PART 2

TANKER INFORMATION

Chapter 7

SHIPBOARD SYSTEMS

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

7.1 Fixed Inert Gas Systems

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

Reference should be made to the tanker's operations manual and the manufacturer's instructions and installation drawings, as appropriate, for details on the operation of a particular system.

7.1.1 General

Hydrocarbon gas normally encountered in petroleum tankers cannot burn in an atmosphere containing less than approximately 11% oxygen by volume. Accordingly, one way to provide protection against fire or explosion in the vapour space of cargo tanks is to keep the oxygen level below that figure. This can be achieved by using a fixed piping arrangement to blow inert gas into each cargo tank in order to reduce the air content, and hence the oxygen content, and render the tank atmosphere non-flammable.

See Section 1.2.3 and Figure 1.1 for detailed information on the effect of inert gas on flammability.

7.1.2 Sources of Inert Gas

Typical sources of inert gas on inland tankers are:

- An independent inert gas (nitrogen) generator.
- Inert gas (nitrogen) supplied at terminal facilities.
- Inert gas (nitrogen) stored on board.

7.1.3 Composition and Quality of Inert Gas

Inert gas systems should be capable of delivering inert gas with an oxygen content in the inert gas main of not more than 5% by volume at any required rate of flow; and of maintaining a positive pressure in the cargo tanks at all times with an atmosphere having an oxygen content of not more than 8% by volume except when it is necessary for the tank to be gas free.

When an independent inert gas generator is fitted, the oxygen content can be automatically controlled within finer limits, usually within the range 1.5% to 2.5% by volume.

In certain ports, the maximum oxygen content of inert gas in the cargo tanks may be set at 5% to meet particular safety requirements, such as the operation of a vapour emission control system.

7.1.4 Methods of Replacing Tank Atmospheres

If the entire tank atmosphere could be replaced by an equal volume of inert gas, the resulting tank atmosphere would have the same oxygen level as the incoming inert gas. In practice, this is impossible to achieve and a volume of inert gas equal to several tank volumes must be introduced into the tank before the desired result can be achieved.

The replacement of a tank atmosphere by inert gas can be achieved by either inerting or purging. In each of these methods, one of two distinct processes, dilution or displacement, will predominate.

Dilution takes place when the incoming inert gas mixes with the original tank atmosphere to form a homogeneous mixture throughout the tank so that, as the process continues, the concentration of the original gas decreases progressively. It is important that the incoming inert gas has sufficient entry velocity to penetrate to the bottom of the tank. To ensure this, a limit must be placed on the number of tanks that can be inerted simultaneously. Where this limit is not clearly stipulated in the operations manual, only one tank should be inerted or purged at a time when using the dilution method.

Displacement depends on the fact that inert gas is slightly lighter than hydrocarbon gas so that, while the inert gas enters at the top of the tank, the heavier hydrocarbon gas escapes from the bottom through suitable piping. When using this method, it is important that the inert gas has a very low velocity to enable a stable horizontal interface to be developed between the incoming and escaping gas. However, in practice, some dilution inevitably takes place owing to the turbulence caused in the inert gas flow. Displacement generally allows several tanks to be inerted or purged simultaneously.

Whichever method is employed, and whether inerting or purging it is vital that oxygen or gas measurements are taken at several heights and horizontal positions within the tank to check the efficiency of the operation. A mixture of inert gas and flammable gas, when vented and mixed with air, can become flammable. The normal safety precautions taken when flammable gas is vented from a tank therefore should not be relaxed.

7.1.5 Cargo Tank Atmosphere Control

7.1.5.1 Inert Gas Operations

Tankers using an inert gas system should maintain their cargo tanks in a non-flammable condition at all times. It follows that:

- Tanks should be kept in an inert condition at all times, except when it is necessary for them to be gas free for inspection or work, i.e. the oxygen content should be not more than 8% by volume and the atmosphere should be maintained at a positive pressure.
- The atmosphere within the tank should make the transition from the inert condition to the gas free condition without passing through the flammable condition. In practice, this means that, before any tank is gas freed, it should be purged with inert gas until the hydrocarbon content of the tank atmosphere is below the critical dilution line (line GA in Figure 1.1).

7.1.5.2 Inert Gas System Maintenance

It is emphasised that the protection provided by an inert gas system depends on the proper operation and maintenance of the entire system.

Where applicable, there should be close co-operation between the deck and engine departments to ensure proper maintenance and operation of the inert gas system. It is particularly important to ensure that non-return barriers function correctly, especially block and bleed valves, so that there is no possibility of product gases or liquids passing back to the machinery spaces.

To demonstrate that the inert gas plant is fully operational and in good working order, a record of inspection of the inert gas plant, including defects and their rectification, should be maintained on board.

7.1.5.3 Degradation of Inert Gas Quality

Tanker personnel should be alert to the possible degradation of inert gas quality within tanks as a result of inappropriate operation of the inert gas systems. For instance:

- Not topping up the inert gas promptly if the pressure in the system falls, due to temperature changes at night.
- Prolonged opening of tank apertures for tank gauging, sampling and dipping.

7.1.6 Application to Cargo Tank Operations

Before the inert gas system is put into service, the tests required by the operations manual or manufacturer's instructions should be carried out. If a fixed oxygen analyser and recorder are being used they should be tested and proved to be in good order. Appropriate portable oxygen and explosion limit meters should also be prepared and tested.

7.1.6.1 Inerting of Empty Tanks

When inerting empty tanks that are gas free, for example following a dry docking or tank entry, inert gas should be introduced through the distribution system while venting the air in the tank to the atmosphere. This operation should continue until the oxygen content throughout the tank is not more than 8% by volume. Thereafter, the oxygen level will not increase if a positive pressure is maintained by using the inert gas system to introduce additional inert gas when necessary.

If the tank is not gas free, the precautions against static electricity given in Section 7.1.6.8 should be taken until the oxygen content of the tank has been reduced to 8% by volume.

When all tanks have been inerted, they should be kept common with the inert gas main and the system pressurised with a minimum positive pressure. If individual tanks have to be segregated from a common line (e.g. for product integrity), the segregated tanks should be provided with an alternative means of maintaining an inert gas blanket.

7.1.6.2 Loading Cargo or Ballast into Tanks in an Inert Condition

When loading cargo or ballast, the inert gas plant, if applicable, should be shut down and the tanks vented through the appropriate venting system. On completion of loading or ballasting, and when all ullaging is completed, the tanks should be closed and the inert gas system restarted and re-pressurised. The system should then be shut down and all safety isolating valves secured.

Local regulations may prohibit venting after unloading.

7.1.6.3 Simultaneous Cargo and/or Ballast Operations

In the case of simultaneous loading and discharge operations involving cargo and/or ballast, venting to the atmosphere should be minimised, or possibly completely avoided. Depending on the relative pumping rates, pressure in the tanks may be increased or a vacuum drawn, and it may therefore be necessary to adjust the inert gas flow accordingly to maintain tank pressures within normal limits.

Particular attention should be paid to the potential impact of free surface effects when undertaking ballast operations during loading or unloading (see Section 11.2.2).

7.1.6.4 Vapour Balancing During Tanker-to-Tanker Transfers

Vapour balancing is used to avoid the release of any gases to the atmosphere through vents and to minimise the use of the inert gas systems when transferring cargo from tanker-to-tanker. As a minimum, the following recommendations should be followed:

Before commencing cargo transfer:

- Equipment should be provided on at least one of the tankers to enable the oxygen content of the vapour stream to be monitored.
- The oxygen content of the vapour space of each tank should be checked and confirmed to be less than 8% by volume.

During the cargo transfer:

- The inert gas system on the discharging tanker, if applicable, should be kept operational and on standby.
- Cargo tank pressure on both tankers should be monitored and each tanker advised of the other's pressure on a regular basis.
- No air should be allowed to enter the cargo tanks of the discharging tanker.
- Transfer operations should be suspended if the oxygen content of the vapour stream exceeds 8% by volume and should only be resumed once the oxygen content has been reduced to 8% or less by volume.
- The cargo transfer rate must not exceed the design rate for the vapour balancing system.

7.1.6.5 Loaded Passage

A positive pressure of inert gas should be maintained in the ullage space at all times during the loaded passage in order to prevent the possible ingress of air (see also Section 7.1.5.3). If the pressure falls below the established low pressure level or alarm level, it will be necessary to start the supply of inert gas to restore an adequate pressure in the system.

Loss of pressure is normally associated with leakages from tank openings and falling air and water temperatures. In the latter cases, it is all the more important to ensure that the tanks are gas tight. Gas leaks are usually easily detected by their noise and every effort must be made to eliminate leaks at tank hatches, ullage lids, tank washing machine openings, valves, etc.

Leaks that cannot be eliminated should be marked and recorded for sealing during the next ballast passage or at another suitable opportunity.

Certain oil products, principally aviation turbine kerosenes and diesel oil, can absorb oxygen during the refining and storage process. This oxygen can later be liberated into an oxygen deficient atmosphere such as the ullage space of an inerted cargo tank. Although the recorded incidence of oxygen liberation is low, cargo tank oxygen levels should be monitored so that any necessary precautionary measures can be taken prior to the commencement of discharge.

7.1.6.6 Discharge of Cargo from Tanks in an Inert Condition

The inert gas supply must be maintained throughout cargo discharge operations to prevent air entering the tanks. If a satisfactory positive inert gas pressure can be safely maintained without a continuous supply of inert gas, then it is acceptable to re-circulate or stop the supply of inert gas provided that the inert gas plant is kept ready for immediate operation.

Throughout the discharge of cargo, the oxygen content of the inert gas supply must be carefully monitored. Additionally, both the oxygen content and pressure of the inert gas main should be monitored during discharge. For action to be taken in the event of failure of the inert gas plant during discharge from inerted tanks, see Section 7.1.12.

If hand dipping of a tank is necessary, pressure may be reduced while dipping ports are open, but care must be taken not to allow a vacuum to develop since this would pull air into the tank. To prevent this, it may be necessary to reduce the cargo pumping rate, and discharge should be stopped immediately if there is a danger of the tanks coming under vacuum.

7.1.6.7 Ballast Passage

During a ballast passage, cargo tanks other than those required to be gas free should remain in the inert condition and under positive pressure to prevent ingress of air. Whenever pressure falls to the low pressure alarm level, the inert gas plant should be restarted to restore the pressure, with due attention being paid to the oxygen content of the inert gas delivered.

7.1.6.8 Static Electricity Precautions

In normal operations, the presence of inert gas prevents the existence of flammable gas mixtures inside cargo tanks. Hazards due to static electricity may arise however, mainly in the case of a failure of the inert gas system. To avoid these hazards, the following procedures are recommended:

- If the inert gas plant breaks down during discharge, operations should be suspended (see Section 7.1.12). If air has entered the tank, no dipping, ullaging, sampling or other equipment should be introduced into the tank until at least 30 minutes have elapsed since the injection of inert gas ceased. After this period, equipment may be introduced provided that all metallic components are securely earthed. This requirement for earthing should be applied until a period of five hours has elapsed since the injection of inert gas ceased.
- During any necessary re-inerting of a tank following a failure and repair of the inert gas system, or during initial inerting of a non-gas free tank, no dipping, ullaging, sampling or other equipment should be inserted until the tank is in an inert condition, as established by monitoring the gas vented from the tank being inerted. However, should it be necessary to introduce a gas sampling system into the tank to establish its condition, at least 30 minutes should elapse after stopping the injection of inert gas before inserting the sampling system. Metallic components of the sampling system should be electrically continuous and securely earthed. (See also Chapter 3 and Section 11.8.)

7.1.6.9 Tank Washing

Before each tank is washed, the oxygen content must be determined, both at a point 1 metre below the deck and at the middle level of the ullage space. At neither of these locations should the oxygen content exceed 8% by volume. The oxygen content and pressure of the inert gas being delivered during the washing process should be monitored.

If, during washing, the oxygen content in the tank exceeds 8% by volume or the pressure of the atmosphere in the tanks is no longer positive, washing must be stopped until satisfactory conditions are restored (see also Section 7.1.12).

7.1.6.10 Purging

When it is required to gas free a tank after washing, the tank should first be purged with inert gas to reduce the hydrocarbon content to 2% or less by volume. This is to ensure that, during the subsequent gas freeing operation, no portion of the tank atmosphere is brought within the flammable range.

The hydrocarbon content must be measured with an appropriate meter designed to measure the percentage of flammable gas in an oxygen deficient atmosphere. The usual flammable gas indicator is not suitable for this purpose (see Section 2.4).

If the dilution method of purging is used, it should be carried out with the inert gas system set for maximum capacity to give maximum turbulence within the tank. If the displacement method is used, the gas inlet velocity should be lower to prevent undue turbulence (see Section 7.1.4).

7.1.6.11 Gas Freeing

Before starting to gas free, the tank should be isolated from other tanks. When fixed fans connected to the cargo pipeline system are used to introduce air into the tank, the inert gas inlet should be isolated. If the inert gas system fan is employed to draw air into the tank, both the line back to the inert gas source and the inert gas inlet into each tank that is being kept inerted, should be isolated.

7.1.6.12 Preparation for Tank Entry

For general advice on entry into enclosed spaces see Chapter 10.

7.1.7 Precautions to be Taken to Avoid Health Hazards

7.1.7.1 Inert Gas on Deck

Certain wind conditions may bring vented gases back down onto the deck, even from specially designed vent outlets. Furthermore, if gases are vented at low level from cargo hatches, ullage ports or other tank apertures, the surrounding areas can contain levels of gases in harmful concentrations and may also be oxygen deficient. In these conditions, all non-essential work should cease and only essential personnel should remain on deck, taking all appropriate precautions.

When the last cargo carried contained hydrogen sulphide tests should also be made for hydrogen sulphide. If a level in excess of 5 ppm is detected, no personnel should be allowed to work on deck unless they are wearing suitable respiratory protection. (See Sections 2.3.6 and 11.1.9.) However, it should be noted that (inter)national legislation may be more stringent with regard to level detected and actions to take.

7.1.7.2 Ullaging and Inspection of Tanks from Cargo Hatches

The low oxygen content of inert gas can cause rapid asphyxiation. Care should therefore be taken to avoid standing in the path of vented gas (see Section 11.8.3).

7.1.7.3 Entry into Cargo Tanks

Entry into cargo tanks should be permitted only after they have been gas freed, as described in Sections 7.1.6.10 and 7.1.6.11. The safety precautions set out in Chapter 10 should be observed and consideration given to the carriage of a personal oxygen deficiency alarm. If the hydrocarbon and oxygen levels specified in Section 10.3 cannot be achieved, entry should be permitted only in exceptional circumstances and when there is no practicable alternative. A thorough risk assessment should be carried out and appropriate risk mitigation measures put in place. As a minimum, personnel must wear breathing apparatus under such circumstances (see Section 10.7 for further details).

Cargo and ballast tanks under inert gas should be identified by the use of warning signs placed adjacent to tank hatches. Examples of warning signs are given below.

7.1.7.4 N/A

7.1.8 Cargo Tank Protection Against Over/Under-Pressure

Serious incidents have occurred on oil tankers due to cargo tanks being subjected to extremes of over or under-pressure. It is essential that venting systems are thoroughly checked to ensure that they are correctly set for the intended operation. Once operations have started, further checks should be made for any abnormalities, such as unusual noises of vapour escaping under pressure or pressure/vacuum valves lifting. (See Section 7.2.2 for detailed information on the likely causes of tank over-pressurisation and under-pressurisation and the precautions to be taken to avoid them.)

Tanker's personnel should be provided with clear, unambiguous operating procedures for the proper management and control of the venting system and should have a full understanding of its capabilities.

7.1.8.1 N/A

7.1.8.2 Pressure/Vacuum Valves

These are designed to provide for the flow of the small volumes of tank atmosphere, caused by thermal variations, in a cargo tank. The pressure/vacuum valves should be kept in good working order by regular inspection and cleaning.

7.1.8.3 Full Flow Pressure/Vacuum Venting Arrangements

In inert gas systems fitted with tank isolating valves, secondary protection from over and under-pressurisation of the cargo tanks may be provided by using high velocity vent and vacuum valves as the full flow protection device. Where this is the case, particular attention should be paid to ensuring that the valves operate at the required pressure and vacuum settings. Planned maintenance procedures should be established to maintain and test these safety devices. See Section 7.2.1 for details.

7.1.8.4 Individual Tank Pressure Monitoring and Alarm Systems

In inert gas systems fitted with tank isolating valves, indication of the possible over and under-pressurisation of the cargo tank is provided by using individual tank pressure sensors connected to an alarm system. Where such systems are used, planned maintenance procedures should be established to maintain and test these sensors and to confirm that they are providing accurate readings.

7.1.9 N/A

7.1.10 N/A

7.1.11 Cold Weather Precautions for Inert Gas Systems

The inert gas system may be subject to operational faults when operating in extreme cold weather conditions.

7.1.11.1 Condensation in Inert Gas Piping

The piping system shall be so designed as to prevent accumulation of cargo or water in the pipeline under all normal conditions. However, in extreme cold conditions, residual water in the inert gas may freeze in the inert gas main. Operators should be aware of this and should therefore operate the system to minimise residual water and closely monitor the system's operation.

7.1.11.2 Control Air

Air operated control valves fitted to the inert gas system outside the engine room may not operate correctly if exposed to extremely low ambient temperatures if the control air has a high water vapour content.

Water separators in control air systems should be drained frequently and the control air dryers should be checked regularly for efficient operation.

7.1.11.3 Safety Devices

In extremely cold weather, ice may prevent the pressure/vacuum valves from operating and may block the flame screens on the pressure/vacuum valves and mast risers.

7.1.11.4 N/A

7.1.12 Inert Gas System Failure

Each tanker fitted with an inert gas system should be provided with detailed instruction manuals covering operations, safety and maintenance requirements, and the occupational health hazards relevant to the installed system and its application to the cargo tank system. The manual must include guidance on procedures to be followed in the event of a fault or failure of the inert gas system.

7.1.12.1 Action to be Taken on Failure of the Inert Gas System

In the event that the inert gas system fails to deliver the required quality and quantity of inert gas, or to maintain a positive pressure in the cargo tanks, action must be taken immediately to prevent any air being drawn into the tanks. All cargo and or ballast discharge from inerted tanks must be stopped, the inert gas deck isolating valve closed, the vent valve between it and the gas pressure regulating valve (if provided) opened, and immediate action taken to repair the inert gas system.

Tanker Masters are reminded that national and local regulations may require the failure of an inert gas system to be reported to the harbour authority, terminal operator and to the port and flag state administrations.

Section 11.8.3.1 gives guidance on special precautions to be taken in the event of a breakdown of the inert gas system when loading static accumulator oils into inerted cargo tanks.

7.1.12.2 N/A

7.1.12.3 Follow-up Action on Tankers with Coated Cargo Tanks

Tank coatings usually inhibit the formation of pyrophors in the cargo tanks of tankers. If it is considered totally impracticable to repair the inert gas system, discharge may therefore be resumed with the written agreement of all interested parties, provided that an external source of inert gas is provided or detailed procedures are established to ensure the safety of operations. The following precautions should be taken:

- The manual referred to in Section 7.1.12 above should be consulted.
- Devices to prevent the passage of flame or flame screens (as appropriate) are in place and are checked to ensure that they are in a satisfactory condition.
- Special attention should be given to ensuring that the amount of supplied inert gas is in balance with the discharge rate. In any case, a positive pressure inside the cargo tanks should be carefully regulated and monitored to prevent the potential opening of P/V valve(s) due to over or under pressure.
- No free fall of water or slops is permitted.

- No dipping, ullaging, sampling or other equipment is introduced into the tank unless essential for the safety of the operation. If it is necessary for such equipment to be introduced into the tank, it should be done after at least 30 minutes have elapsed since the injection of inert gas has ceased. (See Section 7.1.6.8 for static electricity precautions relating to inert gas and Section 11.8 for static electricity precautions when dipping, ullaging and sampling.)
- All metal components of any equipment to be introduced into the tank should be securely earthed. This restriction should be applied until a period of five hours has elapsed since the injection of inert gas has ceased.

7.1.13 Inert Gas Plant Repairs

As inert gas causes asphyxiation, great care must be taken to avoid the escape of inert gas into any enclosed or partly enclosed space.

Before opening the IG system, it should, if possible, be gas freed and any enclosed space in which the system is opened up should be ventilated to avoid any risk of oxygen deficiency.

Continuous positive ventilation must be maintained before and during the work.

7.2 Venting Systems

7.2.1 General

It is important that venting systems are operated to meet their design intent and are properly maintained.

To facilitate dilution of the flammable vapours into the atmosphere clear of the tanker's deck, venting systems allow vapours to be released either:

- At a low velocity, high above the deck from a vent riser, if present; or
- At high velocity from a high velocity valve closer to the deck. This facilitates dilution of the flammable vapours in the atmosphere clear of the tanker's deck.

Vents are sited in selected locations to prevent the accumulation of a flammable atmosphere on the tank deck or around any accommodation or engine room housings (see Section 2.5.4).

Tanker's personnel should be fully conversant with the operation and maintenance of all components of the venting system and should be aware of its limitations in order to prevent over or under-pressurisation of the tank(s) the system is serving (see Section 7.2.2 below).

7.2.2 Tank Over-Pressurisation and Under-Pressurisation

7.2.2.1 General

Over-pressurisation of cargo and ballast tanks is due to compression of the ullage space by the inadequate release of vapour or by the overfilling of the tank. Under-pressurisation can be caused by not allowing inert gas vapour or air into the tank when liquid is being discharged. The resulting over or under-pressure in the tank may result in serious deformation or catastrophic failure of the tank structure and its peripheral bulkheads, which can seriously affect the structural integrity of the tanker and could lead to fire, explosion and pollution. (See also Section 7.1.8.)

Structural damage can also be caused by not allowing inert gas, vapour or air into a tank whilst liquid is being discharged. The resulting under-pressure in the tank can result in deformation of the tanker's structure, which could result in fire, explosion or pollution.

To guard against over and under-pressurisation of tanks, owners/ operators should give serious consideration to fitting protection devices as follows:

- Individual pressure sensors with an alarm for each tank.
- Individual full flow pressure/release devices for each tank.

7.2.2.2 Tank Over-Pressurisation - Causes

Over-pressurisation usually occurs during ballasting, loading or internal transfer of cargo or ballast. It can be caused by one of the following:

- Overfilling the tank with liquid.
- Incorrect setting of the tank's vapour or inert gas isolating valve to the vapour line or inert gas line.
- Failure of an isolating valve to the vapour line or inert gas line.
- Failure or seizure of the venting valve or high velocity valve.
- A choked flame arrester or screen.
- Loading or ballasting the tank at a rate which exceeds the maximum venting capacity. (See Section 7.3.3.1.)
- Ice forming on the vents, or freezing of the pressure/vacuum or high velocity valves or ice on the surface of the ballast. (See Section 7.1.11.3.)
- Restriction in the vapour lines caused by wax, residues or scale.

7.2.2.3 Tank Over-Pressurisation - Precautions and Corrective Actions

The major safeguard against tank over-pressurisation is adherence to good operating procedures. These should include:

- On tankers without an inert gas system, a procedure to control the setting of the isolating valves on the vapour lines. The procedure should include a method of recording the current position of the isolating valves and a method for preventing them from being incorrectly or casually operated.

On tankers with inert gas systems where isolating valves are fitted to the branch line to each tank, it is recommended these valves be “provided with locking arrangements which shall be under the control of the responsible officer”. This statement should be taken to mean that the valves must be locked to prevent the possibility of any change in the valve setting without application to the Responsible Person to obtain the means of releasing the locking system on the valve.

- A method of recording the status of all valves in the cargo system and preventing them from being incorrectly or casually operated.
- A system for setting the valves in the correct position for the operation, and monitoring that they remain correctly set.
- Restricting the operation of the valves to authorised personnel only.

A process of regular maintenance, pre-operational testing and operator awareness of isolating valves, pressure/vacuum valves or high velocity vents can guard against failure during operation.

To protect against over-pressurisation through filling tanks too quickly, all tankers should have maximum filling rates for each individual tank and these should be available for reference by tanker’s personnel (see also Section 7.3.3). Tank vents should be checked to ensure that they are clear when the operation commences and, during freezing weather conditions, they should be inspected at regular intervals throughout the operation.

Where over-pressurisation of a tank or tanks is suspected, the situation requires appropriate corrective action. Loading of liquid should cease immediately.

7.2.2.4 Tank Under-Pressurisation - Causes

The causes of under-pressurisation are similar to those of over-pressurisation, namely:

- Incorrect setting of the tank’s isolating valve to the vapour line or inert gas line.
- Failure of an isolating valve on the vapour line or inert gas line.
- Failure in one of the inert gas supply valves.
- A choked flame screen on the vapour inlet line.
- Ice forming on the vents of ballast tanks during cold weather conditions.
- Unloading or deballasting the tank at a rate which exceeds the maximum venting capacity. (See Section 7.3.3.1.)

7.2.2.5 Tank Under-Pressurisation - Precautions and Corrective Actions

The precautions to guard against under-pressurisation are the same as those relating to over-pressurisation (see Section 7.2.2.3).

Where under-pressurisation of a tank or tanks is suspected, the situation requires corrective action. Discharge of liquid should cease immediately.

The methods of reducing a partial vacuum in a tank are either to raise the liquid level in the tank by running or pumping cargo or ballast into the affected tank from another tank, or to admit inert gas or air into the tank ullage space.

Cautions

- On a tanker with an inert gas system, there is a possibility that the quality of the inert gas may be compromised by air leaking past the seals in the tank access locations.
- Admitting inert gas at a high velocity to return the tank to a positive pressure could cause an electrostatic hazard.
- The precautions identified in Section 11.8.3 should be observed when measuring and sampling.
- On tankers without an inert gas system where it is not possible to reduce the partial vacuum by raising the liquid level, care should be exercised to ensure that the rush of air does not draw into the tank foreign objects with a possible ignition capability, e.g. rust.

7.3 Cargo and Ballast Systems

This Section describes the pipelines and pumps used for the loading and discharging of cargo and ballast. For the purposes of this Guide, the cargo heating system where fitted, is considered to be part of the cargo system.

7.3.1 Operation Manual

The tanker's crew should have access to up to date drawings and information on the cargo and ballast systems, and be provided with an Operation Manual describing how the systems should be operated.

The cargo system is one of the prime locations where breaching of cargo containment may occur and care should be taken not to over-pressurise sections of the system or to subject it to shock loads.

Operation of the cargo and ballast systems should only be carried out by personnel who are familiar with the correct operation of the pumps and associated systems, as described in the Operation Manual.

7.3.2 Cargo and Ballast System Integrity

The cargo and ballast systems are subjected to many conditions that may ultimately lead to failure resulting in loss of containment. These include the following:

- Turbulence in the flow, caused by poor pipeline design or excessive flow rates, and abrasion due to solid particulates in the cargo or ballast, can result in local erosion and pitting in the pipelines.
- The main fore and aft pipeline runs are usually located at the bottom of the tanks and on the main deck where the effects of hogging, sagging and the cyclical motions of a tanker in a seaway are most pronounced. These movements may result in damage to pipeline connections and bulkhead penetrations, and to local external damage at pipeline supports.

- Handling cargoes for which the system has not been designed. Particular care should be taken to prevent damage to cargo valve seals and pump seals that are not suited to aggressive cargoes
- Corrosion due to oxidation (rusting) when pipe systems are used for both water and oil service.

Preferential corrosion is found where internal coatings have failed and the corrosion is concentrated at a small location. This localised corrosion may be accelerated when water is allowed to lie in the bottom of pipelines, in association with sulphurous products from cargo, or if electrolytic corrosion cells are set up when pipeline connections are not securely bonded.

The presence of any latent defect in the cargo system will usually reveal itself when the system is pressurised during the discharge operation. It is good practice to pressure test cargo lines on a periodic basis, depending on the trade of the tanker. Although these pressure tests may provide an indication of the system's condition at the time of the test, they should not be considered a substitute for regular external inspection of the pipeline system and periodic internal inspections, particularly at known failure points, such as pump discharge bends and stub pipe connections.

The presence of any latent defect in the ballast system will usually reveal itself when the system is being used during the deballasting operation. The inability to fully discharge or drain ballast tanks may result in stability problems on double bottom or double hull tankers and, in some instances, could result in the tanker being in an overloaded condition.

7.3.3 Loading Rates

Tanker Masters should be provided with information on maximum permissible loading rates for each cargo tank and, where tanks have a combined venting system, for each group of cargo or ballast tanks. This requirement is aimed at ensuring that tanks are not over or under-pressurised by exceeding the capacity of the venting system, including any installed secondary venting arrangements.

Other considerations will also need to be taken into account when determining maximum loading rates for oil tankers. Precautions against static electricity hazards and pipeline erosion are described in Section 7.3.3.2.

7.3.3.1 Venting Arrangements

Venting capacity is based on the maximum volume of cargo entering a tank plus an approximate 25% margin to account for gas evolution (vapour growth).

When loading cargoes having a very high vapour pressure, gas evolution may be excessive and the allowance of 25% may prove to be insufficient. Actions to consider in order to ensure that the capacity of the venting system is not exceeded include a close monitoring of vapour line pressures on inerted tankers and limiting loading rates on non-inerted tankers throughout the loading period. It should be noted that the vapour growth increases when the liquid levels in the tank are above 80%. On inerted tankers, close attention should be given to monitoring inert gas system pressures, particularly when topping-off during loading operations.

When calculating loading rates, a maximum venting line velocity of 36 metres per second should be considered. This flow rate should be calculated for each diameter of line used. The volume throughputs may be aggregated where a common vent riser is used, but the maximum flow rate should not be exceeded anywhere within the system.

7.3.3.2 Flow Rates in Loading Lines

Depending upon the trade of the tanker, a number of loading rates need to be determined for each cargo tank. These loading rates will be dependent on the maximum flow rates in the cargo lines for different products and loading operations. In general, the following flow rates may need to be calculated for each section of the cargo system.

- A loading rate based on a linear velocity of 1 metre/second at the tank inlet for the initial loading rate for static accumulator cargoes into non-inerted tanks.
- A loading rate based on a linear velocity of 7 metres/second for bulk loading static accumulator cargoes into non-inerted tanks.
- A loading rate based on a linear velocity of 12 metres/second for loading non-static accumulator cargoes and also for loading static accumulator cargoes into inerted tanks. This velocity is provided for guidance only and is generally considered as a rate above which pipeline erosion may occur at pipe joints and bends.

Where a number of tanks are loaded through a common manifold, the maximum loading rate may be determined by the flow rate through the manifold or drop lines. For this reason, it is important that a constant check is kept on the number of cargo tank valves that are open simultaneously and that a suitable loading rate is determined for the particular loading operation.

7.3.3.3 Rate of Rise of Liquid in the Cargo Tank

Small tanks may have larger filling or suction valves than their size would normally require, to accommodate certain operations for which they may be used. In such instances, the limiting factors of the venting flow rate and the liquid line flow rate may not be suitable for assessing maximum loading rates. It is then also necessary to consider the rate of rise of the liquid in the tank if over-filling is to be avoided.

To exercise control over the rate of liquid rise in any cargo tank, it may be appropriate to set the loading rate to limit the rate of rise of liquid in a cargo tank to a maximum of 150 millimetre/minute.

7.3.3.4 Loading Rates for Ballast Tanks

Loading rates for ballast tanks should be determined in the same manner as for cargo tanks, taking into account the size of vent outlets using a vent velocity of 36 metres/second. Liquid filling rates can be calculated using a pipeline flow rate of 12 metres/second, and a similar rate of rise of liquid of 150 millimetre/minute should also be considered, where practical.

7.3.4 Monitoring of Void and Ballast Spaces

Void and ballast spaces located within the cargo tank block should be routinely monitored to check that no leakage has occurred from adjacent tanks. Monitoring should include regular atmosphere checks for flammable content and regular sounding/ullaging of the empty spaces (see also Section 11.8).

7.4 Power and Propulsion Systems

While a tanker is berthed at a terminal, its main engines, steering machinery and other equipment essential for manoeuvring should normally be kept in a condition that will permit the tanker to be moved away from the berth in the event of an emergency. See Section 22.7.1.1 for advice about planned immobilisation.

A terminal may allow some degree of immobilisation of the propulsion plant whilst the tanker is alongside. The tanker must, however, obtain permission from the Terminal Representative or local authority before taking any action affecting the readiness of the tanker to move under its own power.

Any unplanned condition that results in the loss of operational capability, particularly to any safety system, should be immediately communicated to the terminal.

7.5 N/A

7.6 N/A