CHAPTER 12

Shipboard Operations

12.1 Cargo operations

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This chapter covers the full range of shipboard operations, including loading and discharging cargo, hose clearing, tank cleaning and gas freeing, ballasting, STS transfers and mooring.

The chapter also looks at the safe handling of particular cargoes, such as static accumulator oils, those having a high vapour pressure and those containing H_2S.

Other operations addressed include the use of VECSs and COW.

12.1 Cargo operations

12.1.1 General

All cargo operations should be carefully planned and documented well in advance. The plans should be discussed with all personnel on the ship and at the terminal and may require modification after this consultation. Plans may also need to be modified after consultation with the terminal and following changing circumstances, either on board or ashore, and these changes should again be communicated and understood by ship and terminal personnel, and formally recorded. Chapter 21 contains details of cargo plans and relevant communications. The company's SMS should include guidance on the requirements outlined below to ensure that these are implemented.

12.1.2 Setting of lines and valves

Before starting any loading or discharging, the ship's cargo pipelines and valves should be set in line with the loading or discharging plan and checked independently and by other personnel under the control of the Responsible Officer. If a change in the line-up is required during a change of grades, the valves should be checked in the same way. The Responsible Officer should document the completion of the task and sign it.

12.1.3 Valve operation

Valves at the downstream end of a pipeline system should not be closed against the flow of liquid, except in an emergency, to avoid the risk of pressure surges. This should be emphasised to all personnel responsible for cargo handling operations on the ship and at the terminal (see section 12.1.4).

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

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

12.1.4 Pressure surges

The incorrect operation of pumps and valves can produce pressure surges caused by the kinetic energy of the liquid flow in a pipeline system.

These surges may be severe enough to damage the pipeline, hoses or Marine Loading Arms (MLAs). One of the most vulnerable parts of the system is the ship/shore connection. Pressure surges are produced upstream of a closing valve and may become excessive if the valve is closed too quickly. Pressure surges are more likely to be severe where long pipelines, high flow rates or significant differences in elevation between the ship and shore tank are present.

The risk of pressure surges means the ship and terminal need to exchange information and draw up a written agreement on the control of flow rates, the rate of valve closure and pump speeds. This should include the time that remotely controlled and automatic shutdown valves take to close. The agreement should be part of the operational plan, discussed at the pre-transfer conference and documented in part 8 of the Ship/Shore Safety Checklist (SSSCL).

12.1.5 Butterfly and Non-Return (check) Valves

The risk of butterfly and NRVs slamming shut against high flow rates should be considered. This can cause very large surge pressure and lead to line, hose or MLA failures or even structural damage to jetties. These failures are usually because the open valve disc is not completely parallel to, or fully withdrawn from, the flow. This can create a closing force that may shear either the valve spindle of butterfly valves or the hold-open pin of pinned back NRVs. To prevent damage, it is important to check all valves are fully open when they are passing cargo or ballast.

12.1.6 Loading procedures

12.1.6.1 General

The responsibility for safe cargo handling is shared between the ship and the terminal and rests jointly with the Master and the Terminal Representative. How this responsibility is shared should be agreed at the pre-transfer conference so that all aspects of the operations are covered.

12.1.6.2 Joint agreement on readiness to load

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

12.1.6.3 Emergency Shutdown plan

The ship and the terminal should have agreed an Emergency Shutdown (ESD) procedure and alarm and recorded it on an appropriate form. This agreement sets out those circumstances when operations should stop immediately. It also accounts for the possible dangers of a pressure surge caused by an ESD procedure (see section 16.8).

12.1.6.4 Supervision

The following safeguards should be maintained throughout loading:

- A Responsible Officer should be on watch and enough crew members should be on board to deal with the operation and security of the ship.
- A watch of the tank deck should be maintained.
- The agreed ship to shore communications system should be maintained in good working order.
- At the start of loading, and at each change of watch or shift, the Responsible Officer and the Terminal Representative should each confirm that the communications system remains operational.
- All personnel concerned should fully understand the agreed standby notice period for the normal stopping of shore pumps on completion of loading and the emergency stop system for both the ship and terminal.

Many terminals require a standby period for stopping pumps that should be understood and noted (section 21.4.2).

For instructions for completing the SSSCL, see section 25.4.

12.1.6.5 Inert Gas procedures

Before loading starts, the IG plant, if operational, should be stopped and the IG pressure in the tanks reduced as per company procedures unless cargo is to be simultaneously loaded and discharged.

12.1.6.6 Closed loading

For effective closed loading, cargo should be loaded with the ullage, sounding and sighting ports securely closed. The gas displaced by the incoming cargo should be vented to the atmosphere via a mast riser, VRL or a high velocity or constant velocity vent valve. Devices fitted to mast risers or vent stacks that prevent the passage of flame should be checked regularly to confirm they are correctly installed, clean and in good condition.

To undertake closed loading the ship should have ullaging equipment that can monitor the tank contents without opening tank apertures (closed gauging and sampling are discussed in section 12.8.1). Most ships are also fitted with a remote gauging system that uses floats, radar or another sensing method that can be read in the cargo control room.

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

12.1.6.6.1 Risk of overfilling

Loading a cargo tank under normal closed conditions comes with a risk of overfilling. The reliance on closed gauging systems means it is important they are fully operational and an independent overfill alarm arrangement should provide backup.

Two alarm points should be fitted. The first is known as 'high level' and is normally set to alarm at 95% capacity. This may be activated from the tank level gauging system or from a float switch. A 'high-high level' or 'overfill' alarm is normally set at 98% capacity and should be independent of the tank gauging system. This alarm is normally activated by a float switch. The high-high level/overfill alarm should be audible and visible in the cargo control room and on deck. Cargo tanks should not be filled higher than the high-high level/overfill alarm as this is the last barrier and no further warnings will be given before the tank overflows.

Before any cargo operation, individual high level and overfill alarms should be tested at the tank to ensure they are working properly.

On ships without IG systems, this equipment should comply with the precautions in section 12.8.2.

Ships with IG are considered capable of closed loading at all times.

12.1.6.7 Starting to load alongside a terminal

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

12.1.6.8 Starting to load at offshore buoy berths

Before loading starts at a buoy berth offshore, the ship should confirm its full understanding of the communications system that will control the operation. A secondary communications system should be ready for immediate use should the primary system fail.

After an initial slow loading rate to test the system, the flow rate may be brought up to the agreed maximum. A close watch should be kept on the sea around the seabed/Pipeline End Manifold (PLEM) to check for leaks. If safe and practical, during darkness a bright light should be shone on the water in the area of the hoses.

12.1.6.9 Starting to load through a stern manifold

Before loading starts through a stern manifold, the dangerous area that extends at least three metres from the manifold valve should be clearly marked. No unauthorised personnel should be allowed in this area during the loading operation.

A close watch should be maintained for any leaks. All openings, air inlets and doors to enclosed spaces should be kept tightly closed.

Firefighting equipment should be laid out ready for use near the stern manifold:

- The cargo hose connection should be carefully inspected for correct alignment and secure coupling. Where possible, a water pressure test of the coupling seals should be made.
- If fitted, any Emergency Release Systems (ERSs) for the mooring and cargo connection should be operational. These systems should be tested before mooring.
- All primary and secondary communication links with the loading terminal should be tested, including any telemetry control system.
- Smoking and naked light requirements should be strictly enforced.

A responsible crew member should keep continuous watch at the stern throughout loading. During darkness, the lighting on and around the ship's stern should allow an effective visual watch to be maintained on the mooring point, mooring system, cargo hose connection, loading hoses and water around the stern.

12.1.6.10 Starting to load through a bow connection

Bow loading ships, which will be designed to work at particular terminals (normally Single Point Moorings (SPMs)), will have their own specific and detailed operating and safety procedures.

However, in general, the following checks should be carried out before loading:

- The mooring system should be inspected for a secure connection.
- The cargo hose connection should be carefully inspected for correct alignment and secure coupling. Where possible, a water pressure test of the coupling seals should be made.
- Any ERSs provided for the mooring and cargo connection should be operational and should be tested before mooring.
- Mooring load monitoring systems should be activated and tested.
- All primary and secondary communication links with the loading terminal should be tested, including any telemetry control system.

A responsible crew member should keep continuous watch on the bow throughout loading. During darkness, the lighting on and around the ship's bow should allow an effective visual watch to be maintained on the mooring point, mooring system, cargo hose connection, loading hoses and water around the bow.

12.1.6.11 Loading through pumproom lines

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

12.1.6.12 Cargo sampling at the start of loading

Where facilities exist, a cargo sample should be taken as soon as possible after the start of loading. The product's visual quality should be checked to ensure the correct grade is being loaded. This should be done before opening up subsequent tanks for loading (see section 12.8).

When loading static accumulating cargoes, follow the precautions against static electricity hazards when taking the sample (see section 12.1.7).

12.1.6.13 Periodic checks during loading

Throughout loading, monitor and regularly check all full and empty tanks to confirm that cargo is entering the designated cargo tanks only and that no cargo has escaped into pumprooms or cofferdams or through sea and overboard discharge valves.

Tank ullages should be checked at least hourly and a loading rate calculated. Cargo figures and rates should be compared with shore figures to identify any discrepancy.

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

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

Frequently inspect the cargo deck and pumproom for any leaks. Overside areas should also be checked regularly. During darkness, where safe and practical, illuminate the water around the ship.

12.1.6.14 Topping-off on board the tanker

The ship should advise the terminal when tanks are to be topped-off. It should ask the terminal, giving plenty of warning, to reduce the loading to a rate that allows effective control of the flow on board the ship. After topping-off individual tanks, master valves should be closed where possible to provide two valve segregation of loaded tanks. The ullages of topped-off tanks should be checked from time to time to ensure that cargo flow has stopped so that leaking valves or incorrect operations do not cause overflows.

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

Not all of the tanker's valves should be closed against the flow of oil. The minimum number of tanks to be kept open during topping-up should be established.

Before loading is completed, the ship should advise the shore to standby for stopping cargo, including stopping pumps and closing valves. From this moment, the loading rate should be reduced and done by gravity where possible so that shore control valves can be closed as soon as requested by the ship. Shore control valves should be closed before the ship's valves.

12.1.6.15 Blending operations

SOLAS VI, Regulation 5-2, prohibits the physical blending of bulk liquid cargoes during a sea voyage. Physical blending is when the ship's cargo pumps and pipelines internally circulate two or more different cargoes to produce a cargo with a new product specification.

This does not prevent the Master from undertaking cargo transfers for the safety of the ship or protection of the marine environment in an emergency. Circulating cargo is also permitted for cargo conditioning.

Blending operations in port should be planned to ensure they comply with the applicable MARPOL regulations and local port requirements. A risk assessment that considers the grades to be loaded, vapour pressure of the cargoes, compatibility of the grades and the crew's experience of blending should be completed.

12.1.6.16 Doping and additives: anti-static, inhibitors, dyes, hydrogen sulphide knockdown

Doping is when cargoes are treated with small quantities of specialised additives and fluids, such as dyes, liquid markers, anti-static agents and lubricants, during loading or before leaving the port.

As far as possible, doping should be carried out ashore or in closed in-line condition. When the cargo or additives are flammable or toxic, a closed doping operation is recommended. However, some terminals do not have a closed in-line additive injection system, so the additives have to be added manually. Any manual doping activity should be risk assessed. Appropriate procedures should be in place to control the associated hazards. Manual doping operations should be carefully planned to minimise the health, safety and environmental impact.

The associated risk assessment should include a review of the Safety Data Sheet (SDS) of the cargo and the additive, suppliers' instructions, PPE, physical and operational hazards, supervision, weather, equipment, resources and contingency measures. Any free fall of additives into non-inerted cargo tanks should be avoided.

The supplier/contractor should draw up a doping plan and communicate this to the ship's Master before any doping. On receiving the plan, the Master should carry out their own onboard risk assessment and check that all relevant items have been addressed and the risks reduced to As Low As Reasonably Practicable (ALARP).

The flowchart in figure 12.1 outlines a doping plan that should contain the three main priorities to be considered and the associated minimum precautions to consider when preparing the risk assessment. These are:

Type of cargo additive:

- SDS should be reviewed for flammability and toxicity information.
- Required PPE and handling equipment should be identified and made available.
- Storage requirements for any additive to be carried on board.
- Considerations for any spillages during operation and method of clean up.
- Requirements for diluting the additive prior to doping.
- Confirm the tank coating is compatible.

Method of doping under consideration:

- Preference is for injection at a shore location or via an in-line injection system, e.g. via a spool piece at the ship's manifold:
  - Pressure test records for the injection system should be verified prior to commencing cargo operation.
- Where injection is required via a cargo tank vapour lock:
  - No doping should be undertaken on a live (loading) tank.
  - Personnel undertaking the operation should stand upwind of the tank opening to minimise gas exposure.
  - PPE is required to be fully implemented, including use of a personal gas monitor.
  - Anti-static precautions are to include ensuring the doping pump/container is properly grounded and the hoses are of an anti-static type.
  - Doping should only be undertaken one tank at a time.
  - When the ship has IG:
    - The tank branch line should be shut and the tank depressurised prior to doping.
    - After the doping operation, the tank oxygen content is to be reconfirmed and the tank re-pressurised.
  - When the ship does not have IG:
    - Free fall of additive into the cargo tank is prohibited.
    - When no full depth sounding pipes are provided, a minimum 30 minute relaxation period is required before and after the addition of additives.
- In exceptional cases only, when doping is required via an open tank lid:
  - All cargo operations should be halted.
  - Non-essential personnel should not be allowed on deck.
  - Personnel undertaking the operation should stand upwind of the tank opening to minimise gas exposure.
  - PPE is required to be fully implemented, including use of a personal gas monitor and (where necessary) use of:
    - SCBA.
    - EEBD.
    - Chemical resistant suits, face masks, etc.
    - Doping should only be undertaken one tank at a time:

- When the ship has IG:
  - The tank branch line should be shut and the tank de-pressurised before doping.
  - After the doping operation, the tank oxygen content is to be reconfirmed and the tank re-pressurised.
- When the ship does not have IG:
  - Free fall of additive into the cargo tank is prohibited.

Mixing ratio of the additive:

- Identify when the additive should be added and the required mixing ratio.
- Understand final sampling requirements for any confirmatory testing.

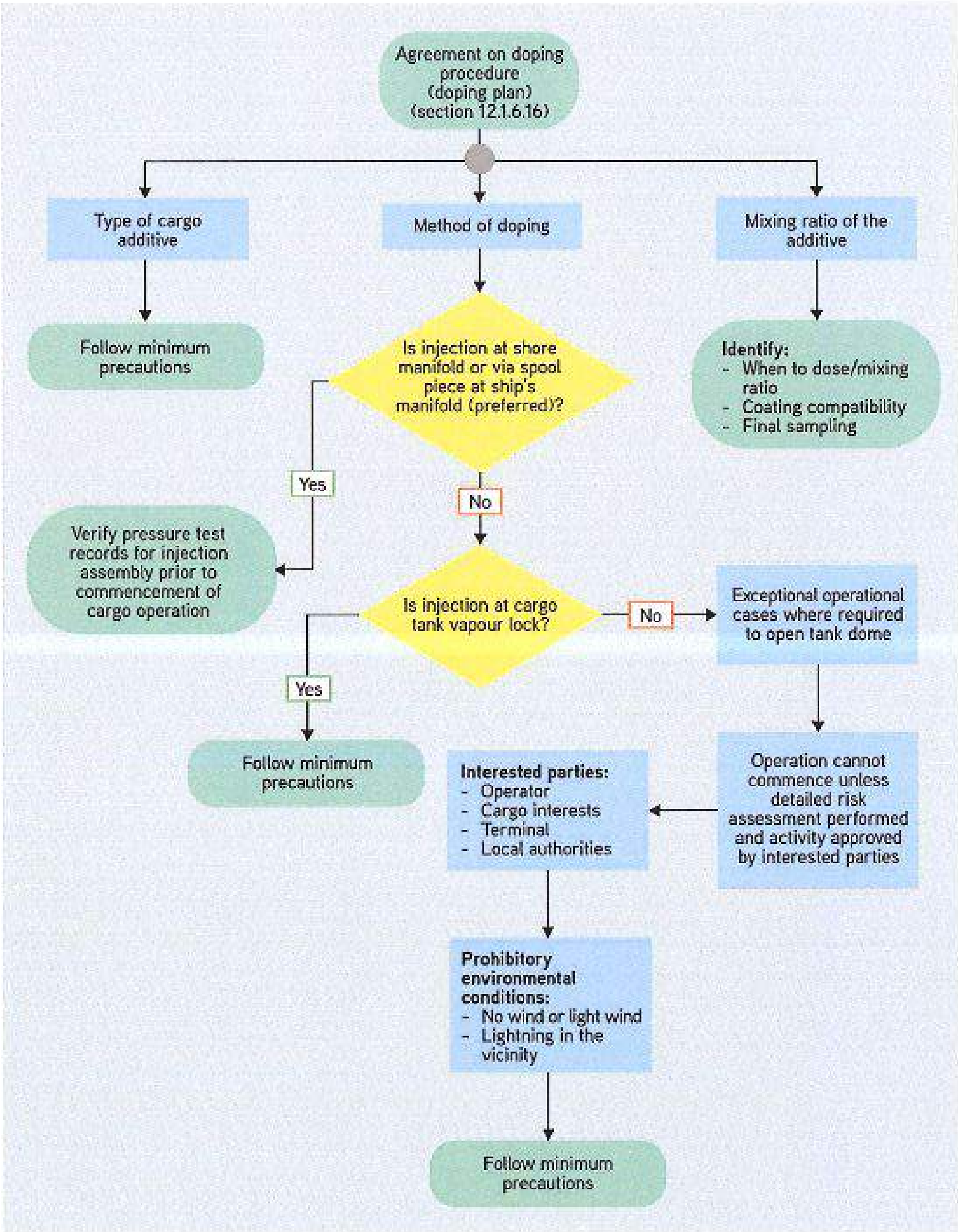


Figure 12.1: Cargo doping flowchart

The doping plan should be discussed by all personnel involved on the ship and in the terminal. As a minimum, the plan should include the method of doping, PPE to be used and the contingency measures.

The SDS for any additives should be reviewed as part of the risk assessment process regarding hazard identification and risk mitigation measures. A copy of the SDS should be kept in the vicinity of the doping operation.

If additives are to be stowed on board, they should be well secured; see section 13.5 for further guidance.

12.1.6.17 Checks after loading

After loading is completed, a Responsible Officer should confirm that all the required valves are closed and P/V valves are set correctly.

12.1.7 Loading static accumulator oils

12.1.7.1 General

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

Since the conductivities of distillates are not normally known and may not be included in an SDS or other common documents, they should all be treated as static accumulators unless they contain an anti-static additive that raises the conductivity above 50pS/m (for cautions on the effectiveness of anti-static additives, see section 12.1.7.9). A static accumulator may carry enough charge to be an incendive ignition hazard during loading and for up to 30 minutes after loading.

Bonding (see section 3.2.2) is an essential precaution for preventing electrostatic charge accumulation. Its importance cannot be overemphasised. However, while bonding helps relaxation it does not prevent accumulation and the production of hazardous voltages so it is not a universal remedy for eliminating electrostatic hazards. This section describes ways to control electrostatic generation by preventing charge separation, which is another essential precaution (see section 3.1.2).

12.1.7.2 Controlling electrostatic generation

Failure to follow the guidance in this section will lead to the hazardous conditions that can cause electrostatic ignition accidents.

Electrostatic discharge has long been known as a hazard associated with handling petroleum products.

If a flammable atmosphere is possible within the tank, specific precautions are required for maximum flow rates, safe ullaging, sampling and gauging when handling static accumulator products.

Mixtures of oil and water are a potent source of static electricity. Take extra care to prevent excess water and unnecessary mixing.

When a tank is verified as inert, no anti-static precautions are necessary.

12.1.7.3 During the initial filling of a tank

The generally accepted way to control electrostatic generation in the initial stages of loading is to restrict the velocity of oil entering the tank to one metre per second (m/sec) until the tank inlet and any other structure on the base of the tank has been submerged to twice the diameter of the filling pipe. This will stop all splashing and surface turbulence in the tank (see section 3.2.1).

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

Minimum diameter of piping* (mm)	Approx. flow rate (m^3/hr)
80	17
100	29
150	67
200	116
250	183
305	262
360	320
410	424
460	542
510	676
610	987
710	1,354
810	1,782

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

Table 12.1: Rates corresponding to 1m/sec

Table 12.1 shows the approximate volumetric flow rates that correspond to a linear velocity of 1m/sec in piping of various diameters.

The reasons for the low linear velocity at 1m/sec are:

1. At the beginning of filling a tank, there is the greatest likelihood of water being mixed with the oil entering the tank. Mixtures of oil and water are a potent source of static electricity.
2. A low product velocity at the tank inlet minimises turbulence and splashing as oil enters the tank. This helps reduce the generation of static electricity and also reduces the dispersal of any water present, so that it quickly settles out to the bottom of the tank where it can lie relatively undisturbed when the loading rate is subsequently increased.
3. A low product velocity at the tank inlet minimises the formation of mists that may accumulate a charge, even if the oil is not considered to be a static accumulator. This is because the mist droplets are separated by air, which is an insulator. A mist can result in a flammable atmosphere even if the liquid has a high flashpoint and is not normally capable of producing a flammable atmosphere.

Figure 12.2 is a flowchart to help identify the precautions needed when loading static accumulator cargoes.

12.1.7.4 Minimising hazards from water

Mixtures of oil and water are a potent source of static electricity, so care should be taken to prevent excess water, from operations such as water washing, ballasting or line flushing, entering a tank that contains or will contain a static accumulator oil. For example, cargo tanks and lines that have been flushed with water should be drained before loading. Water should not be allowed to accumulate in tanks. Lines should not be displaced with water back into a tank containing a static accumulator cargo (for an explanation of line displacement, see section 12.1.14.2).

Any water remaining in the shore or ship pipeline system after the initial filling might be flushed into the cargo tank when loading at the maximum rate (the minimum product velocity for flushing water out of pipelines effectively is 1m/sec). The resulting mixing and agitating of oil and water in the tank will increase the generation of static charge to a level that is unsafe in a flammable atmosphere. Before increasing to the bulk loading rate, it is necessary to ensure that, as far as practicable, all excess water lying in low spots in the pipelines has been flushed out of the system either before loading started or during the initial filling of the tank (for more on this process, see section 12.1.7.3).

Under normal circumstances, and provided the above precautions to prevent excess water have been taken, the amount of water still present in the system after the initial filling will not be enough to increase static generation when the loading rate is increased. However, if there is reason to believe excess water may still be in the shore pipeline the recommended action is to either:

- Keep the product velocity in the shore pipeline below 1m/sec throughout loading to avoid flushing the water into the ship's tank(s).
- Keep the product velocity at the tank inlet(s) below 1m/sec throughout loading to avoid turbulence in the tank(s).

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

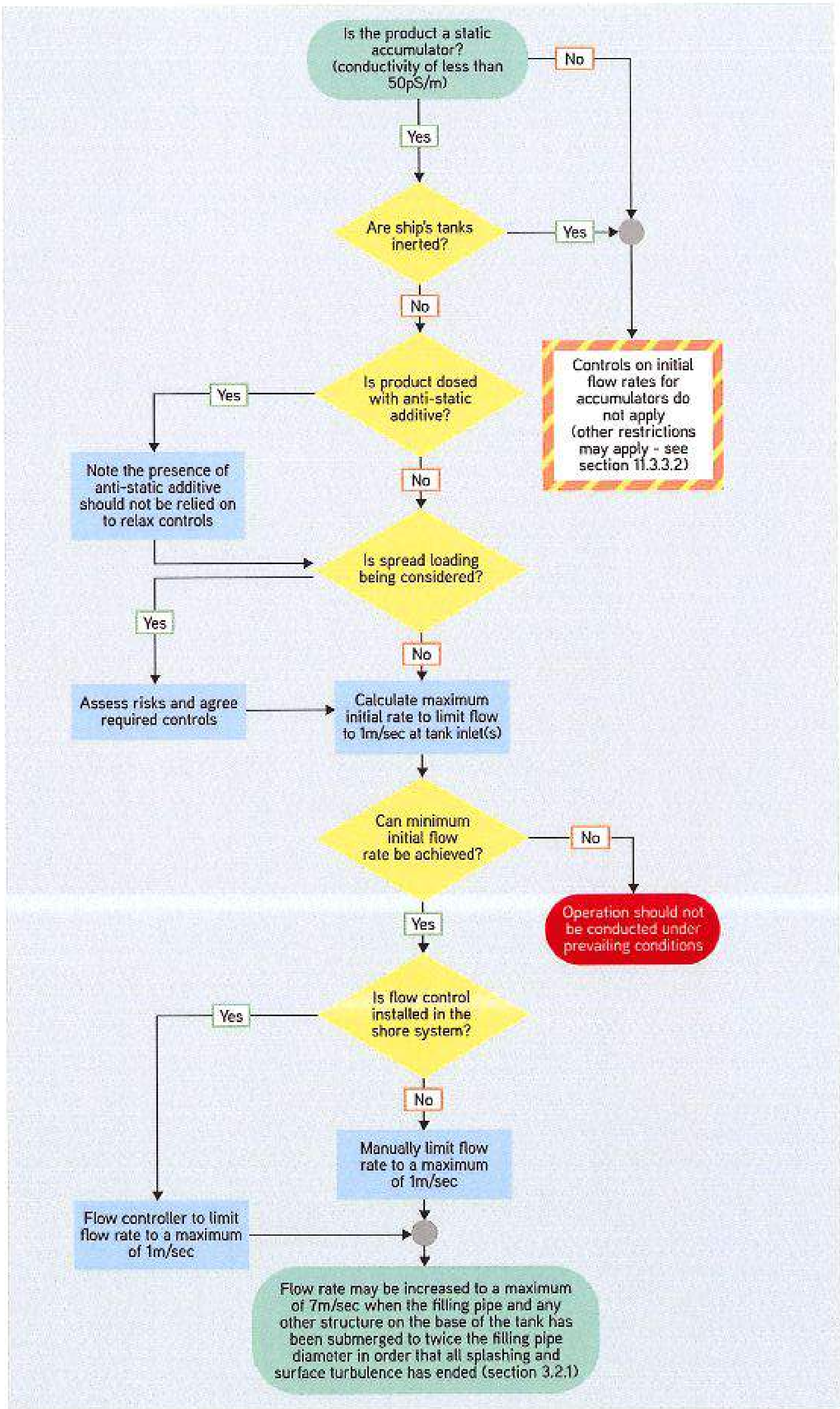
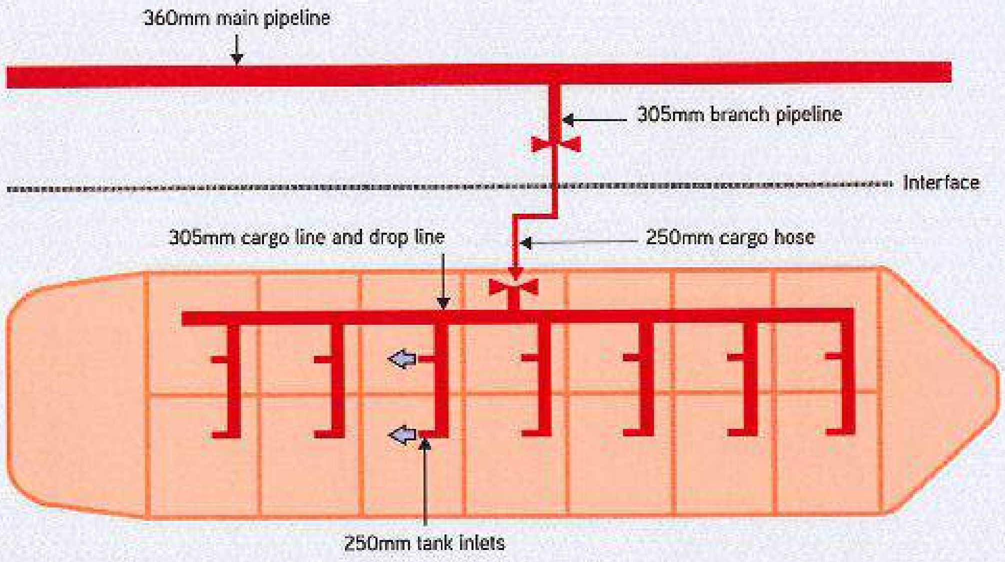


Figure 12.2: The control hazards associated with the initial loading of static accumulator cargoes flowchart

12.1.7.5 Examples

Initial loading phase

Figure 12.3 shows the pipeline arrangements for a ship loading a static accumulator product at a berth. The table defines the pipeline sizes and the volumetric flow rates at a velocity of 1m/sec. For initial loading to two cargo tanks in the example, the limitation will allow a loading rate of 366m³/hr.



Determining the initial loading rate

Line	Diameter, mm	Flow rate (m³/hr) at 1m/sec flow
Main shore pipeline	360	320
Shore branch line	305	262
Cargo hose	250	183
Ship's cargo and drop line	305	262
Tank inlets	250	183 x 2 = 366

Controlling parameter: velocity of product entering the tank

Therefore, an initial loading rate of not more than 366m³/hr should be requested for loading to two tanks simultaneously. This will result in the shore line flowing at more than 1m/sec which would clear any water lying in the line while the velocity at the tank inlets is 1m/sec.

Figure 12.3: Initial loading to two cargo tanks

12.1.7.6 Practical considerations

In practice, not all terminals have flow control devices to regulate the loading rate, so they may not be able to set a loading rate to one cargo tank equivalent to 1m/sec. Some terminals achieve, or try to achieve, a low loading rate by starting to load by gravity flow alone.

12.1.7.7 Spread loading

Spread loading is the practice of mitigating a terminal's lack of flow control by starting to load via a single shore pipeline to several of the ship's cargo tanks simultaneously. The aim is a loading rate that will give a maximum velocity of 1m/sec at each of the tank inlets.

Spread loading can present significant static generation risks that should be assessed and properly managed if the practice is to be used safely. For example:

- Uneven flow in the ship's cargo lines can create a backflow of vapour (gas or air) from other open tanks to the tank receiving product. This eductor effect creates a two phase mixture of product and vapour that results in increased turbulence and mist formation in the tank.
- There is a possibility of more than 1m/sec at one tank inlet due to uneven distribution of product between the open tanks.

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

- The overall loading rate should be chosen to ensure a maximum product velocity of 1m/sec into any one tank, assuming an even distribution of cargo between tanks.
- Possible different flow distributions into different tanks should be considered and best efforts should be made to ensure equal flow distribution between tanks.
- Not more than four cargo tanks should be loaded during spread loading. Referencing figure 12.3, if the shore line were increased in size to 510mm diameter and it was suspected that water is in the line, the ship would need to load four tanks simultaneously to ensure that the water content could be safely removed and so an initial loading rate of 676m^3/hr should be requested. This will allow the water to be cleared from the shore line while keeping the velocity at the tank inlets below 1m/sec.
- Tank inlet valves should not be used to control cargo flow during the initial loading phase. They will reduce the cross-sectional area of the inlet, resulting in a higher tank inlet velocity and so more turbulence and mist formation. If valves have to be throttled to control flow rate, this should be done upstream of the tank valves.

Managing the risks inherent in spread loading requires a risk assessment. This should consider:

- Terminal's piping configuration, including flow control capability.
- Ship's piping configuration.
- Ship's cargo tank condition, e.g. previous cargo, tank atmosphere or physical condition, e.g. the integrity of heating coils.
- Product to be loaded and the potential for generating a flammable atmosphere.

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

12.1.7.8 Limitation of product velocity (loading rates) after the initial filling period (bulk loading)

After the initial filling period, electrostatic generating processes, such as mist formation and turbulence at the tank bottoms, are suppressed by the rising liquid level and concern switches to ensuring that excessive charge does not accumulate on the bulk liquid. This is also done by controlling the flow rate, although the maximum acceptable velocity is now higher provided the product is clean (as defined in section 3.2.1).

Two phase flows, i.e. through oil and water, give higher charging and may require flow rate limitations throughout loading (see section 12.1.7.4).

When the tank bottom is covered, after all splashing and surface turbulence has stopped and all water has been cleared from the line, the rate can be increased to the lesser of the ship or shore pipeline and pumping system maximum flow rates consistent with proper control of the system. Established practice and experience indicates that hazards do not occur if the product velocity is less than 7m/sec. Some national codes of practice also suggest 7m/sec as a maximum value. However, some industry documents acknowledge that 7m/sec is a precautionary limit and imply that higher speeds may be safe without specifying what the real limits are (all the evidence for safe loading has come from experiments limited to a maximum flow of 7m/sec).

Higher velocities can replace the 7m/sec limit only when well documented evidence shows they can be safely used.

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

Figure 12.3 shows that the smallest diameter section of piping in the system is the cargo hose, with a diameter of 250mm. If a loading velocity of 7m/sec is acceptable to the ship and shore, a maximum loading rate of 1,281m^3/hr should be requested.

12.1.7.9 Anti-static additives

If the oil contains an effective anti-static additive, it is no longer a static accumulator. While this suggests the precautions applicable to a static accumulator can be relaxed, it is still advisable to observe them. The effectiveness of anti-static additives depends on how long since the additive was introduced to the product, proper mixing, other contamination and the ambient temperature. It can never be certain that the product's conductivity is above 50pS/m unless it is continuously measured.

12.1.7.10 Loading different grades of product into unclean tanks (switch loading)

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

In this case, reduce charge generation by avoiding splash loading and other generating mechanisms such as filters in the pipeline. The flow rate should be restricted during initial and bulk loading, as in sections 12.1.7.3 and 12.1.7.8.

Product specification and quality requirements normally mean that switch loading does not occur on tankers handling finished products. However, it may occur when handling cargo slops or off-grade product that require no tank preparation, as the grades can be mixed without risk of contamination. In this case, use the precautions outlined above for switch loading.

12.1.8 Loading very high vapour pressure cargoes

Cargoes with high vapour pressure (see section 2.2.2) introduce problems of cargo loss from excessive vapour release. They can also gas-up cargo pumps, causing discharge difficulties. Special precautions may be necessary, e.g.:

- Permitting only closed loading (see section 12.1.6.6).
- Avoiding loading when the wind speed is less than five knots.
- Using very low initial flow rates into tanks.
- Using very low topping-off rates.
- Avoiding a partial vacuum in the loading line.

- Avoiding loading oil that is hot due to lying in shore pipelines exposed to the sun. If unavoidable, this oil should be loaded to tanks that vent well clear of the superstructure, e.g. forward tanks.
- Providing extra supervision to monitor gas dispersion and to ensure compliance with all safety requirements.
- Monitoring IG main pressure where this indicates the cargo tank pressure. A maximum pressure of around 1,000mm WG should be used and the loading rate adjusted accordingly.

To prevent gassing-up of cargo pumps, the expected TVP of the cargo at the discharge port should, under normal circumstances, not exceed 0.7 bar either for crude oil or products. A TVP of up to 0.8 bar may be considered if the ship is fitted with an IG system, or if some other acceptable method of pressurisation is to be used during discharge.

12.1.9 Loading cargoes containing hydrogen sulphide

12.1.9.1 General

Increasing numbers of cargoes contain significant and increasing quantities of H_2S. Guidance on H_2S toxicity is in section 1.4.6 and guidelines on gas measurement and gas testing are in section 2.4.

This section gives practical guidance on operational measures to minimise the risks associated with loading cargoes containing H_2S, commonly known as sour cargoes.

12.1.9.2 Precautions when loading cargoes containing hydrogen sulphide

Consider the following precautions when preparing to load cargoes containing H_2S:

- Before arriving at the loading port, ensure the cargo system is free of leaks from the cargo piping, tank fittings and the venting system.
- Test the heating coils to prevent any transfer of H_2S to the low pressure steam system.
- Check any liquid filled P/V breakers to ensure they are correctly filled.
- Check that all doors and ports can be securely closed to stop the ingress of H_2S vapour into the accommodation.

When loading a cargo containing H_2S:

- Produce a safety plan for the loading operation. It should include guidance on the venting procedure, vapour monitoring, PPE to be used, ventilation for accommodation and the engine room and any emergency measures.
- Use the closed loading procedures described in section 12.1.6.6.
- Avoid venting to the atmosphere at a relatively low tank pressure, particularly in calm wind conditions.
- Stop cargo loading if there is no wind to disperse the vapours or the wind direction takes vapours towards the accommodation.
- Allow only personnel actively engaged in ship security and cargo handling on open decks. Regular maintenance on deck should be limited or postponed until cargo operations have finished. Visitors should be escorted to and from the accommodation spaces and briefed on the hazards of the cargo and the emergency procedures.
- H_2S is highly corrosive, so mechanical gauges are more likely to fail than is usual. Check their condition frequently. If a gauge fails, do not repair it unless an appropriate permit has been issued and all necessary precautions observed.
- H_2S is heavier than air, so in STS transfers and at terminals where there is a significant difference in freeboard, vapour may not be dispersed freely. Keep vent velocities high on the receiving ship and, if possible, turn the ships to allow the wind to carry vapour away from the accommodation.

12.1.10 Benzene and mercury

12.1.10.1 Cargoes containing benzene

Guidance on benzene toxicity is in section 1.4.5. Cargoes containing benzene should be loaded using the closed operation procedures in section 12.1.6.6 as this will significantly reduce any exposure to benzene vapour. Where a VECS is available ashore, it should be used (see section 23.7.7).

Operators should have procedures to verify the effectiveness of the closed loading system in reducing the concentrations of benzene vapours around the working deck. This will involve checks to determine the potential for exposing personnel to benzene vapour during operations such as loading, discharging, sampling, hose handling, tank cleaning, gas freeing and gauging. Similar checks should check vapour concentrations when cleaning, venting or ballasting tanks that previously held a cargo containing benzene.

The ship's crew should use detector tubes and pumps, toxic analysers or an electronic detector tube to check if vapour concentrations are remaining within OEL-TWAs and whether they should require additional PPE.

These precautions should also be followed to minimise exposure when measuring and sampling cargoes containing benzene.

12.1.10.2 Cargoes containing mercury

Some crude oils and condensates contain high levels of mercury. It may be found either in suspension in cargoes or settled at the bottom. It may also be in the vapour space. It can bond with bulkheads, pipelines, pumps and uncoated structures. Mercury is a health hazard if the body repeatedly absorbs it over a period of time (chronic exposure) via inhalation, absorption or ingestion, or following sudden exposure to high concentrations (acute exposure).

The operator's SMS should contain robust procedures to protect personnel against exposure to mercury. When carrying cargoes containing mercury, take a risk-based approach. As a minimum, the precautions to include are hazard awareness, personnel control, exposure control, vapour control and PPE. Personnel working where mercury might be present should be fully trained in safe practices and provided with appropriate PPE.

Mercury is not soluble in water, so any bound to steel surfaces cannot be easily removed by COW or water washing. Attempts to dilute mercury levels in the tank by carrying subsequent low mercury cargoes is also ineffective.

Any work in contaminated tanks should be carefully risk assessed and exposure minimised. The volume of in-tank waste/residues should be minimised by COW cycles for at least two voyages.

OCIMF's *Safety, Health, Environmental Issues and Recommendations for Shipboard Handling of Elevated Mercury Crude Cargoes* contains guidance on impacts, monitoring, training, cargo operations, contaminated residue handling, repairs and medical surveillance.

12.1.11 Loading heated products/cold oil cargoes

12.1.11.1 Loading heated products

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

Some Classification Societies have rules on the maximum loading temperature for cargoes. Masters should consult the ship operator whenever the temperature of the cargo is more than 60°C.

Precautions that may help to ease the effects of a hot cargo are:

- Spreading the cargo throughout the ship as evenly as possible to dissipate the heat and avoid local heat stress.
- Ensuring that tanks and pipelines are completely free of water before receiving any cargo with a temperature above the boiling point of water.

12.1.11.2 Loading cold oil cargoes

Loading cargoes with a temperature below that allowed by Class rules for the grades of steel used on the ship is a violation of Class that could lead to insurance coverage being withdrawn.

Cold climate oil and gas production continues to increase, along with the expansion and use of cold climate ports and sea routes. Oil tankers typically use grade A steel and it is generally assumed the cargo temperature will be above zero degrees Celsius. Steel becomes brittle at low temperatures, so structures can fracture or shatter when loaded to stress levels that would cause no concern at normal temperatures. A brittle fracture is generally characterised by little or no deformity of the metal around the fracture.

Loading cold cargoes introduces the risk of a brittle fracture to the steel structure and cargo piping. By their nature, brittle fractures occur suddenly and without warning. They may appear as soon as cold cargoes are loaded, resulting in spills from either the tanks or pipework.

Ship operators and Masters should consider the structural hazards and restrictions of carrying cold oil cargoes. In drawing up a safe operating plan they should consult experts, the Classification Society and insurers. Based on this guidance and endorsement, a procedure for sub-zero cargoes should be developed. The areas this covers should include:

- Suitability of tank coatings.
- Cargo tank venting system.
- Cargo valves.
- Cargo pumping system.
- Cargo stripping system.
- IG system.
- Gauging system.
- Cargo tank alarm systems.
- Ballast piping.
- Ballast venting system.

12.1.12 Loading over the top (or loading overall)

Loading over the top should not be done unless supported by a full risk assessment.

Volatile petroleum or non-volatile petroleum with a temperature higher than its flashpoint minus 10°C should never be loaded over the top into a non-gas free tank (see chapter 1).

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

12.1.13 Discharging procedures

12.1.13.1 Joint agreement on readiness to discharge

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

12.1.13.2 Operating pumps and valves

Throughout pumping operations, make no abrupt changes in the rate of flow.

During discharge the ship should control the flow of cargo in line with the agreement with the terminal. The discharge rate should not be substantially changed without informing the terminal.

Centrifugal pumps should be operated at speeds that do not cause cavitation, which can damage the pump and other equipment on the ship or at the terminal.

Reciprocating cargo pumps can set up excessive vibration in loading/discharging arms, which, in turn, can cause leaks in couplers and swivel joints and even mechanical damage to the support structure. If possible, do not use such pumps. If they are used, take care to select the least critical pump speed. If more than one pump is used, choose a combination of pump speeds that give an acceptable level of vibration. Keep a close watch on the vibration level throughout the cargo discharge.

12.1.13.3 Closed discharging

Ships that correctly use their IG systems are considered to be conducting closed discharging.

When non-inerted ships are discharging, gauging and sampling, all ullage, sounding and sighting ports should be closed. Air should be admitted to the tanks only by the approved venting system.

If the venting system cannot cope with the discharge rate, the rate should be reduced to match the capacity of the venting system and going below the 100mm WG in the tanks should be avoided.

12.1.13.4 Inert Gas procedures

An IG system must be fully operational and, while discharging, produce IG with an oxygen content of not more than 5%. For more on the operation of an IG system, see section 11.1.

Cargo discharge should not start until:

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

A low but positive IG pressure after discharging will allow the manifold drip tray to be drained into a tank. The IG pressure in the tanks should not be less than the safety settings on any associated pumping arrangements.

12.1.13.5 Failure of the Inert Gas system during cargo discharge

If the IG plant breaks down during discharge, suspend operations. If air has entered the tank, do not introduce any dipping, ullaging, sampling or other equipment into the tank until at least 30 minutes after the injection of IG has stopped. After this, equipment can be introduced provided that all metallic components are securely earthed. This earthing is necessary for up to five hours after the IG injection stopped.

When a tank is re-inerted following a failure or repair to the IG system, or when a non-gas free tank is initially inerted, do not insert dipping, ullaging, sampling or other equipment until the tank is inert. Check this by monitoring the gas vented from the tank. If it is necessary to insert a gas sampling system into the tank to establish its condition, leave at least 30 minutes after stopping the IG injection. Any metallic components of the sampling system should be electrically continuous and securely earthed (see section 11.1.11 for IG failure).

12.1.13.6 Crude Oil Washing

If some or all of the ship's tanks need a crude oil wash during discharge, the Responsible Officer should add a COW plan to the discharge plan set out in section 21.6.

A full description of the requirements for COW is in section 12.5.

12.1.13.7 Starting discharge alongside a terminal

The ship should be informed when the shore tanks are higher than the ship's manifold and whether NRVs are fitted.

Before the ship's manifold valves are opened, shore valves should be fully open to receiving tanks.

The tanker's manifold valves should not be opened until the pumps have developed enough pressure to prevent backflow.

Start the discharge at a slow rate and only increase it to the agreed rate once both parties are satisfied that the flow of oil to and from the designated tanks is confirmed.

12.1.13.8 Starting discharge at an offshore terminal

Before discharge starts at an offshore terminal, communications between ship and shore should be fully tested. The ship should not open its manifold valves or start its pumps until a clear signal has been received from the shore that the terminal is ready.

Discharge should start slowly until the system has been tested and then gradually brought up to the maximum agreed flow rate or pressure. Keep a close watch on the sea around the hoses for any leaks. During darkness, and if safe and practical, light up the water around the hoses (see OCIMF's *Single Point Mooring Maintenance and Operations Guide*, *Guidelines for the Design, Operation and Maintenance of Multi Buoy Moorings* and *Guide for Offshore Tanker Operations*).

12.1.13.9 Starting discharge through a stern line

Before discharge starts through a stern line, a dangerous area that extends for at least three metres from the manifold valve should be clearly marked. No unauthorised personnel should be allowed in this area during the discharge operation.

Maintain a close watch for any leaks. All openings, air inlets and doors to enclosed spaces should be kept tightly closed.

Firefighting equipment should be laid out and ready for use near the stern manifold:

- The cargo hose connection should be carefully inspected for correct alignment and secure coupling. Where possible, a water pressure test of the coupling seals should be made.
- If fitted, any ERSs for the mooring and cargo connection should be operational. Test these before mooring.
- All primary and secondary communication links with the loading terminal should be tested, including any telemetry control system.
- Smoking and naked light requirements should be strictly enforced.

A responsible crew member should maintain a continuous watch by the stern throughout discharge. During darkness, the lighting on and around the ship's stern should allow an effective visual watch to be maintained on the mooring point, mooring system, cargo hose connection, loading hoses and the water around the stern.

12.1.13.10 Periodic checks during discharge

Throughout discharging, monitor and regularly check all full and empty tanks to confirm that cargo is only leaving the designated cargo tanks and is not escaping into pumprooms, cofferdams or through sea and overboard discharge valves.

Check tank ullages at least hourly and calculate a discharge rate. Compare cargo figures and rates with shore figures to identify any discrepancy. If possible, these checks should include observations and recordings of the shear forces, bending moments, draught and trim and any other relevant stability requirements specific to the ship. Check this information against the required discharging plan to see that all safe limits are met and that the discharging sequence can be followed or amended as necessary. Immediately report any discrepancies to the Responsible Officer.

Any pressure drops or marked discrepancy between tanker and terminal estimates of quantities could indicate pipeline or hose leaks, particularly in submarine pipelines, and require that cargo operations be stopped until investigations have been made.

Frequently inspect the cargo deck and pumproom for any leaks. Overside areas should also be checked regularly. During darkness, if safe and practical, illuminate the water around the ship.

12.1.13.11 Stripping and draining cargo tanks

When the main bulk of cargo is being discharged and a slop tank or other selected tank is receiving drainings from tanks being stripped, personnel should be alert to the fact that the ullage in the receiving tank will be decreasing. Take great care to avoid an overflow and ensure proper precautions are in place in case any vapours are emitted.

Air or gas bubbles in a liquid can generate static electricity so, as far as possible, stripping pumps and eductors should be operated to avoid trapping air or gas in the liquid stream.

12.1.14 Pipeline and hose clearing after cargo operations

12.1.14.1 General

The procedure for clearing the pipelines and hoses or arms between the shore valve and ship's manifold depends on the facilities available and whether these include a slop tank or other receptacle. The relative heights of the ship and shore manifolds may also be a factor.

12.1.14.2 Line displacement with water

On ships with a segregated ballast system, avoid the practice of using cargo pumps on a sea suction. However, at the end of cargo operations, some terminals require ships to displace the contents of the hoses or MLAs, and perhaps the shore pipelines, with water. This practice risks pollution, so it should be done only if essential and should be carefully planned and executed. Before starting the displacement the ship and terminal should agree the procedures to be used, particularly the amount to be pumped and the pumping rate.

Pay particular attention to venting the cargo pumps and ensuring there is no outflow of oil when opening the sea valve.

Refer to OCIMF/ICS' *Prevention of Oil Spillages through Cargo Pumproom Sea Valves.*

12.1.14.3 Line draining

When loading is completed, the ship's cargo deck lines should be drained into appropriate cargo tanks to ensure that thermal expansion in the lines cannot cause leaks or distortion. The hoses or MLAs and sometimes part of the pipeline system between the shore valve and the ship's manifold, are also usually drained into the ship's tanks. Enough ullage space should be left in the final tanks to accept the cargo drained in this way.

When discharging is complete, the ship's cargo deck lines should be drained into an appropriate tank and then the contents will be discharged ashore or into a slop tank.

When draining is complete, and before hoses or MLAs are disconnected, the ship's manifold valves and shore valves should be closed. The drain valves at the ship's manifold should then be opened to drain into fixed drain tanks or portable drip trays. Draining any product from the MLAs or hoses into open drip trays should be avoided. Cargo manifolds and MLAs or hoses should be securely blanked after being disconnected. The contents of portable or fixed drip trays should be transferred to a slop tank or other safe container.

12.1.14.4 Clearing hoses and Marine Loading Arms to the terminal

If hoses or MLAs have to be cleared to the terminal using compressed air or IG, follow these strict precautions to avoid creating a hazardous static electrical charge or mechanical damage to tanks and equipment:

- The procedure should be agreed between tanker and terminal.
- There should be adequate ullage in the reception tank.
- To keep the amount of compressed air or IG to a minimum, the operation should stop when the line has been cleared.
- The inlet to the receiving tank should be well above any water in the bottom of the tank.
- The line clearing operation should be continuously supervised by a Responsible Officer.

12.1.14.5 Clearing hoses and Marine Loading Arms to the ship

Do not clear hoses and loading arms to the ship using compressed air because of the risks of:

- Static charge generation.
- Compromising IG quality.
- Over pressurisation of tanks or pipelines.
- Oil mists coming from tank vents.

12.1.14.6 Clearing ship's cargo pipelines

When compressed air or IG is used to clear the ship's pipelines, the hazards are similar to those above and the same precautions should be taken. Line clearing operations should be done in accordance with the specific operating procedures for the ship.

12.1.14.7 Gas release in the bottom of tanks

A pumproom contains the largest concentration of cargo pipelines in the ship. Leaks of a volatile product from any part of this system could quickly generate a flammable or toxic atmosphere. The pumproom may also contain a number of potential ignition sources. To control them, structured maintenance, inspection and monitoring procedures should be strictly followed.

Blowing air or IG into the bottom of a tank containing a static accumulator oil can generate a strong electrostatic field. If the cargo contains water or particulate matter, the effect is worse. The rising gas bubbles will disturb the particulates and water droplets and the settling contaminants will generate a static charge within the cargo. Allow a settling period of at least 30 minutes after blowing any lines to a non-inerted tank or a tank that could contain a flammable atmosphere.

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

Cargo lines should be drained by gravity whenever possible.

12.1.14.8 Receiving nitrogen from shore

Personnel should be aware of the potential hazards associated with nitrogen and, in particular, those related to entering enclosed spaces or areas in way of tank vents or outlets that may be oxygen depleted. High concentrations of nitrogen are particularly dangerous because they can displace enough air to reduce oxygen levels to a point where personnel entering the area can lose consciousness due to asphyxiation. Nitrogen cannot be detected by human senses, so smell cannot be relied upon and personnel may not be able to recognise the physical or mental symptoms of overexposure in time for them to take preventive measures (see chapter 10).

If shore supplied nitrogen is used, e.g. to purge tanks, for padding cargo or to clear lines, be aware that this may be at HP (up to ten bar) and at a high flow rate, making it potentially hazardous because of the risk of over pressurising the cargo tanks. Carry out a risk assessment: the operation should only proceed if appropriate risk mitigations are in place. As a minimum, follow the precautions for over pressurisation in section 11.2.2.

One way to reduce the risk is to ensure the tank has vents with a greater flow rate capacity than the inlet, so the tank cannot be over pressurised. If vapour control and emission regulations require closed operation, the incoming flow of nitrogen should be restricted to a rate equal to or less than the maximum flow of vapour possible through the VRL. Measures to ensure this should be agreed. A small hose or reducer before the manifold can be used to restrict the flow rate, but the terminal should control the pressure. A gauge will allow the ship to monitor the pressure.

Attempting to throttle a gas flow with a ship's manifold valve designed to control liquid flow is inappropriate. However, the manifold may be used as a rapid safety stop in an emergency. Note that the effect of a pressure surge in a gas is not as violent as in a liquid.

Sensitive cargoes, e.g. highly specialised lubricating oils, may have to be carried under a pad or blanket of nitrogen supplied from the shore. In this case, it is better to purge the entire cargo tank before loading. After purging, loading the cargo in a closed condition will create the pad within the tank. This significantly reduces the risk of over pressurisation when padding with shore supplied nitrogen.

12.1.15 Pumproom operational precautions

12.1.15.1 General precautions

Before starting any cargo operation:

- An inspection should ensure that strainer covers, inspection plates and drain plugs are in position and secure.
- Drain valves in the pumproom cargo system, especially those on cargo oil pumps, should be firmly closed.
- Any bulkhead glands should be checked and adjusted or lubricated, as necessary, to ensure an efficient gas-tight seal between the pumproom and the machinery space.

During all cargo operations, including loading:

- The pumproom should be inspected regularly for leaks from glands, drain plugs and drain valves, especially those fitted to the cargo pumps.
- If the pumps are in use, pump glands, bearings and the bulkhead glands should be checked for overheating. In the event of leakage or overheating the pump should be stopped.
- Make no attempt to adjust the pump glands on rotating shafts while the pump is in service.

12.1.15.2 Cargo and ballast line draining procedures

On some ships, no provision is made for effective line draining where the practice is to drain final line contents to the pumproom bilge. It is an unsafe practice and volatile product should not be drained to the bilge.

Consider a comprehensive stripping arrangement to enable all lines and pumps to be drained effectively, to a cargo tank, slop tank or dedicated reception tank, for subsequent discharge ashore.

After de-ballasting, if lines used for ballast have to be drained to the pumproom bilge, take care to ensure that the drainings do not contain cargo residues.

12.1.15.3 Routine maintenance and housekeeping issues

It is important that the integrity of pipelines and pumps is maintained and that any leaks are detected and rectified as soon as possible.

Pumproom bilges should be kept clean and dry. Particular care should be taken to prevent hydrocarbon liquids or vapour escaping into the pumproom.

Pipelines should be visually examined and routinely pressure tested to verify their condition. Other non-destructive testing or examination, such as ultrasonic wall thickness measurement, may be appropriate but should always be supplemented by a visual examination.

Procedures should be established to verify that mud boxes and filters are properly sealed after they have been opened for routine cleaning or examination.

Valve glands and drain cocks should be regularly inspected to ensure they do not leak.

Bulkhead penetrations should be routinely checked to ensure the seals are effective.

Critical bolts on the cargo pumps and associated fittings, such as pedestal fixing bolts, pump casing bolts and bolts securing shaft guards, should be secure. Include the requirements for examining them in routine maintenance procedures.

The pumproom rescue harness and rope should be checked regularly to ensure it is fit for use and rigged for immediate operation. Use of fire retardant materials should be considered for rescue harness and rope assembly.

Emergency escape routes should be regularly checked to ensure they are properly marked and clear of obstructions. Where an escape trunk is fitted, check doors for ease of operation. Door seals should be effective and lighting within the trunk should be operational.

12.1.15.4 Maintaining electrical equipment in the pumproom

Incorrect maintenance procedures may compromise the design integrity of explosion-proof or intrinsically safe electrical equipment. To ensure such equipment remains safe, even the simplest repair or maintenance task should be carried out in strict compliance with the manufacturer's instructions.

Only personnel qualified to undertake such work should carry out maintenance of explosion-proof and intrinsically safe equipment. This is especially vital with explosion-proof lights, where incorrectly closing them after changing a lamp could compromise their integrity.

To help routine servicing and repair, ships should have detailed maintenance instructions for the specific systems and arrangements fitted on board. The company's permit to work system should be followed, as applicable.

12.1.15.5 Inspecting and maintaining pumproom ventilation fans

Pumproom ventilation fans operate by drawing air out of the space. If a gas is in the pumproom and the blades of the fan impeller touch the casing, or the fan bearings or seals overheat, the vapours could ignite.

Pumproom extractor fans, including impellers, shafts and gas seals, should be inspected regularly.

Inspect the condition of the fan trunking and confirm that the changeover flaps and fire dampers are operating properly.

Consider routine vibration monitoring and analysis as an early way to detect component wear.

12.1.15.6 Testing of alarms and trips

If fitted, pump alarms and trips, level alarms, etc. should be tested regularly to ensure that they are functioning correctly. The results of these tests should be recorded.

These tests should be as thorough as possible to verify the complete operability of the system and should not be limited to an electrical function test of the alarm itself.

12.1.15.7 Miscellaneous

The safety of pumprooms can be enhanced in a number of other ways, some of which are mandatory for some tankers:

- A fixed gas detection system capable of continuously monitoring for hydrocarbon, oxygen and toxic gases that activate audible and visual alarms in the cargo control room, engine room and the navigating bridge. Where such equipment is fitted, procedures should be developed to ensure it is regularly inspected and calibrated. Procedures should also be developed for the action to take when an alarm is triggered, especially for vacating the space and stopping the cargo pumps. Whenever practicable, gas detection should monitor a number of levels within the pumproom, not just the lower area.
- A fixed sampling arrangement to monitor oxygen content within the pumproom from the deck by a portable meter before entering the pumproom. Where such an arrangement is fitted, it should ensure that remote parts of the pumproom can be monitored.
- Temperature monitoring devices fitted to the main cargo pumps to provide remote indication of the temperature of pump casings, bearings and bulkhead seals. Where such equipment is fitted, procedures should be developed for the action to take when an alarm is triggered.
- A high level alarm in pumproom bilges that activates audible and visual alarms in the cargo control room, engine room and the navigating bridge.
- Manually activated trips for the main cargo pumps at the lower pumproom level and at the top (main deck) level.
- Spray arresters around the glands of all rotary cargo pumps to reduce the formation of mists during minor leaks from the gland.
- Examining the feasibility of fitting a double seal arrangement to contain any leaks from the primary seal and to activate a remote alarm to indicate a leak. The impact of any retrofit on the integrity of the pump will need to be assessed in conjunction with the pump manufacturer.
- Particular attention to be given to the adequacy of fire protection in the immediate area of the cargo pumps.
- Given the problems associated with flashback re-ignition after using the primary firefighting medium, consider providing a backup system, such as high expansion foam or water drenching, to supplement the existing system.
- On ships fitted with an IG system, an emergency facility for inerting the pumproom could be an option, although careful attention should be paid to the safety and integrity of the arrangement.
- Providing the pumproom with readily accessible EEBDs.

12.2 Stability, stress, trim and sloshing considerations

12.2.1 General

Oil tankers usually have a high metacentric height in all conditions, so they remain inherently stable. While tanker personnel have always had to take account of longitudinal bending moments and vertical shear forces during cargo and ballast operations, the actual stability of the ship has seldom been a major concern. Masters and officers should account for free surface and sloshing effects during all stages of cargo and ballast operations. Double hull tankers, particularly those without centreline bulkheads in cargo tanks and/or having U-shaped ballast tanks, may face potential issues from large free surface effects influencing their stability.

12.2.2 Free surface effects

The main problem likely to be encountered is the effect on the Transverse Metacentric Height (GM) of liquid free surface in the cargo and double hull ballast tanks.

Depending on the design, type and number of these tanks, the free surface effect could significantly reduce the GM. The situation will be most severe in the case of a combination of wide cargo tanks with no centreline bulkhead and ballast tanks with no centreline bulkhead (U tanks).

The most critical stages of any operation will be while filling the double bottom ballast tanks during cargo discharge and emptying these tanks during cargo loading. If enough cargo tanks and ballast tanks are slack simultaneously, the overall free surface effect could reduce the GM to a point that threatens the transverse stability of the ship. This situation is further exacerbated, with large free surface areas especially likely to threaten stability at greater soundings, with an associated high vertical centre of gravity.

The combination of these factors could result in the ship suddenly developing a severe list or angle of loll and it is, therefore, imperative that tanker and terminal personnel involved in cargo and ballast operations are aware of this potential problem.

All cargo and ballast operations must be conducted strictly in line with the ship's stability booklet, approved by the administration, which provides information on any restrictions as well as standard operating conditions for developing acceptable loading, discharging and ballasting plans in accordance with applicable stability criteria. Additionally, the stability booklet must contain other necessary guidance for the safe operation of the ship under normal and emergency conditions. Where the information in the stability booklet identifies particular combinations of slack ballast and/or cargo tanks that could result in the development of stability issues that are outside of the ship's safe operating parameters, these should be clearly posted in the cargo control room along with guidance on action to be taken to mitigate any stability issues developing during non-standard or emergency situations.

12.2.3 Heavy weather ballast

Ship specific procedures should ensure that heavy weather ballast is taken in plenty of time for personal safety and that stability and hull shear forces and bending moments should be maintained within acceptable limits at all stages of the heavy weather ballast operation.

Masters and officers need to be aware that partially loading a cargo tank with heavy weather ballast may present a potential sloshing problem. The combination of free surface and the flat tank bottom can generate wave energy with enough power to severely damage the internal structure and pipelines.

The decision to take heavy weather ballast may also be guided by the need to mitigate the risk to the ship's machinery should the propeller clear the water and the engine overspeed when pitching.

12.2.4 Loading and discharge planning

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

12.2.5 Intact and damage stability

Complying with intact stability may not meet the damage stability criteria. This should be verified for the departure condition of the ship.

12.3 Tank cleaning

12.3.1 General

This section deals with procedures and safety precautions for cleaning cargo tanks after discharging petroleum products from cargo tanks. Guidance is also given on cleaning contaminated ballast spaces.

12.3.2 Tank washing risk management

All tank washing operations should be carefully planned and documented. The potential hazards of planned tank washing operations should be systematically identified and risk assessed. Appropriate preventive measures should be put in place to reduce the risk to ALARP.

In planning tank washing operations, the prime risk is a fire or explosion caused by a simultaneous flammable atmosphere and source of ignition. The focus should be on eliminating one or more of the hazards, namely the sides of the fire triangle of air/oxygen, ignition source and fuel, i.e. flammable vapours.

12.3.3 Supervision and preparation

Supervision

A Responsible Officer should supervise all tank washing operations.

Before starting the operation, all the crew involved should be fully briefed by the Responsible Officer on the tank washing plans and on their roles and responsibilities.

All other personnel on board should be notified that tank washing is about to begin. This should, in particular, be extended to those on board not involved directly in the tank washing operation but whose own concurrent tasks may affect its safety.

Preparation

Before and during tank washing operations, the Responsible Officer should be satisfied that all the relevant precautions set out in chapter 4 are being observed. If craft are alongside the tanker, their personnel should also be notified. They need to confirm their compliance with all appropriate safety measures. Before starting to tank wash alongside a terminal, the following additional measures should be taken:

- Observe the relevant precautions in chapter 23.
- Consult the appropriate personnel ashore to check that conditions on the jetty do not present a hazard and to get agreement that operations can start.

The method of tank washing used on board a tanker depends on how the atmospheres in the cargo tanks are managed and the equipment fitted to the ship.

12.3.4 Tank atmospheres

12.3.4.1 Inert

This is a condition where the tank atmosphere is known to be at its lowest risk of explosion by virtue of the atmosphere being maintained at all times as non-flammable through the introduction of IG and the resultant reduction of the overall oxygen content in any part of any cargo tank to a level not exceeding 8% by volume while under a positive pressure (see section 11.1.5.1).

The lowest risk comes from washing the tank in an inert atmosphere. This is clear and causes no ambiguity. To be inert the tank must meet the SOLAS requirement for inerting cargo tanks and reducing the oxygen content of the atmosphere in each tank to a level that cannot support combustion.

If direct measurement fails to prove that the tank is inert, it should by default be considered non-inert.

The requirements for maintaining an inert atmosphere and the precautions to observe during washing are in section 11.1.6.9. These provide the most certain level of control of an atmosphere during tank washing.

In fire triangle terms, this method physically removes and controls the oxygen.

12.3.4.2 Non-inert

For this chapter, a non-inert atmosphere is where the oxygen content has not been confirmed as less than 8% by volume.

On ships with no access to IG, either on board from an IG plant or from the shore, only two sides of the fire triangle can be addressed – the fuel and the sources of ignition. In a non-inert condition there are no physical barriers that will ensure that either of these two hazards can be eliminated. Therefore, the safety of non-inert tank washing depends on the integrity of the equipment and implementation of strict procedures to ensure these two hazards are controlled.

Non-inert cargo tanks should only be washed when a combination of measures control the flammability of the tank atmosphere and sources of ignition.

To control tank atmospheres, tankers that operate in a non-inert condition should be designed and equipped to mechanically ventilate cargo tanks at the same time as tank washing.

Recognising that tank washing and gas freeing operations in non-inert atmospheres present an increased risk, extra control measures are required to reduce the risk to ALARP. These control measures should address two sides of the fire triangle, i.e. fuel and sources of ignition.

12.3.5 Tank washing

12.3.5.1 Washing in an inert atmosphere

Control measures for washing in inert atmospheres are in section 11.1.6.9.

During tank washing, verify that the atmosphere in the tank remains non-flammable (the oxygen content does not exceed 8% by volume) and is maintained at a positive pressure.

Cargo tanks can be purged during water washing to reduce the hydrocarbon content of the tank atmosphere.

12.3.5.2 Washing in a non-inert atmosphere

Non-inert cargo tank washing should only be done when both the source of ignition and the flammability of the tank atmosphere are controlled. To do this, the following precautions should be taken.

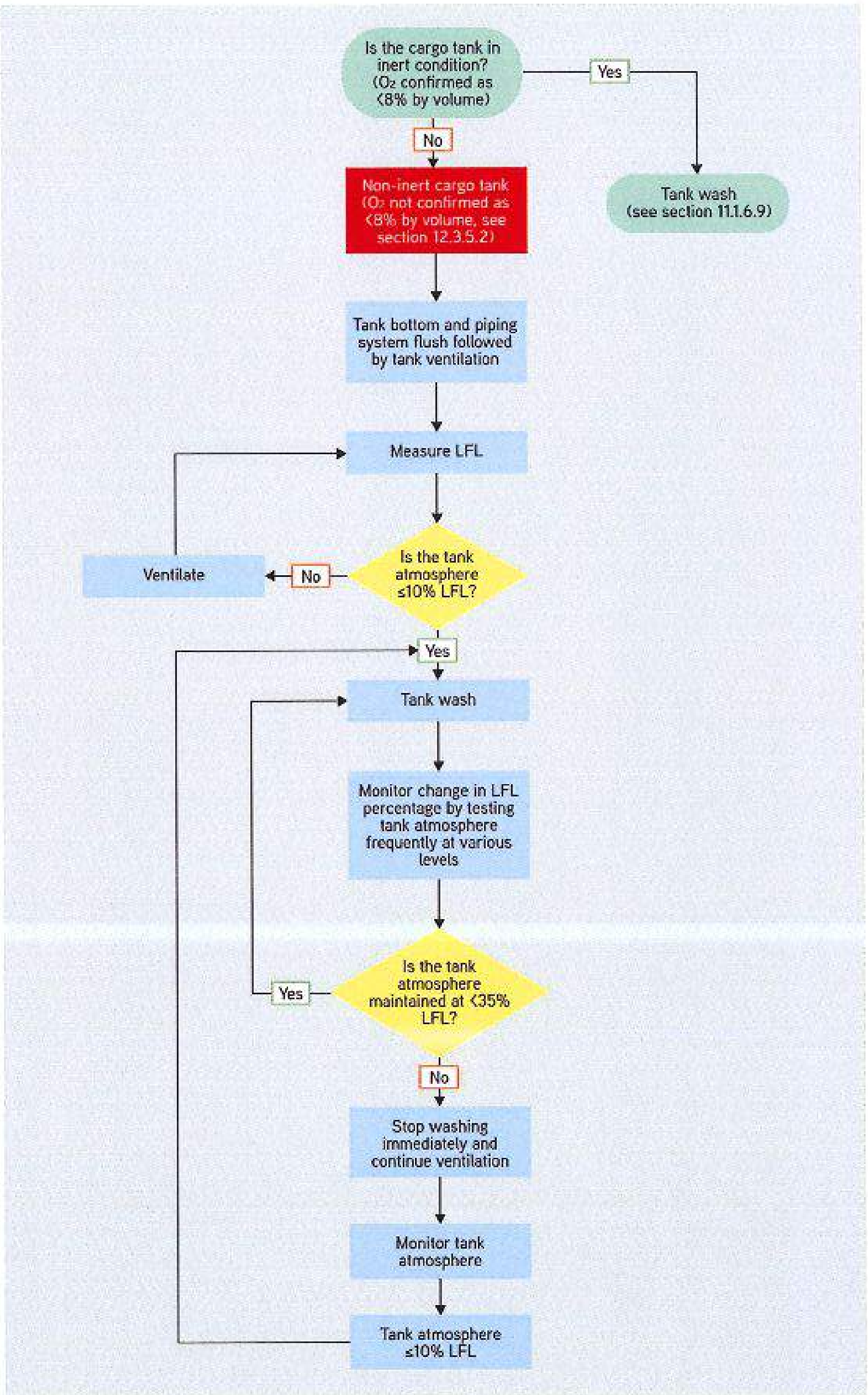


Figure 12.4: Steps to control the fuel (flammable vapours) while tank washing in a non-inert tank atmosphere flowchart

To control the fuel in the tank atmosphere (see figure 12.4)

Before washing:

- Flush the tank bottom with water, so that all parts are covered, then strip. To do the flush, use the main cargo pumps and lines. Alternatively, permanent pipework extending the full depth of the tank should be used. Do not use the tank washing machines.
- Flush the piping system with water (including cargo pumps, crossovers and discharge lines). Drain the flushing water to the tank designed or designated to receive slops.
- Ventilate the tank to reduce the gas concentration of the atmosphere to 10% or less of the LFL. Test for gas at various levels and be aware that pockets of flammable gas may exist, in particular near potential sources of ignition such as mechanical equipment that might generate hot spots, e.g. moving parts in submerged cargo pump impellers.
- Start washing only when the tank atmosphere reaches 10% or less of the LFL.

During washing:

- Monitor the change in LFL percentage by testing the atmosphere frequently and at various levels inside the tank.
- Consider suspending washing to take readings as water can affect the efficiency of gas measuring equipment.
- Provide a free flow of air from one end of the tank to the other, with continual mechanical ventilation whenever possible.
- Monitor the tank atmosphere more frequently if mechanical ventilation is not possible as the likelihood of rapid gas build-up is greater.
- Maintain the tank atmosphere at not more than 35% LFL. If the gas level reaches 35% at any measured location within a tank, immediately stop the washing in that tank.
- Only resume washing when continued ventilation has reduced the gas concentration to 10% or less of the LFL and is able to maintain it.
- Isolate any tank with a venting system that is common to other tanks to prevent gas leaking from other tanks.

To control the sources of ignition in the tank

- Restrict the throughput of individual tank washing machines to no greater than $60m^3$/hr.
- Keep the total water throughput per cargo tank as low as practicable. Do not let it exceed $180m^3$/hr.
- Different washing methods create different risks, so follow these precautions when tank washing in non-inert conditions:
  - Never use recirculated wash water.
  - Heated wash water may be used but stop if the gas concentration reaches 35% of the LFL. Use a hot wash for a low flashpoint product only after a full, i.e. top to bottom, cold wash cycle.
  - Increase the frequency of monitoring the gas concentration if the hot wash water temperature is above 60°C.
  - Only consider using chemical additives if the temperature of the wash water does not exceed 60°C.
  - Never inject steam into a tank that may contain hydrocarbon vapours and that is in a non-inert condition. Only consider injecting steam into a tank after it has been verified as being gas free (see section 3.1.2).
- Keep the tank drained during washing. Stop the washing to clear any build-up of wash water.
- Keep the discharge into the wash water reception/slop tank below the liquid level in that tank at all times.

- Make up and test the electrical continuity of all hose connections before introducing any portable washing machines to the tank. Do not introduce any portable washing machines until the LFL level is 10% or less.
- Do not break any connections before the machine has been removed from the tank. To drain the hose, a coupling may be partially opened (but not broken) and then re-tightened before the machine is removed.
- Introduce sounding rods and other equipment into the tank using a full depth sounding pipe. If a full depth sounding pipe is not fitted, ensure that any metallic components of the sounding rod or other equipment are bonded and securely earthed to the ship before introducing them to the tank and that they remain earthed until removed.
- Observe this precaution during washing and for five hours afterwards to allow enough time for any mist carrying a static charge to dissipate. If the tank is continuously mechanically ventilated after washing, this can be reduced to one hour. During this time:
  - A metal interface detector can be used if earthed to the ship by a clamp or bolted metal connection.
  - A metal rod on the end of a metal tape can be used if earthed to the ship by a clamp or bolted metal connection.
  - Do not use a metal sounding rod suspended on a fibre rope, even if the end at deck level is fastened to the ship. The rope cannot be relied on to provide an earthing path.
  - Entirely non-metallic equipment may be used, e.g. a wooden sounding rod suspended on a natural fibre rope without earthing.
  - Do not use ropes made of synthetic polymers to lower equipment into cargo tanks.
- Take measures to guard against ignition from machinery defects, e.g. in-tank cargo pumps, tank washing machines, tank gauging equipment, etc.
- Take precautions to eliminate the risk of mechanical sparks from objects falling into the tanks, e.g. metallic objects, including hand tools, sounding rods and sample buckets, etc.
- Do not allow the use of non-intrinsically safe equipment, e.g. torches and inspection lamps, mobile phones, communications radios, handheld computers, etc.

12.3.6 Precautions for tank washing

12.3.6.1 Portable tank washing machines and hoses

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

The coupling arrangement for the hose should give an effective bonding between the tank washing machine, the hoses and the fixed tank cleaning water supply line.

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

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

12.3.6.2 Portable hoses for fixed and portable tank washing machines

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

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

12.3.6.3 Testing tank cleaning hoses

All hoses supplied for tank washing machines should be tested for electrical continuity in a dry condition before use. In no case should the resistance exceed six ohms per metre length.

12.3.6.4 Tank cleaning concurrently with cargo handling

As a general rule, tank cleaning and gas freeing should not run concurrently with cargo handling. If for any reason this is necessary, consult closely with both the Terminal Representative and/or the port authority and get their written agreement.

12.3.6.5 Free fall

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

12.3.6.6 Spraying water

Spraying water into a tank containing a substantial quantity of static accumulator oil could generate static electricity at the liquid surface, either by agitation or water settling. Tanks that contain static accumulator oil should always be pumped out before they are washed with water, unless the tank is kept inert (see section 3.2.7).

12.3.6.7 Excluding cargo oil from the engine room

To prevent cargo oil from getting into the engine room, any part of the tank washing system that extends into the engine room should be blanked off as soon as tank cleaning operations have finished.

12.3.6.8 Special tank cleaning procedures

After carrying certain products, tanks can only be properly cleaned by steaming or adding tank cleaning chemicals to the wash water.

Steaming

The hazard of static electricity means that steam should not be introduced to cargo tanks if there is a risk of a flammable atmosphere. Bear in mind that a non-flammable atmosphere cannot be guaranteed in all cases where steaming might be thought useful.

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

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

The static electricity precautions in chapter 3 should be strictly observed.

Using chemicals in wash water

Constraints on the use of chemicals in wash water will depend on the type of tank atmosphere (see section 12.3.5.2).

Certain tank cleaning chemicals may introduce a toxic or flammable hazard. Personnel should be made aware of the OEL of the product. Detector tubes are particularly useful for detecting the presence of specific gases and vapours in tanks. Tank cleaning chemicals that can produce a flammable atmosphere should only be used when the tank has been inerted.

Using chemicals for local cleaning

Some tank cleaning chemicals may be used to hand wipe tank bulkheads and blind spots, provided only a small amount is used and the personnel entering the tank observe all the requirements for entering an enclosed space.

Any manufacturer's instructions or recommendations for the use of these products should also be followed. If the ship is in port, local authorities may impose additional requirements.

An SDS for tank cleaning chemicals should be on board the ship before they are used. Its advice and precautions should be followed.

12.3.6.9 Leaded gasoline

Leaded gasoline is rarely used in most countries. It is, however, possible that gasoline containing tetraethyl lead (TEL) and tetramethyl lead (TML) could still be carried. When the ship's tanks alternate between different products, they present little risk. However, ships that regularly carry leaded gasoline should flush the bottom of the tanks with water after every cargo discharge.

12.3.6.10 Removing sludge, scale and sediment

Before removing sludge, scale and sediment by hand, the tank atmosphere is to be confirmed as safe for entry. Appropriate control measures are in place to protect the health and safety of personnel entering the space. The precautions in section 10.9 should be maintained throughout the work (see section 12.1.10.2 cargoes containing mercury).

Any equipment used for further tank cleaning, such as removing solid residues or products in tanks that have been gas freed, should be designed and constructed to introduce no risk of ignition.

12.3.6.11 Cleaning contaminated ballast spaces

If a cargo tank leaks into a ballast tank, both will need to be cleaned in order to comply with MARPOL and to carry out repairs.

This is a difficult task when the contamination is crude or black oils and especially difficult in a double hull or double bottom space.

As far as possible, and particularly during the initial stages, tank cleaning should be carried out by methods other than hand hosing. This may include using portable machines or detergents, or washing the bottom of the tank with water and detergent. Hand hosing should be permitted only for small areas of contamination or for final cleaning. Whichever method is used, the tank washings must always be handled in line with MARPOL regulations.

After a machine or detergent wash, prior to entry for final hand hosing, the tank should be ventilated in line with the procedures in section 12.4.7 until readings at each sampling point show that the atmosphere is safe for entry according to the criteria in chapter 10. Suitable control measures should be implemented to protect the health and safety of personnel entering the space.

If cleaning is to be done, the precautions in section 12.3.5.2 should be followed, including the monitoring of tank atmospheres.

12.3.7 Wash water analysis

Testing the wash water is a process that assesses the cleanliness of the cargo tank and cargo lines. It is an alternative to pre-loading inspection, with the benefit of reducing tank entry and unnecessary cleaning.

Wash water is continuously pumped out of the tanks while tank cleaning. Samples are collected at the manifold and analysed by UV spectrometer. A comparison between the wash water going into the tank and the sample indicates the trace level of previous cargo. When this shows that the cargo tanks and lines are clean enough for the next cargo, preparations for the new cargo can be done without entering the tank.

Bear in mind that a wash test may not detect the tank construction, cargo absorption by tank coatings and the cargo UV profile.

A wash water analysis process would include the following:

Wash water sampling

The wash water sampling should be done, drawing samples:

- From points at the end of the cargo system.
- During the last cleaning stages.

Wash water test

Testing the wash water should follow these steps:

1. Compare the wash water sample against the reference sample drawn directly from the tank cleaning line before it enters the cargo tank.
2. Depending on results, decide if tank cleaning needs to continue or stop.
3. Confirm analysis and document the results.

12.4 Gas freeing

12.4.1 General

Gas freeing is generally one of the most hazardous tanker operations, whether for entry, hot work or cargo quality control. The cargo vapours displaced during gas freeing are highly flammable, so good planning and firm overall control are essential. The extra risk from toxic petroleum gas cannot be overemphasised and should be impressed on all personnel concerned. All operations connected with gas freeing demand the greatest possible care. Regional and local regulations may prohibit the release of cargo vapours when in coastal or port areas.

12.4.2 Gas free for entry

To be gas free for entry without breathing apparatus, a tank or space should be ventilated until tests confirm that the concentration of hydrocarbon gas throughout the compartment is less than 1% of the LFL and that the oxygen content is 21% by volume. Toxic gases should also be tested and confirmed at acceptable levels as in chapter 10.

A water wash will improve the condition of a cargo tank or space containing hydrocarbons before entry. If entry is required without water washing, the SMS should have operational and contingency guidance to support safe entry. These should identify the entry as a non-routine operation and require a risk assessment that identifies the preparations needed to achieve safe entry.

Any entry should be based on the hazards and the associated safety and PPE requirements (see chapter 10).

12.4.3 Procedures and precautions

The following recommendations apply generally to gas freeing:

- A Responsible Officer should supervise all gas freeing operations.
- Check all local, regional, and national regulations on emissions of VOC or other limits.
- Notify all personnel on board that gas freeing is about to begin.
- Enforce all appropriate no smoking regulations.
- Before starting, all instruments to be used for gas measurement should be checked and tested in line with the manufacturer's instructions.
- Sampling lines should be entirely suitable for use with the gases present and impervious to their effects.
- Keep all tank openings closed until the actual ventilation of the individual compartment is about to start.
- Use the ship's approved method to vent flammable gas. Where gas freeing involves gas escaping at deck level or through hatch openings, control the degree of ventilation and number of openings to produce an exit velocity that will carry the gas clear of the deck.
- If possible, adjust the intakes of central air conditioning or mechanical ventilation to recirculate air within the spaces and so prevent the entry of petroleum gas (see section 4.8).
- If at any time it is suspected that gas is being drawn into the accommodation, stop the central air conditioning and mechanical ventilation systems and cover or close the intakes.
- Electrically disconnect any window-type air conditioning units that are not certified as safe for use in the presence of flammable gas, or that draw in air from outside the superstructure, and close any external vents or intakes.
- Clear gas vent riser drains of water, rust and sediment and test any steam smothering connections to prove they are satisfactory.
- If several tanks are connected by a common venting system, isolate each tank to prevent gas transferring to or from other tanks.
- If hydrocarbon vapours persist on deck in high concentrations, stop gas freeing.
- If wind conditions cause funnel sparks to fall on deck, stop gas freeing.
- Tank openings within enclosed or partially enclosed spaces should not be opened until the compartment has been sufficiently ventilated by openings that are outside these spaces. When the gas level in the tank has fallen to 35% of the LFL, or under, openings in enclosed or partially enclosed spaces may be opened to complete the ventilation. Test enclosed or partially enclosed spaces for gas during this subsequent ventilation.

When planning gas freeing:

- As a general rule, gas freeing should not take place at the same time as cargo handling. If for any reason this is necessary, consult the relevant authorities, including the Terminal Representative, and get their written agreement.
- Consult the Terminal Representative to check that conditions on the jetty do not present a hazard and to get agreement that operations can start.
- If craft are alongside the tanker, notify the personnel and get them to verify that they will comply with all safety measures.

Further considerations that apply when tanks have been inerted are in section 11.1.6.12.

12.4.4 Gas testing and measurement

To maintain a proper control of the tank atmosphere and to check the effectiveness of gas freeing, a number of gas measuring instruments should be available on the ship. Section 2.4 provides further details of these instruments.

Test the atmosphere regularly during gas freeing to monitor progress.

Test at several levels and in each compartment of the tank if it is subdivided by a swash bulkhead. In large compartments, tests at widely separate positions.

Once gas freeing of any compartment is completed, leave about ten minutes before taking final gas measurements. This allows relatively stable conditions to develop in the space.

If the gas readings are not satisfactory, resume ventilation.

On completion of gas freeing, close or guard all openings except the tank hatch.

On completion of all gas freeing, carefully check the gas venting system, paying particular attention to the efficient working of the P/V valves and any high velocity vent valves. If the valves or vent risers are fitted with devices designed to prevent the passage of flame, they should be checked and, if necessary, cleaned.

12.4.5 Fixed gas freeing equipment

Fixed gas freeing equipment can be used to gas free more than one tank at the same time, but not if the system is being used to ventilate another tank where washing is in progress.

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

Before putting a fixed gas freeing system into service, flush the cargo piping system, including crossovers and discharge lines, through with sea water and strip the tanks. Then close and secure all valves on the cargo piping system, except those required for ventilation.

Not all fixed gas freeing lines have NRVs and there is a risk of cargo entering the fixed gas freeing line.

To avoid this, the connection between the fixed gas freeing line and the cargo system should be removed prior to cargo transfer. The Responsible Officer should also check that any isolating spool piece connections are removed and the fixed gas freeing line isolated from the cargo system.

12.4.6 Portable fans

Do not use electric portable fans or blowers. Air and water driven fan construction materials should be such that no hazard of incendiary sparking arises if, for any reason, the impeller touches the inside of the casing. If steam driven fans are used, take care to ensure that the exhaust does not vent into the cargo tank, where it could cause a build-up of static electricity.

The capacity and penetration of portable fans should be able to make the entire atmosphere of the tank non-flammable in the shortest possible time.

Extension tubes for the fans can be effective when gas freeing deep cargo tanks and tanks with deep structural members in the bottom. If these extension tubes incorporate synthetic materials, take care to ensure that they are effectively bonded to the ship's structure.

Portable fans and the ventilation openings should be arranged so that all parts of the tank are equally and effectively gas freed.

Ventilation outlets should, generally, be as far away as possible from the fans.

Portable fans should be connected to the deck so that an effective electrical bond exists between them.

12.4.7 Ventilating double hull ballast tanks

The complexity of the structure in double hull and double bottom tanks makes them difficult to ventilate. It is strongly recommended that the operator develops guidelines and procedures for ventilating ballast tanks that may include filling and emptying to ensure air is transferred efficiently.

The use of a ballast water treatment system may call for extra measures to ensure that the space is properly ventilated. Toxic gases in the tank atmosphere, or chemicals in the remaining ballast water, may mean precautions need to be taken before entering the tank.

Ballast water should be checked before de-ballasting. Any hydrocarbon leaks into the ballast tank will contaminate the ballast, which must then be handled in line with MARPOL regulations.

When filling a tank for ventilation, do not let it overflow onto the deck unless permitted by Class or the Flag State.

Procedures for ventilating ballast tanks should be developed. These should not be based purely on a volumetric capacity calculation but should also address the complexity of the tank's structure. They should give details of the configuration of each tank, the method of ventilation and the equipment to be used. The time required for each ventilation method to gas free the tank for safe entry should also be included.

The procedures should also include an effective method for checking the atmosphere of the tanks.

When portable fans are used for ventilation, this information should be provided for a range of drive pressures and for different numbers of fans.

If portable ducts or sleeves are used, take care to ventilate remote corners of the tanks.

Ships fitted with an IG system may be able to use the emergency connection to allow air from IG systems operating in the air mode to be blown into the water ballast tanks.

12.4.8 Gas freeing in preparation for hot work

The requirements in section 12.4.2 and chapter 9 should be complied with.

12.5 Crude Oil Washing

12.5.1 General

A crude oil tanker fitted with an IG system and approved fixed washing equipment in its cargo tanks can use crude oil from the cargo as the tank washing medium. This may take place either in port or at sea between discharge ports. It is most frequently done while the tanker is discharging cargo and means cargo residues remaining on tank surfaces can be removed. These deposits, which would normally remain on board after discharge, are discharged with the cargo. As a result, the need to water wash the discharged tanks during the ballast voyage to remove residues is much reduced and in some cases eliminated.

Refer to the IMO's *Crude Oil Washing Systems* and the tanker's approved operations and equipment manual for detailed guidance on the procedures.

12.5.2 Advance notice

When COW is needed during cargo discharge, the Master should inform the terminal (or other ship during STS transfer) at least 24 hours in advance, or in such time as required by the terminal. COW should only proceed when they give their written approval.

12.5.3 Tank washing machines

Only fixed tank washing machines may be used for COW.

12.5.4 Control of tank atmosphere

The oxygen content of the tank must not exceed 8% by volume, as described in section 11.1.6.9.

12.5.5 Precautions against leaks from the washing system

Before arriving in a port where it is intended to COW, the tank washing system should be pressure tested to normal working pressure and examined for leaks.

Drain down the system after testing to avoid the risk of thermal expansion causing leaks.

Any leaks found should be repaired, then the system re-tested to prove it is leak free.

During COW, the system should be kept under constant observation so that any leak can be detected immediately and action taken to deal with it.

When tanks for COW are being changed over, the pressure in the COW line should be reduced to a minimum before any valves on the system are opened or closed. This will minimise the potential for a surge pressure to cause any damage.

12.5.6 Avoiding oil and water mixtures

Mixtures of crude oil and water can produce an electrically charged mist during washing. The electrical potential of these mixtures is much higher than dry crude oil. The use of dry crude oil is therefore important. Before washing begins, any tank to be used as a source of crude oil for washing should be partly discharged by at least one metre of ullage to remove any water that has settled out during the voyage.

For the same reason, if the slop tank is to be used as a source of oil for washing, it should first be completely discharged ashore and refilled with dry crude oil.

12.5.7 Isolating the tank cleaning heater

If the tank washing water heater is fitted outside the engine room, it should be blanked off during COW to prevent any ingress of oil.

12.5.8 Supervision

The PIC of COW operations should be suitably qualified in accordance with the requirements laid down by the tanker's flag administration and any local port regulations.

12.6 Ballast operations

This section covers routine ballast operations for double hull tankers and non-routine operations such as taking heavy weather ballast in cargo tanks or meeting air draught restrictions for navigational purposes. Discharging dirty ballast to shore is also covered.

12.6.1 General

Before ballasting or de-ballasting in port, the Responsible Officer and Terminal Representative should discuss the operation and agree it in writing. Any discharge of ballast must comply with IMO and local port or State regulations. The ship's Ballast Water Management (BWM) plan should be followed and the ballast water record book maintained.

The Terminal Representative should give a specific agreement before any simultaneous handling of cargo and non-segregated ballast can begin.

Ballast should be loaded and discharged in a way that avoids subjecting the ship's hull to excessive stress during the operation.

12.6.2 Loading cargo tank ballast

When loading ballast into cargo tanks, observe the following precautions:

- Before taking ballast into tanks containing hydrocarbon vapour, the Responsible Officer should consult with the Terminal Representative. Observe all safety checks and precautions for loading volatile petroleum. Follow closed loading procedures.
- On crude oil tankers, any tank to be ballasted should be crude oil washed beforehand unless discharge of ballast will be to an approved shoreside ballast water processing facility.
- When taking ballast into cargo tanks that contain hydrocarbon vapour, gas is expelled that may be within the flammable range on mixing with air. This gas should, therefore, be vented through the approved venting system.
- When taking ballast into tanks that previously contained cargoes requiring closed operations, the ballast should also be taken using closed loading. Follow the procedures in section 12.1.6.6.
- Ballast should not be loaded over the top (overall) into tanks containing hydrocarbon vapour.
- Follow the guidance in section 12.1.3 when operating ballast tank valves.

12.6.2.1 Operation of cargo pumps

When starting to ballast, operate the cargo pumps so that no oil is allowed to escape overboard when the sea suction valve is opened (see OCIMF/ICS' *Prevention of Oil Spillages through Cargo Pumproom Sea Valves*).

12.6.2.2 Sequence of valve operations

Use the following procedures when loading ballast into a non-inerted tank that contains hydrocarbon vapour:

- The first valve to be opened is the tank valve. The last one is the sea valve.
- Restrict the initial flow of ballast at the pump discharge so that the entrance velocity into the tank is less than 1m/sec until the bottom longitudinals are covered. If there are no longitudinals, restrict velocity until the depth of the ballast in the tank is at least 1.5m.

These precautions will avoid the spraying effect that may cause an electrostatic charge to build-up in a mist or spray cloud near the point where the ballast enters the tank (see chapter 3). When the charge is high enough, a static discharge and ignition is possible.

12.6.3 Loading segregated ballast

In general, there are no restrictions on ballasting segregated ballast tanks during the cargo discharge operation. However, be aware of the following:

- Confirm that the tank to be loaded is free of hydrocarbon.
- Take ballast as necessary to meet air draught requirements on the berth, particularly when MLAs are connected.
- Do not load ballast if it may cause the ship to exceed the maximum safe draught for the berth.
- Maintain hull shear forces and bending moments within allowable limits.
- Take care to ensure that excessive free surface is not allowed to occur as this may cause the ship to develop an angle of loll, jeopardising the integrity of the loading arms. This is particularly relevant to U-shaped ballast tank double hull tankers (see also section 12.2).

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12.6.4 Discharging segregated ballast

To prevent contaminated segregated ballast causing pollution, where possible the surface of the ballast should be sighted before de-ballasting. When de-ballasting starts, a watch should be established to observe the ballast as it discharges into the sea. If any contamination is seen, stop the de-ballasting immediately.

12.6.4.1 Discharging segregated ballast to shore

At some terminals, environmental requirements mean that segregated ballast must be discharged into shore tanks. On tankers with segregated ballast, this requires the cross-connection of the cargo and ballast systems, which could create a risk of contamination between the systems unless a deck manifold for ballast is fitted.

Operators should draw up careful procedures for this operation, which should cover:

- Fitting the cross-connection.
- The loading and de-ballasting sequence.
- Draught and air draught requirements.
- Managing hull stresses.
- Setting the cargo lines.
- Operating the cargo pump(s).
- Segregating ballast and cargo.
- Draining the ballast tank(s).
- Removing the cross-connection and isolating the systems.

12.6.5 Ballast water exchange at sea

Ballast water is commonly exchanged at sea to comply with the BWM Convention regulations. In this case, the overall design, strength and stability of the ship should permit it to do so safely in the prevailing weather. If not managed carefully, emptying and filling tanks at sea may lead to lower stability, higher stresses, sloshing or excessive trim and reduced draughts. The tanker's approved BWM plan should set out the necessary procedures and precautions.

12.7 Cargo leaks into double hull tanks

12.7.1 Action to be taken

If a hydrocarbon leak is discovered, the first step is to check the atmosphere in the tank to establish the hydrocarbon content. Note that the atmosphere in the tank could be above the Upper Flammable Limit (UFL), within the flammable range, or below the LFL. Regardless of the number of samples taken, the complexity of the structure means any or all of these conditions may exist in different parts of the tank. Therefore, to establish the true profile of the tank atmosphere, take gas readings at different levels and from as many points as possible.

If hydrocarbon gas is detected in a tank, there are a number of options for maintaining a safe tank atmosphere:

- Continuous ventilation.
- Inerting.
- Filling or partially filling with ballast.
- Securing with P/V valves.
- Securing with vent valves fitted with flame screens.
- A combination of these.

The chosen option will depend on several factors, especially the degree of confidence in the hydrocarbon content of the atmosphere, bearing in mind the potential problems already identified.

If inerting, fitting a P/V valve will be a way of pressing up the tank with IG after inerting to less than 8% oxygen.

When ventilating the tank, consider fitting flame screens to allow air to flow safely and maintain a non-flammable atmosphere in the air space.

Operators should develop procedures that account for the tank structure and any limitations of the available atmosphere monitoring system. These procedures should help the crew to choose the most appropriate way to make the atmosphere safe.

Filling or partially filling the tank with ballast to make the atmosphere safe and/or stop any further leaks into the tank should take prevailing stress, trim, stability and load line factors into account. Bear in mind that MARPOL regulations class all ballast loaded into a tank after a leak, and all tank washings used to clean the tank, as dirty ballast. This means they must be processed in line with those regulations and be either transferred directly to a cargo or slop tank for further processing or, if discharged directly to sea, passed via the oil content monitor. The spool piece that connects the ballast system to the cargo system should be clearly identified and stowed close to its working position. It should not be used for any other purpose.

If the tank is ventilated or inerted instead of filling, sound it regularly to check the rate of liquid build-up and leakage. If the quantity of cargo leaking into the space is pumpable, transfer it to another cargo tank via the emergency ballast/cargo spool piece connection (see above) or other emergency transfer route. This will minimise contamination of the space and help subsequent cleaning and gas freeing.

Ships should have written procedures on board that set out the steps to take to safely transfer the cargo from the ballast space.

Nobody should be allowed to enter the tank until it is safe to do so and there is no further possibility of a hydrocarbon leak. If, for any reason, it is essential to enter the tank before it is safe, this should be done in accordance with section 10.7.

12.7.2 Inerting double hull tanks

The complexity of the structure in double hull and double bottom tanks makes them more difficult to inert than conventional tanks. The operator should use these guidelines as a basis for developing procedures (similar to those in section 12.4.7) for inerting such tanks. If possible, the procedures should be developed with the ship builder and be based on actual tests and experiments as well as calculations. They should describe the process for each tank, the equipment to be used and its configuration, and the time it takes to reduce the oxygen level in the tank to less than 8% by volume.

For tanks that are identical in structure and size, and where the method of inerting is identical, the data can be taken from tests on a representative tank. Otherwise, the tests should be carried out for each tank.

Introducing IG into a tank may create electrostatic charging. The compartmentalised structure of the tanks means this charge is unlikely to reach incendive levels. However, certain areas within the tank may have a flammable atmosphere, so comply with all the electrostatic precautions set out in sections 3.2 and 11.1.6.8 throughout the inerting process and for 30 minutes afterwards.

Clearly identify the flexible hoses used for inerting double hull tanks. They should be dedicated solely to this use and stowed safely and correctly. The hose string should be electrically continuous. Verify this before putting hoses into service. Confirm that the string is properly earthed before inerting starts.

To minimise the transfer of hydrocarbon vapour from cargo tanks, temporarily close all cargo tank IG supply valves where fitted. Before connecting the hoses, purge the IG line with IG. The hoses should not be connected until needed.

Once the tank has been inerted, consider keeping the tank permanently connected to the IG system. This will enable constant pressure monitoring, over pressure protection via the deck water breaker and ease of topping-up. It will also enable protection against any potential problems of vapour transfer and vulnerability of the hose to heavy seas.

If the hoses remain connected, then all the cargo tank IG inlet valves should be re-opened. If the hoses are disconnected, the IG system should be returned to its original status.

If leaked oil is to be transferred from a ballast space that has been inerted, it is important to ensure that further inerting is carried out during the operation to avoid the introduction of oxygen into the tank. Once inerted, keep the tank topped up as necessary to ensure that a positive pressure is maintained and the oxygen content stays below 8% by volume.

During inerting, ventilate the exhaust vapour from the tank through an opening at least two metres above the deck. Use portable standpipes where necessary.

Double hull tanks are not usually fitted with devices such as P/V valves, which allow a positive pressure to be maintained in the tank. The guidelines and procedures above and in section 12.4.7 should cover methods for sealing openings that might let air into the tank and for ensuring the tank cannot be over pressurised.

The progress of inerting can be monitored by measuring the oxygen content of the exhaust vapour. However, atmosphere measurements to determine when the tank is fully inert, and subsequent monitoring measurements, should be taken at all designated sampling points and with the IG supply stopped.

12.8 Cargo measurement, ullaging, dipping and sampling

12.8.1 General

Cargo measurement and sampling is undertaken using a variety of methods that should conform to the requirements for safe handling of the intended cargoes. Which system is used will be determined by the type of tanker, the toxicity and/or volatility of the particular cargo and associated regulatory requirements.

In general, there are three main methods of gauging – closed, open and restricted:

- Closed: a gauging device that penetrates the cargo tank, but which is part of a closed system maintaining the complete integrity of cargo containment. This device is designed and installed so as not to release cargo liquid or vapour in any amount to the atmosphere, e.g. automatic float, continuous tape (magnetic coupled), sight glass (protected), electronic probe, magnetic, differential pressure cell.
- Open: a gauging method that uses an opening in the cargo tank, such as a gauge hatch or ullage port. This method may expose the user to the cargo and its vapours.
- Restricted: a gauging device that penetrates the cargo tank and which, during operation, can allow the release of small quantities of cargo vapour or liquid. The amount of release is controlled by a small diameter tank penetration opening and by a locally operated valve (sometimes known as a vapour lock) or similar closure device in that opening. When not in use, this type of gauging device is closed to maintain the complete integrity of cargo containment, e.g. rotary tube, fixed tube, slip tube and sounding tube.

As a closed gauging system offers complete integrity and flexibility for varying cargo types and trades, its use is preferred at all times. Open gauging and restricted gauging should only be allowed where:

- Open venting is allowed by the relevant regulations, e.g. the IMO's *International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code)*.
- Means are provided for relieving tank pressure before the gauge is operated.

In consultation with the terminal and cargo surveyors, remote gauging may be considered for cargoes with a toxic content. Evidence will be needed to demonstrate the accuracy of the remote gauging system, such as a calibration certificate and test records.

Cargo compartments may be pressurised, so only authorised personnel should open vapour lock valves, ullage ports or covers to control the release of any pressure.

Avoid escaping vapour and wear proper PPE if risk of gas exposure exists (see sections 23.3.1 and/or 23.3.2 and 24.2.1). Stand at right angles to the direction of the wind. Standing immediately upwind of the ullage port might create a back eddy of vapour towards the operator. Depending on the cargo, consider using appropriate RPE (see sections 10.8 and 12.8.4).

When open gauging, the tank opening should be uncovered only for as long as it takes to complete the operation.

Cargo sampling

Sampling is an integral part of cargo operations. Taking clean, representative and uncontaminated samples is essential for all parties involved in the voyage (shipper, charterer, terminal, supplier or receiver).

Cargo dosing/doping (introducing additives) may also be needed for product quality, specification, operational or legal reasons.

These operations pose a potential hazard to personnel, exposing them to toxic and/or flammable cargo vapours, so they need to be done with care.

Closed sampling

All cargo sampling and additive handling should be under closed conditions and with dedicated closed sampling equipment. The focus should be on protecting personnel against the safety risks and minimising the operational and environmental hazards. The SMS should include procedures and guidance on closed sampling.

Open sampling

At times, despite taking precautions to ensure good quality samples, the samples drawn through the closed sampling method may be unsatisfactory. Viscosity and pour point issues can make closed sampling difficult.

In this case, the parties involved may consider open sampling.

Open sampling is an exception, not a readily available alternative. It risks exposing personnel to harmful cargo vapours and poses electrostatic hazards (see section 12.8.2).

If open sampling is needed, it should be done according to the operator's SMS and agreed by the Master and the Terminal Representative.

The risk of open sampling should be evaluated and risk assessed considering the characteristics of the cargo, personal exposure to toxic/flammable vapours, the electrostatic hazard and the weather.

Open sampling should not be carried out under no wind or light wind conditions or with lightning in the area.

To reduce the risk, ensure the level of PPE, including RPE, meets the requirements of the risk assessment. Isolate the IG branch valve and release the cargo tank pressure, open one tank at a time and stop any cargo operation. Use a toolbox talk to brief the crew involved in operation on the hazards and safety procedures.

Once the open sampling is complete, restore the system to normal operation and check the oxygen content to confirm the tank remains inert.

12.8.2 Measuring and sampling non-inerted tanks

12.8.2.1 General

Electrostatic discharges are possible whenever equipment is lowered into non-inerted tanks. They may come from charges on the equipment itself or from charges already in the tank, e.g. in the liquid contents or on water or oil mists. If a flammable mixture of hydrocarbon gas and air is possible, take precautions to avoid any incendive discharges throughout the system.

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

- Introducing equipment that may act as a spark promoter to a tank that already contains charged materials.
- Introducing a charged object to a tank.

Each requires different mitigation.

Table 12.2 summarises the precautions to prevent electrostatic hazards when ullaging and sampling non-inerted tanks.

12.8.2.2 Introducing equipment to a tank

Measures to avoid spark promoters

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

Equipment should be designed to make earthing easy. For example, the frame that holds the wheel of a metal measuring tape should have a threaded stud that a sturdy bonding cable can be bolted to. The stud should have electrical continuity through the frame to the metal measuring tape. The other end of the bonding cable should terminate in a spring-loaded clamp that can be attached to the rim of an ullage opening.

Companies that supply non-conductive and intermediate conductive equipment to ships should be satisfied that the equipment will not act as spark promoters. Non-conducting components should not insulate any metal components from earth. For example, if a plastic sample bottle holder includes a metallic weight, the weight should be bonded as above or be fully encapsulated in at least 10mm thick plastic.

Cargo tank operation when hazard can occur	Lowering of equipment with ropes or tapes of synthetic material	Loading clean oils	Tank washing
Electrostatic hazard (chapter 3)	Rubbing together of synthetic polymers (section 12.8.2.2)	Flow of static accumulator liquids (sections 12.1.7 and 12.8.2.3)	Water mist droplets (sections 3.2.7 and 12.8.2.5)
Precautions necessary for dipping, ullaging and sampling with:	(sections 12.8.2.3 and 12.3.5.2)	(section 12.8.2.3)	(sections 12.3.5.2 and 12.8.2.5)
i. metallic equipment not earthed or bonded	Do not use ropes or tapes made of synthetic materials for lowering into cargo tanks at any time	Not permitted at any time	Not permitted during washing and for five hours thereafter
ii. metallic equipment that is earthed and bonded from before introduction until after removal	"	Not permitted during loading and for 30 minutes thereafter	No restrictions
iii. non-conducting equipment with no metallic parts	"	If sampler is more than one litre capacity, Not permitted during loading and for 30 minutes thereafter	No restrictions
Exceptions permitted if:	"	Sounding pipe is used	a. Sounding pipe is used, or b. Tank is continuously mechanically ventilated, when five hours can be reduced to one hour

Table 12.2: Summary of precautions against electrostatic hazards when ullaging and sampling non-inerted tanks

Measures to avoid charged objects

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

A material of intermediate conductivity, such as wood or natural fibre, has enough conductivity because of water absorption to avoid the accumulation of electrostatic charge. At the same time, the conductivity of these materials is low enough to ensure that instantaneous release of a charge is not possible. These materials should have a leakage path to earth so that they are not totally insulated, but this need not have the very low resistance normal for bonding and earthing metals.

In practice, such a path usually occurs naturally on ships, either by direct contact with the ship or indirect contact via the operator of the equipment.

12.8.2.3 Static accumulator oils

It is wise to assume that the surface of a non-conducting liquid (static accumulator) may be charged and at a high potential during and immediately after loading. Metallic dipping, ullaging and sampling equipment should be bonded and earthed to avoid sparks. However, the possibility remains of a brush discharge between the equipment and the charged liquid surface as the two approach each other.

After loading a tank, allow a settling time of 30 minutes before starting dipping, ullaging, sampling and any other operation that introduces equipment into the tank. This allows gas bubbles, water or particulate matter to settle in the liquid and any electrical potential to dissipate.

Since such discharges can be incendive, and because a flammable gas mixture may be present, no dipping, ullaging or sampling with metallic equipment should take place while a static accumulator is being loaded.

Figure 12.5 summarises the situations when these restrictions on metallic equipment should apply.

Non-metallic equipment

Discharges between the surface of a static accumulator oil and non-metallic objects have not been found to be incendive. Therefore, dipping and ullaging with non-metallic equipment lowered on clean natural fibre line can be done at any time.

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

Refer to section 3.2.1 on the use of non-metallic sampling containers.

Sounding pipes

A sounding pipe is a conducting pipe that extends the full depth of the tank and is effectively bonded and earthed to the tank structure.

A sounding pipe can be used at any time because, as long as it is designed and installed properly, it is not possible for any significant charge to accumulate on the surface of the liquid within it. The pipe should be slotted to prevent any pressure differential between the pipe and the tank and to ensure that true levels are indicated.

The electrostatic field strength in a metal sounding pipe is always low due to the small volume and the shielding from the rest of the tank. This means dipping, ullaging and sampling within a metal sounding pipe can be done at any time, provided any metallic equipment is properly earthed. Sounding pipes may also use non-metallic equipment, in which case the precautions against introducing charged objects should be applied.

12.8.2.4 Static non-accumulator oils

A flammable atmosphere may be present above a static non-accumulator oil in a non-inerted or non-gas free environment. Follow the precautions in section 12.8.2 and figure 12.5.

12.8.2.5 Ullaging and dipping in water mists

During tank washing, no unearthed metallic conductor should be in the tank and none should be introduced while the charged mist persists, i.e. for up to five hours afterwards (see sections 12.3.5.2 and 12.3.6). Earthed and bonded metallic equipment can be used at any time because any discharges to the water mist take the form of a non-incendive corona. The equipment can contain or consist entirely of non-metallic components. Intermediate conductors and non-conductors are acceptable, although certain materials, e.g. polypropylene (PP) ropes, should be avoided (see section 3.2.7).

All metallic components should be securely earthed. If there is any doubt about earthing, do not allow the operation.

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

12.8.3 Measuring and sampling inerted tanks

Ships fitted with IG systems should have closed gauging systems for taking measurements during cargo operations. Ships should have vapour locks to enable closed gauging and sampling for custody transfer.

Ships with a vapour lock on each cargo tank should measure and sample cargo without reducing the IG pressure unless needed for vapour emission control, e.g. high H_2S. Vapour locks are used with specially adapted measurement devices, such as sonic tapes, samplers and temperature tapes. When using the equipment, the valves of the vapour lock should not be opened until the instrument is properly attached to the standpipe. Take care to ensure that there is no blow-back of vapour. Open gauging or sampling should not take place on ships with vapour locks unless it is necessary to prevent cross contamination when sampling highly sensitive cargoes.

Sonic tapes, temperature tapes, etc. should be used in line with good safety practices and the manufacturer's instructions. The requirements for portable electrical equipment apply to these devices (see section 4.12).

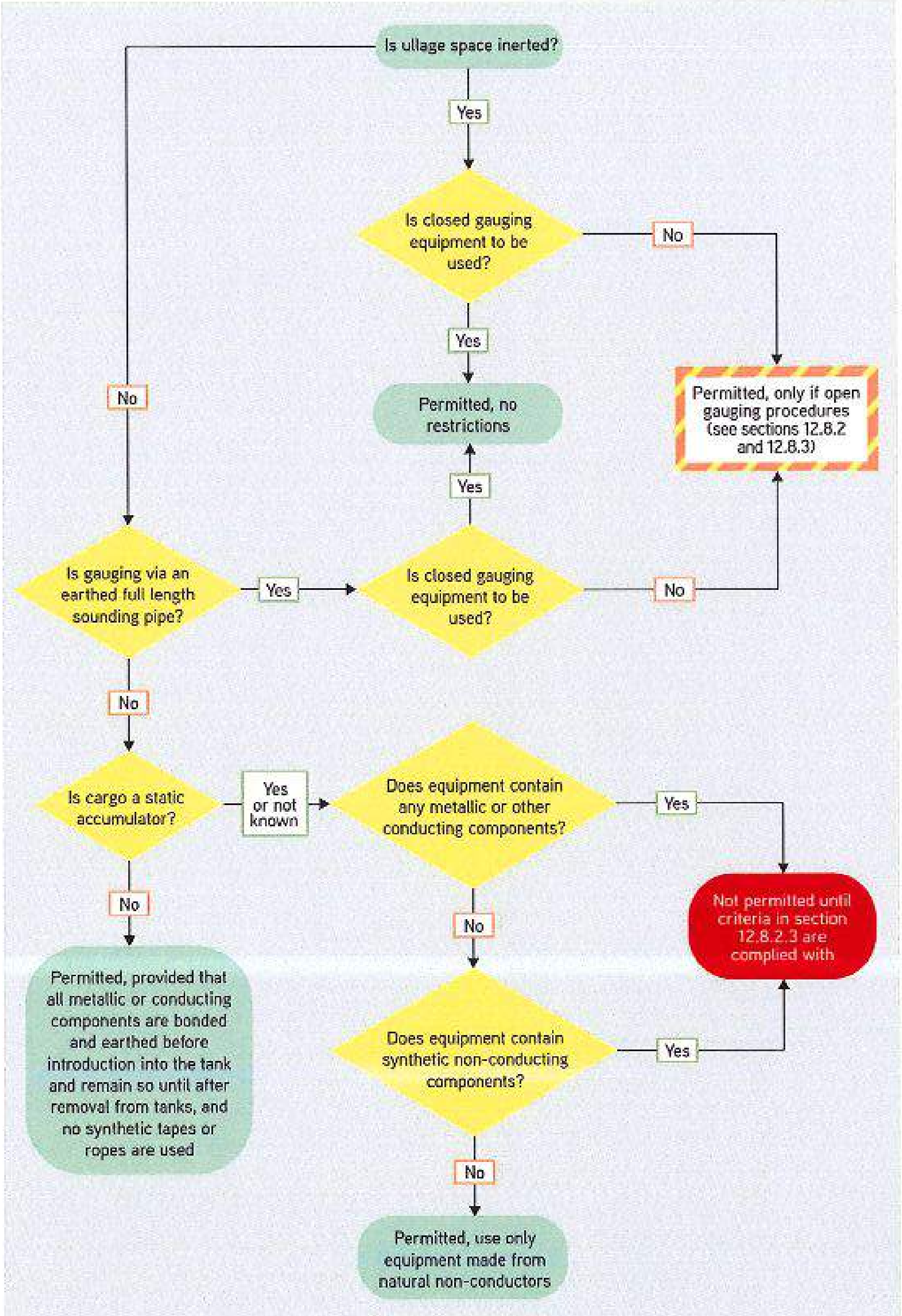

Figure 12.5: Precautions when using portable measuring and sampling equipment flowchart

On ships not equipped with vapour locks, or if highly sensitive cargoes need to be sampled, take the special precautions detailed in section 12.8.1. When the pressure in any tank needs to be reduced for measuring and sampling, take the following precautions:

- Maintain a minimum positive IG pressure when measuring and sampling. The chemical composition and low oxygen content of IG, and particularly nitrogen IG, can rapidly cause asphyxiation, so take care to avoid standing in the path of vented gas when measuring and sampling (see section 12.8.1). No cargo or ballast operations are permitted in cargo compartments while the IG pressure is reduced to allow measuring and sampling.
- Open only one access point at a time and for as short a time as possible. In the intervals between the different stages of cargo measurement, e.g. between ullaging and taking temperatures, keep the relevant access point firmly closed.
- After completing the operation and before starting to discharge cargo, secure all openings and re-pressurise the cargo tanks with IG (see section 11.1 for operating the ship's IG system during cargo and ballast handling).
- When mooring and unmooring or while tugs are alongside, do not carry out any measuring and sampling that require the IG pressure to be reduced and cargo tank access points opened. Note that if access points are opened while at anchor or moored in open waters any movement of the ship might result in the tanks breathing. To minimise this risk, maintain sufficient positive pressure within the tank being measured or sampled.
- When discharge is nearly complete and it is necessary to sound the tanks, the IG pressure can again be reduced to a minimum safe operational level to allow sounding through sighting ports or sounding pipes. Avoid air leaks or an excessive release of gas.

12.8.3.1 Static accumulator cargoes in inerted cargo tanks

Precautions are not normally needed against static electricity hazards when using IG because the IG prevents the formation of a flammable gas mixture. However, particulates suspended in IG mean high electrostatic potentials are possible. If a tank is no longer thought to be inert, then dipping, ullaging and sampling should be restricted as in sections 11.1.6.8 and 12.8.2.

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

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

IG particulates may carry a very high potential, so do not assume that corona discharges from conducting equipment lowered into the tank will be non-incendive if the tank contains a flammable atmosphere. No object should be introduced into the tank until the very high potential has had a chance to decay. Allow 30 minutes after the IG injection has stopped. After this, equipment may be introduced provided all metallic components are securely earthed and subject to the same precautions for water mists caused by washing (see section 3.2.7). This earthing is required for at least five hours after the injection of IG stopped (see section 12.8.2.5).

If a tank needs to be re-inerted after a failure of the IG system, or a non-gas free tank is being initially inerted, no dipping, ullaging, sampling or other equipment should be inserted until the tank is inert.

12.8.4 Measuring and sampling cargoes containing toxic substances

Special precautions are needed when ships carry cargoes that contain toxic substances in hazardous concentrations.

Loading terminals are responsible for advising the Master, by providing the SDS, if the cargo to be loaded contains hazardous concentrations of toxic substances. Similarly, the Master is responsible for advising the receiving terminal, by providing the SDS, if the cargo to be discharged contains toxic substances. This is covered by the SSSCL (chapter 25).

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

Ships carrying cargoes containing toxic substances should use closed sampling and gauging procedures if possible. In consultation with the terminal and cargo surveyors, remote gauging may be considered. Evidence needs to demonstrate the accuracy of the remote gauging system, e.g. a calibration certificate, vessel experience factor and periodic test records.

If remote gauging, closed gauging or closed sampling are not possible, a risk assessment should be carried out. Follow the precautions set out in section 12.8.1 for open sampling.

Tests should assess the vapour concentrations near each open access point to ensure they do not exceed the Occupational Exposure Limit - Short-term Exposure Limit (OEL-STEL) of the toxic substances. If monitoring shows the limit could be exceeded, personnel should wear suitable respiratory protection. Access points should be opened only for the shortest possible time.

If effective closed operations cannot be maintained, or if concentrations of vapour are rising because of defective equipment or still air, consider suspending operations and closing all venting points until defects are corrected or the weather changes and gas dispersion improves.

Refer to section 1.4 for details of the toxicity of petroleum and its products.

12.8.5 Closed gauging for custody transfer

Gauging tanks for custody transfer should be done with a closed gauging system or via vapour locks. For the ullaging system to be acceptable, the gauging system should be described in the ship's tank calibration documentation. The ship's Classification Society should check and approve corrections for datum levels and for list and trim.

Temperatures can be taken using electronic thermometers inserted through the tanks' vapour locks. The thermometers should also be calibrated and have the appropriate approval certificates.

Samples should be taken using special sampling devices via the vapour locks.

12.8.6 Cargo tank monitoring systems

Tank monitoring equipment often has multiple functions, such as radar or other types of remote gauging, temperature measurement, tank pressure sensors and level alarms. It may be integrated with other cargo monitoring or control equipment or with loading computers or control systems. Manufacturers may refer to these multi-function units as cargo tank monitoring systems.

Whether provided as a complete system or as separate elements, planned maintenance procedures should be established to ensure maintenance, test and calibration of this equipment per the manufacturer's instructions.

A risk assessment should identify procedures to enable work to continue if tank monitoring equipment fails. If temporary exchange with a unit from another tank unit is considered, check the compatibility. The equipment may need to be re-calibrated.

12.9 Transfers between ships

12.9.1 Ship to Ship transfers

In STS transfers, both tankers should comply fully with the safety precautions for normal cargo operations. If either ship is not observing the precautions, the operations should not start or should be stopped if in progress.

STS transfers in port or at sea should be approved by the port or local marine authority, in accordance with MARPOL regulations. This approval may have specific conditions attached.

12.9.1.1 Transfer guide

STS transfers alongside a berth (also known as double banking – see section 16.3) may include a simultaneous cargo transfer to shore as well as between the participating tankers. These operations should be risk assessed (see section 4.2.2) taking into account applicable limiting conditions for operations alongside terminals (see section 16.1) and include, as a minimum, the following:

- Local port/coastal authority and regulatory approvals.
- Use of lightering advisors and the PIC of operations.
- SIMOPS considerations (see section 4.6).
- Numbers of crew (in addition to normal watchkeeping), their competency and experience.
- Environmental sensitivity of location.
- Metocean conditions: weather, waves and swell, currents and tides, etc.
- Communications.
- Terminal or port requirements.
- Notifications.
- Emergency and contingency planning.

12.9.2 Ship to barge and barge to ship transfers

In ship to barge or barge to ship transfers of hydrocarbons, only authorised and properly equipped barges should be used. Precautions similar to those in ICS/SIGTTO/CDI/OCIMF's *Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases* should be followed. If the barge or the tanker are not observing the precautions, the operations should not start or should be stopped if in progress. Ship Masters should be aware that barge crews may not be familiar with the requirements of the *Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases.*

The pumping rate from ship to barge should be controlled according to the size and nature of the barge, particularly if the freeboard difference is large. In any case, the barge crew should allow for sufficient space in tanks for hose contents to be transferred upon cargo completion.

An agreed method of communication should be established and maintained throughout the duration of operations.

Arrangements should be made to release the barge in an emergency, accounting for nearby shipping or property. If the tanker is at anchor, the barge may drop anchor clear of the tanker. It can remain secured there, waiting for assistance.

A barge should be cleared from the ship's side as soon as possible after it has finished loading or discharging volatile petroleum.

12.9.3 Ship to Ship transfers using vapour balancing

Specific operational guidance should be developed to address the particular hazards associated with vapour emission control during STS transfer using vapour balancing techniques. Such transfers should only be between inerted ships. Follow the recommendations in section 11.1.6.4.

12.9.4 Ship to Ship transfers using terminal facilities

When a tanker at a berth is transferring cargo to a tanker at another berth through the shore manifolds and pipelines, the two tankers and the terminal should comply with all regulations relating to ship to shore transfers, including written operating arrangements and communications procedures. The terminal's cooperation in setting up these arrangements and procedures is vital. Consider appointing a responsible party to provide equipment and naming a PIC.

12.9.5 Ship to Ship electric currents

The principles for controlling arcing during STS transfers are the same as in ship to shore transfers.

In ships dedicated to STS transfers, an insulating flange or a single non-conducting length of hose should be used in the hose string. When transferring static accumulator oils, it is essential that these measures are not taken by both ships, leaving an insulated conductor between them that could accumulate an electrostatic charge. For the same reason, when a dedicated ship is transferring ship to shore, take care to ensure no insulated conductor is between the ship and shore, e.g. using two insulating flanges on one line (see *Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases*).

If the ships cannot be positively isolated, the electrical potential between them should be reduced as much as possible. This is probably best achieved if they both have working impressed current cathodic protection systems and they leave them running. Likewise, if one has an impressed system and the other a sacrificial system, the impressed system should remain in operation.

However, if one ship does not have cathodic protection, or its impressed system has failed, consider switching off the impressed system on the other ship well before the two ships come together.

For more, refer to sections 17.4.2, 17.4.5 and 18.2.

12.10 Personnel transfer

The transfer of personnel between ships should be kept to an absolute minimum. If a transfer is being considered, a risk assessment should evaluate how this is done, bearing in mind the residual risks may still be unacceptable. Abandoning the transfer should always remain an option.

When planning and carrying out personnel transfers, refer to OCIMF's *Transfer of Personnel by Crane between Vessels*, which covers hazard identification, equipment, maintenance and testing, training and contingency planning.

12.11 Liquefied Natural Gas fuelled ship alongside a terminal

Liquefied Natural Gas (LNG) is stored under cryogenic conditions in bunker tanks. While these are well insulated, an increase in the temperature and pressure of the fuel is possible. To avoid a release of natural gas through the pressure relief valve and vent stack, measures should be in place to manage the temperature and pressure.

Before arrival, the ship and terminal should exchange information on the type of fuel used during the stay alongside and on the emergency plan. The ship should confirm the ongoing integrity of the LNG containment, Boil-Off Gas (BOG) management and monitoring systems.

As a minimum, the Master and engineering officers on ships subject to the *International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels (IGF Code)* should receive training in line with the specific requirements of the *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1979 (STCW)* and hold a certificate of proficiency in LNG.

For more information, refer to the IGF Code, which requires the means to maintain the bunker tank pressure below the set pressure of the relief valves for a period of 15 days with the ship in idle condition, i.e. without consuming the BOG in the main engine. Methods of achieving this include pressurised tanks or cooling via top sprays (see section 24.3.2.4).

12.12 Lifting equipment

12.12.1 Inspection and maintenance

All shipboard lifting equipment should be examined at least once a year and load tested at least every five years unless local, national or company regulations require more frequent examinations.

Lifting equipment includes:

- Cargo hose handling cranes, derricks, davits and gantries.
- Gangways and associated cranes and davits.
- Store cranes and davits.
- Chain blocks, hand winches and similar mechanical devices.
- Personnel lifts and hoists.
- Lifting points, e.g. pad eyes in the manifold area.
- Strops, slings, chains and other ancillary and portable equipment.

All equipment should be tested by suitably qualified individuals and be clearly marked with its Safe Working Load (SWL), serial number and test date.

All lifting equipment should be maintained in line with the manufacturer's guidelines. The ship's PMS should include periodic checks.

The ship's lifting equipment register should record all tests and inspections. These records should be available for inspection by Terminal Representatives when their personnel are involved in lifting operations using the ship's equipment.

For further guidance, refer to OCIMF's *Recommendations for the Tagging/Labelling, Testing and Maintenance, Documentation/Certification for Ships' Lifting Equipment*.

12.12.2 Training

Safe operation of all lifting equipment requires that all operators of lifting devices are correctly trained in their function and safe operation.

Appropriate training requirements should be established by the company based on the type of lifting equipment and the operations to be conducted.

Training may be undertaken in-house, on the job, e.g. by a supervisor, or externally, e.g. by the equipment manufacturer or an appropriate outside entity.

In addition, lifting equipment operators should be familiarised with the specific lifting equipment and operation planned prior to being assigned the task.

The following should be confirmed prior to operating lifting equipment:

- General operating principles of the applicable lifting equipment are fully understood by the operator.
- Operator is familiar with the specifics of the lifting equipment, e.g. manoeuvring handles and start/stop of the equipment, etc.
- Understanding of the limitations of the equipment, e.g. SWL, breaking strength, etc.
- Identify and understanding of the emergency stops and resetting method(s) (if fitted).
- Understanding of the risks and dangers with respect to the lifting equipment and its operation and the associated mitigating safety measures.
- Agreed method of communication between the operator and the signaller, where applicable.

In addition, a practical test should be performed prior to commencement of the lifting operation, where considered necessary.