPM. As in the case of the butadiene, the odour threshold is more than a hundred times the TLV. Therefore, the same considerations as detailed above are applicable in this case. Long exposure to low concentrations is suspected to cause cancer of the liver.

18.7.2.1 TOXICITY

All precautions as described for butadiene are applicable in this case. There are some additional requirements as follows.

Personnel protection

Respiratory and eye protection suitable for emergency escape purpose must be provided for all persons on board. Note that canister type escape sets are not acceptable. ELSA sets or equivalent should have service duration of at least 15 minutes. Two such sets must be permanently located on the bridge. As mentioned earlier, **such escape sets must not be used for fire fighting and cargo handling and must be marked to that effect (IGC 14.4.2).**

However, suitable canister-type facemasks can be used for cargo operations.

Decontamination showers

Suitably marked decontamination showers and eyewash must be available on deck in convenient locations. These shower and eyewashes should be of an all-weather type. Shower and Eyewash pipelines on deck should be insulated so that they can be used in low temperature conditions.

Tank gauging

Slip-tubes are not permitted to be used with this cargo.

18.7.2.2 INHIBITION

VCM may be carried in either inhibited or non-inhibited form. For an inhibited cargo, follow all precautions as listed under butadiene.

VCM may be shipped uninhibited. In this case the oxygen content of the cargo system must not be more than 0.1%. A positive pressure must be maintained in the tank at all times even during ballast voyages between successive carriages with inert gas having an oxygen content of 0.1% or less.

Before the loading is started inert gas samples from the tank and pipeline must be analysed to confirm compliance.

For VCM, compressor discharge temperatures should be limited to 90^oC to prevent polymerisation

Pipe lines or tanks should not contain any material which are identified as unsuitable on data sheets. Temperature of self reacting cargo should be closely monitored.

19. ODOURIZING

19.1 GENERAL

Methane, propane and butane are all odourless. In order to detect these gases, by smell, when they are marketed as fuel gases, it has become a regular practice to add a warning agent, which when mixed with gas imparts a characteristic odour. This process is called odourizing. In seaman's parlance this is also called stenching. These two terms may be used interchangeably in the following sections.

19.1.1 SHIP BOARD ODOURIZING

The practice of shipboard odourizing tends to be most common in Thailand, India, Hong Kong, People's Republic of China, West Africa and the Caribbean, but is not unknown outside of these areas.

SIGTTO recommends that shipboard stenching should not take place unless there is no reasonably practical alternative. They suggest that as far as practicable this operation should take place at the terminal. However, if required to be carried out on board, SIGTTO guidelines for equipment and operation should as far as practicable be followed. The SIGTTO publication 'Guidelines on the Ship-board odourisation of LPG' must be referred to.

19.1.2 TYPES OF ODOURANTS

Modern gas odourants are organosulpher compounds. Some of these compounds are the most odourous substance known. Two broad types of organosulpher compounds are currently in use as odourants; mercaptans and sulphides.

They are generally known under various trade names and the most common compounds used for the odourisation of LPG are:

Chemical name (abbreviation)	Trade names and synonyms
Ethyl Mercaptan (EM)	Ethanethiol or Scentinel A
Diethyl Sulphide (DES)	Ethylthioethane
Tetrahydrothiophene (THT)	Scentinel T or Thiophene

Of these EM is the most suitable for the stenching of LPG and is most commonly used.

19.1.3 DOSAGE

The typical domestic requirement is that adequate warning of the presence of gas must be given by an odourant at a concentration of 1% gas in air. This corresponds to approximately 20% LFL of methane in air. The following dosage will usually achieve this. The exact PPM requirement should be obtained from the receivers.

Ethyl Mercaptan	1 lb. per 10,000 US gallons 1 kg per 84 m^3
Tetrahydrothiophene	6.4 lb. per 10,000 US gallons 1 kg per 13 m^3

19.2 ACTION IN THE EVENT OF SPILLAGE

It is important that if spills or leaks occur, the mercaptans are promptly neutralized and the odour masked. There are several agents available for this.

An effective method is based on converting the spilled mercaptans to a relatively low odour disulphide, through chemical oxidation. Spraying or flooding the spill area with a dilute bleach solution does this. Either sodium hypochlorite or calcium hypochlorite in dilute solution in water may be used. Dilute solutions are more effective than commercial or concentrated solutions

For example fifty litres of a 0.5% solution is generally more effective than 5 litres of 5% solution although the amount of the active ingredient is the same.

Avoid the use of dry calcium hypochlorite powder on a concentrated mercaptan because the heat of reaction may cause ignition of the organic mercaptan.

Spilled liquid should be absorbed using dry sand and the material placed in sealed drums.

19.3 STORAGE ON BOARD SHIP

In case a quantity of odourants is kept on board, a dedicated storage area should be provided. The containers should be securely stowed, protected from the elements, well ventilated and away from accommodation areas. Suitable fire fighting and pollution prevention equipment and stocks of neutralizing agents kept should be readily available.

A high standard of housekeeping should be maintained in all areas where odourants are stored or handled.

19.4 RISK MANAGEMENT AND SAFETY

(1) The odourant manufacturers chemical data sheet must be available on board the vessel and followed at all times.

(2) Odourants have an odour platform, whereby the concentration in air can increase significantly without noticeable increase in smell.

(3) Ethyl mercaptan is particularly harmful when in mist form. Therefore under no circumstances should it be injected by pressurization unless the system has been specifically designed for this purpose.

(4) Skin and eye contact must be prevented.

(5) It is recommended that a full facepiece air-purifying respirator, with an organic vapour cartridge should be worn in concentrations up to 25 ppm, including for escape purposes. Because of the rapidity that EM can evaporate, particularly when the temperature is over 20^0 C, it is essential that suitable respirators are available when connecting and disconnecting the injection equipment.

19.5 MATERIAL COMPATIBILITY

Copper and copper-based alloys are attacked by odourants and should not be used in the construction of odourant injection or storage equipment.

COMPATIBILITY CHART FOR ETHYL MERCAPTAN

Also suitable for
Diethyl sulphide (DES) and Tetrahydrothiophene (THT)

Aluminium	Yes
Butyl rubber	No
Carbon steel	Yes
Copper	No
Copper alloys	No
Glass	Yes
Graphite	Yes
Natural rubber	No
Polyethylene	No
Polypropylene	No
PTFE	Yes
Stainless steel	Yes
Teflon	Yes
Titanium	Yes
Viton	yes

- Materials shown in bold in the table above are preferred for the construction of injection equipment in contact with EM, DES and THT.
- Pumps should be hermetically sealed or double diaphragm type.
- Gaskets should be PTFE or Viton.
- Carbon steel piping may be used but remember that the first time EM comes in contact with carbon steel some of it reacts to form an oxide film on the steel and will not form the calculated level of stenching. Two or three times the quantity of the odourant may be needed when commissioning a new system.
- Dry break coupling should be used for connecting the equipment to ship's pipe work and the odourant container.
- The inner lining of any flexible hose used should be stainless steel braided. Natural or butyl rubber must not be used. They must be rated for the maximum pressure that may be encountered in the system.

19.6 ADMINISTRATION

If the stenching is to be done by a representative of the terminal, or a third party, on the vessel, they should submit a written procedure to the ship for the master's approval. However should there be an incident during this operation the master of the vessel will most certainly be held responsible. Hence, follow all the precautions described above even in such a case.

If the ship has agreed, or is required under the terms of a charter party, to inject odourant on behalf of the receiver, it should be the responsibility of the receiver to calculate the quantity of odourant required and inform the ship in writing, of the quantity to be injected.

19.7 INJECTION

Odourant may be injected into the ship's cargo tanks or into the ship's cargo manifold during discharge. Both these systems have advantages and disadvantages.

Injection in the cargo tank requires a lower injection pressure and simpler equipment than injecting into the discharge manifold. By using the ship's cargo pump for injecting the odourant via an injection pot, the system can be left recirculating until the operator is confident that all traces of the liquid odourant have been flushed from the system. Furthermore, an injection pump may not be required, simplifying the system and reducing the potential for leakage. The drawback of this system is that the odourant may impregnate into any rust coating on the cargo tanks and put any subsequent cargo off grade. This method is not recommended for refrigerated cargoes.

Injection into the discharge manifold requires higher pressures, particularly when handling fully pressurized propane and hence a greater risk of leakage. However, the odourant does not come in contact with the bulk product in the cargo tank with the attendant risk of future contamination.

When shipboard odourisation cannot be avoided, it is considered that odourant injection into the ship's manifold pipe-work during discharge, is the preferred method.

19.8 MAINTENANCE

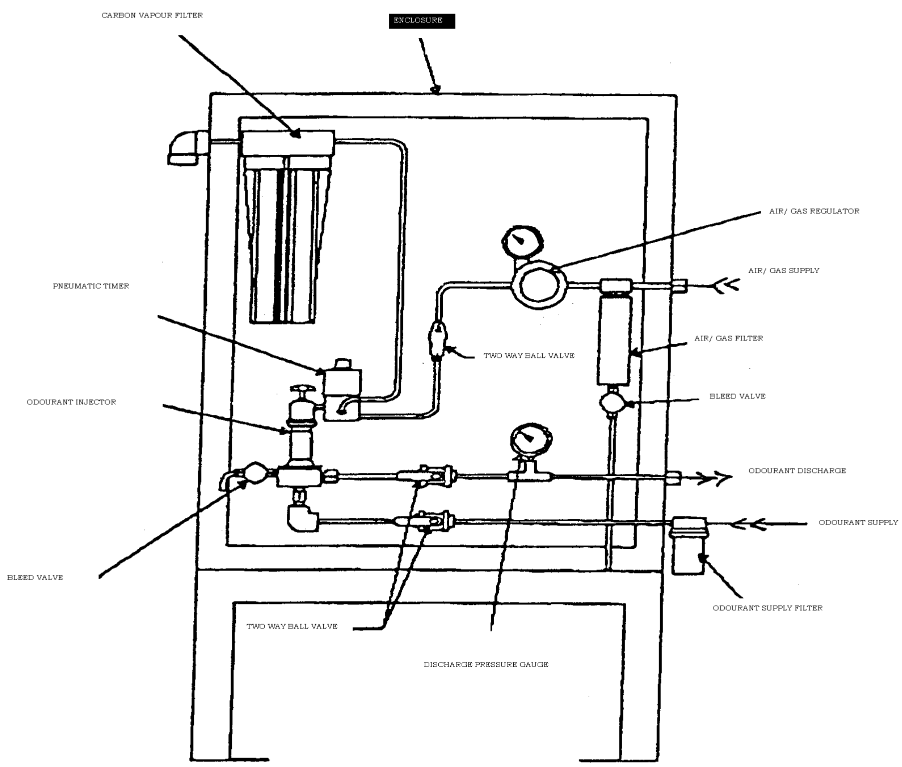
Before undertaking any maintenance on the injection equipment, it should be disconnected from the ship's pipe work and odourant container. Flush through all the pipe work first with methanol and then a neutralizing agent. Use a volume of methanol at least twice the volume of the of the injection system. Ensure that there are no "dead legs" in the piping system, with trapped odourant, which can escape to the atmosphere when the equipment is dismantled.

Before the system is filled with odourant or recommissioned after maintenance it should be pressure tested. The most suitable test will be nitrogen at the working pressure of the equipment. If a hydraulic test is considered necessary, do not use water as a test medium as in the presence of EM water may cause severe corrosion. Kerosene may be considered instead.

19.9 DISPOSAL OF EMPTY CONTAINERS

If the odourant is supplied in heavy duty drums specially constructed and supplied by the manufacturer, then the same can be returned to them for refilling. Otherwise the drums must be completely drained and neutralized before putting them ashore for disposal.

DIAGRAM OF SHIP-BOARD ODOURANT INJECTION SYSTEM



AS PER VIQ 8.22 UNFAMILAIR GAS CARGOES

20. HYDRATES

20.1 GENERAL

Some hydrocarbon cargoes like propane or butane, combine with water under some conditions of temperature and pressure to form hydrates. Hydrates resemble crushed ice or slush. Hydrates are not ice and may be formed at temperatures above the freezing point of water. However, hydrates can form only in the presence of free water. This problem is associated with the carriage of liquefied LPG cargoes. Ice formation will also cause similar problems as posed by hydrates.

Pressurized LPG systems operating at or above +6^{o} C for propane and +3^{o} C for butane presents no hydrate problem.

20.1.1 HAZARDS

Hydrates can cause pumps to seize and equipments to malfunction. Hydrate formation may enter cargo pumps, block lubricating passages, unbalance impellers and seize bearings. They may also block filters and reliquefaction regulating valves.

20.1.2 TYPICAL CONDITIONS

Hydrates may form in propane vapour or liquid at a temperature below +6^{o}C and at pressures from the saturated vapour pressure of 5.61 bar absolute to as high as 35 bar absolute. While hydrate formation is particularly relevant to propane, commercial butane containing propane or iso-butane will also produce stable hydrates.

For a propane condensate (83.4% propane, 12.4% ethane, 4.2% methane) Hydrates form under the following temperatures and pressures:

Pressure Bars absolute	**Temperature ^{o}C**
0.0	-2
0.7	0
2.7	3
4.1	5
5.2	6

The above data is only to illustrate some typical values and to show that hydrates can form at temperatures above the freezing point of water. For other hydrocarbon gases the temperature and pressure values, which will lead to hydrate formation, will be different.

20.1.3 SOURCES OF FREE WATER

The water for hydrate formation can come from purge vapours with incorrect dewpoint, water in the cargo system or water dissolved in the cargo. Rust in the cargo tanks is also a source of water. Rust that dehydrates in this way looses its ability to adhere to the tank surface and gathers as fine loose powder in the bottom of the tank. Water can enter the ship's cargo system from shore storage during loading.

20.2 THEORY

20.2.1 HYDRATE FORMATION

Hydrates are a solid water lattice with hydrocarbons within the lattice. The bonding forces are of the loose physical type rather than the firm chemical type. If the conditions of pressure and temperature are suitable and if enough water is present, the formation of hydrates is a continuing process. Once hydrate has begun to form a **seeding effect** promotes rapid crystal growth.

20.2.2 SOLUBILITY

LPG is peculiar in that, certainly at temperatures above 0^{o} C, the boil off vapour will contain a higher proportion of water than the liquid with which it is in equilibrium. Semi-refrigerated propane at $+6^{o}$ C, for example containing 40-PPM water by weight in solution, will produce boil-off vapour containing 580-PPM water by weight. On reliquefaction, this excess water is released as free water. If the temperature and pressure conditions are conductive to hydrate formation, the reaction will proceed now.

Thus, properly dried commercial LPG can also give rise to sufficient free water to form hydrates.

20.3 AVOIDING HYDRATE OR ICE FORMATION

Since the presence of water is a prerequisite for hydrate formation, its removal is clearly the most important step in avoiding this problem.

20.3.1 DURING INERTING

The inert gas or nitrogen used for this purpose should ideally have a dew point below that of the lowest tank temperatures. Drying of inert gas on board can be done either by using solid desiccants (molecular sieve, silica or alumina) or by expansion refrigeration. They are not used on board for drying cargo gases.

20.3.2 DURING GASSING UP

The gas from the top of an LPG shore storage tank will contain more water PPM than the liquid, due to the effect described in paragraph 25.2.2. If on the other hand vapour for gassing up is generated by taking liquid from shore tanks and then converted to vapour on board by passing through a vaporizer then the water content of the vapour will be less.

20.3.3 DURING CARGO CONDITIONING

Normally freezing point depressants, like methanol, are used for this purpose. However, methanol injection has many additional hazards, which are considered separately in section 25.5. Please read that section before contemplating methanol injection.

20.4 GENERAL PRECAUTIONS

- In case of Deepwell pumps, turn the pump shaft by hand before starting the pump. Before starting the pump, ensure free and smooth rotation of the shaft. **Do not start the cargo pump if the shaft does not rotate freely.** You may now suspect freezing up or hydrate formation. Prepare for methanol injection as described in section 25.5.
- For submerged pumps, use the nitrogen injection system, if fitted to blow nitrogen in the bearing lubrication line to confirm that bearings are free of ice and hydrates.
- For submerged pumps, it is very difficult to assess whether the pump is frozen or not. Hence, if you suspect the presence of hydrates try and use the other cargo pumps to discharge cargo from the tank, provided that, that pump is not seized by hydrates. Failing that, try and use the emergency pump. The emergency pump will not be seized, as it is not in the tank sump.
- Do not inject methanol for hydrate control without the permission of the master. A general guideline for anti freeze injection is detailed in the next section.
- Always use inline filters at the manifold during loading to trap hydrates from entering the ships tank from shore storage. Some ships have portable filters. Fit these in place before loading.
- If possible, arrange to fit pressure gauges on either side of these filters to detect choking by hydrates.
- When loading propane, depending on the ship’s manifold configuration, always try to present manifold flanges to the terminal in a way, such that if the propane line is choked, another liquid line can be presented to the terminal.
- **Do not add antifreeze without obtaining written permission from the shippers.**

- Use of methanol must not be made in chemical gas cargoes (Diethyl ether, Ethylene oxide/Propylene oxide mixtures, Isoprene, Isopropylamine, Monoethylamine, Pentanes, Pentene, Propylene oxide, Vinyl ethyl ether and Vinylidene chloride).

  Because of the sensitivity of many cargoes to hydrate control products, the use of hydrate control must be strictly in accordance with the instructions of the shipper/charterer. There may be alternative ways of providing hydrate control other than by the use of anti-freeze compounds.

- Carriage of methanol is prohibited with some cargoes as Ethylene or LNG, as in addition to causing contamination, methanol freezes at –87 deg C (VIQ 8.33)

Additionally the following precautions are applicable for the reliquefaction system:

- On ballast passages avoid vapour temperatures from warming up to more than -10^{o} C. otherwise hydrates will create more problems when the tanks are warmer.

- Put the condensate return into the bottom of the tank. This way you will find hydrates choking up the filters at the expansion valves. You can now open up and clean the filters. Continue this for some time and then resume spraying.

- As tanks cool back, hydrates usually cease to be a problem.

- Beware of water getting into cargo tanks through leaking condenser tubes.

- If the tank sprays are choked, run hot gas from the compressor into the spray lines. Bear in mind temperature and pressure restrictions of pipelines. Once lines are clear, resume cooling.

20.5 ANTI FREEZE

20.5.1 GENERAL

Adding temperature depressants is the most normally adopted method of hydrate control on board ships. The most widely used depressant in the LPG trade is methanol. Such substances are also called anti-freeze.

20.5.2 WHERE TO INJECT

Temperature depressants are commonly injected on board in to reliquefaction units, condensate return line filters and cargo pumps. On fully pressurized ships the only place to inject methanol will be in the cargo pump. Follow the manufacturer's instructions regarding this.

20.5.3 HAZARDS ASSOCIATED WITH METHANOL

Methanol is both flammable and toxic. Great care must be exercised in storage and handling of methanol. **Ingestion and eye contact with methanol must be avoided.** Ingestion of methanol leads to blindness and death. Consult and follow all precautions listed in the material data sheets regarding the handling of such substances.

20.5.4 COMMERCIAL CONSIDERATIONS

Some LPG cargo quality specifications limit the maximum methanol content. For chemical cargoes such as ethylene, even one litre of antifreeze per two hundred tons of cargo could make the cargo commercially valueless. Therefore, **you must obtain the shipper's permission before adding freezing point depressants.**

20.5.5 INHIBITED CARGOES

In case of inhibited cargoes, the anti-freeze could adversely affect the inhibitor. **Hence, addition of antifreeze to such cargoes is prohibited.**

20.5.6 ADMINISTRATIVE

In case a stock of anti freeze is carried on board or there is provision for adding antifreeze to the cargo system, then the master must prepare written procedures covering the process. This procedure must address the above points.

APPENDIX I

COMPANY GAS CARGO STANDING ORDERS

(This Appendix 1 is a repetition of section 7 of this manual)
The Master shall appoint a Deck Officer (normally the Chief Officer) as the Cargo Officer in charge of all cargo, ballast and tank cleaning operations and shall instruct this Officer regarding the operational circumstances in which the Master shall be called or consulted.

The duties of the Cargo Officer are to plan, organise, control and supervise all deck, tank and pumproom aspects of the appropriate operations and to liaise with the Chief Engineer to ensure timely availability of systems.

A Deck Watch shall be on duty to assist during all cargo, ballast and tank cleaning operations and the Cargo Officer shall organise other Deck Officers and Ratings into these Watches.

The strength of a Deck Watch may vary from time to time at the discretion of the Master but, when operating alongside a terminal or other ship, a Watch shall consist of at least:

- The Cargo Officer
- One Deck Officer
- The Gas Engineer
- Two Ratings at least

The rotation of Deck Watch personnel shall be so organised as to ensure that they receive adequate rest periods. This watchkeeping schedule must be documented and posted up for reference. Gas Engineer can alternate his with Chief engineer and Chief officer.

The prepared loading/discharge plan must include a bar chart showing the planned progress of the operation. Company has developed standard forms for planning cargo and ballast operations(6a-1-3There is a documented procedure for planning cargo and ballast operations and the master approves each operation./ Pre-arrival planning incorporates stability and stress checking at all stages of the proposed operation, including any limitation on the number and location of slack tanks. Additional information includes all details relating to load/discharge rates, ballast operations, ullages, trim, cargo stowage and management of tank atmosphere and is available at the ship–shore interface meeting and complies with ISGOTT recommendations. Communications and coordination between ship and shore are discussed.

The Cargo Officer shall fully brief the Watch Officers of the planned operation and make full use of the Watch Officer to control and supervise the routine aspects of the operation. However, the Cargo Officer shall personally:

- Check cargo loading arm/hose connections before commencing to load or discharge.

- Supervise and check all pipeline valve and blanking device settings (including sea valves and inert gas system tank valves) during lining up and closing down procedures.
- Check the venting arrangement/system
- Supervise the commencement and completion of loading and discharging of cargo or ballast in cargo tanks.
- Supervise the topping off of all cargo tanks whether loading cargo or ballast.
- Supervise all Crude Oil Washing on crude oil tankers.
- Supervise all intentional discharges to the sea where an oil pollution risk exists.
- Before he leaves the deck for any length of time the Cargo Officer shall give clear written instructions to the Watch Officer regarding the continuance of current operations and the time or circumstances when he is to be called.

When the Cargo Officer is absent from the deck the Watch Officer shall assume responsibility for continuing all planned operations as outlined in the “Standing Orders and Operations” and written instructions. He shall control and supervise all routine aspects of monitoring tanks, pumps and equipment in use as well as the general shipkeeping requirements of moorings, gangway, draught, etc. He may regulate tank valves and pump controls in progressing the planned operation but he shall not depart from the plan without direct instructions from the Cargo Officer. He shall call the Cargo Officer immediately if any emergency arises or any unforeseen circumstance becomes apparent. In an emergency he shall not hesitate to stop all operations if he considers that the circumstances require such action.

The Watch Officer shall record the events of the operations as they occur in the Cargo Logbook and maintain records of all the parameters monitored.

A copy of these Standing Orders shall be displayed at the Cargo Control Station. A further copy shall be inserted in the Master's Night Order Book and each Deck Officer shall sign that he has read and fully understands these Standing Orders before participating in his first Deck Watch on any ship.

APPENDIX II

SHIP / SHORE SAFETY CHECKLIST

Berth : ______________________ **Port :** ____________________

Date of Arrival : ______________________ **Time of Arrival:** ____________________

Instructions for Completion

The safety of operations requires that all questions should be answered affirmatively by clearly ticking the appropriate box. If an affirmative answer is not possible, the reason should be given and agreement reached upon appropriate precautions to be taken between the ship and the terminal. Where any question is considered not applicable, then a note to that affect should be inserted in the remarks column.

A box in the columns 'ship' and 'terminal' indicates that checks should be carried out by the party concerned.

The presence of the letters A, P or R in the column 'Code' indicates the following:

A – any referenced procedures and agreements should be in writing in the remarks column of this check list or other mutually acceptable form. In either case, the signature of both parties should be required

P – in the case of a negative answer the operation should not be carried out without the permission of the Port Authority

R – indicates items to be rechecked at intervals not exceeding that agreed in the declaration

***NOTE: THE USE OF THIS CHECKLIST MAY BE WAIVED IF THE TERMINAL UTILIZES AN INTERNATIONAL SHIP/SHORE SAFETY CHECKLIST BASED ON SIGGTO GUIDELINES.**

	GENERAL	SHIP	TERMINAL	CODE	REMARKS
1	Is the ship securely moored?			R	Stop cargo at: kts wind vel. Disconnect at: kts wind vel. Unberth at: kts wind vel.
2	Are emergency towing wires correctly positioned?			R	
3	Is there safe access between ship and shore?			R	
4	Is the ship ready to move under its own power?			PR	
5	Is there an effective deck watch in attendance onboard and adequate supervision on the terminal and on the ship?			R	
6	Is the agreed ship/shore communication system operative?				
7	Has the emergency signal to be used by the ship and shore been explained and understood?			A	
8	Have the procedures for cargo, bunker and ballast handing been agreed?			AR	
9	Have the hazards associated with toxic substances in the cargo being handled been identified and understood?				
10	Has the emergency shut down procedure been agreed?			A	
11	Are fire hoses and fire fighting equipment on board and ashore positioned and ready for immediate use?			R	
12	Are cargo and bunker hoses /arms in good condition, properly rigged and appropriate for the service intended?				
13	Are scuppers effectively plugged and drip trays in position, both on board and ashore?			R	
14	Are unused cargo and bunker connected properly securely with blank flanges fully bolted?				
15	Are sea and overboard discharge valves, when not in use, closed and visibly secured?				
16	Are all cargo and bunker tank lids closed?			AR	
17	Is the agreed tank venting system being used?				

18	Are hand torches of an approved type?				
19	Are portable VHF / UHF transceivers of an approved type?				
20	Are the ship's main radio transmitter aerials earthed and radars switched off?				
21	Are electric cables to portable electrical equipment disconnected from power?				
22	Are all external doors and ports in the accomodation closed?			R	
23	Are window-type air conditioning units disconnected?				
24	Are air conditioning intakes which may permit the entry of cargo vapors closed?				
25	Are the requirements for use of galley and other cooking appliances being observed?				
26	Are smoking regulations being observed?			R	
27	Are naked light regulations being observed?				
28	Is there provision for emergency escape?				
29	Are sufficient personnel on board and ashore to deal with an emergency?			R	
30	Are adequate insulating means in place in the ship / shore connection?				
31	Have measures been taken to ensure sufficient pumproom ventilation?			R	
32	If the ship is capable of closed loading, have requirements for closed operations been agreed?			R	
33	Has an adequate vapor return line been connected?				
34	If a vapor return line is connected, have operating parameters been agreed?				
35	Are ship emergency fire control plans located externally?				

	BULK LIQUEFIED GASES	SHIP	TERMINAL	CODE	REMARKS
1	Is information available giving the necessary data for the safe handling of the cargo including, as applicable, a manufacturer's inhibition certificate?				
2	Is the water spray system ready for use?				
3	Is sufficient suitable protective equipment (including self-contained breathing apparatus) and protective clothing ready for immediate use?				
4	Are hold and inter-barrier spaces properly inerted or filled with dry air as required?				
5	Are all remote control valves in working order?				
6	Are the required cargo pumps and compressors in good order, and have maximum working pressures been agreed between ship and shore?			A	
7	Is reliquefaction or boil off control equipment in good order?				
8	Is the gas detection equipment properly set of the cargo, calibrated and in good order?				
9	Are cargo system gauges an alarms correctly set and in good order?				
10	Are emergency shutdown systems working properly?				
11	Does shore know the closing rate of ship's automatic valves; does ship have similar details of shore system?			A	Ship : .... Shore : ....
12	Has information been exchanged between ship and shore on the maximum / minimum temperature / pressures of the cargo the be handled?			A	
13	Are cargo tanks protected against inadvertent overfilling at all times while any cargo operations are in progress?				
14	Is the compressor room properly ventilated; the electric motor room properly pressurized and is the alarm system working?				
15	Are cargo tank relief valves set correctly and actual relief valve settings clearly and visibly displayed?				

Tank No. 1: ____________________ Tank No. 6: ____________________
Tank No. 2: ____________________ Tank No. 7: ____________________
Tank No. 3: ____________________ Tank No. 8: ____________________
Tank No. 4: ____________________ Tank No. 9: ____________________
Tank No. 5: ____________________ Tank No.10: ____________________

DECLARATION :

We the undersigned have checked, where appropriate jointly, the items of this checklist 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 marked with the letter 'R' in the column 'Code' should be re-checked at intervals not exceeding _____________ hours.

FOR SHIP		**FOR TERMINAL**	
Name :		Name :	
Rank :		Rank :	
Signature :		Signature :	
Date : Time :			

APPENDIX III

SHIP TO SHIP TRANSFER
CHECKLIST 1 - PRE-FIXTURE INFORMATION (FOR EACH SHIP)
(BETWEEN SHIP OPERATOR / CHARTERER AND ORGANIZER)

Ship's Name:

Ship Operator:		**Ship Chartered:**	**STS Organizer:**	
			Ship Operator's Confirmation	**Remarks**
1.	Is the transfer area agreed?			
2.	Are fendering arrangements agreed as being satisfactory?			
3.	Are communication procedures advised to each ship?			
4.	Are the hoses to be used suitable for the cargo, its pressure and temperature?			
5.	Is the centre of the ship's cargo manifold 4.0 meters or less either forward of aft of mid length position?			
6.	Is the centre of cargo manifold at least 9.0 meter above the deck (or above the working platform, if fitted)?			
7.	Is the height of the centre of cargo manifold no greater than 1.5 meters above the deck (or above the working platform, if fitted)?			
8.	What is the horizontal spacing between liquid and vapour-return manifold connections measured centre to centre?			
9.	Is the ship fitted with a hose support rail at the ship's side constructed of curved plate or piping having a diameter of not less than 150 mm?			
10.	Is the hose support rail (if fitted) at least 700 mm below the centre of cargo manifold?			
11.	Is the ship able to present liquid and vapour-return manifold connections?			
12.	Is the ship fitted with sufficient enclosed fairleads to receive all the other ship's mooring lines?			
13.	Are two enclosed fairleads fitted for the other's ships spring lines and are they positioned within 35 meters forward and within 35 meters aft of amidships?			

14.	Can the ship supplying the moorings provide soft mooring ropes or soft rope tails?		
15.	Are there mooring bitts of sufficient strength (suitably located) near to all enclosed fairleads to receive mooring ropes' eyes?		
16.	Are both sides of the ship clear of any overhanging projections?		
17.	Is a contingency plan established for the transfer area?		
For Ship Operator:			
Position:			
Signature:			**Date:**

SHIP TO SHIP TRANSFER
CHECKLIST 2 - BEFORE OPERATIONS COMMENCE

Discharging Ship's Name: ______________________

Receiving Ship's Name:				
Date of Transfer:		**Discharging Ship Checked**	**Receiving Ship Checked**	**Remarks**
1.	Have the two ships been advised by ship owners that Checklist 1 has been completed satisfactory?			
2.	Are radio communications well established?			
3.	Is language of operation agreed?			
4.	Is the rendezvous position agreed?			
5.	Are berthing and mooring procedures agreed and is it decided which ship will provide the mooring ropes?			
6.	Is the ship upright (having no list) and at a suitable trim?			
7.	Are engines, steering gear and navigational equipment tested and found in good order?			
8.	Are the engineers briefed on engine speed (and speed adjustment) requirements?			
9.	Has a weather forecast been obtained for the transfer area?			
10.	Is hose lifting equipment suitable and ready for use?			
11.	Are hoses in good condition?			
12.	Are fenders and fender pennants in good condition?			
13.	Are the crew briefed on the mooring procedure?			
14.	Is the contingency plan agreed?			
15.	Have local authorities been advised about the operation?			
16.	Has a navigational warning been broadcast?			
17.	Is the other ship advised that Checklist 2 is satisfactorily completed?			

FOR DISCHARGING-SHIP / RECEIVING -SHIP (Delete as appropriate)	
Name:	
Rank:	
Signature:	**Date:**

SHIP TO SHIP TRANSFER
CHECKLIST 3 - BEFORE RUN-IN AND MOORING

Discharging Ship's Name: ______________________________

Receiving Ship's Name:			
Date of Transfer:	**Discharging Ship Checked**	**Receiving Ship Checked**	**Remarks**
1. Has Checklist 2 been completed satisfactorily?			
2. Are primary fenders floating in their proper place? Are fender pennants in order?			
3. Are secondary fenders in place, if required?			
4. Have over-side protrusions on side of berthing been retracted?			
5. Is a proficient helmsman at the wheel?			
6. Are cargo manifold connections ready and marked?			
7. Has course and speed information been exchanged and understood?			
8. Is engine speed adjustment controlled only by changes to revolutions?			
9. Are navigational signals displayed?			
10. Is adequate lighting available, especially overside in vicinity of fenders?			
11. Is power on winches and windlass and are they in good order?			
12. Are rope messengers, rope stoppers and heaving lines ready for use?			
13. Are all mooring lines ready?			
14. Are the crew standing by at their mooring stations?			
15. Are communications established with mooring gangs?			
16. Is the anchor on opposite side to transfer made ready for dropping?			

17.	Is the other ship advised that Check List 3 is satisfactorily completed?			
FOR DISCHARGING-SHIP / RECEIVING -SHIP (Delete as appropriate)				
Name :				
Rank :				
Signature :				**Date :**

SHIP TO SHIP TRANSFER
CHECKLIST 4 - BEFORE CARGO TRANSFER

Discharging Ship's Name : ______________________________

Receiving Ship's Name :				
Date of Transfer :		**Discharging Ship Checked**	**Receiving Ship Checked**	**Remarks**
1.	Are all requirements from the International Ship / Shore Safety Checklist compiled with?			
2.	Is the gangway in good position and well-secured?			
3.	Is an inter ship communication system established?			
4.	Are emergency signals and shutdown procedures agreed?			
5.	Is an engine room watch maintained throughout transfer and is the main engine on standby?			
6.	Are fire axes in position at fore and aft mooring stations?			
7.	Is a bridge watch and / or an anchor watch established?			
8.	Is a deck watch established to pay particular attention to moorings, fenders, hoses, manifold observation and cargo pump controls?			
9.	Is the initial cargo transfer rate agreed with other ship?			
10.	Is the maximum cargo transfer rate agreed with other ship?			
11.	Is the topping off rate agreed with other ship?			
12.	Are the cargo hoses tested (after connection)?			
13.	Are the cargo hoses well supported and suspended?			
14.	Are tools required for rapid disconnection located at the cargo manifold?			

15.	Is the other ship advised that Checklist 4 is satisfactorily completed?			

FOR DISCHARGING-SHIP / RECEIVING -SHIP (Delete as appropriate)
Name :
Rank :
Signature : Date :

SHIP TO SHIP TRANSFER
CHECK LIST 5 - BEFORE UNMOORING

Discharging Ship's Name :

Receiving Ship's Name :				
Date of Transfer :		**Discharging Ship Checked**	**Receiving Ship Checked**	**Remar ks**
1.	Are cargo hoses properly purged prior to hose disconnection?			
2.	Are cargo hoses or manifolds blanked?			
3.	Is the transfer side of the ship clear of obstructions (including hose lifting equipment)?			
4.	Has the method of unberthing and of letting go mooring s been agreed with the other ship?			
5.	Are fenders, including fender pennants, in good order?			
6.	Is power on winches and windlass?			
7.	Are rope messengers and rope stoppers at all mooring stations?			
8.	Are the crew standing by at their mooring stations?			
9.	Are communications established with other ship?			
10.	Are communications established with mooring gangs?			
11.	Has shipping traffic in the vicinity been checked?			
12.	Are mooring gangs instructed to let go only as requested by the manoeuvring ship?			
13.	Is the other ship advised that Checklist 5 is satisfactorily completed?			
14.	Has the navigational warning been cancelled (when clear of other ship)?			

FOR DISCHARGING-SHIP / RECEIVING -SHIP (Delete as appropriate)	
Name :	
Rank :	
Signature :	Date :

SHIP TO SHIP TRANSFER CHECK LIST 6

Ship's Name ______________________________

Berth : ____________________ Port : ____________________

Date of Arrival : ____________________ Time of Arrival: ____________________

PART 'A' - BULK LIQUID GENERAL

	GENERAL	Ship	Other vsl	Code	**Remarks**
1	Is the ship securely moored?			R	Stop cargo at: kts wind vel. Disconnect at: kts wind vel. Unberth at: kts wind vel.
2	Are emergency towing wires correctly positioned?			R	
3	Is there safe access between ship and shore?			R	
4	Is the ship ready to move under its own power?			PR	
5	Is there an effective deck watch in attendance onboard and adequate supervision on the other vessel and on own ship?			R	
6	Is the agreed ship/ship communication system operative?				
7	Has the emergency signal to be used by the own ship and other vessel been explained and understood?			A	
8	Have the procedures for cargo, bunker and ballast handing been agreed?			A R	
9	Have the hazards associated with toxic substances in the cargo being handled been identified and understood?				

10	Has the emergency shut down procedure been agreed?			A	
11	Are fire hoses and fire fighting equipment on board and on other vessel positioned and ready for immediate use?			R	
12	Are cargo and bunker hoses /arms in good condition, properly rigged and appropriate for the service intended?				
13	Are scuppers effectively plugged and drip trays in position, both on board and on other vessel?			R	
14	Are unused cargo and bunker connected properly securely with blank flanges fully bolted?				
15	Are sea and overboard discharge valves, when not in use, closed and visibly secured?				
16	Are all cargo and bunker tank lids closed?			A R	
17	Is the agreed tank venting system being used?				
18	Are hand torches of an approved type?				
19	Are portable VHF / UHF transceivers of an approved type?				
20	Are the ship’s main radio transmitter aerials earthed and radars switched off?				
21	Are electric cables to portable electrical equipment disconnected from power?				
22	Are all external doors and ports in the accommodation closed?			R	
23	Are window-type air conditioning units disconnected?				
24	Are air conditioning intakes, which may permit the entry of cargo vapours, closed?				

25	Are the requirements for use of galley and other cooking appliances being observed?				
26	Are smoking regulations being observed?			R	
27	Are naked light regulations being observed?				
28	Is there provision for emergency escape?				
29	Are sufficient personnel on board and on other vessel to deal with an emergency?			R	
30	Are adequate insulating means in place in the ship/ ship connection?				
31	Have measures been taken to ensure sufficient pumproom ventilation?			R	
32	If the ship is capable of closed loading, have requirements for closed operations been agreed?			R	
33	Has an adequate vapour return line been connected?				
34	If a vapour return line is connected, have operating parameters been agreed?				
35	Are ship emergency fire control plans located externally?				

PART 'B' - BULK LIQUEFIED GASES

	Bulk Liquefied Gases	Ship	Terminal	Code	Remarks
1	Is information available giving the necessary data for the safe handling of the cargo including, as applicable, a manufacturer's inhibition certificate?				
2	Is the water spray system ready for use?				
3	Is sufficient suitable protective equipment (including self-contained breathing apparatus) and protective clothing ready for immediate use?				
4	Are hold and inter-barrier spaces properly inerted or filled with dry air as required?				
5	Are all remote control valves in working order?				
6	Are the required cargo pumps and compressors in good order, and have maximum working pressures been agreed between ship and other vessel?			A	
7	Is reliquefaction or boil off control equipment in good order?				
8	Is the gas detection equipment properly set of the cargo, calibrated and in good order?				
9	Are cargo system gauges an alarms correctly set and in good order?				
10	Are emergency shutdown systems working properly?				
11	Does other vessel know the closing rate of ship's automatic valves; does ship have similar details of other vessels' system?			A	Own Ship....... .... Other Vessel... ....
12	Has information been exchanged between ship and other vessel on the maximum / minimum temperature / pressures of the cargo the be handled?			A	

13	Are cargo tanks protected against inadvertent overfilling at all times while any cargo operations are in progress?				
14	Is the compressor room properly ventilated; the electric motor room properly pressurized and is the alarm system working?				
15	Are cargo tank relief valves set correctly and actual relief valve settings clearly and visibly displayed?				

Tank No. 1:	______________	Tank No. 6:	______________
Tank No. 2:	______________	Tank No. 7:	______________
Tank No. 3:	______________	Tank No. 8:	______________
Tank No. 4:	______________	Tank No. 9:	______________
Tank No. 5:	______________	Tank No.10:	______________

DECLARATION :

We the undersigned have checked, where appropriate jointly, the items of this checklist 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 marked with the letter 'R' in the column 'Code' should be re-checked at intervals not exceeding ______________ hours.

FOR DISCHARGING SHIP		**FOR RECEIVING SHIP**	
Name :		Name :	
Rank :		Rank :	
Signature :		Signature :	
Date : Time :			

APPENDIX IV

PURGING AND GRADE CONVERSION

A4.1 GENERAL

The following considerations apply to both pressurized and refrigerated carriage.

A4.1.1 INTRODUCTION

In this section, we will describe the procedures for both gas-freeing a tank for the purpose of man entry as well as for grade conversion. Both processes involve purging as the first step. Purging is defined by SIGTTO as the process of replacing a hazardous tank environment by inert gases to render the atmosphere safe. This term and the term inerting will be used interchangeably. The next step in the case of man entry will be to introduce atmospheric air into the tank. In case of grade conversion this will be gassing up. The methods for achieving this are:

a) Displacement.
b) Dilution.

Dilution is described in detail in section 14.3.2.2. Here the method of displacement is described in detail. Displacement should be the preferred method of changing a tank atmosphere unless otherwise indicated.

A4.1.2 PURGING

A4.1.2.1 BASIC CONSIDERATIONS

Inerting of cargo tanks on board can be done either with shore supply of Nitrogen or with shipboard generated inert gases. In our fleet we could have either inert gas generators or nitrogen generating plants fitted on board.

The inert gas generating plants on board gas tankers differ from those on oil tankers in that these do not use flue gas but use dedicated oil burners in order to produce the basic stock. This inert gas does not contain any sulpher compounds. This is then further cleaned, dried etc. Most such plants are not designed to produce inert gas with oxygen content below 0.5percent. In actual practice getting down to 1 to 2 percent, oxygen content may be difficult. Some of our gas carriers cannot generate anything below 1- percent oxygen content, as per design. Such levels of oxygen concentration could be all right when the basic consideration is to prepare the tank environment for eventual injection of fresh air in order to prepare the tank for man entry. However, this would not be adequate for cleaning tanks for the change of grade. **(Please refer to Table 1).**

The nitrogen generating plants on the other hand are very convenient. It is possible to reduce the oxygen content of the inert gas to 0.1 percent, which is adequate to load even uninhibited VCM. The associated problem in this case is the reduced output of the inert gas. Output volume is directly proportional to the oxygen content. It is important to take the actual output at the requisite oxygen content when calculating the expected period envisaged for the purging operation.

This generates another problem. At very slow rates of nitrogen injection, some diffusion takes place across the interface between the tank content and the purge gas leading to a certain amount of inevitable dilution. This reduces the efficiency of the displacement.

When time restricted, the only solution might be to use shore nitrogen. This is fast and convenient, but more expensive. There are ways to reduce the amount of nitrogen needed to inert tanks. This procedure is considered later.

Whether to use shore nitrogen or inert gas generated on board will depend on the following factors:

1. The characteristics of the plant on board with respect to:
   - ❑ Designed capabilities of the plant as to the achievable oxygen content.
   - ❑ The designed out put of the plant at the required oxygen level.
2. Any specific constraint placed on the tank environment by the shipper.
3. Time at hand.
4. Any constraints placed on venting due to the specific location of the vessel.

A4.1.2.2 EQUIPMENT

For the purpose of inerting, there might be either an inert gas generator or a nitrogen generator fitted on board.

<u>The Inert Gas Generator:</u>

The actual design and performance of this equipment will vary from ship to ship. However, the basic design will incorporate an oil burner, a scrubber, and an air blower with its drive and a drier unit. There will also be control elements, oxygen and humidity monitors and an associated alarm system fitted. The gas code requires continuous oxygen monitoring in the inert gas stream.

The oxygen content should normally be no more than about 1.0 percent. High oxygen content can trigger an alarm but this would not normally trip the plant. This would normally divert the flow of gas to the atmosphere via a vent riser.

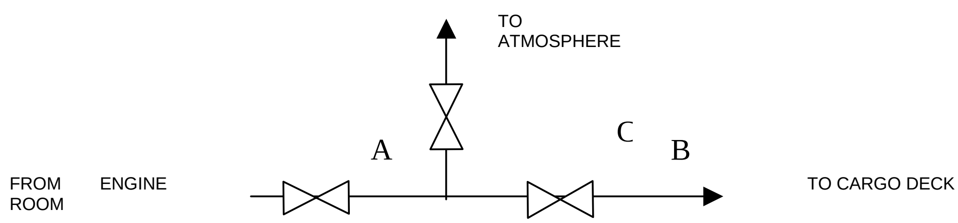
This type of generator must be located outside the cargo area and is usually installed in the ship’s engine room.

In principle, burning diesel in a dedicated combustion chamber reduces the oxygen content of atmospheric air. This oxygen-depleted air is then washed, dried, and eventually supplied to the cargo area.

There is no deck seal on the supply line segregating the cargo deck from the engine room. There would be two screw-down non-return valves incorporated in the supply line to protect against any accidental back flow.

It is essential that these valves are tested prior to every operation. Non return valve should be checked / overhauled every 3 months and a record of this should be maintained.

One way to test these would be to pressurize the outlet end of the IG supply line with compressed air. To this end, a flange may need to be fabricated, which would permit connecting a compressed air line to the IG outlet on cargo deck. These valves have a tendency to fail, as any debris in the line accidentally carried with the inert gas would not permit the valve to sit properly.



Referring to the above diagram, "A" & "B" are the in-line non-return valves. "C" is a valve on the venting line, which could be pneumatically operated. This valve is linked to the IG generator. This valve closes when the plant is operational and opens when the plant is stopped.

Nitrogen Generator

In such systems, oxygen is removed from atmospheric air by means other than combustion. On many of our ships, a fiber bundle filter that selectively permits the flow of gases does this. The vent gas out of the system (permeate stream) is oxygen enriched. It typically contains about 30% oxygen but can be as high as 45%. **While oxygen will not burn, oxygen concentrations above 25% will support combustion of other materials much more readily than air.** For example, materials that smoulder in air could burn fiercely in this atmosphere. It is imperative that vent gas is discharged only in well-ventilated and safe areas.

The same consideration for the testing of the in line non-return valves apply here as well.

A4.1.2.3 PHYSICAL CONSIDERATIONS

The preferred method of inerting is by the method of displacement. This is reasonable because this would involve only one change of tank atmosphere. On the other hand, dilution involves at least three changes of the tank atmosphere. The more the difference between the densities of the tank atmosphere and the inert gas the better the stratification and the better is the efficiency of this method.

The first step towards a successful inerting is to decide to what extent the tank needs to be inerted. The following could be some of the factors to consider:

1. Whether the tank is to be converted to some other cargo.

2. Whether air is to be introduced into the tank after inerting. In the second case it is sufficient to inert the tank to below the critical dilution line with a margin of safety in hand. In practice, a fifty- percent margin of safety is considered adequate. This allows for a degree of poor mixing in practical circumstances while gas readings are taken.

(How to draw the critical dilution line)
1. Take the flammability diagram of the product in the tank.
2. Mark a point on the X-axis at 21%
3. Draw a tangent to the flammable envelope from this point. This tangent represents the critical dilution line.
4. During any gas freeing operation, the tank condition may be regularly plotted on this diagram. It is essential to ensure that the locus the tank environment is following remains clearly below the flammable envelope of the cargo.

A4.1.2.4 DISPLACEMENT

<u>Density consideration:</u>

Since displacement is dependent on gas densities it is essential to check the density of the cargo gas to be displaced against the density of nitrogen or inert gas as the case may be. Please remember the word NAIL that lists gases in the increasing order of density as follows:

N - Nitrogen (lightest)

A - Air

I - Inert gas

L - LPG (heaviest)

It is easy to see that LPG is better displaced by nitrogen than by inert gas, as nitrogen is lighter than inert gas.

In order to displace a heavy gas by a light gas the latter must be introduced from the top and the heavy gas vented out from the bottom. In order to displace a light gas by a heavy gas, introduce the heavy gas from the bottom and vent off the light gas from the top.

A4.1.2.5 OPERATING PRECAUTIONS:

(1) Never stop the process mid way. This will destroy the interface and further displacement will be impossible.

(2) Give as many openings for the vent gas as is possible.

(3) Do not pressurize the tanks. This will cause turbulence when the pressure is released. This will again destroy the interface between the purge gas and the tank atmosphere.

(4) Do not let the tank pressure fall below atmospheric. Out side air may be drawn into the tank. This will increase the oxygen content of the tank.

(5) Remember to purge the pump suction line. Unless this is done at the very outset it will be extremely time consuming to purge the bottom part of the tank later.

(6) Monitor the tank atmosphere with the proper equipment. Use a properly calibrated Tankscope to measure the hydrocarbon content in a tank which is being purged by inert gas or nitrogen. This may sound obvious but in the past wrong readings have been obtained by using a normal explosimeter to monitor tank atmosphere under inert condition.

(7) Calibrate the gas measuring instruments using proper span gases appropriate to that instrument. Follow the manufacturer's instructions implicitly.

(8) Follow all other usual precautions, which are adopted during venting of cargo gases.

(9) Stop venting of all cargo gases during thunderstorms or lightning. **Remember the vent gas, which was in too-rich condition in the tank, will become flammable, when mixed with air during venting**.

(10) It has been found that displacement is generally effective down to about 0.5% only, and if lesser concentrations of original tank content are required, dilution method should be used after reaching this level.

A4.1.2.6 CASCADING:

Always try to vent the tank into another tank rather than directly to the atmosphere. This can be done to a series of tanks with only the last tank being vented directly. Initially this will not make any difference to the other tanks, as it will only be cargo gases that are vented out from the tank under active purge. However, as the concentration of cargo gases in the tank under active purge begins to reduce the tank or tanks under cascade will begin to get the benefit of the purge. This will reduce both time as well as the amount of inert gas needed to purge/ inert the system. This process is called cascading.

How exactly this is done will depend on the pipeline layout of the particular ship. In some cases, it has been found that **some non-return valves had to be removed to do this. Remember that it is usually possible to do cascading.**

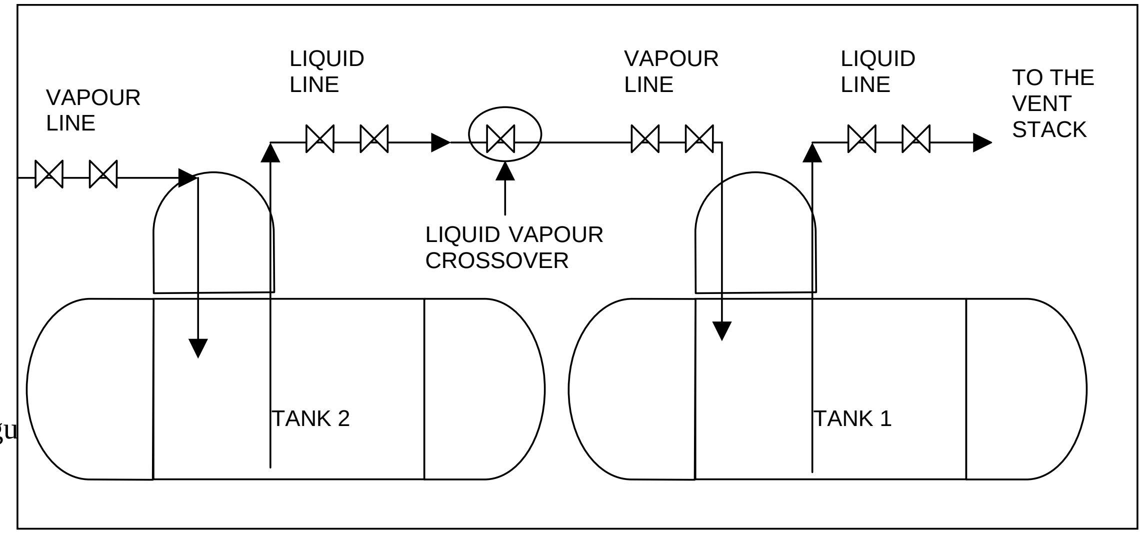
A.4.2 PRESSURIZED SHIPS

A.4.2.1 PROCEDURE

The process of a successful purging starts at the final discharging of the cargo. The tanks must be made completely liquid free. As much vapour as can be discharged to the shore facility must be discharged to reduce the tank pressure to a minimum.

On completion of the discharge, any liquid remaining in the sumps of the cargo pump and the level gauges must be drained out. This can be done by rigging a hose to the sump drains. This venting should be continued until the tank pressure is brought down as near to atmospheric (0 bar) as possible. This will obviously be done at anchor or during passage where venting is allowed. All safety precautions relevant to venting must be followed. On a smaller pressure ship, this could take two to three hours. This time has to be allowed in order to save time on the actual purge later.

Now the vessel is ready to carry out the actual purging. The following diagram shows schematically a ship with two tanks, where tank No.2 is under active purge by inert gas or nitrogen and tank No.1 is under cascade. The tank atmosphere is heavier than the purge gas.



Figu

A.4.2.2 PURGING WITH SHORE NITROGEN:

The basic considerations as described in the previous sections apply here as well. In particular we will consider three scenarios:

1. **<u>In port with vapour return</u>:** this is the ideal situation and presents no technical difficulties. The procedures as described before can be applied directly. The only consideration would be to reduce the amount of nitrogen intake. To this end, cascading should be used. Secondly, shore nitrogen should be taken in as warm a condition as the situation will permit. This is done in order that the density of nitrogen is farther reduced in order to achieve a better displacement. As the difference in densities of nitrogen and atmosphere air is very little, for efficient purging with nitrogen when tanks are under atmospheric conditions, the temperature of the nitrogen should be either much higher than or much lower than the air temperature in the tanks.

2. **<u>In port without vapour return</u>**: Most ports will not allow ships to vent hydrocarbons and purging under these circumstances is a difficult operation. In principle, tanks must be pressurized with shore nitrogen, and vented after the ship has gone out of port limits. This sequence has to be repeated many times to reach the required level of residual hydrocarbons.

To reduce the number of trips, and thus time and expenses, at the first instance shore nitrogen should be admitted to one tank, the content of this tank is then to be displaced to the other tanks. By carefully controlling the rate at which the nitrogen is taken in, it is possible to reduce the hydrocarbon content of this tank to under 1%. Once this is achieved, all tanks will be at the same pressure and should now be isolated while continuing to admit nitrogen in the first tank. This tank should be pressurized with nitrogen to about 3 to 4 bars. The ship can then leave port limits. The other tanks should be first vented, then nitrogen from the first tank is used to displace the hydrocarbons in the other tanks. It is possible this way to reach a low level of hydrocarbons in all tanks, as such, when the ship takes nitrogen again, the local authorities will allow the ship to vent. In case the ship is not allowed to vent at all, only one more trip will be necessary to reach the required level of hydrocarbons.

3. **In port or at anchor where venting is permitted:** the situation here is similar to case 1 and presents no difficulties. It is important to work in close cooperation with the terminal authorities whenever any venting is done alongside and follow their guidelines regarding venting.

A.4.2.3 GASSING UP

Now that the tanks are purged to the required extent, the next step in grade conversion is gassing up. Even in this case the preferred method is displacement. The same considerations as described before will apply regarding density etc.

A.4.2.3.1 DENSITY

In this case, the heavier cargo vapour will be introduced from the bottom and the lighter inert gas or nitrogen displaced from the top. In case ammonia is the next cargo, that will have to be to introduced from the top being lighter than nitrogen.

A.4.2.3.2 CARBAMATES

In order to prepare a tank for ammonia as the next cargo inert gas must not be used, in order to prevent carbamate formation. In such cases, only nitrogen purge is permitted. Carbamate is a chemical compound, which forms through chemical reaction between anhydrous ammonia and oxides of carbon. This compound is like a fine white powder, which will coat the tank body on the inside and clog nozzles etc. in the tank. It is extremely difficult to remove this powder.

A.4.2.3.3 CASCADING

As with purging, cascading is highly recommended. The procedure is as described before. In this case, assuming the next cargo is not ammonia but a gas heavier than air, the pipe set up will need to be changed accordingly. For ammonia, there will be no need to reset the cargo line up.

A.4.2.3.4 TANK PRESSURE

The tank pressure must be reduced to a minimum before attempting to start gassing up. This involves a secondary problem now, this is described in the next paragraph.

A.4.2.3.5 SUB-COOLING

If any liquid cargo is put in the tank, it will flash off because of the reduced pressure in the tank. Latent heat required for evaporation is absorbed from the tank structure thus cooling it down. It is possible for the tanks to be cooled below the designed minimum temperature. Methods for avoiding this are described below when various scenarios are considered. This is particularly relevant to the fully pressurized ships, which generally cannot withstand sub zero temperatures. Generally, when vapour return is not available, the first tank to be loaded should be kept pressurized with nitrogen or inert gas up to 3.5 bar. This will reduce flash off and subsequent sub-cooling.

A.4.2.3.6 Three typical gassing up scenarios:

1) With shore vapour, and with vapour return

This is the simplest situation with little technical difficulties. Considerations regarding density and cascading will apply. For most cargoes, other than ammonia, the pipe line-up will need to be changed now. This is in order to inject the heavier cargo gases to the bottom of the tank, through the liquid line and displace the inert gas or nitrogen through the vapour line. In case of gassing up with ammonia the same pipe line up can be used, as ammonia is lighter than nitrogen.

2) With liquid from shore, and with vapour return

In this situation, the liquid from shore will be taken in through the cargo heater or a dedicated vaporizer, if fitted. The cargo will be converted to vapour here, and then injected into the tanks in the usual manner. It is important to see that no liquid goes directly into the tanks to guard against sub cooling.

3) **With liquid from shore, without vapour return**

In this case, the vessel will need to go outside the port limits to do the venting. In case the ship is fitted with deck pressure vessels, then the ship can take the cargo in this tank and then proceed outside to gas up. In case there are no pressure vessels, then the cargo will need to be taken in one of the cargo tanks. This is the situation which presents the maximum difficulty. The master must consider the possibility of loading without any venting, provided that can be done without over pressurizing the tanks. With some very low vapour pressure cargoes, this may be possible provided tank pressures were at a minimum prior to commencement of loading.

The excess nitrogen pressure may be vented once the vessel has left port and is in an area which the Master considers safe. Alternatively, the vessel may take a partial load of cargo in one of the tanks. The excess pressure may be vented to the other cargo tanks. We will now consider a pressurized ship with two cargo tanks with a typical cargo capacity of about 1600 cbm per tank. The situation can be extrapolated for different tank configurations. The liquid will generally be loaded in No.2 tank.

We must appreciate the fact that in this case there is no other drive than the vapour pressure of the cargo. This will not amount to much. Hence using a cargo compressor is required to create a drive.

a) One way of doing this would be to connect the vapour line from No.2 tank to the liquid line through the liquid-vapour crossover. If a non-return flap backs up this valve, which is usually the case, that flap will need to be removed.

Vapour now goes into the bottom of No.1 tank through the liquid line. The vapour line is now connected to the compressor, which will extract from the top of No.1 tank and vent it out.

Or

b) Alternatively, the compressor will draw from the top of No.2 tank through the vapour line and then inject into the bottom of No.1 tank through the liquid line. To achieve this, one will need to open the liquid-vapour crossover and remove any non-return flap backing up this valve. After this No.1 tank will be vented from the top through the vapour line. In both cases, this is where the difficulty arises since a part of the vapour line is already in use by the compressor for evacuating a tank. It may be necessary to insert a blank in the vapour line to achieve this. The exact place to insert this blank will depend on the piping layout of the ship. It is a good idea to mark out this flange in the process sheet in advance and keep a blank standby for future use rather than look for it when required. On most ships this can be done.

Both tanks can be safely considered gassed-up, when one sees gas being vented out from No.1 tank. However regular monitoring of the tank environment should be done. Of these two methods, method "a" would be considered the preferred method for the following reasons, provided the vessels piping permits it:

1. Injecting the vapour into No.1 with the compressors causes turbulence. This reduces the efficiency of the displacement.

2. While running through the compressor the gas will warm up. This will reduce the density of the cargo. This in turn will reduce the efficiency of the displacement.

The amount of cargo to take in will depend on the following factors:

1) The amount of cargo that will be needed to gas up.
2) Any stability, trim and stress constraints.
3) Any restrictions imposed by the terminal or shipper as to the minimum parcel that they can provide.

Considering point one, theoretically, at the end of the gassing up, the cargo tanks and the pipelines will be full of cargo gas at ambient temperature.
Hence a mass of liquid plus an allowance for process losses is the amount of cargo that will be needed to be loaded for gassing up. Speaking roughly, about 40 tonnes of propane or propylene, or about 15 tonnes of butane or butylene or butadiene is generally needed to gas up a ship of about 3500 cbm. However it is prudent to call for double this amount in order that the vessel need not come back for some cargo to cover for process losses. Coming in for 5 tonnes of additional cargo is economically ruinous.

A.4.3 REFRIGERATED SHIPS

The following section applies to refrigerated carriage

A.4.3.1 GENERAL

In general, the basic considerations as described above regarding density, displacement and cascading apply in this case also. However, the procedure of liquid freeing the tanks is slightly different. We will consider the processes and precautions typical to refrigerated carriage in this section.

A.4.3.2 STRIPPING

A small amount of cargo called “heel” (about 1% of tank capacity) is always retained on board after discharging in a refrigerated ship. This is used for cooling the tanks in the ballast passage. However, if a grade change or gas freeing of the tanks is to be done then the tanks must be completely stripped at the last discharge. Unless this is done the next step called, sparging will take a long time.

Additionally, due to enhanced evaporation in a non-saturated atmosphere residual liquid can become super-cooled to a temperature which could result in brittle fracture of the tank.

A.4.3.3 SPARGING

Sparging is the process of converting remaining liquid in the tank sumps to vapour. Blowing hot gas from the reliquefaction plant into the sumps through specially fitted pipes called puddle heaters does this. **Consult the operating manual of the ship regarding the maximum temperature allowed for this purpose. Otherwise, you will damage the tank insulation. (Typically about 70^{o} C or below).**

When puddle-heating coils are used, the heat source in the coils is hot gas discharged from the cargo compressors. Vapour is drawn from the cargo tank atmosphere and passed through the compressor where the vapour is heated up by the compression. The condenser is bypassed and hot vapour can be led directly to the heating coil system. This evaporates the liquid in the tank.

Alternatively, the hot gas may be directly supplied to the sumps. In this case there are holes in the puddle heater coils. The hot gas comes in direct contact with the liquid in the sumps and causes evaporation. In this case there is no liquid formation.

At sea, in order to finish the operation, cargo tank vapour could be:

1. Sent to the vent riser.
2. Condensed and kept in deck storage tanks.
3. Condensed and drained overboard.

Alongside venting directly to atmosphere is seldom permitted. In such cases the condensate is either pumped ashore or kept in the deck pressure vessels.

The following precautions should be observed:

1. Always keep a trim by the stern. The exact trim needed will of course vary from ship to ship.
2. Keep in mind the arrangement of the thermometer and sparge pipes.
3. Temperature differential between the top and bottom of the tank must not exceed the designed feature. (Typically about 50^{o} C)
4. Monitor the tank pressure closely.

A.4.3.4 INERTING

The next step after sparging is inerting. The general considerations are the same as in the case of pressurized ships.

It may be convenient to supply the inert gas or nitrogen through the reliquefaction gas line (condensate return line) on top, and displace the LPG through the liquid filling line and pump discharge line.

Always gas-free the pump suction and discharge at the very outset. Otherwise, inerting the bottom level of the tank will be extremely difficult.

In case the pump discharge is fitted with a non return line, open the housing and lift the valve. Remember that the pressure of the nitrogen or inert gas will not be sufficient to lift the valve. Do not open this valve completely or it may prevent the turning of the pump.

A.4.3.5 GASSING UP

In case of grade change, the next step is gassing up with the next cargo. All considerations as described for pressurized vessels will apply here. Fully refrigerated ships cannot sustain much pressure so the option of pressurizing the tanks is ruled out. In the event, liquid is directly loaded in the cargo tanks, a problem arises with prismatic or membrane tanks, called sloshing. For details see the next paragraph.

Cool cargo vapours are the best for gassing up. In order to prevent hydrate formation it is best to take liquid from the shore or deck pressure vessels and convert it to vapour in the cargo heaters. Remember there is a danger of dewing if the inert gas supplied is not dry enough.

A.4.3.5.1 SLOSHING

Large prismatic cargo tanks, due to their width and shape, may suffer from substantial sloshing of the cargo in heavy rolling conditions. Such tanks and particularly membrane type tanks, which have no centre line wash bulkhead, may have prohibited filling levels in order to avoid damage to the tank structures or internal fittings. Typically, prismatic tanks are prohibited to load in the 10% to 80% filling level range. For membrane tanks the upper limit could be typically 95%. Although in a gassing up situation it is unlikely, but it must be confirmed that the vessel is not leaving the terminal with liquid cargoes in its tank which falls into the barred range.

A.4.3.6 COOLDOWN

The next step after gassing up is cooldown. Refer to the cargo-operating manual of your ship for specific instructions for this operation. The problem faced in this process is the presence of nitrogen in the tanks. Since nitrogen cannot be condensed by the ship's plant this results in a collection of nitrogen in the cargo condenser leading to high pressure in the second stage discharge of the cargo compressors, the plant will trip. The only solution is to vent the nitrogen out of the compressor.

In most terminals no venting is permitted alongside, even the venting of nitrogen is not permitted. Therefore, under such circumstances this must be vented to a shore flare stack.

A.4.3.7 CASE STUDY

A typical operation on a VLGC with prismatic tanks is considered in the Appendix V.

A 4.4 PREPARING THE TANK FOR MAN ENTRY

This section applies to both pressurized as well as refrigerated ships.
If this was the objective of the initial purge then, once the tank has been inerted sufficiently below the critical dilution line air will be injected into the tank.

Air can be injected in the tanks using:

1. The IG blower.
2. In some cases with the cargo compressors.
3. With portable hydro-blowers or similar equipment.
4. With wind-sails.

The most convenient means of introducing air is using the IG blowers or the cargo compressors. The hydro-blowers tend to be more efficient in exhaust mode than in the supply mode. These can be rigged on the tank manholes to in the exhaust mode where displacement from the top is indicated.

If possible, heat up the cargo tank temperatures above atmospheric when using portable blowers in order to prevent dewing.

All considerations regarding density etc. as described above are applicable here.

A.4.4.1 DISPLACING NITROGEN WITH AIR

In order to displace nitrogen with the air, air should be introduced from the bottom using the liquid line and the nitrogen displaced from the top. Displacing nitrogen with air is difficult as the density difference between the two is very little, nitrogen being nominally lighter than air at the same temperature. However, hot air is lighter than nitrogen. In this situation hot air may be injected from the top using the vapour lines and the nitrogen displaced from the bottom using the liquid line. The upper limit of the temperature of the nitrogen will depend on the tank insulation. Refer to the cargo-operating manual of your ship to check this temperature. This process works better in cold ambient temperatures where the tank atmosphere will be at the ambient temperature. In tropical summers, the only practical solution would be to use the dilution method.

A.4.4.2 DISPLACING INERT GAS WITH AIR

In order to displace inert gas with air, the air should be introduced from the top through the vapour line and the inert gas displaced from the bottom using the liquid line. In this case, it is better to introduce hot air through the inert gas plant to increase the density difference. Remember the upper limit of the temperature with reference to the tank insulation.

A.4.4.3 PRECAUTIONS

1. Venting must be continued until any pockets of gas that may remain in the tank are driven out.

2. The tank atmosphere must be thoroughly checked and enclosed space entry procedure followed before man entry is made.

3. It is prudent to continue forced ventilation of the tanks for the entire duration of the man entry. In some of the wet or dry-docks, it is mandatory to do so.

APPENDIX V

VLGC GAS FREEING AND GASSING UP REPORT

A5.1 GAS FREEING REPORT

CASE 1

Vessel sailed from Oita on 16 July 1999 for Kawasaki. During discharge at Oita, tanks 1 & 4 were emptied in order sparge tanks enroute to Kawasaki.
On 17 July 1999 at 0600 UTC commenced sparging of tanks 1 & 4 with No.1 and No.4 compressors on a hot gas cycle and No.2 and No.3 compressors on reliquefaction cycle to their respective tanks for bleeding off extra vapour generated in No.1 and no.4 tanks.
Completed sparging of No.1 and No.4 tanks at 0300 UTC on 19 July 1999.
Time taken = 45 hours.

Important points to monitor for future reference:

1. Try and use 2 compressors on each tank while sparging. Also, extra vapour that is generated should be vented off immediately, as it takes longer to release pressures from the tank through the compressors.

2. During hot gassing maintain header temperature around 70 deg C, as any temperature above this will damage the insulation.

3. While sparging, it was noticed that the butane content of the cargo was very high; hence it took a long time to make the tank liquid free.

4. Before introducing Inert gas into the tank, ensure that the over all tank temperature is in the region of 15 deg C.

CASE 2

On passage from Kawasaki to Singapore started 2 compressors each on a hot gas cycle on tanks 2 & 3 at 1300 UTC on 20 July 1999.
Completed sparging of tanks 2 & 3 at 0100 UTC on 22 July 1999.
Time taken for sparging tanks 2 & 3 = 36 Hours.

Simultaneously, commenced inerting tanks 1 & 4 with inert gas being introduced through the vapour line and propane vapours being removed from the liquid line, either through the manifold or the vent riser.
Time taken for inerting tanks 1 & 4 = 22 Hours.

After tanks 2 & 3 were liquid free, commenced inerting of tanks 2 & 3 at 0130 UTC on 22 July 1999, as mentioned above.
Completed inerting tanks 2 & 3 at 0130 UTC on 23 July 1999.
Time taken for inerting tanks 2 & 3 = 24 Hours.

During this period all lines in the compressor room were inerted with inert gas from tanks 1 & 4.

CASE 3

The inert gas system was changed over to the fresh air mode and commenced gas freeing tanks 1 & 4 at 0300 UTC on 23 July 1999 with fresh air being introduced in both the tanks simultaneously through the vapour line and inert gas removed from the liquid line, either forward or aft.
Completed gas-freeing tanks 1 & 4 at 0400 UTC on 24 July 1999.
Time taken for gas freeing tanks 1 & 4 = 25 Hours.

Commenced gas freeing tanks 2 & 3 at 0500 UTC on 24 July 1999 with procedure as described above. Completed gas freeing of tanks 2 & 3 at 0800 UTC on 25 July 1999.
Time taken for gas freeing tanks 2 & 3 = 27 Hours.

On completion of gas freeing of cargo tanks, all cargo holds were gas freed simultaneously with the I.G. blower in the fresh air mode at 0900 UTC on 25 July 1999 and completed gas-freeing holds at 0700 UTC on 26 July 1999.
Time taken for gas freeing of holds = 22 Hours.

After gas freeing of all tanks and holds the I.G. blower was kept running in fresh dry air mode in all cargo tanks and holds.

Points to monitor:

1. Tank bulkhead valves to be kept open. Also ensure all sampling cocks, drain valves and pump discharge valves are kept open.

2. If short of time, then tanks can be gas freed using portable blowers, however possibility of moisture condensation is very strong and hence not recommended. Using dry air will reduce possibility of hydrate formation.

Time Taken:

(A) Sparging of tanks: 45 + 36 Hours = 81 Hours.
(B) Inerting of tanks: 22 + 24 Hours = 46 Hours.
(C) Gas Freeing of tanks: 25 + 27 Hours = 52 Hours.
(D) Gas Freeing of holds: 22 Hours.

Total time: 81 + 24 + 52 + 22 = 179 Hours

A5.2 GASSING UP AND COOLING DOWN REPORT

Vessel berthed NGL Terminal Berth No. 71 Yanbu on 19 August 1999 at 0412 LT for taking coolant. After safety meeting was completed, gassing up with Propane liquid was commenced at 0625 LT. During the Safety meeting, Saudi Aramco Loading Master was informed that loading rate will be in the region of 5 – 10 Mts/ Hour and will be spraying line in No. 2 tank, vapours generated will be sent to No. 3 tank and from that tank to the shore flare. However, Loading Master did not agree to this and said that only one tank will be allowed to gas up and cool down. All cargo tank pressures in the region of 0.03 kg/cm^2g with maximum oxygen content of 1.5% and tank dew point in the region of –15 deg C.

Gassing up of No.2 tank commenced at 0625 LT/ 19.08.99 by opening top and side sprays of that tank. Gassing up was suspended from 0700 LT to 0840 LT/ 19.08.99. For cooling down of shoreline. On resumption of loading, loading rate was in the region of 60-bbls/ hour, as manifold pressure kept rising beyond that. Manifold pressure was kept in the region of 2.0 kg/cm^2g. When the manifold pressure was increased, it was found that the liquid loading valve of No. 4 tank starboard side was leaking slightly, even though the valve was fully shut.

From 1520 LT to 1920 LT/ 19.08.99, loading was suspended due to high wind speeds. At this juncture, No.2 tank was about 35% gassed up with tank pressure in the region of 0.10 kg/cm^2g. Shore started loading again at 1950LT, however, vessel did not receive any cargo till 2040 LT. Gassing up was in progress at a slow rate when shore again ceased loading from 0140 LT to 0440 LT/ 20.08.99 for cooling down of their shore lines.

At 1020 LT/ 20.08.99 when No.2 tank was 88% gassed up, loading was suspended for trying our compressors. However, on starting the compressors, condenser pressures kept increasing, hence had to open the condenser vent valve to the mast riser. Since venting was not permitted through the mast riser (Even though it was only inert gas) terminal asked vessel to stop venting and after giving written explanations etc., shore decided to give coolant again for gassing up of No. 2 tank at 1255 LT/ 20.08.99.

By this time No.2 tank bottom temperature was in the region of –25 deg C, hence by 1340 LT, loading rate was increased to 200 bbls with vapour being vented to the shore flare. At 1500 LT/ 20.08.99, hydrocarbon concentration was checked in No. 2 tank and found in the region of 90%. So No.2 compressor was started on a reliquefaction cycle and found that the compressor was coping up without opening the condenser vent valve. Rate was increased to 1000 bbls by 1650 LT and ultimately at 1710 LT confirmed to the terminal that gassing up and cooling down of No.2 tank was completed. Loading rate was increased to 2500 bbls for taking in the balance coolant. Accordingly completed taking balance coolant at 1820 LT/ 20.08.99.

COOLANT LOADED: 528.311 MTS

Pilot boarded at 2024 LT/ 20.08.99 and vessel shifted to anchorage at 2154 Lt/ 20.08.99 for conditioning remaining cargo tanks.

Important Points for Future Reference:

1. It is recommended that No. 4 tank is gassed up as the condensate line has a branch that is connected to No. 4 liquid line. Hence, even if the manifold pressure rises it can be released in no. 4 tank.

2. Spool piece on top of compressor room which connects condenser vents to the vent riser should be kept closed by which it will be connected to the shore vent flare.

3. Initial loading rate should be kept in the region of 5 Mt/Hour, however, after bottom temperature comes to about -25 deg C, loading rate should be increased and liquid taken through the loading line, vapour expelled from top via compressor vent valve to the shore flare. This way amount of cargo that is flared will be also minimized instead of sending it directly to the flare. While taking liquid from the bottom loading rate can be increased gradually to about 100 to 200 Mts/ hour and necessary gassing up/ cooling down operation for that tank is completed.

4. Frequent start/ stops for whatever reasons did not help the matter as it resulted in forming a complete mixture in the tank and consequently landed up taking more time.

5. While gassing up and cooling down of the tank where coolant is to be taken, try to gas up one more tank at that time in order to save time and coolant.

6. If above procedures are followed, estimated about 14 hours will be required for gassing up and cooling down of one tank alongside and another about 4 hours will be required for taking balance coolant.

A5.3 CONDITION OF OTHER CARGO TANKS AT ANCHORAGE

No. 2 (P) tank cargo pump was started on 0001 LT/ 21.08.99 for spraying liquid in no. 4 tank through the top and side sprays. Vapour generated were expelled from the liquid line and sent in to the bottom of no. 3 tank. Excess vapour in no. 3 tank was vented out through the vent riser and forward vapour manifold.
This process continued till 1300 LT, when no. 4 compressor was started for cooling down of no. 4 tank, but since the tank was not gassed up had to keep condenser vent valve open. On doing so found tank pressure in no. 4 tank falling and had to replenish clean propane vapour in that tank continuously. By 2245 Lt/ 21.08.99 found that no. 3 tank was completed gassed up.

Commenced spraying liquid in No. 3 tank at 0050 LT/ 22.08.99. Excess vapour generated was used for gassing up of No. 1 tank from bottom and vapour from No. 1 tank expelled through the vent riser.

Compressor No. 4 was kept running on no. 4 tank for cooling down that tank, but the condenser vent valve was still open, which resulted in very slow cooling down rate and frequent replenishment of clean propane vapour.

No.3 tank was completely cooled down by 1930 LT/ 22.08.99 and no. 3 compressor was started on no. 3 tank directly for keeping it cold.

No. 1 tank was gassed up by 2100 LT/ 22.08.99. All operations were ceased for allowing tank atmospheres to stabilize.

Cooling down of No.1 tank was started at 0130 LT/ 23.08.99 with No. 1 compressor. Started no. 5 compressor also on no. 4 tank along with No. 4 compressor to hasten the cooling rate, but the condenser vent valves were still slightly open which resulted in low cooling down rate and continuous replenishment of propane vapour. No. 4 tank was ultimately cooled by 1600 LT/ 23.08.99. It was noticed that cooling down rate of No. 1 tank was in the region of 1 deg C, so cargo pump was started to spray liquid in No. 1 tank at 1800 LT/ 23.08.99. At 2030 LT to 2230 LT all tanks were de-pressurized and cooled down for required loading.

Tanks 2, 3 & 4 were cooled down for propane loading and tank 1 for butane loading.

Time required for Gassing up and Cooling down of no. 4 tank: <u>64 Hours</u>

Time required for Gassing up no. 3 tank: <u>22.5 Hours</u>

Time required for Cooling down of no. 3 tank: <u>18.5 Hours</u>

Time required for Gassing up no. 1 tank: <u>20 Hours</u>

Time required for Cooling down of no. 1 tank: <u>19 Hours</u>

Total Time required: <u>70.5 Hours</u>

COOLANT ROB: 438 MTS

COOLANT LOST: About 90 MTS

Important points for future:

1. No. 4 tank took a lot of time for gassing up and cooling down due to the presence of in-condensable as liquid as sprayed in the tank. Therefore, a displacement method might be a better option as it will result in saving a lot of cargo and possibly time.
2. Cooling down with compressors is very slow with cooling down rate in the region of 1 deg C/Hour (tank pressure 0.12 kg/cm^{2}g). But with pump running and header pressure around 3.5 kg/cm^{2}g, cooling down rate was much faster in the region of 3 to 4 deg C/Hour.

3. To gas up one tank will require about 18 to 20 hours and further 20 hours for cooling it down by the pump.