Chapter 11

SHIPBOARD OPERATIONS

This Chapter provides information on the full range of shipboard operations, including loading and discharging of cargo, hose clearing, tank cleaning and gas freeing, ballasting, tanker-to-tanker transfers and mooring.

The Chapter also includes information on the safe handling of particular cargoes, such as static accumulator oils, those having a high vapour pressure and those containing hydrogen sulphide.

Other operations that are addressed include the use of vapour emission control systems and efficient stripping.

11.1 Cargo Operations

11.1.1 General

All cargo operations should be carefully planned and documented well in advance of their execution. The details of the plans should be discussed with all personnel, both on the tanker and at the terminal. Plans may need to be modified following consultation with the terminal and following changing circumstances, either on board or ashore. Any changes should be formally recorded and brought to the attention of all personnel involved with the operation. Chapter 22 contains details of cargo plans and communications regarding them.

11.1.2 Setting of Lines and Valves

Before commencement of any loading or discharging operation, the tanker's cargo pipelines and valves should be set as per the required loading or discharging plan by a Responsible Person and checked, independently, by other personnel.

11.1.3 Valve Operation

To avoid pressure surges, valves at the downstream end of a pipeline system should not be closed against the flow of liquid, except in an emergency. This should be stressed to all personnel responsible for cargo handling operations, both on the tanker and at the terminal. (See Section 11.1.4 below.)

In general, where pumps are used for cargo transfer, all valves in the transfer system (both tanker and shore) should be open before pumping begins, although the discharge valve of a centrifugal pump may be kept closed until the pump is up to speed and the valve then opened slowly. In the case of tankers loading by gravity, the final valve to be opened should be that at the shore tank end of the system.

If the flow is to be diverted from one tank to another, either the valve on the second tank should be opened before the valve on the first tank is closed, or pumping should be stopped while the change is being made. Valves that control liquid flow should be closed slowly. The time taken for power operated valves to move from open to closed, and from closed to open, should be checked regularly at their normal operating temperatures.

11.1.4 Pressure Surges

The incorrect operation of pumps and valves can produce pressure surges in a pipeline system.

These surges may be sufficiently severe to damage the pipeline, hoses or metal arms. One of the most vulnerable parts of the system is the tanker-to-shore connection. Pressure surges are produced upstream of a closing valve and may become excessive if the valve is closed too quickly. They are more likely to be severe where long pipelines and high flow rates are involved.

Where the risk of pressure surges exists, information should be exchanged and written agreement reached between the tanker and the terminal concerning the control of flow rates, the rate of valve closure, and pump speeds. This should include the closure period of remotely controlled and automatic shutdown valves. The agreement should be included in the operational plan. (Generation of pressure surges in pipelines is discussed in more detail in Section 16.8.)

11.1.5 Butterfly and Non-Return (Check) Valves

Butterfly and pinned back non-return valves in tanker and shore cargo systems have been known to slam shut when cargo is flowing through them at high rates, thereby setting up very large surge pressures which can cause line, hose or metal arm failures and even structural damage to jetties. These failures are usually due to the valve disc not being completely parallel to, or fully withdrawn from, the flow when in the open position. This can create a closing force that may shear either the valve spindle, in the case of butterfly valves, or the hold open pin, in the case of pinned back non-return valves. It is therefore important to check that all such valves are fully open when they are passing cargo or ballast.

11.1.6 Loading Procedures

11.1.6.1 General

The responsibility for safe cargo handling operations is shared between the tanker and the terminal and rests jointly with the tanker's captain and the Terminal Representative. The manner in which the responsibility is shared should therefore be agreed between them so as to ensure that all aspects of the operations are covered.

11.1.6.2 Joint Agreement on Readiness to Load

Before starting to load cargo, the Responsible Person and the Terminal Representative should formally agree that both the tanker and the terminal are ready to do so safely.

11.1.6.3 Emergency Shutdown System

An emergency shutdown procedure, and alarm, should be agreed between the tanker and the terminal and recorded on an appropriate form.

The agreement should designate those circumstances in which operations must be stopped immediately.

Due regard should be given to the possible dangers of a pressure surge associated with any emergency shutdown procedure (see Section 16.8).

Tankers can be equipped with following emergency shut down systems:

During loading:

If provided with a shut down system, cargo tank high level sensors are installed in each cargo tank. When activated, they should give a visual and audible alarm on board and at the same time actuate an electrical contact which in the form of a binary signal interrupts the electric current loop provided and fed by the shore facility, thus initiating measures at the shore facility against overflowing during loading operations.

The signal should be transmitted to the shore facility via a watertight two-pin plug of a connector device in accordance with (e.g.) standard EN 60309-2 : 1999 for direct current of 40 to 50 volts, identification colour white, position of the nose 10 h.

The plug should be permanently fitted to the tanker close to the manifold position.

The high level sensor should also have the capability of shutting down the tanker’s pumps when discharging.

It is recommended that the high level sensor is independent of the level alarm device.

During discharging:

During discharging by means of the on-board pump, a shut down system will make it possible for the shore facility to shut down the tanker’s pumps. For this purpose, an independent intrinsically safe circuit, fed by the vessel, is switched off by the shore facility by means of an electrical contact.

It should be possible for the binary signal of the shore facility to be transmitted via a watertight two-pole socket or a connector device in accordance with (e.g.) standard EN 60309-2 : 1999, for direct current of 40 to 50 volts, identification colour white, position of the nose 10 h.

This socket should be permanently fitted to the vessel close to the shore connections of the transfer system.

11.1.6.4 Supervision

The following safeguards should be maintained throughout loading:

- A Responsible Person should be on watch and sufficient crew should be on board to deal with the operation and security of the tanker. A continuous watch of the tank deck should be maintained.
- The agreed tanker-to-shore communications system should be maintained in good working order.
- At the commencement of loading, and at each change of watch or shift, the Responsible Person and the Terminal Representative should each confirm that the communications system for the control of operations is understood by them and by personnel on watch and on duty.
- The standby requirements for the normal stopping of pumps on completion of cargo transfer, and the emergency stop system for both the tanker and terminal, should be fully understood by all personnel concerned.

11.1.6.5 Inert Gas Procedures

Prior to the commencement of loading, the inert gas plant, if installed and applicable, should be closed down and the inert gas pressure in the tanks to be loaded reduced.

11.1.6.6 Loading

A: closed loading

For effective closed loading, cargo should be loaded with the ullage, sounding and sighting ports securely closed. The gas displaced by the incoming cargo should be vented to the atmosphere through high velocity valves to ensure that the gases are taken clear of the cargo deck. Devices fitted to vent stacks to prevent the passage of flames should be regularly checked to confirm they are clean, in good condition and correctly installed.

For some products, local, national or international legislation may prohibit the venting of cargo vapours to the atmosphere. If this is the case, closed loading has to employed in conjunction with vapour balancing with the loading terminal. In this case, the Terminal must ensure that the maximum vapour pressure inside the cargo tank of the tanker will not reach the setting of the high pressure velocity valve at any stage of the operation.

In order to undertake closed loading, the vessel should be equipped with ullaging equipment that allows the tank contents to be monitored without opening tank apertures. (Closed gauging and sampling is discussed in detail in Section 11.8.1.)

There is a risk of overfilling a cargo tank when loading under normal closed conditions. Due to the reliance placed on closed gauging systems, it is important that they are fully operational and that backup is provided in the form of an independent overfill alarm arrangement. The alarm should provide audible and visual indication and should be set at a level that will enable operations to be shut down prior to the tank being overfilled. Under normal operations, the cargo tank should not be filled higher than the level at which the overfill alarm is set.

Individual overfill alarms should be tested at the tank to ensure their proper operation prior to commencing loading, unless the system is provided with an electronic self-testing capability which monitors the condition of the alarm circuitry and sensor and confirms the instrument set point.

If, after testing the overfill alarms, it appears the overfill alarm is not working properly loading should not be commenced.

On vessels without inert gas systems, this equipment should comply with the precautions highlighted in Section 11.8.2.

Vessels operating with inert gas are considered always to be capable of closed loading.

B: Open loading

For some products, local, national or international legislation may allow displaced gas to be vented through cargo tank sighting ports, provided they are protected with a flame screen, which is a good fit and is clean and in good condition. In all cases it must be ensured that the gases are taken clear of the cargo deck.

It is not recommended that open loading is routinely employed when handling volatile products generating flammable vapours.

If it is expected that flammable cargo vapours are accumulating on the cargo deck, loading must be stopped immediately.

11.1.6.7 Commencement of Loading Alongside a Terminal

When all necessary terminal and tanker valves in the loading system are open, and the tanker has signified its readiness, loading can commence. The initial flow should be at a slow rate. Whenever possible, this should be by gravity and to a single tank, with the shore pumps not being started until the system has been checked and the tanker advises that cargo is being received in the correct tank(s). When the pumps have been started, the tanker/shore connections should be checked for tightness until the agreed flow rate or pressure has been reached.

11.1.6.8 N/A

11.1.6.9 N/A

11.1.6.10 N/A

11.1.6.11 Loading Through Pumproom Lines

Due to the increased risk of leakage in the pumproom, it is not good practice to load cargo via pumproom lines. Whenever possible, cargo should be loaded through drop lines within the cargo tank area, with all pumproom valves closed.

11.1.6.12 Cargo Sampling on Commencement of Loading

Where facilities exist, a sample of the cargo should be taken as soon after the commencement of loading as possible. This will allow the product's visual quality to be checked to ensure the correct grade is being loaded. This should be done before opening up subsequent tanks for loading. (See Appendix 7.)

On non-inerted tankers loading static accumulator cargoes, precautions against static electricity hazards should be observed when taking the sample. (See Section 11.1.7.)

11.1.6.13 Periodic Checks During Loading

Throughout loading, the tanker should monitor and regularly check all full and empty tanks to confirm that cargo is only entering the designated cargo tanks and that there is no escape of cargo into pumprooms or cofferdams.

The tanker should check tank ullages/innages at least hourly and calculate a loading rate. Cargo figures and rates should be compared with shore figures to identify any discrepancy.

On tankers where stress considerations may be critical, hourly checks should include, where possible, the observation and recording of the shear forces, bending moments, draught and trim and any other relevant stability requirements particular to the tanker. This information should be checked against the required loading plan to confirm that all safe limits are adhered to and that the loading sequence can be followed, or amended, as necessary. Any discrepancies should be reported immediately to the Responsible Person.

Any unexplained drop in pressures, or any marked discrepancy between tanker and terminal estimates of quantities transferred, could indicate pipeline or hose leaks, and require that cargo operations be stopped until investigations have been made.

The tanker should carry out frequent inspections of the cargo deck and pumproom to check for any leaks. Overside areas should likewise be checked regularly. During darkness, where safe and practical, the water around the vessel should be illuminated.

11.1.6.14 Fluctuation of Loading Rate

The loading rate should not be substantially changed without informing the tanker.

11.1.6.15 Cessation of Pumping by the Terminal

Many terminals require a standby period for stopping pumps and this should be understood and noted as discussed under item 24 of the guidelines for completing the Tanker/Shore Safety Check-List before loading commences (see Section 26.4).

11.1.6.16 Topping-Off on board the Tanker

The tanker should advise the terminal when tanks are to be topped-off and request the terminal, in adequate time, to reduce the loading rate sufficiently to permit effective control of the flow on board the tanker. After topping-off individual tanks, master valves should be closed, where possible, to provide two-valve segregation of loaded tanks. The ullages/innages of topped-off tanks should be checked from time to time to ensure that overflows do not occur as a result of leaking valves or incorrect operations. In general, the tanker should give the terminal notice when the last cargo tank will be loaded.

The number of valves to be closed during the topping-off period should be reduced to a minimum.

The tanker should not close all its valves against the flow of oil.

Where possible, the completion of loading should be done by gravity. If pumps have to be used to the end, their delivery rate during the 'standby' time should be regulated so that shore control valves can be closed as soon as requested by the tanker. Shore control valves should be closed before the tanker's valves.

11.1.6.17 Checks After Loading

After the completion of loading, a Responsible Person should check that all valves in the cargo system are closed, that all appropriate tank openings are closed and that pressure/vacuum relief valves are correctly set.

11.1.7 Loading Static Accumulator Oils

11.1.7.1 General

Petroleum distillates often have electrical conductivities of less than 50 picoSiemens/metre (pS/m) and thus fall into the category of static accumulators.

Since the conductivities of distillates are not normally known, they should all be treated as static accumulators unless they contain an antistatic additive, which raises the conductivity of the product above 50 pS/m. (See Section 11.1.7.9 regarding cautions on the effectiveness of antistatic additives.) A static accumulator may carry sufficient charge to constitute an incendive ignition hazard during loading into the tank, and for up to 30 minutes after completion of loading.

Bonding (see Section 3.2.2) is an essential precaution for preventing electrostatic charge accumulation and its importance cannot be over-emphasised. However, while bonding assists relaxation, it does not prevent accumulation and the production of hazardous voltages. Bonding therefore should not be seen as a universal remedy for eliminating electrostatic hazards. This Section describes methods for controlling electrostatic generation, by preventing charge separation, which is another essential precaution (see Section 3.1.2).

11.1.7.2 Controlling Electrostatic Generation

Electrostatic discharge has long been known as a hazard associated with the handling of flammable products.

FAILURE TO FOLLOW THE GUIDANCE GIVEN IN THIS SECTION WILL LEAD TO THE HAZARDOUS CONDITIONS REQUIRED FOR ELECTROSTATIC IGNITION ACCIDENTS TO OCCUR.

When a tank is known to be in an inert condition, no antistatic precautions are necessary.

If a flammable atmosphere is possible within the tank, then specific precautions will be required with regard to maximum flow rates and safe ullaging/innaging, sampling and gauging procedures when handling static accumulator products.

Mixtures of oil and water constitute a potent source of static electricity. Extra care should therefore be taken to prevent excess water and unnecessary mixing.

11.1.7.3 During Initial Filling of a Tank

The generally accepted method for controlling electrostatic generation in the initial stages of loading is to restrict the velocity of oil entering the tank to 1 metre/second until the tank inlet is well covered and all splashing and surface turbulence in the tank has ceased.

The 1 metre/second limit applies in the branch line to each individual cargo tank and should be determined at the smallest cross-sectional area including valves or other piping restrictions in the last section before the tank's loading inlet.

Diameter	Approx. flow rate (m^3/h)
3" / 80 mm	17
4" / 100 mm	29
6" / 150 mm	67
8" / 200 mm	116
10" / 250 mm	183
12" / 300 mm	262

Table 11.1 - Rates corresponding to 1 metre/second

* Note that the diameters given are nominal diameters,
which are not necessarily the same as the actual internal diameters.

Table 11.1 shows approximate volumetric flow rates that correspond to a linear velocity of 1 metre/second in piping of various diameters.

The reasons for such a low linear velocity as 1 metre/second are threefold:

1. At the beginning of filling a tank, there is the greatest likelihood of water being mixed with the oil entering the tank. Mixtures of oil and water constitute a most potent source of static electricity.
2. A low product velocity at the tank inlet minimises turbulence and splashing as oil enters the tank. This helps reduce the generation of static electricity and also reduces the dispersal of any water present, so that it quickly settles out to the bottom of the tank where it can lie relatively undisturbed when the loading rate is subsequently increased.

3. A low product velocity at the tank inlet minimises the formation of mists that may accumulate a charge, even if the oil is not considered to be a static accumulator. This is because the mist droplets are separated by air, which is an insulator. A mist can result in a flammable atmosphere even if the liquid has a high flashpoint and is not normally capable of producing a flammable atmosphere.

Figure 11.1 provides a flow chart to assist in deciding the precautions that need to be taken when loading static accumulator cargoes.

11.1.7.4 Minimising Hazards From Water

Because mixtures of oil and water constitute a potent source of static electricity, care should be taken to prevent excess water from operations such as water washing, ballasting or line flushing entering a tank that contains or will contain a static accumulator oil. For example, cargo tanks and lines that have been flushed with water should be drained before loading and water should not be permitted to accumulate in tanks. Lines should not be displaced with water back into a tank containing a static accumulator cargo.

Any water remaining within the shore or tanker pipeline system after the initial filling period might be flushed into the cargo tank when loading at the maximum rate. (The minimum product velocity for flushing water out of pipelines effectively is 1 metre per second.) The resulting mixing and agitating of the oil and water in the tank will increase the generation of static charge to a level that is unsafe in a flammable atmosphere. Before increasing to the bulk loading rate, it is therefore necessary to ensure that, so far as practicable, all excess water that may have been lying in low spots in the pipelines has been flushed out of the system either before loading commenced or during the initial filling of the tank (see Section 11.1.7.3 for advice on the process).

Under normal circumstances, and provided that the aforementioned precautions to prevent excess water have been taken, the amount of water still present in the system after the initial filling period will be insufficient to increase static separation when the loading rate is increased. However, if there is reason to believe that excess water may still be present in the shore pipeline, then the recommended action is to:

- Keep the product velocity in the shore line below 1 metre per second throughout loading to avoid flushing the water into the tanker’s tank(s); or
- Keep the product velocity at the tank inlet(s) below 1 metre per second throughout loading to avoid turbulence in the tank(s).

Whichever option gives the higher loading rate consistent with safety should be used.

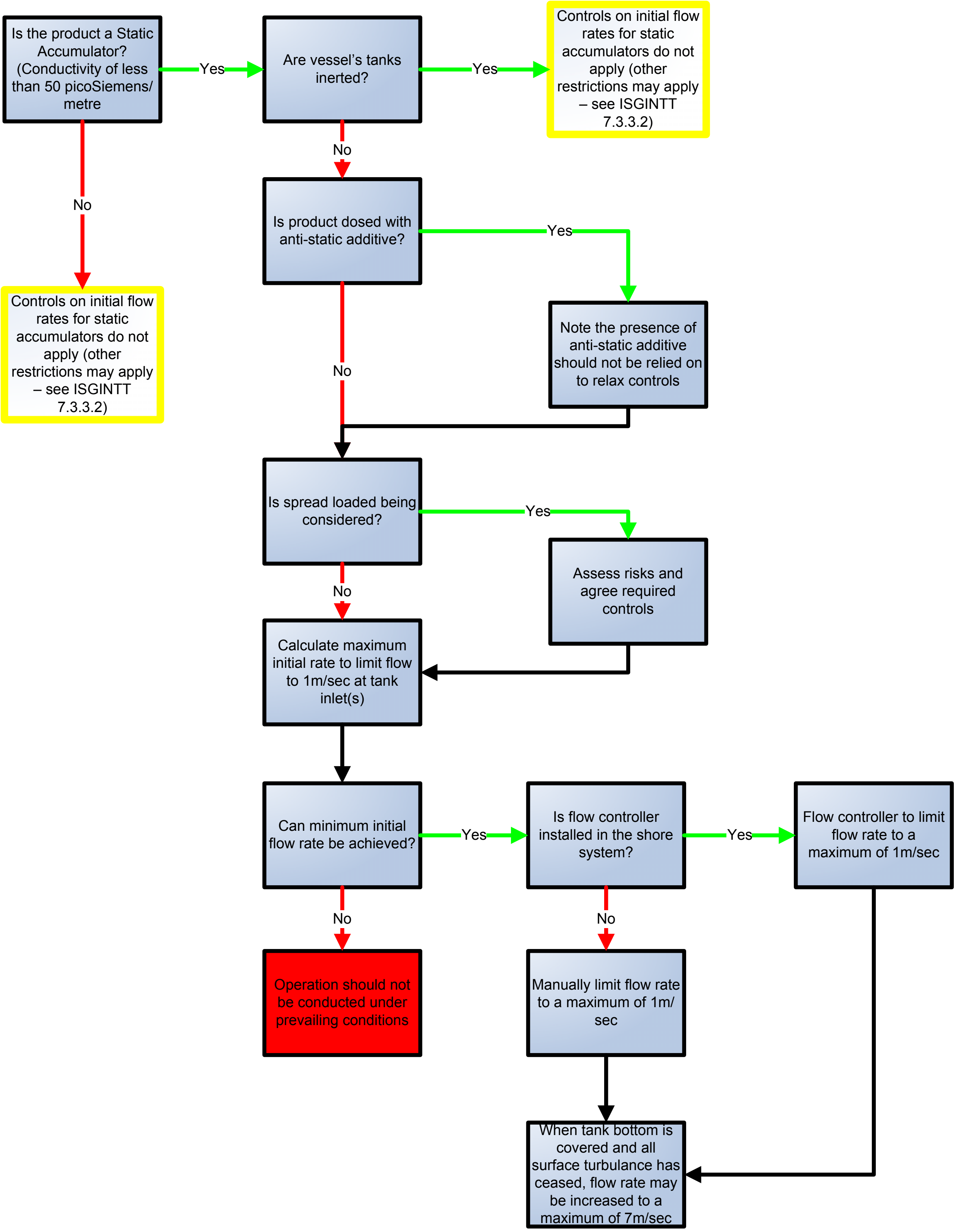


Figure 11.1 - The control hazards associated with the initial loading of static accumulator cargoes

11.1.7.5 Examples

Initial Loading Phase

Figure 11.2 shows the pipeline arrangements for a vessel loading a static accumulator product at a berth. The table defines the pipeline sizes and the volumetric flow rates at a velocity of 1 metre/second. For initial loading to two cargo tanks, the limitation will allow a loading rate of 366 m^3/hour to be requested in the example given. (See also Table 3.2.)

If the shore line were 510 mm diameter and water was suspected of being in the line, the vessel would need to load 4 tanks simultaneously to ensure the water content could be safely removed and an initial loading rate of 676 m^3/hour should be requested. This will allow the water to be cleared from the shore line whilst keeping the velocity at the tank inlets below 1 metre/second.

11.1.7.6 Practical Considerations

In practice, not all terminals are equipped with flow control devices to regulate the loading rate and therefore may not be able to establish a loading rate to one cargo tank equivalent to a velocity of 1 metre/second. Some terminals achieve, or try to achieve, a low loading rate by commencing loading by gravity flow alone.

11.1.7.7 Spread Loading

Spread loading is the practice of commencing loading via a single shore line to several of the tanker's cargo tanks simultaneously where it is necessary to mitigate a terminal's lack of flow control. The aim of this practice is to achieve a loading rate that will give a maximum velocity at each of the tank inlets of 1 metre per second.

Spread loading presents a number of potentially significant static generation risks that should be assessed and properly managed if this practice is to be used safely. For example:

- Uneven flow in the tanker's cargo lines can create a backflow of vapour (gas or air) from other open tanks to the tank that is receiving product. This eductor effect will create a two-phase mixture of product and vapour that will result in increased turbulence and mist formation within the tank.
- The possibility of exceeding 1 metre/second product velocity at one tank inlet due to uneven distribution of product between the open tanks.

The following precautions should be taken to manage the risks associated with the spread loading of static accumulator cargoes:

- The overall loading rate should be selected so as to ensure a maximum product velocity of 1 metre/second into any one tank, assuming even distribution of cargo between tanks.
- Possible different flow distributions into different tanks should be considered and best efforts should be made to ensure equal flow distribution between cargo tanks.
- Not more than four cargo tanks should be loaded at any one time.

- Tank inlet valves should not be used to control cargo flow in the initial loading phase. Their use will reduce the cross-sectional area of the inlet, resulting in increased tank inlet velocity and greater turbulence and mist formation. If it is necessary to throttle valves in order to control flow rate, this should be done upstream of the tank valves.
- The management of the risks inherent in spread loading will require a risk assessment process to be followed. The risk assessment should consider:
  - The terminal's piping configuration, including flow control capability.
  - The tanker's piping configuration.
  - Tanker's cargo tank condition, for example previous cargo, tank atmosphere and physical condition (such as the integrity of heating coils).
  - The product to be loaded and the potential for generating a flammable atmosphere.

Spread loading should only be carried out when the tanker and the terminal are both satisfied that the risks have been identified and that appropriate risk response measures have been taken to minimise, avoid or eliminate them.

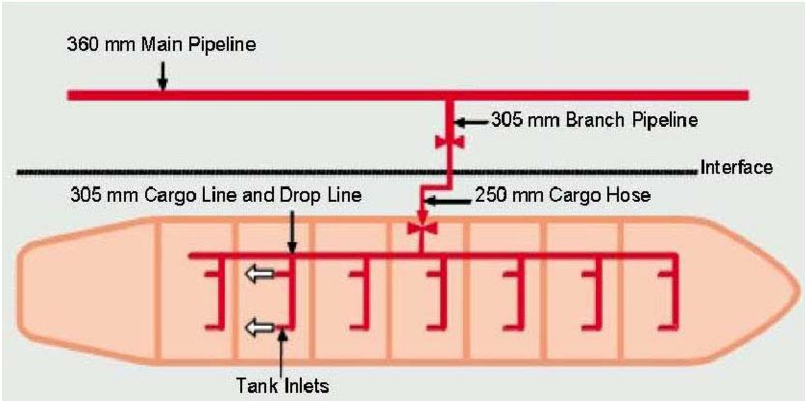
11.1.7.8 Limitation of Product Velocity (Loading Rates) After the Initial Filling Period (Bulk Loading)

After the initial filling period, electrostatic generating processes such as mist formation and stirring up tank bottoms by turbulence are suppressed by the rising liquid level, and the concern changes to ensuring that excessive charge does not accumulate on the bulk liquid. This is also done by controlling the flow rate, but the maximum acceptable velocity is higher than for the initial filling period, provided the product is 'clean' as defined in Section 3.2.1.

Two-phase flows (i.e. through oil and water) give higher charging and may require that flow rate limitations have to be imposed throughout loading (see Section 11.1.7.4).

When the tank bottom is covered, after all splashing and surface turbulence has ceased and after all water has been cleared from the line, the rate can be increased to the lesser of the tanker or shore pipeline and pumping system maximum flow rates consistent with proper control of the system. Established practice and experience indicate that hazardous potentials do not occur if the product velocity is less than 7 metres/second. Some national Codes of Practice also suggest 7 metres/second as a maximum value. However, a number of industry documents acknowledge that 7 metres/second is a precautionary limit and imply that higher speeds may be safe, without specifying what the real limits are. (All the empirical relationships for safe loading have been derived on the basis of experiments limited to a maximum flow of 7metres/second.)

Only where well documented experience indicates that higher velocities can be safely used should be limit of 7 metres/second be replaced by an appropriate higher value.



Determining the Initial Loading Rate

Line	Diameter	Flow Rate (m^3/h) at 1 m/s Flow
Main Shore Pipeline	360	320
Shore Branch Line	305	362
Hose	250	183
Ship's Cargo and Drop Line	305	262
Tank Inlets	250	183 x 2 = 366

Therefore, an initial loading rate of not more than 366 m^3/h should be requested for loading to two tanks simultaneously. This will result in the shore line flowing at more than 1 metre/second which would clear any water lying in the line whilst the velocity at the tank inlets is 1 metre/second.

Determining the Maximum Bulk Loading Rate

The smallest pipeline in the loading system is the cargo hose with a diameter of 250 mm. A maximum linear flow velocity at 7 metres/seconds gives a maximum volumetric rate of 1281 m^3/h.

Figure 11.2 – Determining loading rates for static accumulator cargoes

Operators should be aware that the maximum velocity might not occur at the minimum diameter of the pipeline when the pipeline feeds multiple branch lines. Such configurations would be where a pipeline feeds multiple loading arms or hoses or, on a tanker, where a main cargo line feeds multiple drop lines or tank inlets. For example, where a 150 mm diameter pipeline feeds three 100 mm branch lines, the highest velocity will be in the 150 mm pipeline, not in the branch lines.

Figure 11.2 also shows that the smallest diameter section of piping in the system is the cargo hose, which has a diameter of 250 mm. If a loading velocity of 7 metres/second is acceptable to the tanker and shore, a maximum loading rate of 1,281 m^3/hour should be requested[1].

11.1.7.9 Antistatic Additives

If the oil product contains an effective antistatic additive, it is no longer a static accumulator. Although in theory this means that the precautions applicable to a static accumulator can be relaxed, it is still advisable to adhere to them in practice. The effectiveness of antistatic additives is dependent upon the length of time since the additive was introduced to the product, satisfactory product mixing, other contamination and the ambient temperature. It can never be certain that the product's conductivity is above 50 pS/m, unless it is continuously measured.

11.1.7.10 Loading of Different Grades of Product into Unclean Tanks (Switch Loading)

Switch loading is the practice of loading a low volatility liquid into a tank that previously contained a high volatility liquid. The residues of the volatile liquid can produce a flammable atmosphere even when the atmosphere produced by the low volatility liquid alone is non-flammable.

In this circumstance, it is important to reduce charge generation by avoiding splash loading and other charge generating mechanisms such as filters in the pipeline. The flow rate should be restricted as per Sections 11.1.7.3 and 11.1.7.8 during the initial and bulk loading periods respectively.

Product specification and quality requirements normally mean that switch loading does not arise on tankers handling finished products. This situation however may be encountered when handling cargo slops or off-grade product for which no tank preparation may be required as the grades can be mixed without a risk of product contamination. In this situation, the precautions outlined for switch loading described above should be implemented.

11.1.8 Loading Very High Vapour Pressure Cargoes

Cargoes with high vapour pressure introduce problems of cargo loss due to excessive vapour release and can also cause discharge difficulties due to gassing-up of cargo pumps. Special precautions may therefore be necessary. These include:

- Permitting only closed loading methods (see Section 11.1.6.6).
- Avoiding loading when the wind speed is less than 5 knots.
- Using very low initial flow rates into tanks.
- Using very low topping-off rates.
- Avoiding a partial vacuum in the loading line.

[1] With regard to the requested maximum loading rate it is also very important to check the maximum venting capacity of the tanker. This maximum venting capacity may be given by a calculation of the Classification Society. See also 7.3.3.1.

- Avoiding loading oil that is hot due to lying in shore lines exposed to the sun. If this is unavoidable, this product should be loaded to tanks that vent well clear of the superstructure (e.g. forward tanks).
- Providing additional supervision to see that gas dispersion is monitored and to ensure compliance with all safety requirements.
- Monitoring inert gas main pressure where this gives an indication of the cargo tank pressure.

To prevent gassing-up of cargo pumps, the expected True Vapour Pressure (TVP) of the cargo at the discharge port should be taken into consideration.

11.1.9 Loading Cargoes Containing Hydrogen Sulphide (H_2S)

11.1.9.1 General

The number of cargoes containing significant quantities of Hydrogen Sulphide (H_2S) is increasing. In addition, levels of H_2S contained within the cargoes are also increasing. Guidance on H_2S toxicity is to be found in Section 2.3.6 and guidelines on gas measurement and gas testing are to be found in Sections 2.4 and 8.2.

This Section provides practical guidance on operational measures that can be taken to minimise the risks associated with loading cargoes containing H_2S, commonly referred to as ‘sour’ cargoes.

11.1.9.2 Precautions when Loading Cargoes Containing H_2S

Before loading, the tanker’s crew (Responsible Person/tanker captain) should be advised by the terminal (verbally and in writing) if any cargo to be loaded is suspected to contain H_2S.

In addition, it is to be considered to be best practice always to load cargoes which are suspected to contain H_2S, under fully closed conditions, preferably in combination with vapour balancing.

The following precautions should be considered when preparing to load sour cargoes:

- Before arriving at the loading port, ensure that the cargo system is free of leaks from the cargo piping, tank fittings and the venting system.
- Check that all doors and ports can be securely closed to prevent any small gas ingress.

When loading a cargo containing H_2S:

- A safety plan should be produced for the loading operation which should include guidance on the venting procedure, monitoring for vapour, personal protective equipment to be used, accommodation and engine room ventilation arrangements and emergency measures that have been put in place.
- Closed loading procedures described in Section 11.1.6.6 should be used.
- Venting to the atmosphere at a relatively low tank pressure should be avoided, particularly in calm wind conditions.

- If the cargo is loaded without any means of vapour return connected to the terminal, cargo loading should be stopped if there is no wind to disperse the vapours or if the wind direction takes cargo vapours towards the accommodation.
- Only personnel actively engaged in tanker security and cargo handling should be permitted on open decks. Regular maintenance on deck should be limited or postponed until after the end of cargo operations. Visitors should be escorted to and from the accommodation spaces and briefed on the hazards of the cargo and emergency procedures.
- H_2S is very corrosive and mechanical gauges are therefore more likely to fail than usual. Their operational condition should be checked frequently. In the event of a gauge failure, repairs should not be undertaken unless an appropriate permit has been issued and all necessary precautions observed.
- H_2S is heavier than air. In tanker-to-tanker transfers, particular attention should therefore be given to the difference in freeboards of the tankers and the possibility of vapour not being dispersed freely. Vent velocities should be kept high on the receiving tanker and the tankers should be turned so as to allow the wind to carry vapours away from the accommodation spaces.

11.1.10 Loading Cargoes Containing Benzene

Guidance on benzene toxicity is to be found in Section 2.3.5. Cargoes containing benzene should be loaded using the closed operation procedures described in Section 11.1.6.6 as this will significantly reduce exposure to benzene vapour. Where a Vapour Emission Control System (VECS) is available ashore, it should be used (see Section 11.1.13).

Operators should adopt procedures to verify the effectiveness of the closed loading system in reducing the concentrations of benzene vapours around the working deck. This will involve surveys to determine the potential for exposure of personnel to benzene vapour during all operations such as loading, discharging, sampling, hose handling, tank cleaning, gas freeing and gauging of cargoes containing benzene. These surveys should also be carried out to ascertain vapour concentrations when tank cleaning, venting or ballasting tanks whose previous cargo contained benzene.

Spot checks on vapour concentrations, using detector tubes and pumps, toxic analysers or an electronic detector tube, should be carried out by tanker's personnel to ascertain if TLV-TWAs are being exceeded and therefore whether personal protective equipment should be worn.

In addition to the above, the precautions described in Section 11.8.4 should also be taken in order to minimise exposure when measuring and sampling cargoes containing benzene.

11.1.11 Loading Heated Products

Unless the tanker is specially designed for carrying very hot cargoes, such as a bitumen carrier, cargo heated to a high temperature can damage a tanker's structure, the cargo tank coatings, and equipment such as valves, pumps and gaskets.

Some classification societies have rules regarding the maximum temperature at which cargo may be loaded and tanker captains should consult the tanker operator whenever the cargo to be loaded has a temperature in excess of 60ºC.

The following precautions may help to alleviate the effects of loading a hot cargo:

- Spreading the cargo throughout the tanker as evenly as possible to dissipate excess heat and to avoid local heat stress.
- Adjusting the loading rate in an attempt to achieve a more reasonable temperature.
- Taking great care to ensure that tanks and pipelines are completely free of water before receiving any cargo that has a temperature above the boiling point of water.

11.1.12 Loading Over the Top (sometimes known as ‘Loading Overall’)

Hazardous cargoes should never be loaded over the top.
However, if for any reason, loading over the top is necessary, the following guidance should be considered.

Volatile petroleum, or non-volatile petroleum having a temperature higher than its flashpoint minus 10ºC, should never be loaded over the top into a non-gas free tank.

There may be specific port or terminal regulations relating to loading over the top.

Non-volatile petroleum having a temperature lower than its flashpoint minus 10ºC may be loaded over the top in the following circumstances:

- If the tank concerned is gas free, provided no contamination by volatile petroleum can occur.
- If prior agreement is reached between the Tanker Captain and the Terminal Representative.

The free end of the hose should be lashed inside the tank coaming to prevent movement.

Ballast or slops must not be loaded or transferred over the top into a tank that contains a flammable gas mixture.

11.1.13 Loading at Terminals Having Vapour Emission Control (VEC) Systems

11.1.13.1 General

The fundamental concept of a vapour emission control system is relatively simple. When tankers are loading at a terminal, the vapours are collected as they are displaced by the incoming cargo or ballast and are transferred ashore by pipeline for treatment or disposal. However, the operational and safety implications are significant because the tanker and terminal are connected by a common stream of vapours, thereby introducing into the operation a number of additional hazards which have to be effectively controlled.

Detailed guidance on technical issues associated with vapour emission control and treatment systems is available from a number of sources. IMO has developed international standards for the design, construction and operation of vapour collection systems on tankers and vapour emission control systems at terminals, and OCIMF has initiated and issued guidance on vapour manifold arrangements (see Bibliography).

It should be noted that Vapour Emission Control Systems (VECS) can serve tankers fitted with inert gas systems and also non-inerted tankers.

A summary of the terminal's VECS should be included in the terminal information booklet.

11.1.13.2 Misconnection of Liquid and Vapour Lines

To guard against the possible misconnection of the tanker's vapour manifold to a terminal liquid loading line, the vapour connection should be clearly identified. Pipes for loading and unloading shall be clearly distinguishable from other piping, e.g. by means of colour marking.

11.1.13.3 Vapour Over/Under-Pressure

Although all 'closed' cargo operations require in-tank pressures to be effectively monitored and controlled, the connection to a vapour emission control system results in pressures within the tanker's vapour spaces being directly influenced by any changes that may occur within the terminal's system. It is therefore important to ensure that the individual cargo tank pressure/vacuum protection devices are fully operational and that loading rates do not exceed maximum allowable rates.

11.1.13.4 Cargo Tank Overfill

The risk of overfilling a cargo tank when using a VEC system is no different from that when loading under normal closed conditions. However, owing to the reliance placed on closed gauging systems, it is important that they are fully operational and that backup is provided in the form of an independent overfill alarm arrangement. The alarm should provide audible and visual indication and should be set at a level that will enable operations to be shut down prior to the tank being overfilled. Under normal operations, the cargo tank should not be filled higher than the level at which the overfill alarm is set.

Individual overfill alarms should be tested at the tank to ensure their proper operation prior to commencing loading, unless the system is provided with an electronic self-testing capability which monitors the condition of the alarm circuitry and sensor, and confirms the instrument set point.

11.1.13.5 Sampling and Gauging

A cargo tank should never be opened to the atmosphere for gauging or sampling purposes while the tanker is connected to the shore vapour recovery system unless loading to the tank is stopped, the tank is isolated from any other tank being loaded and precautions are taken to reduce any pressure within the cargo tank vapour space.

On non-inerted tankers, precautions against static hazards should also be followed. (See Section 11.8.)

11.1.13.6 Fire/Explosion/Detonation

The interconnection of tanker and shore vapour streams, which may or may not be within the flammable range, introduces significant additional hazards that are not normally present when loading. Unless adequate protective devices are installed and operational procedures adhered to, a fire or explosion occurring in the vapour space of a cargo tank on board could transfer rapidly to the terminal and vice versa.

A detonation arrestor should be fitted in close proximity to the terminal vapour connection at the jetty head in order to provide primary protection against the transfer or propagation of a flame from tanker to shore or from shore to the tanker.

The design of the terminal vapour collection and treatment system will determine whether or not flammable vapours can be safely handled and, if they cannot, will include provisions for either inerting, enriching or diluting the vapour stream and continuously monitoring its composition.

11.1.13.7 Liquid Condensate in the Vapour Line

The tanker's systems should be provided with means to effectively drain and collect any liquid condensate that may accumulate within vapour pipelines. Any build-up of liquid in the vapour line could impede the free passage of vapours and thus increase in-line pressures and could also result in the generation of significant electrostatic charges on the surface of the liquid. It is important that drains are installed at the low points in the tanker's vapour piping system and that they are routinely checked to ensure that no liquid is present.

11.1.13.8 Electrostatic Discharge

The precautions contained in Section 11.1.7.3, with regard to initial loading rates, and in Section 11.8, with regard to measuring and sampling procedures, should be followed. In addition, to prevent the build-up of electrostatic charges within the vapour collection system, all pipework should be electrically bonded to the hull and should be electrically continuous. The bonding arrangements should be inspected periodically to check their condition. The terminal vapour connections should be electrically insulated from the tanker vapour connection by the use of an insulating flange or a single section of insulating hose.

11.1.13.9 Training

It is important that the Responsible Person has received instruction on the particular vapour emission control system installed on the tanker.

11.1.13.10 Communications

The introduction of vapour emission control reinforces the importance of good co-operation and communications between the tanker and shore. Pre-transfer discussions should provide both parties with an understanding of each other's operating parameters. Details such as maximum transfer rates, maximum allowable pressure drops in the vapour collection system, and alarm and shutdown conditions and procedures must be agreed before operations commence (see Section 26.3 - The Safety Check-Lists).

11.1.14 Discharging Procedures

11.1.14.1 Joint Agreement on Readiness to Discharge

Before starting to discharge cargo, the Responsible Person and the Terminal Representative must formally agree that both the tanker and the terminal are ready to do so safely.

11.1.14.2 Operation of Pumps and Valves

Throughout pumping operations, no abrupt changes in the rate of flow should be made.

Reciprocating main cargo pumps can set up excessive vibration in metal loading/discharging arms which, in turn, can cause leaks in couplers and swivel joints, and even mechanical damage to the support structure. Where possible, such pumps should not be used. If they are, care must be taken to select the least critical pump speed or, if more than one pump is used, a combination of pump speeds to achieve an acceptable level of vibration. A close watch should be kept on the vibration level throughout the cargo discharge.

Centrifugal pumps should be operated at speeds that do not cause cavitation. This effect may damage the pump and other equipment on the tanker or at the terminal.

11.1.14.3 Closed Discharging

Tankers correctly operating their inert gas systems are considered to be conducting ‘closed’ discharging operations.

On non-inerted tankers, discharging, gauging and sampling should normally be carried out with all ullage, sounding and sighting ports closed. Air should be admitted to the tanks by the dedicated venting system or via the vapour return lines

If, for any reason, the admittance of air via the normal venting system is not at a sufficient rate, air may be admitted via a sighting or ullage port, provided it is fitted with a permanent flame screen. In this situation, the tanker is no longer considered to be closed discharging.

11.1.14.4 Inert Gas Procedures

Tankers using an inert gas system (IGS) must have the system fully operational and producing good quality (i.e. low oxygen content) inert gas at the commencement of discharge. The IGS must be fully operational and working satisfactorily throughout the discharge of cargo or deballasting. Section 7.1 gives details on the operation of the IGS.

Cargo discharge must not be started until:

- All relevant cargo tanks, including slop tanks, are common with the inert gas (IG) main.
- All other cargo tank openings, including vent valves, are securely closed.
- The IG main is isolated from the atmosphere and, if a cross connection is fitted, also from the cargo main.
- The IG plant is operating.
- The deck isolating valve is open.

11.1.14.5 Pressurising of Cargo Tanks

When high vapour pressure cargoes reach a low level in cargo tanks, the head of liquid is sometimes insufficient to keep cargo pumps primed. If an inert gas system is installed, it can be used for pressurising cargo tanks in order to improve pump performance.

11.1.14.6 N/A

11.1.14.7 Commencement of Discharge Alongside a Terminal

Shore valves must be fully open to receiving tanks before the tanker's manifold valves are opened. If there is a possibility that, owing to the elevation of the shore tanks above the level of the tanker's manifold, pressure might exist in the shore line and no non-return (check) valves are fitted in the shore line, the tanker must be informed and the tanker's manifold valves should not be opened until an adequate pressure has been developed by the pumps.

Discharge should start at a slow rate and only be increased to the agreed rate once both parties are satisfied that the flow of oil to and from designated tanks is confirmed.

11.1.14.8 N/A

11.1.14.9 N/A

11.1.14.10 Periodic Checks During Discharge

Throughout discharging, the tanker should monitor and regularly check all full and empty tanks to confirm that cargo is only leaving the designated cargo tanks and that there is no escape of cargo into pumprooms (if applicable) or cofferdams and ballast tanks.

The tanker should check tank ullages/innages at least hourly and calculate a discharge rate. Cargo figures and rates should be compared with shore figures to identify any discrepancy. These checks should, where possible, include the observations and recording of the shear forces, bending moments, draught and trim and any other relevant stability requirements particular to the tanker. This information should be checked against the required discharging plan to see that all safe limits are adhered to and that the discharging sequence can be followed, or amended, as necessary. Any discrepancies should be immediately reported to the Responsible Person.

Any drop in pressures or any marked discrepancy between tanker and terminal estimates of quantities could indicate pipeline or hose leaks and require that cargo operations be stopped until investigations have been made.

The tanker should carry out frequent inspections of the cargo deck and pumproom (if applicable) to check for any leaks. Overside areas should likewise be checked regularly. During darkness, where safe and practical, the water around the tanker should be illuminated.

11.1.14.11 Fluctuations in Discharge Rate

During discharge, the flow of cargo should be controlled by the tanker in accordance with the agreement reached with the terminal.

The discharge rate should not be substantially changed without informing the terminal.

11.1.14.12 Simultaneous Ballast and Cargo Handling

Ballasting must be planned and programmed around the cargo operations so as to avoid exceeding specified draught, trim or list requirements, while at the same time keeping shear force, bending moments and metacentric height within prescribed limits.

11.1.14.13 Failure of the Inert Gas System During Cargo Discharge

Reference should be made to the guidance provided in Section 7.1.12 regarding actions to be taken in the event of failure of the inert gas system during cargo discharge.

11.1.14.14 (Efficient) Stripping and Draining of Cargo Tanks

In general, all cargo loaded should be completely discharged at the unloading terminal.

A terminal should have arrangements to receive drainings and should effectively cooperate in this matter.

Arrangements for facilitating draining of the tanker’s tanks can comprise of:
- Suction by a terminal’s pump.
- Discharge by a tanker’s pump (stripping pump).
- Purged by inert gas or air through a stripping line[2]

For theses purposes recommended interface system on the tanker side are
- EN 14 420-6 DN 50 (male connection)
- EN 14 420-7 DN 50 (male connection)

It is recommended that terminals are equipped with one of the above mentioned female connections.

If a terminal is equipped with self sealing couplings the terminal should provide appropriate connectors for the previously mentioned male connectors.

When engaged in efficient stripping, the tanker must be able to provide a liquid pressure of at least 300 kPa (3 bar). The back pressure required to achieve product flow ashore should not exceed 300 kPa (3 bar).

[2] Air and/or gas bubbles in a liquid can generate static electricity. Also see Chapter 3.

11.1.15 Pipeline and Hose Clearing Following Cargo Operations

11.1.15.1 General

The procedure for clearing the pipelines and hoses or marine arms between the shore valve and tanker's manifold will depend on the facilities available and whether these include a slop tank or other receptacle. The relative heights of the tanker and shore manifolds may also influence procedures.

In general, compressed air is not a preferred medium, especially if flammable products are being handled with a flashpoint below 60°C. If compressed air is used for line clearing to shore, the precautions detailed in Section 11.1.15.4 should be strictly adhered to.

11.1.15.2 N/A

11.1.15.3 Line Draining

On completion of loading, the tanker's cargo deck lines should be drained into appropriate cargo tanks to ensure that thermal expansion of the contents of the lines cannot cause leakage or distortion. The hoses or marine arms, and perhaps a part of the pipeline system between the shore valve and the tanker's manifold, are also usually drained into the tanker's tanks. Sufficient ullage must be left in the final tanks to accept the cargo oil drained from hoses or marine arms and tanker or shore lines.

On completion of discharge, the tanker's cargo deck lines should be drained into an appropriate tank and then discharged ashore or into a remainder (slop) tank. See also 11.1.14.14.

When draining is complete, and before hoses or marine arms are disconnected, the tanker's manifold valves and shore valves should be closed and the drain cocks at the tanker's manifold should be opened to drain into fixed drain tanks or portable drip trays. Cargo manifolds and marine arms or hoses should be securely blanked after being disconnected. The contents of portable or fixed drip trays should be transferred to a slop tank or other safe receptacle ashore.

11.1.15.4 Clearing Hoses and Loading Arms to the Terminal

If hoses or marine arms have to be cleared to the terminal using compressed air or inert gas, the following precautions should be strictly observed in order to avoid the possible creation of a hazardous static electrical charge or mechanical damage to tanks and equipment:

- The procedure to be adopted must be agreed between tanker and terminal.
- There must be adequate ullage in the reception tank.
- To ensure that the amount of compressed air or inert gas is kept to a minimum, the operation must be stopped when the line has been cleared.

- The inlet to the receiving tank should be located well above any water that may be in the bottom of the tank.
- To avoid a static charge generation the inlet to the receiving tank should be at least 30 cm below the liquid surface level. See also 11.1.15.7.
- The line clearing operation must be continuously supervised by a Responsible Person (both tanker and terminal)

11.1.15.5 Clearing Hoses and Marine Arms to the Tanker

The clearing of hoses and marine arms to the tanker using compressed air should not be undertaken due to the risks of:

- Static charge generation.
- Compromising inert gas quality (if applicable).
- Over-pressurisation of tanks, pipelines, filter boxes, pump seals or pipeline fittings.
- Oil mists emanating from tank vents.

11.1.15.6 Clearing Tanker’s Cargo Pipelines

When compressed air or inert gas is used to clear tanker’s pipelines, for example when evacuating the liquid column above a submerged pump, sometimes referred to as ‘purging’, similar hazards to those identified above may arise and similar precautions must be observed. Line clearing operations must be undertaken in accordance with the operating procedures previously established for the particular tanker.

11.1.15.7 Gas Release in the Bottom of Tanks

A strong electrostatic field can be generated by blowing air or inert gas into the bottom of a tank containing a static accumulator oil. If water or particulate matter is present in the cargo, the effect is made worse, as the rising gas bubbles will disturb the particulates and water droplets. The settling contaminants will generate a static charge within the cargo. Therefore, a settling period of 30 minutes should be observed after any blowing of lines has taken place into a non-inerted tank or into a tank that could possibly contain a flammable atmosphere.

Precautions should be taken to minimise the amount of air or inert gas entering tanks containing static accumulator oils. However, it is best to avoid the practice of blowing lines back to tanks containing such cargo.

Whenever possible, cargo lines should be drained by gravity. Attention should be given to gas bubbles into the product through the use of compressed air or nitrogen, which can lead to overflow of the receiving tank or miscalculation of quantities.

11.1.15.8 Receiving Nitrogen from Shore

Personnel should be aware of the potential hazards associated with nitrogen and, in particular, those related to entering enclosed spaces or areas in way of tank vents or outlets which may be oxygen depleted. High concentrations of nitrogen are particularly dangerous because they can displace enough air to reduce oxygen levels to a point where people entering the area can lose consciousness due to asphyxiation. Nitrogen cannot be detected by human senses, so smell cannot be relied upon and personnel may not be able to recognise the physical or mental symptoms of overexposure in time for them to take preventive measures.

If there is a requirement to use shore supplied nitrogen, for example for purging tanks, padding cargo or clearing lines, the tanker should be aware that this may be at high pressure (up to 10 bar) and at a high flow rate and that it can therefore be potentially hazardous because of the risk of over-pressurisation of the cargo tanks, pipelines, filter boxes, pump seals or pipeline fittings

A risk assessment should be carried out and the operation should only proceed if appropriate risk responses are in place and operating. As a very minimum, the precautions detailed in Section 7.2.2 must be observed.

One method of reducing the risk of over-pressure is to ensure that the tank has vents with a greater flow rate capacity than the inlet, so that the tank cannot be over-pressurised. Where vapour control and emission regulations require closed operation, the incoming flow of nitrogen must be restricted to a rate equal to, or less than, the maximum flow of vapour possible through the vapour return line. Positive measures to ensure this should be agreed. A small hose or reducer prior to the manifold can be used to restrict the flow rate, but pressure must be controlled by the terminal. A gauge will permit the tanker to monitor the pressure.

It is not appropriate to attempt throttling a gas flow by using a tanker’s manifold valve that is designed to control liquid flow. However, the manifold can, and should, be used as a rapid safety stop in an emergency. It should be noted that the effect of pressure surge in a gas is not as violent as in a liquid.

Sensitive cargoes, for example some highly specialised lubricating oils, may have to be carried under a pad or blanket of nitrogen supplied from ashore. In such cases, it is preferable to purge the entire cargo tank before loading. After such purging has been completed, loading the cargo in a closed condition will create the required pad within the tank. This significantly reduces the risk of over-pressurisation that is present when padding with shore supplied nitrogen as a separate procedure on completion of loading.

11.1.15.9 Pigging

Pigging is a form of line clearing in which an object, most often in the form of a rubber sphere or cylinder and known as a ‘pig’, is pushed through the line by a liquid or by compressed gas. A pig may be used to clear the line completely, in which case it will usually be propelled by water or by compressed gas, or to follow a previous grade to ensure that the pipeline remains as free of product as possible, in which case it is likely to be propelled by the next grade.

A common arrangement for catching the pig is for the shore terminal to provide a pig receiver, which is mounted outboard of the tanker's manifold, and from which the pig may be removed.

A pressure of about 2.7 bar (40 psi) is considered to be the minimum necessary to drive the pig, but pressures of up to 7 bar (100 psi) may be used.

Before any pigging operations are carried out, the Responsible Person and the Terminal Representative should agree the procedures and associated safeguards to be put in place. The propelling gas or liquid volumes, pressures, time required for the pig to travel along the line, volume of residual cargo in the line, and the amount of ullage space available should be discussed and agreed.

During the pigging operation, the terminal should monitor the pressure upstream of the pig to ensure that it is not stuck in the line. Failure of the pig to arrive within the expected time period will also indicate that free movement of the pig has been restricted.

Care should be taken after the pig lands in the pig receiver, as the nitrogen or air that follows directly after the pig through the shore cargo line to the tanker may enter at the bottom of a cargo tank. The nitrogen or air will form a bubble, which will expand in the tank. This could lead to undesirable turbulence in the liquid – the "bubble effect" – that can cause problems on tankers operating 'closed', with the potential to cause damage to the cargo tank, pipelines, filter boxes, pipeline fittings and in-tank equipment.

In order to avoid undesirable affects though turbulence, it is recommended that, once the pig has been received, the pressure in the line is released ashore.

On completion of the pigging operation, the terminal should positively verify that the pig has arrived. Any residual pressure in the shore line must then be bled-off before opening the pig trap or disconnecting cargo arms or hoses.

Personnel at the receiving end should be aware that there may be sediment in the pig receiver unit and there should be means in place to deal with this, for example rags, absorbent material and drums.

11.2 Stability, Stress, Trim and Sloshing Considerations

11.2.1 General

Single hull oil tankers with centreline bulkhead usually have such a high metacentric height in all conditions that they remain inherently stable. While tanker personnel have always had to take account of longitudinal bending moments and vertical shear forces during cargo and ballast operations, the actual stability of the tanker has therefore seldom been a prime concern. However, the introduction of double hulls into tanker design has changed that situation.

11.2.2 Free Surface Effects

The main problem likely to be encountered is the effect on the transverse metacentric height of liquid free surface in the cargo and double hull ballast tanks.

Depending upon the design, type and number of these tanks, the free surface effect and the specific density of the cargo could result in the transverse metacentric height being significantly reduced. The situation will be most severe in the case of a combination of wide cargo tanks with no centreline bulkhead, and ballast tanks also having no centreline bulkhead ('U' tanks).

The most critical stages of any operation will be while filling the double bottom ballast tanks during discharge of cargo, and emptying the tanks during loading of cargo. If sufficient cargo tanks and ballast tanks are slack simultaneously, the overall free surface effect could well be sufficient to reduce the transverse metacentric height to a point at which the transverse stability of the tanker may be threatened. This could result in the tanker suddenly developing a severe list or angle of loll. A large free surface area is especially likely to threaten stability at greater soundings (innages), with associated high vertical centre of gravity.

Double hull tankers need a damage stability plan and a stability calculation. From these plans it should be clear which cargo and ballast situations are in accordance with the plans and which situations are not.

It is imperative that tanker and terminal personnel involved in cargo and ballast operations are aware of this potential problem, and that all cargo and ballast operations are conducted strictly in accordance with the tanker's loading manual, if applicable.

Where they are fitted, interlock devices to prevent too many cargo and ballast tanks from being operated simultaneously, thereby causing an excessive free surface effect, should always be maintained in full operational order, and should never be overridden.

11.2.3 Sloshing

It is imperative that tanker captains are aware that partially loading a cargo tank may present a potential problem due to 'sloshing'. The combination of free surface and the flat tank bottom can result in the generation of wave energy of sufficient power to severely damage internal structure and pipelines.

11.2.4 Loading and Discharge Planning

Ballasting and deballasting must be planned and programmed around the cargo operations so as to avoid exceeding specified draught, trim or list requirements, while at the same time keeping shear force, bending moments and metacentric height within prescribed limits.

11.3 Tank Cleaning

11.3.1 General

This Section deals with procedures and safety precautions for cleaning cargo tanks after the discharge of volatile or non-volatile products carried in non-gas free, non-inert or inert tanks.

11.3.2 Tank Washing Risk Management

All tank washing operations should be carefully planned and documented. Potential hazards relating to planned tank washing operations should be systematically identified, risk assessed and appropriate preventive measures put in place to reduce the risk to as low as reasonably practicable (ALARP).

In planning tank washing operations, the prime risk is fire or explosion arising from simultaneous presence of a flammable atmosphere and a source of ignition. The focus therefore should be to eliminate one or more of the hazards that contribute to that risk, namely the sides of the fire triangle of air/oxygen, ignition source and fuel (i.e. flammable vapours).

Inert Tanks

The method that provides the lowest risk is washing the tank in an inert atmosphere. The inert condition provides for no ambiguity; by definition, to be deemed inert, the tank MUST have an oxygen content in the atmosphere which is at a level that cannot support combustion.

Failure to prove through direct measurement that the tank is inert means, by default, that the tank MUST be considered to be in the non-inert condition.

Non-Inert Tanks

In tankers that do not have access to inert gas, either through on board facilities (e.g. IGS plant) or shore supply, it is only possible to address the ‘fuel’ and the ‘sources of ignition’ sides of the fire triangle. In a non-inert condition, there are no physical barriers that will ensure elimination of these two hazards individually. Therefore, the safety of tank washing in the non-inert condition depends on the integrity of equipment, and implementation of strict procedures to ensure these two hazards are effectively controlled.

Non-inert cargo tank washing should only be undertaken when two sides of the fire triangle are addressed by a combination of measures to control both the flammability of the tank atmosphere AND sources of ignition.

It is recommended that all tankers that operate in the non-inert mode incorporate within their design and equipment the ability to mechanically ventilate cargo tanks concurrently with tank washing, in order to control tank atmospheres.

11.3.3 Supervision and Preparation

11.3.3.1 Supervision

A Responsible Person must supervise all tank washing operations.

All crew involved in the operation should be fully briefed by the Responsible Person on the tank washing plans, and their roles and responsibilities prior to commencement.

All other personnel on board should also be notified that tank washing is about to begin and this notification MUST in particular be extended to those on board not involved directly in the tank washing operation but who, by virtue of their own concurrent tasks, may impact upon the safety of the tank washing operation.

11.3.3.2 Preparation

Both before and during tank washing operations, the Responsible Person should be satisfied that all the appropriate precautions set out in Chapter 4 are being observed. If craft are alongside the tanker, their personnel should also be notified and their compliance with all appropriate safety measures should be confirmed.

Before starting to tank wash alongside a terminal, the following additional measures should be taken:

- Relevant precautions described in Chapter 24 should be observed.
- The appropriate personnel ashore should be consulted to ascertain that conditions on the jetty do not present a hazard and to obtain agreement that operations can start.

The method of tank washing utilised on board a tanker is dependent on how the atmospheres in the cargo tanks are managed and will be determined by the equipment fitted to the vessel.

11.3.4 Tank Atmospheres

Tank atmospheres can be either of the following:

11.3.4.1 Inert

This is a condition where the tank atmosphere is known to be at its lowest risk of explosion by virtue of the atmosphere being maintained at all times non-flammable through the introduction of inert gas and the resultant reduction of the overall oxygen content in any part of any cargo tank to a level not exceeding 8% by volume while under a positive pressure (see Section 7.1.5.1).

The requirements for the maintenance of an inert atmosphere and precautions to be observed during washing are set out in Section 7.1.6.9 and provide the most certain level of control of an atmosphere during tank washing operations.

In fire triangle terms, this method physically removes and controls the ‘oxygen’ side of the fire triangle.

11.3.4.2 Non-Inert

For the purposes of this Chapter, a non-inert atmosphere is one in which the oxygen content has not been confirmed to be less than 8% by volume.

In recognition that tank washing and gas freeing operations in non-inert atmospheres are considered to present a likelihood of increased risk, additional control measures are required to reduce the risk of operations to as low as reasonably practicable (ALARP). These control measures MUST address two sides of the fire triangle namely:

- ‘Fuel’ and
- ‘Sources of ignition’.

11.3.5 Tank Washing

11.3.5.1 Washing in an Inert Atmosphere

To satisfy the control measures for washing in inert atmospheres see Section 7.1.6.9.

During tank washing operations, measures must be taken to verify that the atmosphere in the tank remains non-flammable (oxygen content not to exceed 8% by volume) and at a positive pressure.

11.3.5.2 Washing in a Non-Inert Atmosphere

Non-inert cargo tank washing should only be undertaken when both the source of ignition and the flammability of the tank atmosphere are controlled. To achieve this, the following precautions to control ‘sources of ignition’ and ‘fuel’ MUST be taken for tank washing operations in a non-inert atmosphere condition.

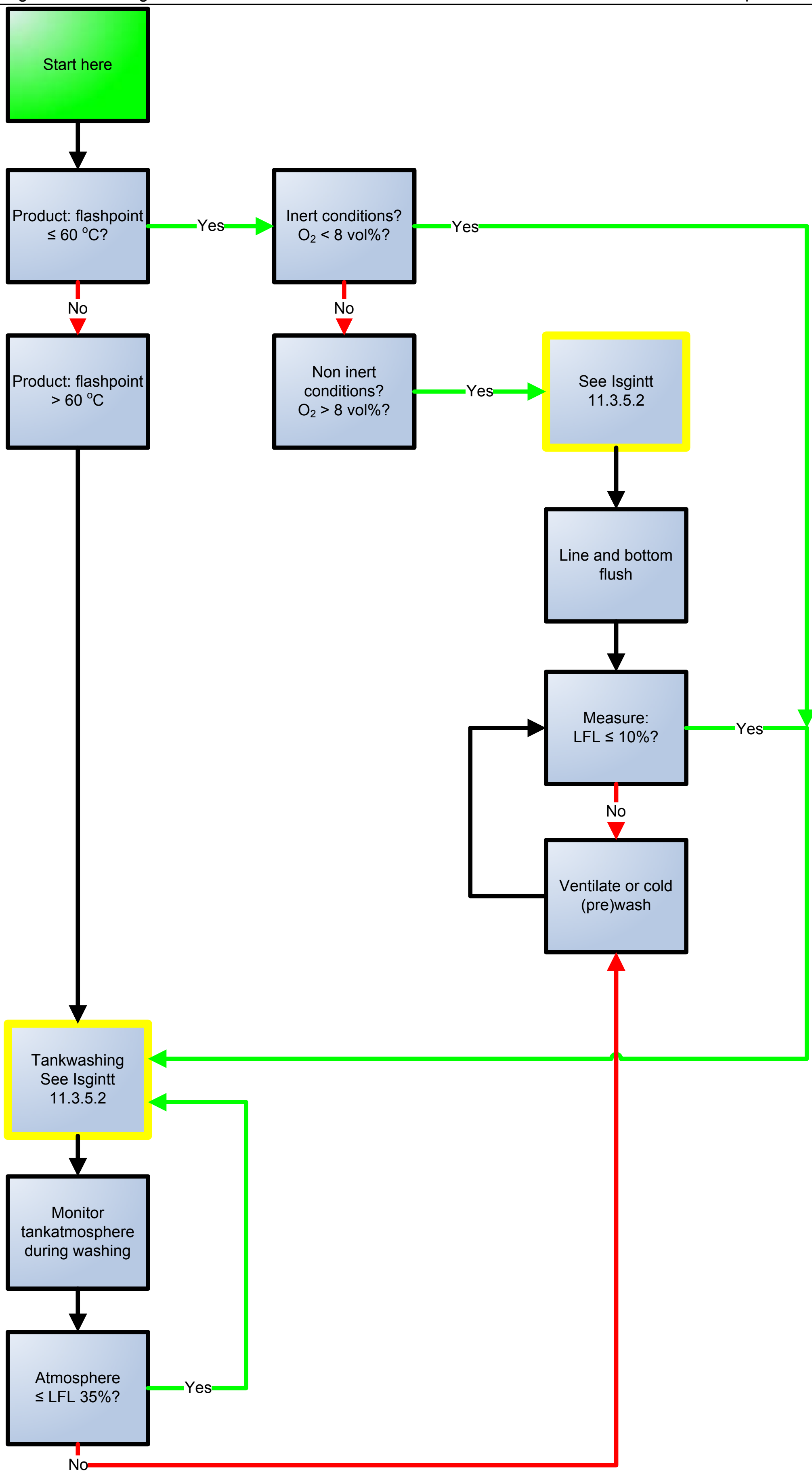


Figure 11.4 - Flow chart showing steps to control the 'fuel' while tank washing in the inert & non-inert tank atmosphere method

To Control the 'Fuel' in the Tank Atmosphere

(See Figure 11.4 Non-inert tank washing flow chart.)

Before tank washing:

- Before starting the tank washing procedure it must be determined whether the product to be cleaned holds a flash point of less than 60°C or 60°C and higher.
- Depending on the flash point of the product different procedures must be followed.
- For the purpose of tank washing, not only the last cargo product should be taking into consideration. It is best practise to check the flash point of the last three (3) cargoes at least.

If the cargo tank to be cleaned contained a product with a flashpoint of less than 60°C:

- It must be checked whether the cargo tank is under inert conditions or not. For this purpose 'under inert conditions' means less than 8% O_2 by volume.
- If a cargo tank is not under inert conditions the steps according to point 1 (below) must be followed.
- If a cargo tank is under inert conditions the steps according to point 2 (below) must be followed.

If the cargo tank to be cleaned contained a product with a flashpoint of 60°C and higher:

- It the cargo tank to be cleaned contained a product holding a flash point of 60°C and higher the steps according to point 2 (below) must be followed.

1. Before Washing:

- The tank bottom should be flushed with water, so that all parts are covered, and then stripped. This flush should be undertaken using the main cargo pumps and lines. Alternatively, permanent pipework extending the full depth of the tank should be used. This flush should not be undertaken using the tank washing machines.
- The piping system, including cargo pumps, crossovers and discharge lines, should also be flushed with water. The flushing water should be drained to the tank designed or designated to receive slops.
- The tank should be ventilated to reduce the gas concentration of the atmosphere to 10% or less of the Lower Explosive Limit (LEL) or a pre-wash with cold water might be considered. Gas tests must be made at various levels and due consideration should be given to the possible existence of pockets of flammable gas, in particular in the vicinity of potential sources of ignition such as mechanical equipment that might generate hot spots, e.g. moving parts such as found in in-tank (submerged) cargo pump impellors.
- Tank washing with heated wash water may only commence once the tank atmosphere reaches 10% or less of the LEL.

2. During Washing with heated wash water:

- Atmosphere testing should be frequent and taken at various levels inside the tank during washing to monitor the change in LEL percentage.
- Consideration should be given to the possible effect of water on the efficiency of the gas measuring equipment and therefore to suspension of washing to take readings.

- Mechanical ventilation should, whenever possible, be continued during washing and to provide a free flow of air from one end of the tank to the other.
- The ability to mechanically ventilate concurrent with tank washing is recommended but, where mechanical ventilation is not possible, the monitoring of the tank atmosphere should be more frequent as the likelihood of rapid gas build-up is increased.
- The tank atmosphere should be maintained at a level not exceeding 35% LEL. Should the gas level reach 35% LEL at any measured location within a tank, tank washing operations in that individual tank MUST immediately cease.
- Washing may be resumed when continued ventilation or cold pre-wash has reduced and is able to maintain the gas concentration at 10% or less of the LEL.
- If the tank has a venting system that is common to other tanks, the tank must be isolated to prevent ingress of gas from other tanks.

To Control the 'Sources of Ignition' in the Tank

a) Individual tank washing machines should not have a throughput greater than 60 m^3/h.

b) The total water throughput per cargo tank should be kept as low as practicable and must not exceed 180 m^3/h.

c) Different washing methods give rise to differing risks and the following should be followed for tank washing in non-inert conditions:
   - Recirculated wash water MUST NOT be used.
   - Heated wash water may be utilised, but use should be discontinued if the gas concentration reaches 35% of the LEL. A hot wash for a low flashpoint product should ONLY take place following a full (i.e. top to bottom) cold wash cycle.
   - If the hot wash water temperature is above 60ºC, monitoring of the gas concentration level should be at an increased frequency.
   - Chemical additives may only be considered if the temperature of the wash water DOES NOT exceed 60ºC.
   - Steam must never be injected into the tank when tank washing in non-inert conditions and MUST NOT be considered until the tank has been verified as gas free (see Section 3.1.2 and Definitions).

d) The tank should be kept drained during washing. Washing should be stopped to clear any build-up of wash water.

e) At all times, the discharge into a wash water reception/slop tank should be below the liquid level in that tank.

f) If portable washing machines are used, all hose connections should be made up and tested for electrical continuity before the washing machine is introduced into the tank.

   Portable washing machines should not be introduced into the tank until the LEL level is 10% or less.

   Connections should not be broken until after the machine has been removed from the tank. To drain the hose, a coupling may be partially opened (but not broken) and then re-tightened before the machine is removed.

g) The introduction of sounding rods and other equipment into the tank should be made utilising a full depth sounding pipe. If a full depth sounding pipe is not fitted, it is essential that any metallic components of the sounding rod or other equipment are bonded and securely earthed to the tanker before introduction into the tank, and remain earthed until removed.

   This precaution should be observed during washing and for five hours thereafter to allow sufficient time for any mist carrying a static charge to dissipate. If, however, the tank is continuously mechanically ventilated after washing, this period can be reduced to one hour. During this period:

   - An interface detector of metallic construction may be used if earthed to the tanker by means of a clamp or bolted metal connection.
   - A metal rod may be used on the end of a metal tape if earthed to the tanker by means of a clamp or bolted metal connection.
   - A metal sounding rod suspended on a fibre rope should NOT be used, even if the end at deck level is fastened to the tanker because the rope cannot be relied upon to provide an earthing path.
   - Equipment made entirely of non-metallic materials may, in general, be used, for example a wooden sounding rod may be suspended on a natural fibre rope without earthing.
   - Ropes made of synthetic polymers should NOT be used for lowering equipment into cargo tanks.

h) Measures should be taken to guard against ignition from mechanical defect of machinery, e.g. in-tank (submerged) cargo pumps, tank washing machines, tank gauging equipment etc.

i) Precautions should be taken to eliminate the risk of mechanical sparks from, for example, metallic objects such as hand tools, sounding rods, sample buckets, etc being dropped into the tank.

j) The use of non-intrinsically safe equipment, for example, torches and inspection lamps, mobile phones, communications radios, handheld computers and organisers, etc should NOT be allowed.

11.3.6 Precautions for Tank Washing

11.3.6.1 Portable Tank Washing Machines and Hoses

The outer casing of portable machines should be of a material that will not give rise to an incendive spark on contact with the internal structure of a cargo tank.

The coupling arrangement for the hose should be such that effective bonding can be established between the tank washing machine, the hoses and the fixed tank cleaning water supply line.

Washing machines should be electrically bonded to the water hose by means of a suitable connection or external bonding wire.

When suspended within a cargo tank, machines should be supported by means of a natural fibre rope and not by means of the water supply hose.

11.3.6.2 Portable Hoses for Use with Both Fixed and Portable Tank Washing Machines

Bonding wires should be incorporated within all portable tank washing hoses to ensure electrical continuity. Couplings should be connected to the hose in such a way that effective bonding is ensured between them.

Hoses should be indelibly marked to allow identification. A record should be kept showing the date and the result of electrical continuity testing.

11.3.6.3 Testing of Tank Cleaning Hoses

All hoses supplied for tank washing machines should be tested for electrical continuity in a dry condition prior to use, and in no case should the resistance exceed 6 ohms per metre length.

11.3.6.4 Tank Cleaning Concurrently with Cargo Handling

As a general rule, tank cleaning and gas freeing should not take place concurrently with cargo handling. If for any reason this is necessary, there should be close consultation with, and agreement from, both the Terminal Representative and the port authority.

11.3.6.5 Free Fall

It is essential to avoid the free fall of water or slops into a tank. The liquid level should always be such that the discharge inlets in the slop tank are covered to a depth of at least one metre to avoid splashing. However, this is not necessary when the slop and cargo tanks are fully inerted.

11.3.6.6 Spraying of Water

The spraying of water into a tank containing a substantial quantity of static accumulator oil could result in the generation of static electricity at the liquid surface, either by agitation or by water settling. Tanks that contain static accumulator oil should always be pumped out before they are washed with water, unless the tank is kept in an inert condition. (See Section 3.3.4.)

11.3.6.7 N/A

11.3.6.8 Special Tank Cleaning Procedures

After the carriage of certain products, tanks can only be adequately cleaned by steaming or by the addition of tank cleaning chemicals or additives to the wash water.

Steaming of Tanks

Because of the hazard from static electricity, the introduction of steam into cargo tanks should not be permitted where there is a risk of a flammable atmosphere. It should be borne in mind that a non-flammable atmosphere cannot be guaranteed in all cases where steaming might be thought to be useful.

Steaming can produce mist clouds, which may be electrostatically charged. The effects and possible hazards from such clouds are similar to those described for the mists created by water washing, but levels of charging are much higher. The time required to reach maximum charge levels is also very much less. Furthermore, although a tank may be almost free of flammable gas at the start of steaming, the heat and disturbance will often release gases, and pockets of flammability may build-up.

Steaming may only be carried out in tanks that have been either inerted or water washed and gas freed. The concentration of flammable gas should not exceed 10% of the LEL prior to steaming. Precautions should be taken to avoid the build-up of steam pressure within the tank.

Strict observance of the static electricity precautions contained in Chapter 3 is essential.

Use of Chemicals in Tank Cleaning Wash Water

Constraints on the use of chemicals in tank cleaning wash water will depend on the type of tank atmosphere (see Section 11.3.5.2).

If tank cleaning chemicals are to be used, it is important to recognise that certain products may introduce a toxicity or flammability hazard. Personnel should be made aware of the Threshold Limit Value (TLV) of the product. Detector tubes are particularly useful for detecting the presence of specific gases and vapours in tanks. Tank cleaning chemicals capable of producing a flammable atmosphere should normally only be used when the tank has been inerted.

Use of Chemicals for Local Cleaning of Tanks

Some products may be used for the local cleaning of tank bulkheads and blind spots by hand wiping, provided the amount of tank cleaning chemical used is small and the personnel entering the tank observe all enclosed space entry requirements.

In addition to the above, any manufacturer's instructions or recommendations for the use of these products should be observed. Where these operations take place in port, local authorities may impose additional requirements.

A Material Safety Data Sheet (MSDS) for tank cleaning chemicals should be on board the tanker before they are used and the advice of any precautions to be taken should be followed.

11.3.6.9 Leaded Gasoline

Whereas shore tanks may contain leaded gasoline for long periods and therefore present a hazard from Tetraethyl Lead (TEL) and Tetramethyl Lead (TML), a tanker's tanks normally alternate between different products and thus present very little risk. However, tankers employed in the regular carriage of leaded gasoline should flush the bottom of the tanks with water after every cargo discharge.

11.3.6.10 Removal of Sludge, Scale and Sediment

Before the removal by hand of sludge, scale and sediment, the tank atmosphere must be confirmed as safe for entry, with appropriate control measures implemented to protect the safety and health of personnel entering the space. The precautions described in Section 10.9 should be maintained throughout the period of work.

Equipment to be used for further tank cleaning operations, such as the removal of solid residues or products in tanks which have been gas freed, should be so designed and constructed, and the construction materials so chosen, that no risk of ignition is introduced.

11.3.6.11 Cleaning of Contaminated Ballast Spaces

Where leakage has occurred from a cargo tank into a ballast tank, it will be necessary to clean the tank for both compliance with local environmental legislation and to effect repairs.

This task is difficult when the contamination is due to black oils and particularly difficult if it occurs in a double hull or double bottom space.

As far as possible, tank cleaning, particularly in the initial stages, should be carried out by methods other than hand hosing. Such methods may include, but not be limited to, using portable machines, the use of detergents, or washing the bottom of the tank with water and detergent. Hand hosing should only be permitted for small areas of contamination or for final cleaning. Whichever method is used, the tank washings must always be handled in accordance with applicable environmental regulations.

After a machine or detergent wash, prior to entry for final hand hosing, the tank must be ventilated in accordance with the procedures referred to in Section 11.4.7, until readings at each sampling point indicate that the atmosphere meets the ‘safe for entry’ criteria in Chapter 10. Suitable control measures should be implemented to protect the safety and health of personnel entering the space.

11.4 Gas Freeing

11.4.1 General

It is generally recognised that gas freeing is one of the most hazardous periods of tanker operations. This is true whether gas freeing for entry, for Hot Work or for cargo quality control. The cargo vapours that are being displaced during gas freeing are highly flammable, so good planning and firm overall control are essential. The additional risk from the toxic effect of cargo vapours during this period cannot be over emphasised and must be impressed on all concerned. It is therefore essential that the greatest possible care is exercised in all operations connected with gas freeing.

It is recommended that gas freeing is avoided as much as possible in order to reduce environmental and health impacts.

11.4.2 Gas Free for Entry Without Breathing Apparatus

In order to be gas free for entry without breathing apparatus, a tank or space must be ventilated until tests confirm that the cargo vapour concentration throughout the compartment is less than 1% of the LEL, that the oxygen content is 21% by volume, and that there are no hydrogen sulphide, benzene or other toxic gases present, as appropriate (see Section 10.3).

Before entering a tank without breathing apparatus, the atmosphere in the tank should be checked by a competent person.

11.4.3 Procedures and Precautions

The following recommendations apply to gas freeing generally:

- A Responsible Person must supervise all gas freeing operations.
- All personnel on board should be notified that gas freeing is about to begin.
- Appropriate 'No Smoking' regulations should be enforced.
- Instruments to be used for gas measurement should be calibrated and tested in accordance with the manufacturer's instructions before starting operations.
- Sampling lines should, in all respects, be suitable for use with, and impervious to, the gases present.
- All tank openings should be kept closed until actual ventilation of the individual compartment is about to commence.
- Venting of flammable gas should be by the tanker's approved method. Where gas freeing involves the escape of gas at deck level or through hatch openings, the degree of ventilation and number of openings should be controlled to produce an exit velocity sufficient to carry the gas clear of the deck.
- Intakes of central air conditioning or mechanical ventilation systems should be adjusted, if possible, to prevent the entry of petroleum gas, by recirculating air within the spaces. (See Section 4.1.)
- If at any time it is suspected that gas is being drawn into the accommodation, central air conditioning and mechanical ventilation systems should be stopped and the intakes covered or closed.
- Window type air conditioning units which are not certified as safe for use in the presence of flammable gas, or which draw in air from outside the superstructure, must be electrically disconnected and any external vents or intakes closed.
- Gas vent riser drains should be cleared of water, rust and sediment, and any steam smothering connections tested and proved satisfactory.
- If several tanks are connected by a common venting system, each tank should be isolated to prevent the transfer of gas to or from other tanks.
- If cargo vapours persist on deck in high concentrations, gas freeing should be stopped.
- If wind conditions cause funnel sparks to fall on deck, gas freeing should be stopped.
- Tank openings within enclosed or partially enclosed spaces, such as under forecastles, should not be opened until the compartment has been sufficiently ventilated by means of openings in the tank that are outside these spaces. When the gas level within the tank has fallen to 25% of the LEL or less, openings in enclosed or partially enclosed spaces may be opened to complete the ventilation. Such enclosed or partially enclosed spaces should also be tested for gas during this subsequent ventilation.

When undertaking gas freeing in port, if permitted, the following should be observed:

- As a general rule, gas freeing should not take place concurrently with cargo handling. If for any reason this is necessary, there should be close consultation with, and agreement from, both the Terminal Representative and the port authority.
- The Terminal Representative should be consulted to ascertain that conditions on the jetty do not present a hazard and to obtain agreement that operations can start.
- If craft are alongside the tanker, their personnel should also be notified and their compliance with all appropriate safety measures should be checked.

11.4.4 Gas Testing and Measurement

In order to maintain a proper control of the tank atmosphere and to check the effectiveness of gas freeing, a number of gas measuring instruments should be available on the tanker. Section 2.4 provides details of these instruments and Section 8.2 contains information on their use.

Atmosphere testing should be undertaken regularly during the gas freeing operation to monitor progress.

Tests should be made at several levels and, where the tank is subdivided by a swash bulkhead, in each compartment of the tank. In large compartments, tests should be made at widely separate positions.

On the apparent completion of gas freeing of any compartment, a period of about 10 minutes should elapse before taking final gas measurements. This allows relatively stable conditions to develop within the space.

If satisfactory gas readings are not obtained, ventilation must be resumed.

On completion of gas freeing, all openings, except the tank hatch, should be closed.

On completion of all gas freeing, the gas venting system should be carefully checked, particular attention being paid to the efficient working of the pressure/vacuum valves and any high velocity vent valves. If the valves or vent risers are fitted with devices designed to prevent the passage of flame, these should also be checked and, if necessary, cleaned.

11.4.5 Fixed Gas Freeing Equipment

Fixed gas freeing equipment may be used to gas free more than one tank simultaneously, but must not be used for this purpose if the system is being used to ventilate another tank in which washing is in progress.

Where cargo tanks are gas freed by means of one or more permanently installed blowers, all connections between the cargo tank system and the blowers should be blanked, except when the blowers are in use.

Before putting a fixed gas freeing system into service, the cargo piping system, including crossovers and discharge lines, should be drained thoroughly and the tanks stripped. Valves on the cargo piping system, other than those required for ventilation, should then be closed and secured.

11.4.6 Portable Fans

Portable fans or blowers should only be used if they are water, hydraulically, or pneumatically driven. Their construction materials should be such that no hazard of incendiary sparking arises if, for any reason, the impeller touches the inside of the casing.

Ventilation outlets should generally be as remote as possible from the fans.

Portable fans should be so connected to the vessel, piping or deck that an effective electrical bond exists between the fan and the deck.

11.4.7 Ventilating Double Hull Ballast Tanks

The complexity of the structure in double hull and double bottom tanks makes them more difficult to gas free than conventional ballast tanks. It is strongly recommended that the Company develops guidelines and procedures relating to the ventilation of each tank. An efficient method is to fill each tank with ballast water and to then empty it. Account must be taken of the stress, trim and loadline factors. However, it must be borne in mind that any cargo leaks into the tank will mean that the ballast will be dirty (polluted) ballast and must be handled in accordance with applicable legislation. If polluted ballast is expected, it should not be allowed to overflow when ballasting the tank.

Whenever possible, these guidelines and procedures should be developed in conjunction with the tanker's builder.

11.4.8 Gas Freeing in Preparation for Hot Work

In addition to meeting the requirements of Section 11.4.2, the requirements of Chapter 9 must also be complied with.

11.5 N/A

11.6 Ballast Operations

11.6.1 Introduction

This Section addresses routine ballast operations when taking extra ballast in cargo tanks to meet air draught restrictions for navigational purposes.

11.6.2 General

Before ballasting or deballasting in port, the operation should be discussed and agreed in writing between the Responsible Person and the Terminal Representative.

The specific agreement of the Terminal Representative must be obtained before the simultaneous handling of cargo and non-segregated ballast takes place.

Ballast must be loaded and discharged in such a way as to avoid the tanker's hull being subjected to excessive stress at any time during the operation.

11.6.3 Loading Cargo Tank Ballast

When loading ballast into cargo tanks, the following precautions should be observed:

- Before taking ballast into tanks containing hydrocarbon vapour, the Responsible Person should consult with the Terminal Representative and all safety checks and precautions applicable to the loading of volatile petroleum must be observed. Closed loading procedures should be followed.
- When taking ballast into cargo tanks that contain cargo vapour, gas is expelled which may be within the flammable range on mixing with air. This gas should therefore be vented through the recognised venting system.

- When taking ballast into tanks that previously contained cargoes that required closed operations, the ballast should also be loaded 'closed' by following the procedures in Section 11.1.6.6.
- Ballast should not be loaded over the top (overall) into tanks containing cargo vapour.
- The guidance given in Section 11.1.3 should be followed when operating ballast tank valves.

11.6.3.1 Operation of Cargo Pumps

When starting to ballast, cargo pumps should be operated so that no oil is allowed to escape overboard.

11.6.3.2 Sequence of Valve Operations

The following procedures should be adopted when loading ballast into a non-inerted tank that contains cargo vapour:

- The tank valve should be the first valve opened and the ballast inlet valve to the pump should be the last.
- The initial flow of ballast should be restricted at the pump discharge, so that the entrance velocity into the tank is less than 1 metre/second until the longitudinals are covered or, if there are no longitudinals, until the depth of the ballast in the tank is at least 1.5 metres. (Also see Table 3.2.)

These precautions are required to avoid the spraying effect that may lead to a build-up of an electrostatic charge in a mist or spray cloud near the point where the ballast enters the tank (see Chapter 3). When a sufficient charge exists, there is always the possibility of a static discharge and ignition.

11.6.4 Loading Segregated Ballast

In general, there are no restrictions on ballasting Segregated Ballast Tanks (SBT) during the cargo discharge operation. However, the following considerations should be taken into account:

- Ballast should be taken as necessary to meet air draught requirements on the berth, particularly when hard cargo arms are connected.
- Ballast should not be loaded if it may cause the tanker to exceed the maximum safe draught for the berth.
- Loading of ballast should not cause extreme shear forces or bending moments on the tanker.
- Care should be taken to ensure that excessive free surface is not allowed to occur as this may result in the tanker assuming an angle of loll, thereby jeopardising the integrity of the loading arms. This is particularly relevant to double hull tankers (see also Section 11.2).

11.6.5 Deballasting in Port

Contaminated ballast water from cargo tanks should be discharged ashore to avoid environmental pollution.

11.6.6 Discharging Segregated Ballast

To avoid pollution due to contaminated segregated ballast, the surface of the ballast should be sighted, where possible, prior to commencing deballasting. When segregated ballast is being discharged, it is prudent to monitor the ballast being discharged overboard by a visual watch. This may give the earliest warning of any inter-tank leakage between cargo and ballast tanks that may have been undetected, or even have been undetectable, before starting the ballast operation. The operation should be stopped immediately in the event of contamination being observed.

11.6.6.1 Air Draught Management

Ballast carried in segregated tanks may be retained on board in order to reduce the freeboard. This may be necessary because of weather conditions or, for example, to keep within the restrictions of the terminal metal loading arms. Care must be taken, however, not to exceed the maximum draught for the berth and to include the ballast weights in the hull stress calculations.

11.6.6.2 Discharging Segregated Ballast to Shore

Some terminals require that segregated ballast is discharged into shore tanks to meet environmental restrictions. On tankers with segregated ballast, this requires the cross-connection of the cargo and ballast systems, with the attendant risk of contamination between the systems unless a deck manifold for ballast is fitted.

Operators should produce carefully considered procedures for managing this operation, which should address the following issues:

- Fitting of cross-connection.
- Loading and deballasting sequence.
- Draught and air draught requirements.
- Hull stress management.
- Cargo line setting procedure.
- Cargo pump operation.
- Segregation of ballast and cargo.
- Ballast tank draining.
- Removal of cross-connection and isolation of the systems.

11.6.7 N/A

11.6.8 N/A

11.7 Cargo Leakage into Double Hull Tanks

11.7.1 Action to be Taken

This Section addresses the actions to be taken in the event of a leak of cargo into a double hull or double bottom tank.

If a cargo leak is discovered, the first step should be to check the atmosphere in the double hull or double bottom tank to establish the cargo content. It should be noted that the atmosphere in this tank could be above the Upper Explosive Limit (UEL), within the flammable range, or below the Lower Explosive Limit (LEL). Regardless of the number of samples taken, any or all of these conditions may exist in different locations within the tank, due to the complexity of the structure. It is therefore essential that gas readings are taken at different levels, at as many points as possible, in order to establish the profile of the tank atmosphere.

It should also be borne in mind that the hazards associated with cargo leakage may also relate to the cargo's toxicity, corrosiveness or other properties and additional measurements may have to be performed to confirm safe conditions for entry.

If cargo gas is detected in a double hull or double bottom tank, there are a number of options which can be considered to maintain the tank atmosphere in a safe condition:

- Continuous ventilation of the tank.
- Inerting the tank.
- Filling or partially filling the tank with ballast.
- Securing the tank with flame screens in place at the vents.
- A combination of the above.

The option chosen will depend upon a number of factors, especially the degree of confidence in the cargo content of the atmosphere, bearing in mind the potential problems identified above.

If a leakage is discovered, the tanker's captain should immediately contact the Company for consultation. It is strongly recommended that operators develop guidelines, taking into account the tank structure and any limitations of the available atmosphere monitoring system, which could assist the tanker's personnel to select the appropriate method of rendering the atmosphere safe. The guidelines should also include the process for contacting authorities and/or the tanker's Classification Society.

Filling or partially filling the double hull or double bottom tank with ballast in order to render the atmosphere safe and/or stop any further leakage of cargo into the tank must take into account prevailing stress, trim, stability and loadline factors. It must also be borne in mind that all ballast loaded into a tank after a leak has been found, and all tank washings associated with cleaning the tank, will be classed as 'polluted ballast' and must be processed in accordance with legislation. This means that they must be transferred directly to a cargo or slop tank for further processing. The spool piece used to connect the ballast system to the cargo system should be clearly identified and it should not be used for any other purpose.

If the double hull or double bottom tank is ventilated or inerted in lieu of filling, it should be sounded regularly to ascertain the rate of liquid build-up and thus of leakage.

If the quantity of cargo leaking into the space is determined to be pumpable, it should be transferred to another cargo tank via the emergency ballast/cargo spool piece connection, if available (see above), or other emergency transfer method, in order to minimise contamination of the space and to facilitate subsequent cleaning and gas freeing operations.

Written procedures, indicating the actions to be taken and the operations necessary for the safe transfer of the cargo from the ballast space, should be available.

Entry into the tank should be prohibited until it is safe for entry and there is no further possibility of cargo ingress. However, if it is deemed essential to enter the tank for any reason, such entry must be carried out in accordance with Section 10.7.

11.7.2 N/A

11.8 Cargo Measurement, Ullaging, Dipping and Sampling

11.8.1 General

Depending on the toxicity and/or volatility of the cargo, it may be necessary to prevent or minimise the release of vapour from the cargo tank ullage space during measurement and sampling operations.

Wherever possible, this should be achieved by the use of closed gauging and sampling equipment.

There are circumstances where it is considered essential to obtain clean samples for quality purposes, such as for high specification aviation fuels. The use of closed sampling equipment may cause cross-contamination of product samples and, where this is the case, the terminal operator may wish to undertake open sampling. A risk assessment should be carried out to ascertain whether open sampling can be achieved safely, taking into account the product volatility and toxicity. Risk mitigation measures, including the use of appropriate personal protective equipment if necessary, should be put in place before starting the operation.

Closed gauging or sampling should be undertaken using the fixed gauging system or by using portable equipment passed through a vapour lock. Such equipment will enable innages, ullages, temperatures, water cuts and interface measurements to be obtained with a minimum of cargo vapours being released. This portable equipment, passed through vapour locks, is sometimes referred to as ‘restricted gauging equipment’.

When it is not possible to undertake closed gauging and/or sampling operations, open gauging will need to be employed. This will involve the use of equipment passed into the tank via an ullage or sampling port or a sounding pipe, and personnel may therefore be exposed to concentrations of cargo vapour.

As cargo compartments may be in a pressurised condition, the opening of vapour lock valves, ullage ports or covers and the controlled release of any pressure should only be undertaken by authorised personnel.

When measuring or sampling, care must be taken to avoid inhaling gas. Personnel should therefore keep their heads well away from the issuing gas and stand at right angles to the direction of the wind. Standing immediately upwind of the ullage port might create a back eddy of vapour towards the operator. In addition, depending on the nature of the cargo being handled, consideration may have to be given to the use of appropriate respiratory protective equipment (see Sections 10.8 and 11.8.4).

When open gauging procedures are being employed, the tank opening should only be uncovered long enough to complete the operation.

11.8.2 Measuring and Sampling Non-Inerted Tanks

11.8.2.1 General

There is a possibility of electrostatic discharges whenever equipment is lowered into non-inerted cargo tanks. The discharges may come from charges on the equipment itself or from charges already present in the tank, such as in the liquid contents, on water or oil mists. If there is any possibility of the presence of a flammable mixture of cargo gas and air mixture, precautions must be taken to avoid incendive discharges throughout the system.

Precautions are necessary to deal with two distinct types of hazard:

- The introduction of equipment that may act as a spark promoter into a tank that already contains charged materials.
- The introduction of a charged object into a tank.

Each requires different mitigation measures.

Table 11.2 provides a summary of the precautions to be taken against electrostatic hazards when ullaging and sampling non-inerted cargo tanks.

11.8.2.2 Introduction of Equipment into a Tank

Measures to Avoid Introducing Spark Promoters

If any form of dipping, ullaging or sampling equipment is used in a possibly flammable atmosphere where an electrostatic hazard exists or can be created, precautions should be taken to ensure that they do not act as an unearthed conductor at any time during the operation. Metallic components of any equipment to be lowered into a tank should be securely bonded together and to the tank before the sampling device is introduced, and should remain earthed until after removal. Bonding and earthing cables should be metallic.

Cargo tank operation when hazard can occur	Lowering of equipment with ropes or tapes of synthetic material	Loading clean oils	Tank washing
Electrostatic hazard [Chapter 3]	Rubbing together of synthetic polymers [Sections 11.8.2.2]	Flow of static accumulator liquids [Sections 11.1.7 & 11.8.2.3]	Water mist droplets [Section 3.3.4 & 11.8.2.5]
Precautions necessary For dipping, ullaging and sampling with:	[Sections 11.8.2.3 & 11.3.5.2 g)]	[Section 11.8.2.3]	[Sections 11.3.5.2 g) & 11.8.2.5]
(i) metallic equipment not earthed or bonded:	Do not use ropes or tapes made of synthetic materials for lowering into cargo tanks at any time	Not permitted at any time	Not permitted during washing and for 5 hours thereafter
(ii) metallic equipment which is earthed and bonded from before introduction until after removal:	"	Not permitted during loading and for 30 minutes thereafter	No restrictions
(iii) non-conducting equipment with no metallic parts:	"	No restrictions	No restrictions
Exceptions permitted if:	"	Sounding pipe is used	a) Sounding pipe is used or b) Tank is continuously mechanically ventilated, when 5 hours can be reduced to 1 hour

Table 11.2 - Summary of precautions against electrostatic hazards when ullaging and sampling non-inerted tanks

Equipment should be designed to facilitate earthing. For example, the frame holding the wheel on which a metal measuring tape is wound should be provided with a threaded stud to which a sturdy bonding cable is bolted. The stud should have electrical continuity through the frame to the metal measuring tape. The other end of the bonding cable should terminate in a spring-loaded clamp suitable for attachment to the rim of an ullage opening.

Those responsible for the supply of non-conductive and intermediate conductive equipment to tankers must be satisfied that the equipment will not act as spark promoters. It is essential that non-conducting components do not lead to the insulation of any metal components from earth. For example, if a plastic sample bottle holder includes a metallic weight, the weight must be bonded as described above or fully encapsulated in a minimum of 10 mm thick plastic.

Measures to Avoid Introducing Charged Objects

The suitability of equipment made wholly of non-metallic components depends upon the volume and surface resistance of the materials employed and their manner of use. Non-conducting and intermediate conducting materials may be acceptable in some circumstances, for example plastic sample bottle holders can be lowered safely with natural fibre (intermediate conductivity) rope. Natural fibre rope should be used because synthetic rope generates significant static charge when sliding rapidly through an operator's gloved hand. This type of apparatus needs no special bonding or earthing.

A material of intermediate conductivity, such as wood or natural fibre, generally has sufficient conductivity as a result of water absorption to avoid the accumulation of electrostatic charge. At the same time, the conductivity of these materials is low enough to ensure that instantaneous release of a charge is not possible. There should be a leakage path to earth from such materials, so that they are not totally insulated, but this need not have the very low resistance normally provided for the bonding and earthing of metals. In practice, such a path usually occurs naturally on tankers, either by direct contact with the tanker or by indirect contact through the operator of the equipment.

11.8.2.3 Static Accumulator Oils

It is prudent to assume that the surface of a non-conducting liquid (static accumulator) may be charged and at a high potential during and immediately after loading. Metallic dipping, ullaging and sampling equipment should be bonded and earthed to avoid sparks. There remains, however, the possibility of a brush discharge between the equipment and the charged liquid surface as the two approach each other. Since such discharges can be incendive, no dipping, ullaging or sampling with metallic equipment should take place while a static accumulator is being loaded, due to the possibility of the presence of a flammable gas mixture.

There should be a delay of 30 minutes (settling time) after the completion of loading of each tank before commencing these operations. This is to allow the settling of gas bubbles, water or particulate matter in the liquid and the dissipation of any electrical potential.

The situations in which these restrictions on the use of metallic equipment should be applied are summarised in Figure 11.5.

Non-Metallic Equipment

Discharges between the surface of a static accumulator oil and non-metallic objects have not in practice been found to be incendive. Dipping, ullaging or sampling with non-metallic equipment lowered on clean natural fibre line is therefore permissible at any time.

Section 3.2.1 should be referred to regarding the use of non-metallic sampling containers.

Sounding Pipes

Operations carried out through sounding pipes are permissible at any time, because it is not possible for any significant charge to accumulate on the surface of the liquid within a correctly designed and installed sounding pipe. A sounding pipe is defined as a conducting pipe which extends the full depth of the tank and which is effectively bonded and earthed to the tank structure at its extremities. The pipe should be slotted in order to prevent any pressure differential between the inside of the pipe and the tank and to ensure that true level indications are obtained.

The electrostatic field strength within a metal sounding pipe is always low due to the small volume and to shielding from the rest of the tank. Dipping, ullaging and sampling within a metal sounding pipe are therefore permissible at any time, provided that any metallic equipment is properly earthed. Non-metallic equipment may also be used in sounding pipes, although the precautions against introducing charged objects must be applied.

11.8.2.4 Static Non-Accumulator Oils

The possibility exists of a flammable atmosphere being present above a static non-accumulator oil in a non-inerted or non-gas free environment and therefore the precautions summarised in Section 11.8.2 and Figure 11.5 should be followed.

11.8.2.5 Ullaging and Dipping in the Presence of Water Mists

When tank washing operations are performed, it is essential that there should be no unearthed metallic conductor in the tank, and that none should be introduced while the charged mist persists, i.e. during washing and for 5 hours after the completion of the operation. Earthed and bonded metallic equipment can be used at any time because any discharges to the water mist take the form of a non-incendive corona. The equipment can contain or consist entirely of non-metallic components. Both intermediate conductors and non-conductors are acceptable, although the use of polypropylene ropes, for example, should be avoided. (See Section 3.3.4.)

It is absolutely essential, however, that all metallic components are securely earthed. If there is any doubt about earthing, the operation should not be permitted.

Ullaging and dipping operations carried out via a full-depth sounding pipe are safe at any time in the presence of a wash water mist.

11.8.3 Measuring and Sampling Inerted Tanks

Tankers fitted with inert gas systems will have closed gauging systems for taking measurements during cargo operations. In addition, many tankers will be provided with vapour locks to enable closed gauging and sampling to be undertaken for custody transfer purposes.

Tankers equipped with a vapour lock on each cargo tank can measure and sample cargo without reducing the inert gas pressure. In many cases, the vapour locks are used in conjunction with specially adapted measurement devices, including sonic tapes, samplers and temperature tapes. When using the equipment, the valves of the vapour lock should not be opened until the instrument is properly attached to the standpipe. Care should be taken to ensure that there is no blow-back of vapour.

Sonic tapes, temperature tapes etc must be used in accordance with good safety practices and the manufacturer’s instructions. The requirements for portable electrical equipment apply to these measurement devices (see Section 4.3).

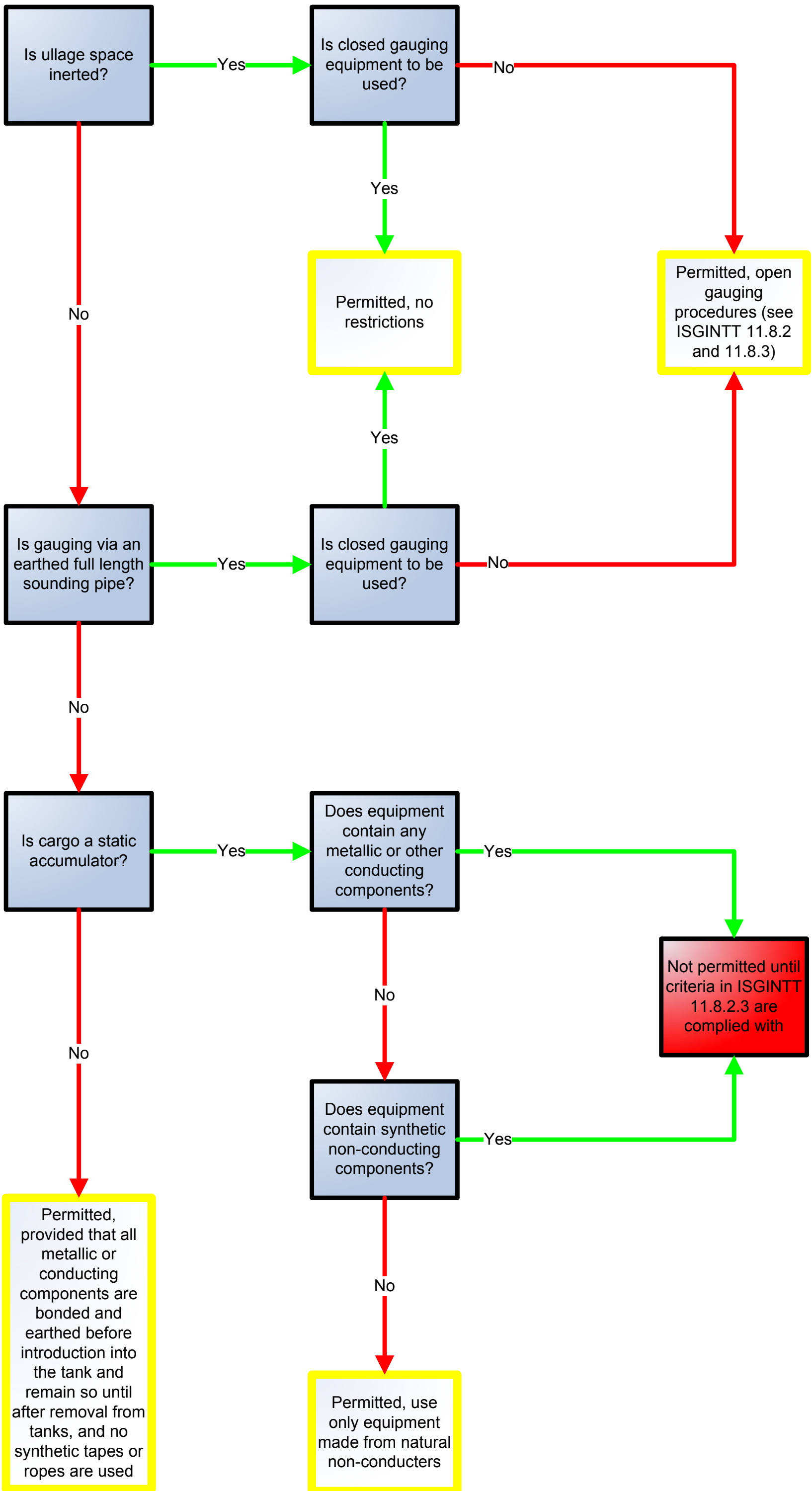


Figure 11.5 - Precautions required when using portable measuring and sampling equipment

On tankers that are not equipped with vapour locks, special precautions need to be taken for the open measurement and sampling of cargo carried in tanks which are inerted. When it is necessary to reduce the pressure in any tank for the purposes of measuring and sampling, the following precautions should be taken:

- If possible, a minimum positive inert gas pressure should be maintained during measurement and sampling. The low oxygen content of inert gas can rapidly cause asphyxiation and therefore care should be taken to avoid standing in the path of vented gas during measurement and sampling (see Section 11.8.1). No cargo or ballast operations are to be permitted in cargo compartments while the inert gas pressure is reduced to allow measuring and sampling.
- Only one access point should be opened at a time and for as short a period as possible. In the intervals between the different stages of cargo measurement (e.g. between ullaging and taking temperatures) the relevant access point should be kept firmly closed.
- After completing the operation and before commencing the discharge of cargo, all openings should be secured and the cargo tanks re-pressurised with inert gas. (See Section 7.1 for the operation of the tanker's inert gas system during cargo and ballast handling.)
- Measuring and sampling which require the inert gas pressure to be reduced and cargo tank access points opened should not be conducted during mooring and unmooring operations. It should be noted that, if access points are opened while a tanker is at anchor or moored in an open roadstead, any movement of the tanker might result in the tanks breathing. To minimise this risk in such circumstances, care should be taken to maintain sufficient positive pressure within the tank being measured or sampled.

If it is necessary to sound the tanks when approaching the completion of discharge, the inert gas pressure can again be reduced to a minimum safe operational level to permit sounding through sighting ports or sounding pipes. Care should be taken to avoid the ingress of air or an excessive release of inert gas.

11.8.3.1 Static Accumulator Cargoes in Inerted Cargo Tanks

Precautions are not normally required against static electricity hazards in the presence of inert gas because the inert gas prevents the existence of a flammable gas mixture. However, very high electrostatic potentials are possible due to particulates in suspension in inert gas. If it is believed that a tank is no longer in an inert condition, then dipping, ullaging and sampling operations should be restricted as detailed in Sections 7.1.6.8 and 11.8.2.

Restrictions would be required in the event of a breakdown of the inert gas system during discharge:

- In the event of air ingress.
- During re-inerting of a tank after such a breakdown.
- During initial inerting of a tank containing a flammable gas mixture.

Because of the very high potential that may be carried on inert gas particulates, it should not be assumed that corona discharges arising from conducting equipment introduced into the tank will be non-incendive if the tank contains a flammable atmosphere. Therefore, no object should be introduced into such a tank until the initially very high potential has had a chance to decay to a more tolerable level. A wait of 30 minutes after stopping the injection of inert gas is sufficient for this purpose. After 30 minutes, equipment may be introduced, subject to the same precautions as for water mists caused by washing (see Section 11.8.2.5).

11.8.4 Measuring and Sampling Cargoes Containing Toxic Substances

Special precautions need to be taken when tankers carry cargoes that contain toxic substances in concentrations sufficient to be hazardous.

Loading terminals have a responsibility to advise the tanker captain if the cargo to be loaded contains hazardous concentrations of toxic substances. Similarly, it is the responsibility of the tanker captain to advise the receiving terminal that the cargo to be discharged contains toxic substances. This transfer of information is covered by the Safety Check-Lists (see Section 26.3).

The tanker must also advise the terminal and any other personnel, such as tank inspectors or surveyors, if the previous cargo contained toxic substances.

Tankers carrying cargoes containing toxic substances should adopt closed sampling and gauging procedures if possible.

When closed gauging or sampling cannot be undertaken, tests should be made to assess the vapour concentrations in the vicinity of each open access point, in order to ensure that concentrations of vapour do not exceed the Short Term Exposure Limit (TLV-STEL) of the toxic substances that may be present. If monitoring indicates the limit could be exceeded, suitable respiratory protection should be worn. Access points should be opened only for the shortest possible time.

If effective closed operations cannot be maintained, or if concentrations of vapour are rising because of defective equipment or due to still air conditions, consideration should be given to suspending operations and closing all venting points until defects in equipment are corrected, or weather conditions change and improve gas dispersion.

Reference should be made to Section 2.3 for a description of the toxicity hazards of bulk liquids.

11.8.5 Closed Gauging for Custody Transfer

The gauging of tanks for custody transfer purposes should be effected by the use of a closed gauging system or via vapour locks. For the ullaging system to be acceptable for this purpose, the gauging system should be described in the tanker’s tank calibration documentation. Corrections for datum levels, and for list and trim, should be checked and approved by the tanker’s classification society.

Temperatures can be taken using electronic thermometers deployed into the tank through vapour locks. Such instruments should have the appropriate approval certificates and should also be calibrated.

Samples should be obtained by the use of special sampling devices using the vapour locks.

11.9 Transfers Between Vessels

11.9.1 Tanker-to-Tanker Transfers

In tanker-to-tanker transfers, both tankers should comply fully with the safety precautions required for normal cargo operations. If the safety precautions are not being observed on either vessel, the operations must not be started or, if in progress, must be stopped.

Tanker-to-tanker transfers undertaken in port or at sea may be subject to approval by the port or local marine authority and certain conditions relating to the conduct of the operation may be attached to such approval.

11.9.2 Seagoing Vessel-to-Inland Tanker and Inland Tanker-to-Seagoing Vessel

In seagoing vessel-to-inland tanker or inland tanker-to-seagoing vessel transfers of bulk liquids, only authorised and properly equipped vessels should be used. If safety precautions are not being observed on either the inland tanker or the seagoing vessel, the operations must not be started or, if in progress, must be stopped.

Tanker captains should be aware Masters of seagoing vessels may work with the ICS/OCIMF 'Tanker-to-Tanker Transfer Guide (Petroleum). See also Appendices 2 and 3 'Seagoing – Inland Tanker/ Inland Tanker Safety Check-List.

The rate of pumping from seagoing vessel to inland tanker must be controlled according to the size and nature of the receiving inland tanker. Communications procedures must be established and maintained, particularly when the freeboard of the tanker is high in relation to that of the inland tanker.

If there is a large difference in freeboard between the seagoing vessel and the inland tanker, the tanker crew must make allowance for the contents of the hose on completion of the transfer.

Arrangements should be made to release the inland tanker in an emergency, having regard to other shipping or property in the vicinity. If the seagoing vessel is at anchor, it may be appropriate for the inland tanker to drop anchor clear of the seagoing vessel, where it could remain secured to wait for assistance.

Inland tankers should be cleared from the seagoing vessel's side as soon as possible after they have completed the loading or discharging of volatile cargoes.

11.9.3 Tanker-to-Tanker Transfers Using Vapour Balancing

Specific operational guidance should be developed to address the particular hazards associated with vapour emission control activities during tanker-to-tanker transfer operations using vapour balancing techniques.

11.9.4 Tanker-to-Tanker Transfers Using Terminal Facilities

Where a tanker at a berth is transferring cargo to a tanker at another berth through the shore manifolds and pipelines, the two tankers and the terminal should comply with all regulations relating to tanker-to-shore transfers, including written operating arrangements and communications procedures. The co-operation of the terminal in establishing these arrangements and procedures is essential.

11.9.5 Tanker-to-Tanker Electric Currents

The principles for controlling arcing during tanker-to-tanker transfer operations are the same as in tanker-to-shore operations.

In tankers dedicated to tanker-to-tanker transfers, an insulating flange or a single non-conducting length of hose should be used in the hose string. However, when transferring static accumulator oils, it is essential that these measures are not taken by both tankers, leaving an insulated conductor between them upon which an electrostatic charge could accumulate. For the same reason, when such a dedicated tanker is involved in tanker-to-shore cargo transfers, care should be taken to ensure that there is no insulated conductor between the tanker and shore through, for example, the use of two insulating flanges on one line.

In the absence of a positive means of isolation between the tankers, the electrical potential between them should be reduced as much as possible. If both have properly functioning impressed current cathodic protection systems, this is probably best achieved by leaving them running. Likewise, if one has an impressed system and the other a sacrificial system, the former should remain in operation.

However, if one of the tankers is without cathodic protection, or its impressed system has broken down, consideration should be given to switching off the impressed system on the other tanker well before the two tankers come together.