

# TANKER VESSEL OPERATIONS IN THE PORT OF BARCELONA

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Full de Cortesia



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*This thesis is dedicated to the loving memory of my great-aunt Ena, who encouraged me to write the thesis, being very supportive throughout everything I've done.*

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## **Abstract**

Tankers are complex vessels that are able to carry large quantities of bulk liquids over large distances in the most efficient possible way.

In order to load or discharge their products, tankers need special installations and dedicated terminals. The Port of Barcelona has a special area dedicated to liquid bulk cargo, called the Inflammables Wharf, or „Muelle de la Energía”. There are various terminals inside the Inflammables Wharf, dedicated to the storage and transport of refined petroleum products, liquefied natural/petroleum gas, edible oils and other chemicals. This area has special restrictions and characteristics that can affect the operation of a tanker.

In this Master’s thesis my aim is to describe the most important parts of a tanker ship’s port operations, in a chronological order starting from voyage planning and other actions carried out prior to arrival at the port, continuing with arrival and berthing manoeuvres and subsequently with cargo operations and their particularities, with an accent on discharge and loading operations, without forgetting to mention other operation-related aspects such as tank prewash and further tank washing, bunkering, pollution prevention, emergency situations etc.

The present thesis could serve as a brief general operating guide of a tanker in port, with an emphasis on the Port of Barcelona and on its particularities regarding tanker operations, presenting the actual situation and suggesting possible improvements for the future.





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## **CHAPTER 1: INTRODUCTION. COMPARATIVE ANALYSIS OF TANKERS**

### **1.1. Introduction to tanker vessels**

One of the most complex type of vessels, tankers are capable of carrying out sea transport of liquid cargo in bulk. Such liquefied freight can include both rock oil excavated from the underwater reservoirs and all other types of liquid freight like alcoholic beverages, hydrogen based organic compounds, chemicals and even juices. They also carry liquefied gaseous substances. Tanker vessels are indispensable in the maritime domain. The utility of these vessels has become even more applicable and viable in the ever-growing nature of maritime liquefied cargo transportation, thanks to the technological advancements that have been made in the structural and constructional facets of these vessel types. Although it is a known fact that many cargo ships cause oceanic pollution and degrade the marine environment, it cannot be denied that in the present day scenario, these tankers shipping offer the best possible transportation efficiency.

Different kinds of tanker vessels are utilized to provide the appropriate transportation facilitation for these various types of liquid freight. Some of the largest vessels in the world today are tanker ships. The construction and the technical structuring of tanker ships are stipulated by the IMO (International Maritime Organization). These stipulations have been amended periodically so as to ensure that the underlying safety aspects of the transportation of such volatile elements are met without any compromises.

Tanker ships are mainly classified on the basis of type of cargo and size of the vessel.

### **1.2. Classification of tanker vessels by size**

Dead weight tonnage (DWT) determines the maximum capacitance of tanker ships. Based on their DWT, tanker ships are classified into:

1. **ULCC:** They are known as Ultra Large Crude Carriers and have a cargo hauling capacitance range up to 500.000 tons. ULCCs are the biggest oil tanker vessels in operation
2. **VLCC:** The second biggest crude and product tanker vessel types in operation are the VLCCs or Very Large Crude Carriers. These tankers have a cargo carrying capacitance of 250.000 tons.
3. **Panamax:** The classification of tankers that can pass through the Panama Canal is known as the Panamax. Panamax tankers have DWTs of up to 80.000 tonnes. Mostly found in North America, transporting crude oil and fuel oil.
4. **Aframax:** The Aframax cargo tankers are that type of tanker ships which are mainly used in the Mediterranean, China Sea and the Black Sea. These tankers have a dead weight tonnage (DWT) between 80.000 and 120.000 tonnes. These tanker types can gain entryway to almost all harbour facilities across the world.
5. **Suezmax:** Panamax tankers are named for vessels which can navigate through the Panama Canal. On similar lines, the Suezmax vessels are so called because of their ease in passing through the Suez Canal. These tankers can have DWTs of up to 200.000 tonnes. After both the canals where underwent expansion, higher capacity tankers have been built to pass through them. These vessels are known as Post-Panamax and Post-Suezmax vessels.
6. **Handysize:** Although there is no official definition, handysize applies to smaller tankers with DWTs of up to 60.000 tonnes, capable to enter smaller ports with length and draft restrictions. Vessels above 35.000 tonnes are referred to Handymax or Supramax.

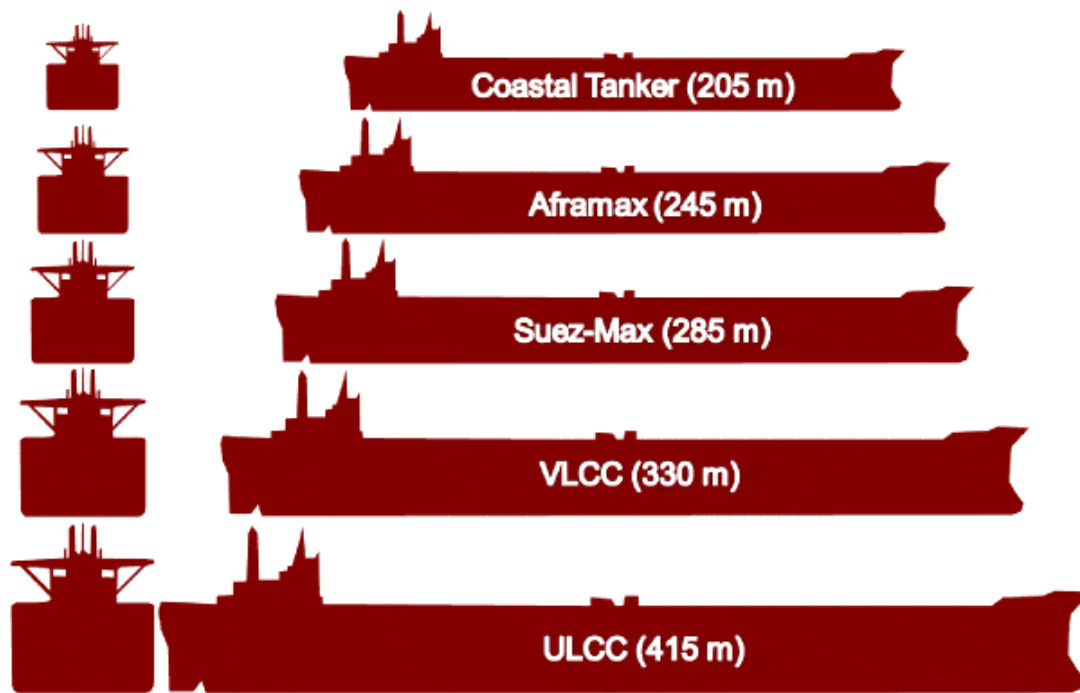


Figure 1: Classification of tankers by size.  
Source: [www.hofstra.edu](http://www.hofstra.edu)

### 1.3. Classification of tanker vessels by type

1. **Oil Tankers:** As their name suggests, oil tankers carry oil and its by products. Oil tanker however, is a generic terminology and includes not only crude oil but also petroleum based products. Oil tankers are further sub-divided into two main types: product tankers and crude tankers:

- **Crude tankers** are specifically used to transport crude oil from the excavation site to the crude oil refining industrial plant
- **Product tankers** are used to transport petroleum based chemicals like petrol, gasoline, kerosene and paraffin

2. **Gas Carriers:** Gas Carriers are those tanker ships that are used to cargo LNG (Liquefied Natural Gas) or LPG (Liquefied Petroleum Gas). These types of tankers require careful and delicate handling owing to the precariousness of the material they carry.

3. **Chemical Tankers:** Chemical tankers are cargo tankers which transport chemicals in various forms. Chemical tankers are specifically designed to maintain the consistency of the

chemicals they carry aboard. These tanker ships are applied with coatings made of certain substances that help in the easy identification of the chemicals that need to be transported.

**4. Slurry Tankers:** Slurry refers to all those materials that do not disperse or dissolve in water, otherwise regarded as waste materials. Slurry is used as a fertilizer and the slurry tankers help to haul slurry to areas where they can be put to productive use.

**5. Hydrogen Tankers:** As the name suggests, hydrogen tankers are cargo tankers used for the shipping and transportation of liquefied hydrogen gas.

**6. Juice Tankers:** Juice tankers or more specifically orange juice tankers which are used for the cargo carrying of orange juice in mass quantities. One of the biggest juice tankers is the Brazilian tanker Carlos Fischer. However, other fruit juices carriers are also available.

**7. Wine Tankers:** Transporting wine has become quite simpler and feasible in contemporary times as sleek tankers have come up which are used specifically to carry wine to their intended destinations.

**8. ITB (Integrated Tug Barges):** ITBs are prominently used in the eastern coast of the United States. These tankers are mainly tugs attached to barges leading to the formation of a single cargo carrying unit.

### **1.3.1. Oil tankers**

The global crude oil and refined product tanker fleet uses a classification system to standardize contract terms, establish shipping costs, and determine the ability of ships to travel into ports or through certain straits and channels. This system, known as the Average Freight Rate Assessment (AFRA) system, was established by Royal Dutch Shell six decades ago, and is overseen by the London Tanker Brokers' Panel, an independent group of shipping brokers.

AFRA uses a scale that classifies tanker vessels according to deadweight tons, a measure of a ship's capacity to carry cargo. The approximate capacity of a ship in barrels is determined by using an estimated 90% of a ship's deadweight tonnage, and multiplying that by a barrel per metric ton conversion factor specific to each type of petroleum product and crude oil, as liquid fuel densities vary by type and grade.



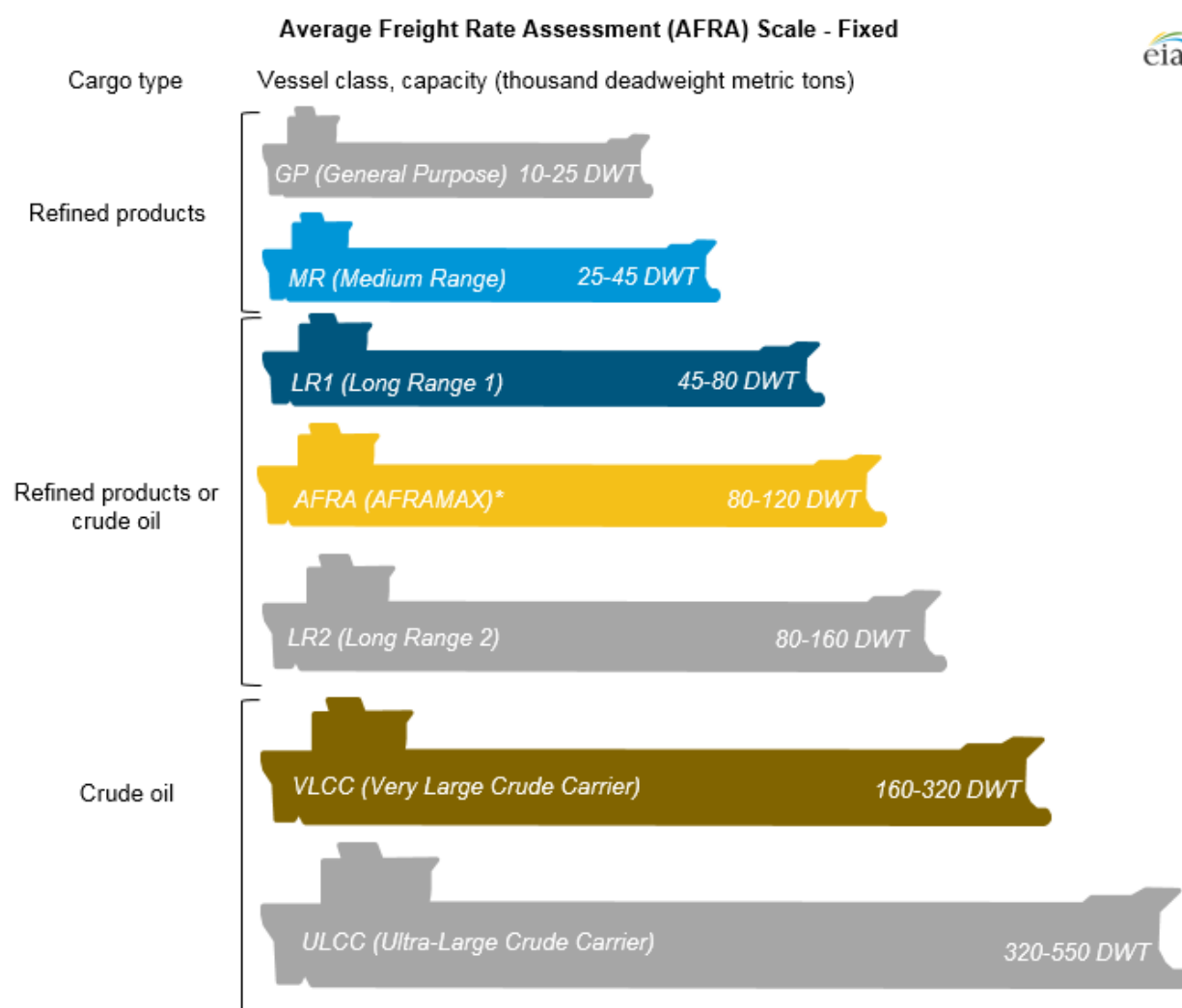


Figure 2: AFRA Scale.  
Source: [www.eia.gov](http://www.eia.gov)

The smaller vessels on the AFRA scale, the General Purpose (GP) and Medium Range (MR) tankers, are commonly used to transport cargos of refined petroleum products over relatively shorter distances, such as from Europe to the U.S. East Coast. Their smaller size allows them to access most ports across the globe. A GP tanker can carry between 8.500 and 22.500 metric tonnes of gasoline (70.000 - 190.000 barrels) and an MR tanker can carry between 22.500 and 40.000 metric tonnes (190.000 – 345.000 barrels).

Long Range (LR) class ships are the most common vessels in the global tanker fleet, as they are used to carry both refined products and crude oil. These ships can access most large ports that ship crude oil and petroleum products. An LR1 tanker would carry between 40.000 and

75.000 metric tonnes of gasoline (345.000 - 615.000 barrels) or between 310.000 barrels and 550.000 barrels of light sweet crude oil (42.000 – 75.000 metric tonnes).

A classification used to describe a large portion of the global tanker fleet is AFRAMAX. AFRAMAX vessels refer to ships between 80.000 and 120.000 DWT. This ship size is popular with oil companies for logistical purposes, and, therefore, many ships have been built within these specifications. The Very Large Crude Carrier (VLCC) and Ultra-Large Crude Carrier (ULCC) were added as the global oil trade expanded and larger vessels provided better economics for crude shipments. VLCCs are responsible for most crude oil shipments around the globe. A VLCC can carry between 1,9 million and 2,2 million barrels (260.000 – 300.000 metric tonnes) of a WTI type crude oil. With current WTI prices near 60 dollars per barrel, a fully loaded VLCC could carry about 120 million dollars' worth of crude oil.

During the 70's, the general aim was to build bigger vessels and carry more. Tankers of over half a million tons were constructed, but the market and regulations forced a change. There are a small number of ULCC vessels currently in use, as their size requires special facilities limiting the number of places where these vessels can load and offload. These massive vessels can carry around 2 million barrels to 3.7 million barrels of crude oil (300.000 – 500.000 metric tonnes).

On older tankers built before 1990, the cargo tank area extended over the length of the hull. There were no double bottoms or double shells so tanks were carried out to the ship's side and bottom. Two continuous longitudinal bulkheads extending throughout the entire length of the cargo space divided it into three tanks across the ship. Machinery spaces and accommodation were positioned aft of the cargo space. No doors into the accommodation were permitted to face the cargo area, and all windows facing the cargo area were fixed, in order to prevent vapours from entering the accommodation. The main pump room was positioned aft of the tank space and immediately forward of the engine room. No cargo was permitted to be pumped through the machinery space. Forward of the cargo tanks the space was for housing ballast, spare bunkers, equipment, spare parts etc. Fuel bunkers, fresh water and machinery space were aft of the cargo space. Each cargo tank was oil tight and a small ullage and inspection hatch was required. Tanks were protected against over or under pressure by means of a vent pipe fitted with a valve that ensured that the pressure in the tank remained close to atmospheric pressure. Since the late 80's, oil tankers have been constructed with double hulls.

Product carriers, though much smaller than crude carriers, are generally divided into a large number of tanks, which enables them to carry a number of different products on the same

voyage. Pumping and piping arrangements are more complicated in order to isolate the different products from one another.

Modern crude carriers and product carriers are subject to more stringent regulations with regard to construction. The MARPOL conventions stipulated that crude carriers over 20000 tons and product carriers over 30000 tons would require completely segregated ballast tanks that have to be placed in a protective location. This meant that ships need to have sufficient ballast space available in order to obtain an acceptable draft without using the oil tanks for water ballast. After the grounding of the Exxon Valdez in Alaskan waters (1989), legislation was brought forward and all tankers operating in US ports had to be fitted with double hulls. According to the MARPOL convention (1993), new tankers have to be constructed with either double hulls or an acceptable, approved alternative design (e.g. Coulombi Egg).

Every oil tanker built after 1 June 1979 was required to be constructed with protectively located ballast tanks and fitted for crude oil washing (COW). These ballast tanks were fitted around the outer hull of the vessel and, while giving protection from a side impact or collision, they gave no protection to the ship's bottom from grounding or stranding, which would be achieved by the double hull.

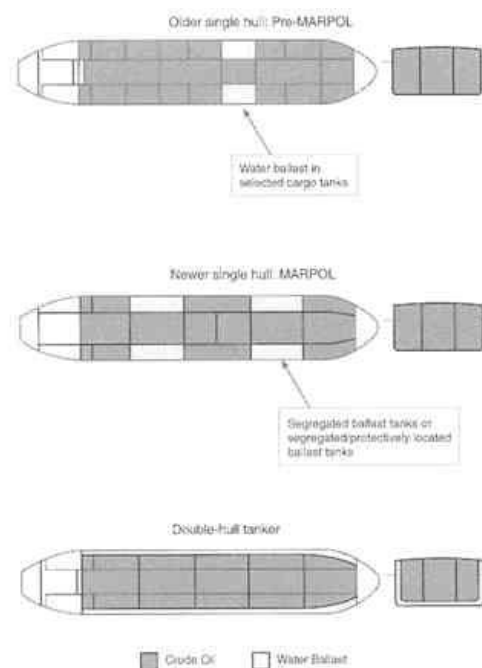


Figure 3: Pre-Marpol, SBT tankers and double hull tankers.  
Source: [www.nap.edu](http://www.nap.edu)

With double hull construction, ships can experience free surface of liquids in both the cargo and the double bottom tanks. This can be limited by including centre line bulkheads. However, free surface effect can be critical while ballasting or de-ballasting simultaneously during cargo

operations. Double hull tankers are provided with interlock devices that control the number of tanks with free surface open at one time. Heavy liquid sloshing in partly loaded tanks can damage tank structures through the wave energy of liquid movement, assisted by the flat smooth bottom tank plating.

The operation of double hull tankers, which were mainly introduced to reduce the quantity of oil released in collision and grounding incidents, has added to the tank management workload and changed some of the operational conditions. One effect of a double hull is that while the ship is at sea, the loading temperature of the cargo is maintained for a longer period of time because of the insulation between the cargo and the outside sea temperature, which can impact the vapour release from the cargo. The corrosion of the internal tank structure bottom plating is high. Therefore, internal tank surface coating and inspection procedures are very necessary, such as the Enhanced Survey Programme (ESP), a requirement for all chemical tankers.

After loading a warm temperature cargo, the vapour in the ullage space of the cargo tank may be subject to rapid cooling through a single deck layer of steel. With earlier single hull ships, this can result in large quantities of condensation on the underside of the deck plating, which can in turn produce corrosion. However, in an area with double hull tensile steel lightweight scantling construction, the flexing of the steel plate can shed that corrosion, leaving new surfaces to continue the process. Therefore, internal tank surface coating and inspection procedures are very necessary.

#### Alternative design to double hull tankers: The Coulombi Egg

The Coulombi Egg design is thought to provide better protections for VLCC and Suezmax crude oil tankers.

The Coulombi Egg design positions all the segregated ballast in the top side tanks in the cargo tank body, which becomes a collision crush zone in case collision should take place. The risk of breach to a cargo oil centre tank above the waterline, followed by a fire in the event of a collision, is reduced considerably as the crush zone is much wider than on a double hull vessel. The risk of explosion in the ballast space is also reduced as the Coulombi Egg ballast spaces are much easier to ventilate and access. The Coulombi Egg is the only alternative tanker design approved by the IMO as per MARPOL since 1993. However, up to present date, no Coulombi Egg tanker has been built.

The Coulombi Egg tanker grounding protection is expected to reduce the initial exchange losses to virtually nil. When a Coulombi Egg tanker runs aground and is slowed by the grounding force, the bottom is breached and water flows in, the oil bubble formed in a lower

tank is pushed forward and pressed up into a big access trunk forward and aft of each tank, from where the cargo can later escape by gravity, under controlled conditions, into the top side ballast tanks, acting as evacuation tanks. By permitting the oil bubble to expand upwards through air, which offers less resistance than water, and allowing an equivalent amount of water to enter the breached tank, the risk of oil spills below the forward bulkhead during these initial exchange losses is reduced. Some oil may spill out if the lateral is ripped away, but the amounts should be small. The Coulombi Egg arrangement is the only tanker grounding protection that eliminates all further grounding pollution due to falling tides, as all cargo at risk is pushed up to the top side ballast tanks before the tide falls.

In case of grounding, as the Coulombi Egg tanker does not increase its displacement, it is expected that the ship can quickly float off the ground and move to a sheltered location, without assistance of tugs. The tanker can then be surrounded with booms, oil in the breached tanks can be transferred to the ballast tanks or to a lightering tanker, and the vessel should be able to proceed to the discharge port. The best solution is to off-load all cargo, trim the vessel, clean the damaged lower cargo tanks and seal the tanks before proceeding to a repair yard.

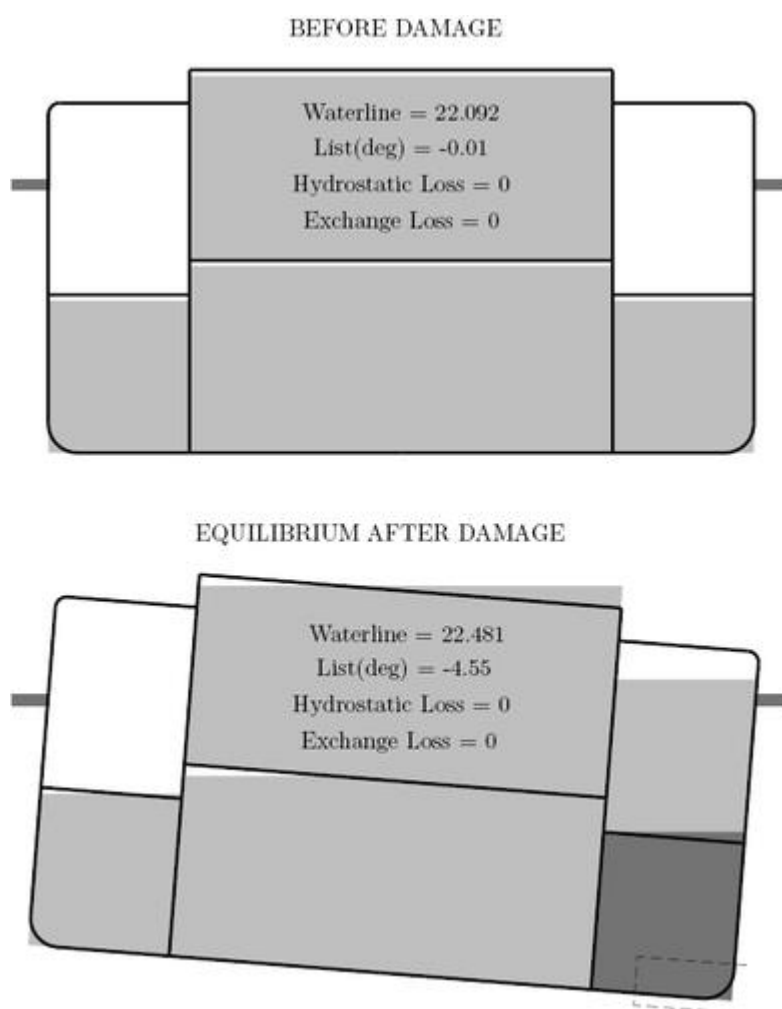


Figure 4: Coulombi Egg tanker design.  
Source: [www.wikipedia.org](http://www.wikipedia.org)

Currently, many oil tankers that were built with single hull configuration continue in operation. Regulations require enhanced surveys of the ship from 15 to 25 years after the delivery date, at which time the options become limited. The owner can scrap the ship, but if the tanker is in a reasonable condition and well maintained, he may have to take into consideration fitting a double hull (which is prohibitively expensive) or protectively located segregated ballast tanks. Another alternative is to adopt hydrostatic balanced loading.

Hydrostatic balanced loading means that the tanks are loaded to a reduced level, at a pressure equal or lower than the pressure of the sea water surrounding the ship.

### **1.3.2. Chemical tankers**

Chemical tankers are much more complicated than other types of liquid carrying tankers. They usually have more tanks, more valves, more pumps, more blanks and more lines. They may have many different kinds of cargo on-board at the same time. The cargoes may be bulk liquid chemicals, solvents, lubricating oils, vegetable and animal oils, petroleum products and other such liquids. There are 3 main types of chemical tankers that can be encountered (a total global fleet of about 5000 ships):

- Type 1 for the most hazardous cargoes (offering the highest level of protection)
- Type 2 for intermediate protection
- Type 3 the lowest form of protection for the least harmful chemicals

Type 1 tankers are designed for the carriage of IBC Code chapter 17 products which have severe environmental and safety hazards which require maximum preventive measures to preclude an escape of such cargo. These vessels are of a smaller size and are often dedicated to single cargo trading. The tanks have to be coated, or from stainless steel, and may not exceed 1250 m<sup>3</sup> of capacity.

The regulations state that for Type 1 vessels:

- The wing tank should have a minimum width of  $B/5$  ( $B$  = breadth) or 11,5 m (whichever is less)
- The double bottom should have a minimum height of  $B/15$  or 6 m (whichever is less)



Figure 5: Inside the tank of a chemical tanker.  
Source: [www.wikipedia.org](http://www.wikipedia.org)

Type 2 tankers are designed for the carriage of IBC Code chapter 17 products that have moderately severe environmental and safety hazards which require significant preventive measures to preclude an escape of such cargo. These ships can be up to 40.000 tonnes DWT and may have as many as 54 cargo tanks, each with its own individual pump and pipeline. The tanks are usually from stainless steel, which gives maximum flexibility of cargo selection. The temperature and other specifications of the compartments can be according to the specific requirements of the type of liquid being transported. Typically, these tankers carry a high number of high value cargoes in small amounts. The maximum tank size is 3000 m<sup>3</sup>.

Regulations for type 2 vessels:

- The wing tank should be a minimum of 760 mm
- The double bottom should be a minimum of B/15 or 6 m (whichever is less)



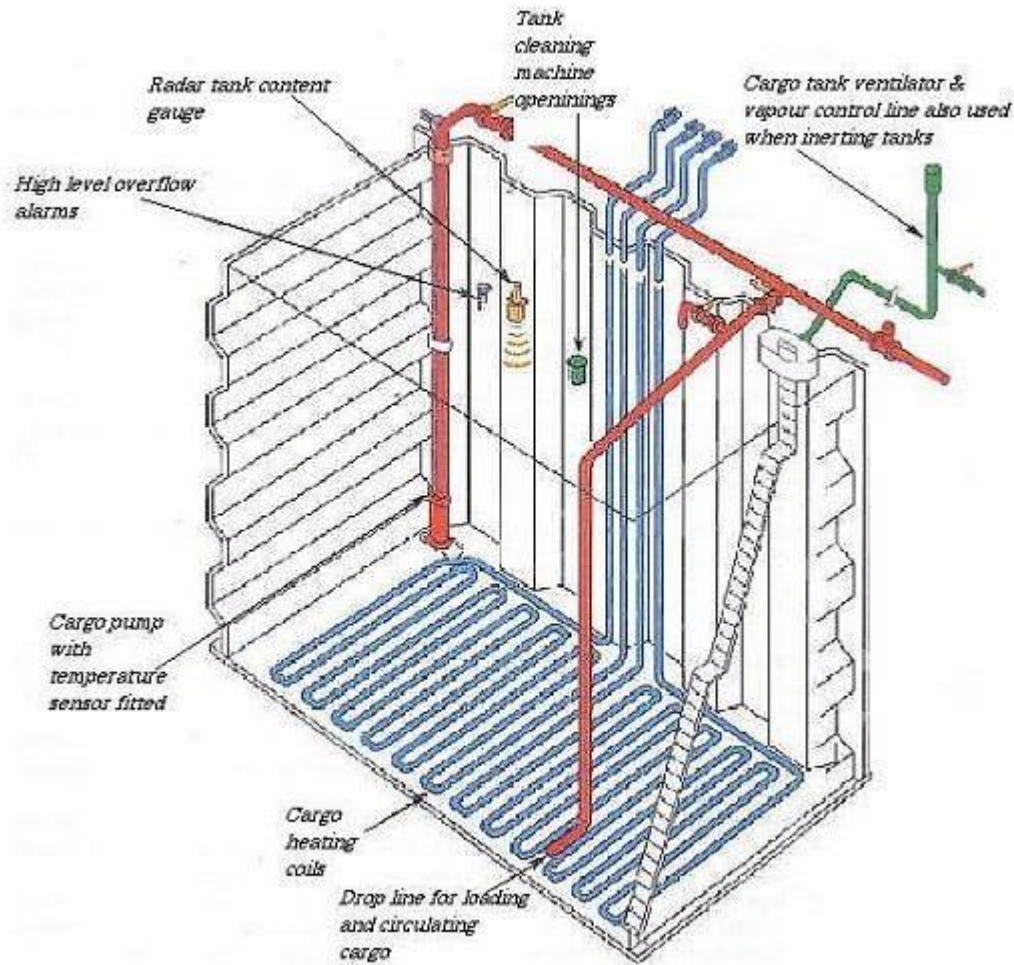


Figure 6: Tank internal structure.  
Source: [www.chemicaltankerguide.com](http://www.chemicaltankerguide.com)

Type 3 tankers are designed to carry IBC Code Chapter 17 products with sufficiently severe environmental and safety hazards which require a moderate degree of containment to increase survival capability in a damaged condition. There are no restrictions for the location of cargo tanks in a Type 3 ship.

Type 3 tankers will be of similar size to type 2, but with fewer cargo tanks. Pump and pipeline arrangements are less complex and less flexible. Tanks are most likely to be constructed from coated steel, rather than stainless steel. Double bottoms are necessary for Type 1 and Type 2 tankers, but not for Type 3.

Scantlings have to be used for a number of reasons:

- Cargoes with high specific gravity increase loading stresses
- High relief valve settings increase internal pressure
- Large tanks produce high dynamic loads when slack
- Cargoes carried at high temperatures produce high thermal stress within the structure



Because of danger of corrosion created by many of the chemicals, most tanks are either coated with a suitable lining or constructed from stainless steel. Gauging of tanks may be open, restricted or closed, depending on the nature of the chemicals being carried. Tank venting can be open or controlled depending on the cargo carried. Where controlled venting is necessary, pressure vacuum relief valves are fitted to each tank. Masts with controlled venting arrangements must be at least 10 m from air intakes, openings to accommodation spaces and should be at least 4 m above the weather deck.

### **1.3.3. Liquefied Gas Carriers**

The current fleet of liquefied gas ships is approximately 1100 (year 2013), of which about 800 are LPG carriers, about 200 LNG carriers and approx. 100 ethylene carriers. Gas carriers are divided into two main groups:

1. Liquefied Petroleum Gas (LPG) Carriers, designed to carry mainly butane, propane, butadiene, propylene, vinyl chloride monomer (VCM) and are able to carry anhydrous ammonia.
2. Liquefied Natural Gas (LNG) Carriers, which are designed to carry liquefied natural gas (a blend of gases which is 95% methane).

Based on their hazard potential, gas carriers can be classified into 3 types:

1. Type 1G, designed to carry the most hazardous cargoes
2. Type 2G and 2PG, designed to carry cargoes having a lesser degree of hazard
3. Type 3G, designed to carry cargoes of the least hazardous nature.

Most gas carriers fall into the category of 2G or 2PG carriers.

All gas cargoes are transported in liquid form (they are not carried as a gas in its vapour form) and, because of their physical and chemical properties, they are carried either at pressures greater than atmospheric, or at temperatures below ambient, or a combination of both.

Therefore, gas carriers are generally grouped as follows:

- Fully Pressurised
- Semi-pressurised and refrigerated
- Fully refrigerated

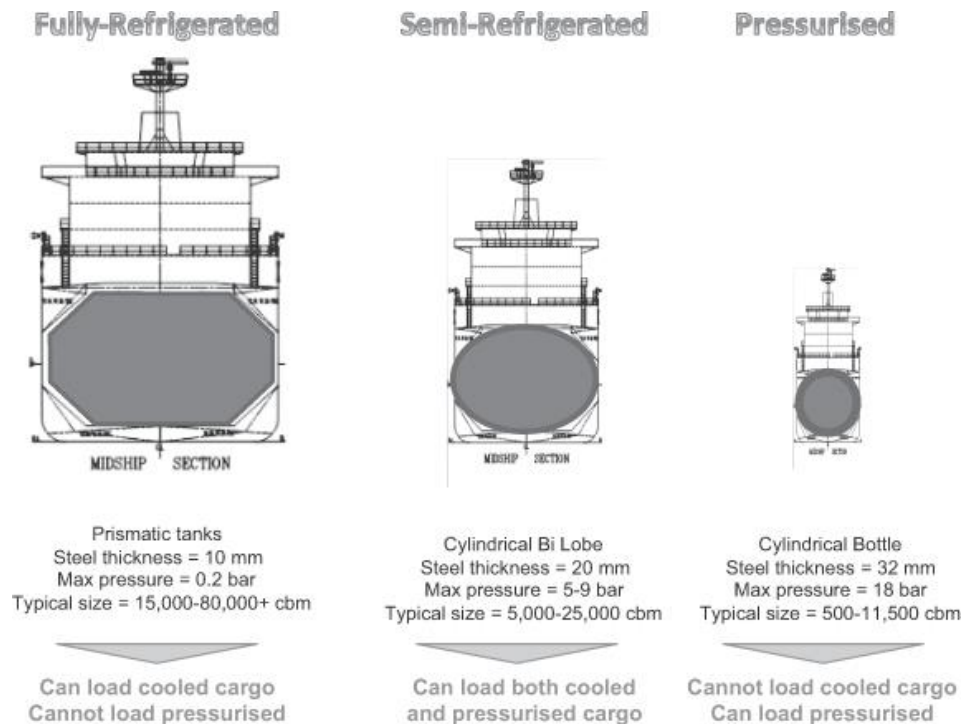


Figure 7: Classification of gas carriers.  
Source: [www.witherbyseamanship.com](http://www.witherbyseamanship.com)

### Fully pressurized ships

Fully pressurized ships were the first generation of ships to carry liquefied gases. The ships have a cargo capacity up to 10500 m<sup>3</sup>. These vessels carry the cargo in spherical or cylindrical steel tanks, designed for a working pressure of 17,5 kg/cm<sup>2</sup>. This corresponds to the vapour pressure of propane at 45 °C, which is the maximum ambient temperature in which the ship is likely to operate. No means of temperature or pressure control is necessary. The tanks are generally Type C spheres and no secondary barrier is required. A double bottom is constructed for ballast water. The hold space around the cargo tanks does not need to be inerted.

Among the advantages of this type of gas carrier we can mention the fact that they are built with ordinary grades of steel as the cargo is carried at ambient temperature and no insulation is required, no re-liquefaction plant is required and operations are simpler.

Disadvantages include:

- High design pressure requires considerable tank wall thickness, with consequent increase in displacement weight and cost
- The weight in tons of cargo carried is lower than for a refrigerated ship of similar size, due to cargo density difference

- As the diameter of the tanks increases, the wall thickness increases to withstand the same pressure. The decreasing ratio of cargo carried to weight of tank makes this solution uneconomical over long haul routes.

#### Semi-pressurized/semi-refrigerated or semi-pressurized/fully refrigerated

Vessels are fitted with a refrigeration plant that provides a fully refrigerated function while having a high design pressure for the cargo tanks, but below the pressure value required for fully pressurized carriage. The tanks are cylindrical in shape and of a thinner construction than in the case of pressurized vessels. Semi-pressurized, semi-refrigerated ships are now quite rare, and ranged up to 5000 m<sup>3</sup> in size. Their design is based on carrying propane at a pressure of 8,5 kg/cm<sup>2</sup>, and a temperature of -10 °C.

Semi-pressurized, fully-refrigerated ships generally range up to 15000 m<sup>3</sup> capacity. They can carry the full range of cargoes in cylindrical or spherical tanks and are designed for a minimum service temperature of -48 °C and a working pressure of 5 - 8 kg/cm<sup>2</sup>.

The re-liquefaction plant on these vessels generally has a substantial capacity and can, if required, load the cargo as a gas and then re-liquefy it on-board. They are able to heat or cool the cargo during loading operations, or while at sea, and are also able to raise the temperature of the cargo when discharging. A re-liquefaction plant allows a reduced wall thickness of the tanks. The inner hull volume is used more efficiently than fully pressurized vessels, and the number of tanks varies between 2 to 6. A double bottom is provided for ballast water and the hold space around the cargo tanks doesn't need to be inerted.

Advantages over fully –pressurized ships:

- More cargo can be carried in a tank of the same capacity
- A tank of the same capacity is lighter and cheaper to build
- Larger and more economical ships can be built.

#### Fully refrigerated gas carriers

The economic advantages of transporting LPG and ammonia in a fully refrigerated, non-pressurised condition are more evident for longer haul and larger quantity cargoes. The self-supporting prismatic shape of the cargo tanks allows for a better utilization of the available hold space than the type of ships described previously. The tanks are usually designed for a maximum working pressure of about 0,28 kg/cm<sup>2</sup> and a minimum working temperature of -50° C making them suitable for the carriage of butane, butadiene, VCM, ammonia, propane and propylene. The ships are typically in the range 15.000 m<sup>3</sup> – 85.000 m<sup>3</sup>, with three common sizes for LPG/Ammonia trades of 30.000 m<sup>3</sup>, 52.000 m<sup>3</sup> and 80.000 m<sup>3</sup>. The trend for longer

voyages has imposed a demand for larger ships, and with the increasing size of the ship, the pumping and refrigeration plant capacity has increased proportionally.

The tanks nearly extend to the full width of the ship, with ballast in the double bottom and upper hopper or wing tanks. These tanks normally have a centreline bulkhead fitted with two equalizing valves. Vessels develop a list alongside as the tanks carry a large free surface area and if the vessel has problems with the ballast or levelling the cargo during load they can quickly list over to 2 or 3°.

### Ethylene carriers

Ethylene carriers are a special type of gas carrier that can transport ethylene fully-refrigerated at its atmospheric pressure boiling point of -104 °C. Such vessels are often built for specific trades. Many ethylene carriers can also carry LPG cargoes, which increases their flexibility. Cargo capacity depends on the trade for which the vessel was constructed and range from 1.500 – 15.000 m<sup>3</sup>. These types of vessels are fitted with thermal insulation and a high capacity re-liquefaction plant.

Ethylene Carriers have Containment systems that can either be Type C, Type B or Type A prismatic free-standing. For reasons of economy, Type C tanks have predominated in this trade. Ballast is carried in a full double bottom and wing tank ballast system.

### LNG Carriers

LNG carriers are generally specialised ships transporting LNG at its atmospheric pressure boiling point of approximately -162 °C, depending on the cargo grade.

These ships are usually dedicated vessels, but some smaller examples may also carry basic LPG cargoes. If an LNG ship is capable of carrying basic LPG cargoes, a re-liquefaction plant is installed to handle the boil-off LPG cargo vapours.

LNG carriers are typically in the range 120-140.000 m<sup>3</sup>, with the largest ships carrying about 260.000 m<sup>3</sup>.

Current world fleet of LNG tankers consists of approx. 600 vessels.

LNG is liquefied by refrigeration to -162 °C and this process is carried out ashore, before the cargo is loaded onto the ship. LNG carriers are fully insulated because it is not cost effective to liquefy methane on-board. As the ship has no re-liquefaction plant any boil-off vapours are burned as fuel gas in the engine room. A typical LNG carrier has four to six tanks located along

the centre-line of the vessel. Surrounding the tanks is a combination of ballast tanks, cofferdams and voids; in effect, this gives the vessel a double-hull type design.

Inside each tank there are typically three submerged pumps. There are two main cargo pumps which are used in cargo discharge operations and a much smaller pump which is referred to as the spray pump. The spray pump is used for either pumping out liquid LNG to be used as fuel (via a vaporizer), or for cooling down cargo tanks. It can also be used for “stripping” out the last of the cargo in discharge operations. All of these pumps are contained within what is known as the pump tower which hangs from the top of the tank and runs the entire depth of the tank. The pump tower also contains the tank gauging system and the tank filling line, all of which are located near the bottom of the tank.

In membrane-type vessels there is also an empty pipe with a spring-loaded foot valve that can be opened by weight or pressure. This is the emergency pump tower. In case both main cargo pumps fail the top can be removed from this pipe and an emergency cargo pump lowered down to the bottom of the pipe. The top is replaced on the column and then the pump is allowed to push down on the foot valve and open it. The cargo can then be pumped out.

All cargo pumps discharge into a common pipe which runs along the deck of the vessel; it branches off to either side of the vessel to the cargo manifolds, which are used for loading or discharging.

All cargo tank vapour spaces are linked via a vapour header which runs parallel to the cargo header. This also has connections to the sides of the ship next to the loading and discharging manifolds.

A typical cargo cycle starts with the tanks in a “gas free” condition, meaning the tanks are full of air, which allows maintenance on the tank and pumps. Cargo cannot be loaded directly into the tank, as the presence of oxygen would create an explosive atmospheric condition within the tank, and the rapid temperature change caused by loading LNG at  $-162\text{ }^{\circ}\text{C}$  could damage the tanks.

First, the tank must be “inerted” to eliminate the risk of explosion. An inert gas plant burns diesel in air to produce a mixture of gases (typically less than 5%  $\text{O}_2$  and about 13%  $\text{CO}_2$  plus  $\text{N}_2$ ). This is blown into the tanks until the oxygen level is below 4%.

Next, the vessel goes into port to “gas-up” and “cool-down”, as one still cannot load directly into the tank: The  $\text{CO}_2$  will freeze and damage the pumps and the cold shock could damage the tank's pump column.

LNG is brought onto the vessel and taken along the spray line to the main vaporiser, which boils off the liquid into gas. This is then warmed up to roughly  $20\text{ }^{\circ}\text{C}$  in the gas heaters and

then blown into the tanks to displace the “inert gas”. This continues until all the CO<sub>2</sub> is removed from the tanks. Initially, the IG (inert gas) is vented to atmosphere. Once the hydrocarbon content reaches 5% (lower flammability range of methane) the inert gas is redirected to shore via a pipeline and manifold connection by the HD (high duty) compressors. The shore terminal then burns this vapour to avoid the dangers of having large amounts of hydrocarbons around which may explode.

Now the vessel is gassed up and warm. The tanks are still at ambient temperature and are full of methane. The next stage is cool-down. LNG is sprayed into the tanks via spray heads, which vaporises and starts to cool the tank. The excess gas is again blown ashore to be re-liquefied or burned at a flare stack. Once the tanks reach about -140 °C the tanks are ready to load bulk.

Bulk loading starts and liquid LNG is pumped from the storage tanks ashore into the vessel tanks. Displaced gas is blown ashore by the HD compressors. Loading continues until typically 98,50% full is reached (to allow for thermal expansion/contraction of cargo).

The vessel can now proceed to the discharge port. During passage various boil-off management strategies can be used. Boil-off gas can be burned in boilers to provide steam for propulsion, or it can be re-liquefied and returned to the cargo tanks, depending on the design of the vessel.

Once in the discharge port, the cargo is pumped ashore using the cargo pumps. As the tank empties, the vapour space is filled by either gas from ashore or by vaporising some cargo in the cargo vaporiser. Either the vessel can be pumped out as far as possible, with the last being pumped out with spray pumps, or some cargo can be retained on board as a “heel”.

It is normal practice to keep on board 5-10% of the cargo after discharge in one tank. This is referred to as the heel and this is used to cool down the remaining tanks that have no heel before loading. This must be done gradually otherwise the tanks will be cold shocked if loaded directly into warm tanks. Cool-down can take roughly 20 hours on a Moss vessel (and 10–12 hours on a membrane type vessel), so carrying a heel allows cool-down to be done before the vessel reaches port giving a significant time saving.

If all the cargo is pumped ashore, then on the ballast passage the tanks will warm up to ambient temperature, returning the vessel to a gassed up and warm state. The vessel can then be cooled again for loading.

If the vessel is to return to a gas free state, the tanks must be warmed up by using the gas heaters to circulate warm gas. Once the tanks are warmed up, the inert gas plant is used to remove the methane from the tanks. Once the tanks are methane free, the inert gas plant is

switched to dry air production, which is used to remove all the inert gas from the tanks until they have a safe working atmosphere.

Today there are four containment systems in use for new build vessels. Two of the designs are of the self-supporting type, while the other two are of the membrane type

#### *Moss tanks (spherical IMO type B LNG tanks)*

Most Moss type vessels have 4 or 5 tanks. The tank is supported around its circumference by the equatorial ring which is supported by a large circular skirt which takes the weight of the tank down to the ship's structure. This skirt allows the tank to expand and contract during cool-down and warm-up operations. During cool-down or warm-up the tank can expand or contract about 60 cm. Because of this expansion and contraction all piping into the tank comes in the top and is connected to the ship's lines via flexible bellows.

Spherical tanks are generally produced in aluminium or 9% nickel steel. The sphere is welded to a steel skirt that is connected to the hull of the ship and is then free to expand and contract as necessary. Insulation is fitted to the outside shell of the sphere but no secondary barrier is regarded as necessary across the upper part of the sphere. However, below the sphere, an aluminium drip tray, together with splash plates, provides secondary protection for the hull.

Tanks normally have a working pressure of up to 22 kPa (3,2 psi), but this can be raised for an emergency discharge.

Prismatic IMO type B LNG tanks are currently employed in only a couple of vessels. Type B tanks limit sloshing problems, an improvement over Membrane LNG carrier tanks which may break due to sloshing impact, therefore destroying the ship's hull. In addition, IMO type B LNG tanks can sustain internal accidental damage due for example to internal equipment releases. This was incorporated into the design following several incidents that occurred inside membrane LNG tanks.



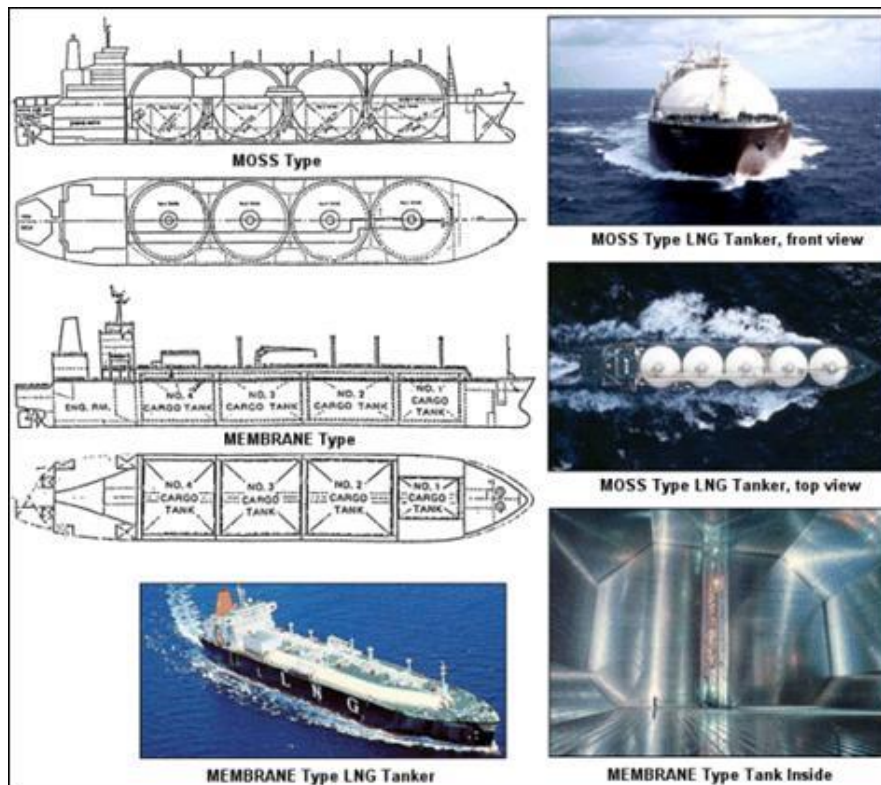


Figure 8: LNG gas carrier types.  
Source: <http://www.epd.gov.hk/eia>

### Membrane Type “Technigaz”

Designed by Technigaz, these tanks are of the membrane type, which consists of stainless steel with “waffles” to absorb the thermal contraction when the tank is cooled down. The primary barrier, made of corrugated stainless steel of about 1,2 mm thickness is the one in direct contact with the cargo liquid (or vapour in empty tank condition). This is followed by a primary insulation which in turn is covered by a secondary barrier made of a material called “triplex” which is basically a metal foil sandwiched between glass wool sheets and compressed together. This is again covered by a secondary insulation which in turn is supported by the ship's hull structure from the outside.

From the inside of the tank outwards, the layers are:

- LNG
- Primary barrier of 1,2 mm thick corrugated/waffled 304L stainless steel
- Primary insulation (also called the inter-barrier space)
- Secondary barrier within triplex membrane
- Secondary insulation (also called the insulation space)
- Ship's hull structure.



### Membrane Type “Gaz Transport”

Designed by Gaz Transport, the tanks consists of a primary and secondary thin membrane made of the material Invar (36% nickel-iron low expansion alloy, which has almost no thermal contraction). One acts as the primary barrier and the other the secondary barrier and they are separated by plywood boxes of perlite insulation. The integrity of both membranes is permanently monitored by detection of hydrocarbon in the nitrogen. An evolution is proposed with the replacement of nitrogen by argon as the flushed inert and insulation gas. Argon has a better insulation power than nitrogen, which could save 10% of boil-off gas.

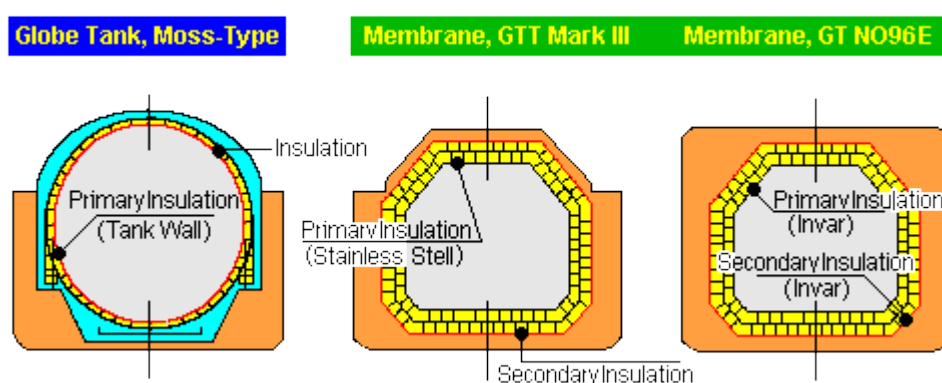


Figure 9: Tank cross section. Left: Moss Tanks, Centre: Membrane, type Gaz Transport, Right: membrane, type Technigaz.

Source: [www.inocrete.co.jp](http://www.inocrete.co.jp)

### 1.3.4. Other types of ships that can carry liquid in bulk: Ore/Bulk/Oil Carriers and Ore/Oil Carriers

Ore/Bulk/Oil Carriers are designed to carry either oil or a variety of dry bulk cargoes. The ship has a double bottom hull, and the holds are used to carry the cargo transported. In some vessels, the upper hopper tanks are also used for cargo. When carrying liquid cargoes it is important to ensure not to allow too many holds to be filled partially filled at any one time, because the slack surface of the liquid can cause the vessel to become unstable. The Ore/Bulk/Oil ships are capable of carrying their full deadweight when transporting heavy ore concentrates. This type of ship is also designed to carry other types of dry bulk cargoes, such as grain and coal, but in such cases she will not reach the full deadweight, even if the total cubic capacity is in use.

Holds usually extend along the full breadth of the ship, with upper and lower hopper tanks and double bottom tanks. In some cases holds have wing tanks.

Oil or dry bulk cargo is carried in the holds. Wing tanks for the carriage of oily slops are fitted aft of the cargo holds. These are known as slop tanks. Ballast may be carried in top and bottom hopper tanks and in the double bottom tanks. Conventional bulk carrier hatches, which are normally of the side rolling type, have a special sealing arrangement.

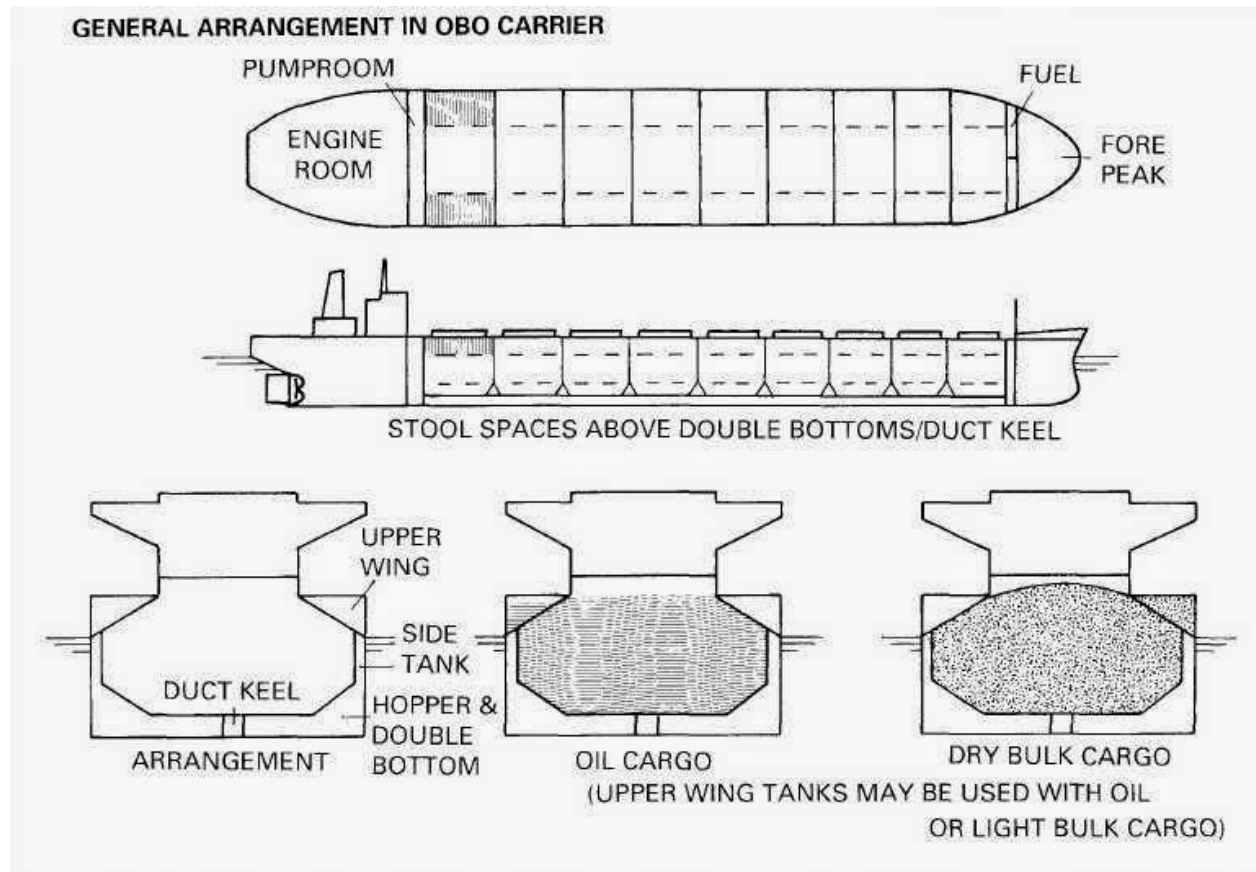


Figure 10: General structure of an OBO carrier.  
Source: Google Images

Ore/Oil Carriers are designed to carry either a cargo of heavy ore in the holds or a cargo of oil, which may be carried in the side tanks as well as in all of the holds. The holds are designed to permit the ship to be loaded to the full load deadweight with a comfortable GM value and no excess of sheer force or bending moment stresses. Tank stiffening is located within the wing tanks, which allows for easier cleaning of the centre holds. Ore/oil ships are designed to carry their full deadweight when trading as a tanker or carrying heavy ore concentrates. They are not designed to carry light bulk cargoes such as grain. Holds extend along approximately one half of the total breadth of the ship. Hatches are generally one piece side rolling with a similar arrangement to Ore/Bulk/Ore ships.

## CHAPTER 2: BARCELONA PORT STATISTICAL DATA. MAIN TYPES OF LIQUID BULK CARGO HANDLED

### 2.1. Statistical data

In terms of total tonnage of cargo handled, Barcelona is the 3<sup>rd</sup> port in the country, behind Algeciras and Valencia.

<b>Number of ships</b>	
National traffic	
Number of vessels	2.522
gross tonnage	60.223.238
International traffic	
Number of vessels	6.206
gross tonnage	250.115.561
<b>Commercial traffic (tons)</b>	<b>47.512.963</b>
Export	23.364.458
Solid bulk	2.224.693
Liquid bulk	790.128
Liquid bulk – hydrocarbons (including natural gas, gasoline, fuel-oil, gasoil, naphtha, kerosene, asphalt)	1.833.526
General cargo	18.516.111
Import	24.148.505
Solid bulk	2.206.105
Liquid bulk	1.585.206
Liquid bulk – hydrocarbons (including natural gas, gasoline, fuel-oil, gasoil, naphtha, kerosene, asphalt)	7.192.853
General cargo	13.164.341
<b>Containers</b>	
TEUs	2.236.960
Tons	20.935.060
<b>Passengers</b>	<b>3.958.960</b>
Inbound	1.416.916
Outbound	1.414.269
Exterior traffic	1.127.775
<b>Automobiles (units)</b>	<b>916.834</b>
Import	233.53
Export	576.481
Traffic	106.823

Table 1: Barcelona port - Traffic statistics year 2016.

Source: [www.idescat.cat](http://www.idescat.cat)

Liquid bulk (tons)	Import	Export	Transit	TOTAL
Crude Oil	-	-	-	-
Fuel Oil	743885	43076	532477	1319438
Gas Oil	1413426	15172	964142	2392740
Gasoline	1045791	17075	1782091	2844957
Other petroleum products	229738	31586	82924	344248
LPG	18677	26614	1012	46303
Natural Gas	2397676	132608	50108	2580392
Biofuels	91819	161753	739676	993248
Chemicals	1785982	2290968	603020	4679970
Oils and fats	489409	368393	87949	945751

Table 2: Total Liquid cargo handled - 2015.  
Source: Puertos del Estado

By looking at the stats over the previous years, the highest percentage of the total liquid bulk handled represents imports and transit. The port of Barcelona is an importer of Fuel Oil, Gas Oil, Gasoline and Natural gas, with large volumes of transit cargo handled, and is an exporter of Biofuels. Barcelona port ranks first in the country in total volumes of Natural Gas and Biofuels handled.

The Port of Barcelona doesn't have any facility for the reception, storage and treatment of crude oil, which is discharged in the nearby port of Tarragona.

## 2.2. Liquid bulk

### 2.2.1. Hydrocarbons

Crude oil is found in large underground deposits in various places worldwide. The chemical analysis shows that it consist almost exclusively of hydrocarbons, organic compounds formed from 2 elements: carbon and hydrogen. After releasing the gaseous elements at atmospheric pressure, crude oil is a liquid with a density of 0,78-0,95 at 15 °C. Besides hydrogen and carbon, crude oil contains small amounts of sulphur (0,1-7%), nitrogen (0,01-0,9%), oxygen (0,06-0,4%) vanadium (up to 1200 ppm) and nickel (up to 200 ppm). Crude oils with a high content of sulphuric acid liberate a foul odour and are also known as sour crude oils, while crude oils with a low content of sulphuric acid lack this bad smell and are also called sweet crude oils.

Crude oil is fractionally distilled in refineries. Because it is composed of more than 1000 hydrocarbons, the process does not aim at separating each one, but obtaining fractions of composition and similar properties, distilling between two predetermined temperatures.

Crude is desalinated, heated to 350 °C and sent to the fractionating column (distillation tower) where different boiling temperature ranges are applied in order to obtain the different distillation products. The distillation column runs continuously, therefore as crude oil enters the column, the various fractionating products are extracted at different heights of the column, establishing a dynamic equilibrium between the crude that enters and the refined extracted. The temperature inside the distillation tower varies progressively, from 350 °C at the bottom to 100 °C at the top.

The boiling intervals depend on the type of crude oil and other technical aspects. A typical division could be the following:

Boiling interval, °C	Product
Less than 0	Propane / butane
0 – 70	Light gasoline
70 – 140	Petroleum ether
140 – 180	Naphtha
180 – 250	Kerosene
250 – 350	Gasoil
> 350	Residues

Table 3: Petroleum distillation products

There are many types of gasolines, divided into two large groups: automotive gasolines and aviation gasolines. Leaded gasoline is toxic and highly pollutant to other products. In many countries these are already prohibited. Petroleum ether is an intermediate distillate between gasoline and naphtha, with a boiling interval of 70-140 °C. White spirit is an intermediate distillate between gasoline and kerosene, with a boiling point of 150-200 °C. Aromatic liquids extremely volatile and contain benzene, which is highly dangerous. Naphtas are explosive, pollutants and dangerous. Kerosenes are hydrocarbons with a distillation interval between 180 – 250 °C.

Gasoil is a dense, oily liquid, that has a distillation interval of 250-350 °C and a density of 0,85 – 0,9. The remaining residue, that cannot be distilled, is extracted from the base of the fractionating tower. It is called fuel oil and has a density of 0,9-1. It is black and viscous and thanks to its excellent caloric properties it's used in thermo electrical power plants, boilers and large marine motors. When loading fuel oil, the cargo temperature during transport is clearly

specified in the shipping agreement. Intermediate Fuel Oil (IFO) is a combustible liquid obtained from Fuel Oil and gasoil. IFO 180 is used in marine engines. If the fuel oil undergoes a second fractioned distillation (in vacuum), carried out at a very low pressure, new fractions will be separated. These are the lubricating oils and are transported in jerry cans or in bulk. Other products extracted during distillation are vaseline, paraffin, aromatic extracts and asphalts.

Contamination may occur by way of the remains of a previous cargo or by tank cleaning substances, as a result of improperly cleaned tank and/or pipelines. Damage may also occur through chemical changes in the product itself, brought about by contact with coatings on tank walls and pipelines, or by contamination by moisture or sea water.

### **2.2.2. Acids**

Acids are mostly categorized as Dangerous Goods and their transport is carried out in accordance to the IMDG (International Maritime Dangerous Goods) Code.

Phosphoric acid is a colourless, odourless, sparkling liquid or transparent, crystalline solid, depending on concentration and temperature. Phosphoric acid has a wide variety of uses: reactant to obtain fertilizers, in the food industry, detergents, pharmaceuticals, as a rust inhibitor, for home cleaning products etc. For handling phosphoric acid, stainless steel type 316L and 317L has been proved to be the most effective tank material. However, phosphoric acid can attack and damage inner tank surface under the form of general wastage or elephant skin.

Sulphuric acid is a highly corrosive strong mineral acid, colourless to slightly yellow viscous liquid which is soluble in water at all concentrations. It has various uses in the chemical industry, such as: manufacture of fertilizers, explosives, plastics, purification of petroleum, in storage batteries etc. Sulphuric acid is carried in various concentrations, most common being 93,2%. In this concentration it has the aspect of a syrupy oily liquid sometimes called oil of vitriol. Another concentration frequently used for transport is 78%. Diluted acids with less than 77% concentration react with and corrode most of the common metals. Concentrations of less than 50% must be carried in rubber-coated tanks. When shipped is difficult and dangerous cargo to handle after a long voyage because of the possibility of corrosion and expansion.

### **2.2.3. Oils and fats**

For edible oils, the only problem is ensuring the absolute cleanliness of the cargo tanks where the product is going to be loaded. There mustn't remain any trace of previous cargoes,



therefore the surveyors are very thorough when checking this aspect. The FOSFA lists of substances that are acceptable as previous cargoes in tanks which are to be used for the carriage of edible oils and of others which are unacceptable are very relevant in preventing contamination by previous cargoes.

Oils and fats spoil by readily becoming rancid. Rancidity is promoted by light, atmospheric oxygen and moisture and leads to changes in odour and taste. Thus, the tanks must be filled as full as possible, taking into consideration the coefficient of cubic expansion, so that as little ullage space as possible is left above the cargo. Loading, travel and pumping temperatures must be precisely complied with, since any change in consistency which occurs during transport may prove irreversible. If the oil solidifies in the tanks, it cannot be liquefied again even by forced heating. In the vicinity of the heating coils, the oil melts, scorches, discolours and becomes rancid.

Pumping out may be difficult in cold weather. The oil may cool too rapidly in the long lines and solid deposits form on the outer walls, which cannot be pumped out and prevent the still liquid cargo from reaching the suction valve. This problem can be solved by appropriate heating or insulation of the lines.

Product – Oil or Fat	In Transit		Handling	
	Min. °C	Max. °C	Min. °C	Max. °C
Castor Oil	20	25	30	35
Coconut Oil	27	32	40	45
Coconut Fatty Acids	40	45	45	48
Cottonseed Oil	Ambient	Ambient	20	25
Distilled Fatty Acids	40	45	45	48
Fish Oil	20	25	30	35
Grease	38	41	50	55
Groundnut Oil	Ambient	Ambient	20	25
Illipe	38	41	50	55
Lard	38	41	51	54
Linseed Oil	Ambient	Ambient	15	20
Maize Oil	Ambient	Ambient	15	20
Oiticia Oil	24	32	35	38
Oleo Margarine (Argentine)	45	50	50	55
Oleo Stearine	40	45	60	65
Oleo Stearine (Argentine)	55	60	60	65
Olive Oil	Ambient	Ambient	15	20
Palm Acid Oil	42	50	67	72
Palm Fatty Acid Distillate	42	50	67	72
Palm Kernel Oil (Crude)	27	32	40	45
Palm Oil	32	40	50	55
Palm Oleine	25	30	32	33
Palm Stearine	40	45	60	65
Rapeseed Oil	Ambient	Ambient	15	20
Safflower Oil	Ambient	Ambient	15	20
Sesame Oil	Ambient	Ambient	15	20
Sheanut Butter	38	41	50	55
Soy Acid Oil (Fatty)	35	40	45	50
Soyabean Oil	Ambient	Ambient	20	25
Sunflowerseed Oil	Ambient	Ambient	15	20
Sun/Soya Acid Oil (Fatty)	32	35	49	55
Tallow	44	49	55	60
Teaseed Oil	Ambient	Ambient	Ambient	20
Tung Oil	20	25	20	25

Table 4: Handling and transport conditions for edible oils and fats.  
Source: [www.cargohandbook.com](http://www.cargohandbook.com)

Edible oils will suffer quality (essentially flavour) deterioration because of chemical changes within them. They may also be contaminated with substances which promote quality deterioration or other adverse chemical changes. To avoid contact with air, tanks must be designed to drain completely so that no pockets of oil remain standing, waiting to be oxidized. For the same reason valves must have no pockets in which oil may lodge and pipelines should drain to a low point fitted with a drain valve and be designed for “pigging”. Incompletely filled ship’s tanks with the inevitable slopping will promote oxidative rancidity but the addition of antioxidants, as provided for in edible oil standards, and a blanket of inert gas, such as nitrogen, reduces the risk. Tank coatings are usually polymeric plastic coatings, mainly polyurethane or epoxy resins. With mild steel tanks there is the danger of mechanical contamination by rust flakes or powder, or the formation of iron salts by interaction with fatty acids in acid oils. The dangers of metal contaminations can be eliminated by using stainless steel.

The trend is to guarantee total segregation of edible oil cargoes and dedicated pumps and pipelines. Where common pumps and pipelines are still used, contamination is reduced by respecting the following discharge sequence: edible oils, fully refined, partly refined, crude; technical grade oils; acid oils; fatty acids; other liquid cargoes.

In case of fish oil, as it often happens with crude palm oil, pumping the entire product out of the cargo tanks can be quite difficult, crew having to enter the tanks and push out the last part of the cargo towards the aspiration pumps using shovels. The atmosphere inside the tank is neither toxic nor suffocating, but it can be very irritating especially for the eyes, therefore using adequate protection equipment is essential.

Sugar cane molasses are another type of product that requires heating in order to be discharged. The shipper almost never uses the real density of the product, using instead an approximated value of it. The calculation of the total quantity is made using the vessel’s drafts. When loading molasses in some tanks while leaving other tanks empty, the bottoms will most probably deform inwards in the empty tanks and outwards, in the full ones. There were cases in which a tanker loaded with molasses broke halfway into two due to an incorrect distribution of the cargo.

#### **2.2.4. Caustic soda and fertilizers**

When loading caustic soda or liquid fertilizers, great care must be taken regarding the inherent risks of these products. Most are highly corrosive and can be toxic.



Caustic soda has uses in many industries, mostly as a strong chemical base in the manufacture of pulp and paper, textiles, drinking water, soaps, detergents, drain cleaner and in the refining of vegetable oils. Caustic soda is transported in bulk as a 50% or 70% solution, a colourless or grey syrupy liquid with a slight characteristic odour. Stainless steel tanks are necessary for handling caustic soda up to 50% maximum concentration at 65-75 °C. At higher concentrations the solution needs a temperature of 100-110 °C to maintain the liquid state and stainless steel has inadequate corrosion resistance, so pure nickel is required.

### **2.2.5. Chemicals**

Due to their properties and inherent risks, many chemicals are classified Dangerous Goods and their transport is carried out in accordance to the IMDG (International Maritime Dangerous Goods) Code.

Some of the chemicals discharged/loaded from the Inflammables Wharf in Barcelona are:

- Styrene monomer: colourless oily liquid that is the precursor of polystyrene
- Monoethylene (MEG) and Diethylene glycol (DEG): colourless syrupy sweet tasting liquids, used as automotive antifreeze and as precursors to polymers
- Methyl tertiary butyl ether (MTBE): flammable colourless liquid used as a fuel component in fuel for gasoline engines
- Dichloromethane (DCM or methylene chloride): colourless volatile liquid used as a solvent
- Methyl ethyl ketone (MEK): colourless liquid with sharp sweet odour used in the manufacturing process for plastics, textiles, paraffin wax and in household products as a solvent etc.
- Ethanol: clear colourless liquid used for alcoholic beverages, cosmetics, in the pharmaceutical industry, as a solvent and for the synthesis of other products
- Dichloroethane (EDC): colourless liquid with strong odour, used as intermediate for other organic compounds and as a solvent
- Diisonylphthalate (DINP) and diisodecyl phthalate (DIDP): used as plasticizers, to make soft and flexible PVC
- Methanol: light, volatile, colourless, flammable toxic liquid used as antifreeze, solvent, fuel or as a denaturant for ethanol; also used for producing biodiesel
- Propylene glycol: odourless and tasteless synthetic liquid used in the chemical, food and pharmaceutical industries.

### **2.2.6. Biofuels**

Biodiesel is a diesel fuel based on a vegetable oil or animal fat. Biodiesel is typically made by chemically reacting lipids (vegetable oil, soybean oil, tallow etc.) with an alcohol, producing fatty acid esters. The most common form uses methanol to produce methyl esters (commonly referred to as Fatty Acid Methyl Esters).

As biodiesel has the tendency to gel (freeze) at higher temperatures than petro-diesel, temperature during cargo handling and transport is an important factor. The gel point of the biodiesel depends on the oil or fat it was originally made from. Heat, sunlight and oxygen can cause biodiesel to degrade more rapidly. Biodiesel can also degrade due to contact with water. During storage and transportation, moisture from the air or water present in the tanks and pipes can contaminate the fuel.

It's important that the tanks are clean and without traces of water. The tank may need heating, depending on the weather.

## **CHAPTER 3: THE INFLAMMABLES WHARF AND ITS CHARACTERISTICS**

### **3.1. Characteristics of the Inflammables Wharf**

The Inflammables Wharf (Muelle de la Energia) is the special area of the Port of Barcelona dedicated to the storage, receipt, treatment and distribution of liquid bulk products with a total storage capacity of over 3.500.000 m<sup>3</sup>. It covers a rectangular area of approx. 1,20 km<sup>2</sup>, surrounded from three parts by water.



*Figure 11: Location of the Inflammables Wharf inside the Port of Barcelona.  
Source: [www.portdebarcelona.cat](http://www.portdebarcelona.cat)*

Inside the Inflammables Wharf there are various terminals dedicated to different types of liquid bulks. There are liquid bulk terminals located outside of the Inflammables Wharf: Cargill, Bunge, and CLH.

Currently, inside the Inflammables Wharf there are 8 jetties dedicated to oil/chemical tanker vessel operations (32A-32G and 34B), one for bunker and residues barges (32H) and two for gas tankers (33A-33C).

Tankers can also operate from Alvarez de la Campa Wharf, jetties 24A, 26A and 26B (CLH Terminal and Cargill Terminal) or Oest Wharf 23A (Bunge Terminal).



Figure 12: Inflammables Wharf general layout and jetties.  
Source: Google Maps

#### Technical characteristics of jetties 32A-32G

Jetty	32A	32B	32C	32D	32E	32F	32G
Max. LOA (m)	200	185	185	185	185	185	185
Max. draft (m)	11,55	11,55	11,45	11,70	11,70	11,70	11,70
Maximum displacement	55.000	55.000	55.000	55.000	55.000	55.000	55.000
Discharge/loading	Hard arms 10"	Flexible hoses 6"	Flexible hoses 4-6"	Flexible hoses 4-6"	Flexible hoses 4-6" Hard arms 10"	Flexible hoses 6" Hard arms 10"	Flexible hoses 6" Hard arms 10"
Terminals that operate it	Decal Koalagas Tepsa	Meroil Terquimsa	Decal Relisa Tepsa Terquimsa	Decal Meroil Tepsa	Relisa Tepsa Tradebe	Meroil Relisa	Relisa Tradebe
Distances between jetties (m)	154,1	155,70	159,44	169,60	169,58	114,40	

Table 5: Jetty characteristics in the Inflammables Wharf

## Technical characteristics of jetty 34B

Max. LOA of vessel (m)	275
Max. draft (m)	15,90
Maximum displacement (tons)	175.000
Maximum DWT	150.000
Discharge/loading equipment	Hard arms of 6", 8", 10", 12"
Terminals that operate at jetty	Decal, Meroil, Tepsa, Terquimsa

Table 6: Characteristics of Inflammables Wharf jetty 34B

The layout of the Inflammables Wharf is in such a way that due to operational and safety reasons the terminals are situated at a certain distance from the jetties, being connected to the jetties and between each other by a complex system of pipelines. Because of working with products that can be transported without great difficulty by means of pipes, it is common that between the point of unloading or loading and the storage tanks there are considerable distances, of several hundred meters or even more.



Figure 13: Pipeline system inside the Inflammables Wharf.  
Source: [www.portdebarcelona.cat](http://www.portdebarcelona.cat)

Carbon steel pipes are usually used for shore pipelines and, for certain products, stainless steel can be employed, with very variable diameters depending on the volumes to be sent and the desired. Generally, the pipes' diameter tends to be between 20 and 30 cm.

There are three types of pipe in common use in this industry: seamless, seam welded and spiral welded. There are three types of pipe fitting in general use:

- Screwed fittings, which are generally for small diameter pipes,
- Screwed flanged, used for larger diameter pipes
- Welded flange, either slip-on or welded neck flange.

Dimensions and materials of pipes, flanges and fittings are usually standardized for various classes of service. For hydrocarbon products, only carbon steel or alloy steel pipes, flanges or fittings are used, with the steel type dependent on the temperature and pressure the



material has to withstand. It is essential to clearly identify all product and utility lines. This is normally done by colour coding, either by painting or by using adhesive tapes with the name of the product or substance printed on it.

The pumpability of oils that have a high viscosity or pour point is generally improved by heating them to a temperature of 60 °C. To maintain this temperature during transport, these lines are insulated. For pipes carrying products below 0 °C, such as LPG (-50 °C) or LNG (-162 °C) it is necessary to prevent diffusion of water vapour through the insulation, or ice will form in the air spaces of the insulation, gradually reducing its efficiency. A variety of insulating materials can be applied around hot pipes, such as resin bonded rock wool, magnesia, cork, fibre glass, asbestos film, calcium silicate etc.

Expansion and contraction of pipelines because of temperature extremes is usually absorbed through the use of expansion loops, or through bellows. With hazardous materials, fixed pipes with expansion loops are preferred.

The most common types of valves found on the pipelines from jetty to plant are ball valves, gate valves, globe valves and non-return valves.

The grounding system for static currents in the plant and pipes is very similar to those deployed in other types of installations.

## 2.2. Description of the terminals situated inside the Inflammables Wharf

### Decal

Decal terminal is part of the Decal Spa Group, an Italian group that operates terminals in the Mediterranean (various terminals in Italy and Spain), Brazil, Panama and Russia. The Barcelona terminal provides services of storage and handling, product blending, quality and additivation of oil products and blending with biofuels.



Figure 14: Decal Terminal.

Source: <https://www.decalstorage.com/terminals/spain/barcelona.html>

Occupying a total surface of 12,86 ha, it has a total storage capacity of 445.000 m<sup>3</sup> distributed over 25 tanks with capacities between 1000 to 35.000 m<sup>3</sup>.

The products manipulated by Decal Terminal are: automotive gas oil, agricultural and heating gas oil, fuel oil, cutter stocks, gasoline, components for gasoline blending and biofuels.

Decal uses 3 jetties for vessel discharge/loading: 32A, 32D and 34B, equipped with discharge/loading arms (capacity of 1500 mT/hour) or hoses.

The truck loading/discharge capacities include 8 single bays plus 2 double bays, capable of handling up to 500 trucks/day.

Apart from the reception and storage of liquid bulk products, it offers various services such as: nitrogen blanketing, in-line additivation during ship discharge or truck loading, blending in tank and automatic in-line blending for bunker products and biofuels, bunkering, biodiesel in-line blending, bio-ethanol in-line blending with gasoline and connection with CLH Terminal and other terminals.

### Koalagas

Situated next to Decal terminal, it offers storage and handling services for LPG.

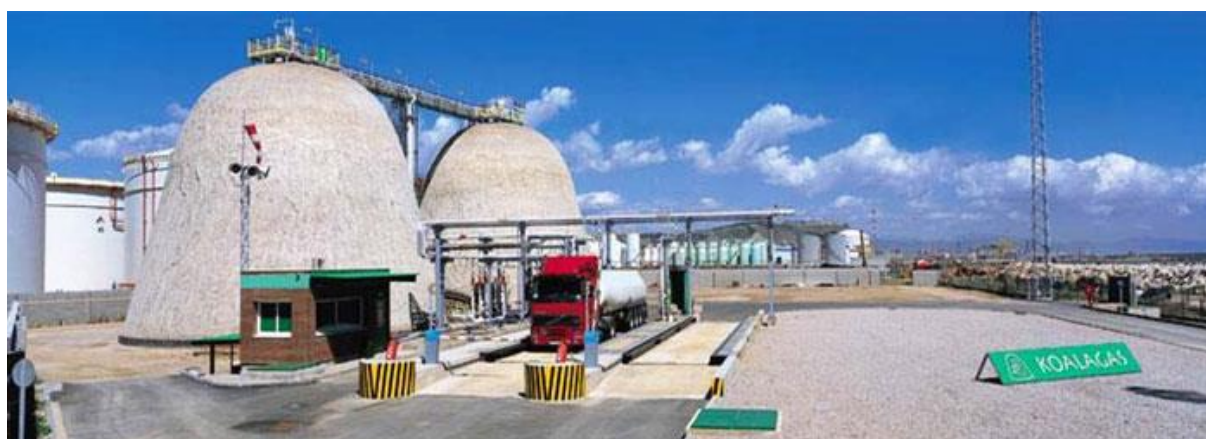


Figure 15: Koalagas Terminal.

Source: <https://www.decalstorage.com/terminals/spain/koalagas.html>

Koalagas terminal uses an innovative technology for the storage of propane and butane. The 2 LPG spheres are coated with TEXSOL and the wall structure (plastic thread and sand) makes the tanks more resistant to fire and explosion than conventional LPG tanks.

It uses one jetty 32A for vessel discharge.

Occupying a surface of 1,75 ha, it has a total storage capacity of 4000 m<sup>3</sup>, being capable of handling up to 20 trucks a day.

Apart from vessel and truck operations, Koalagas terminal offers following services: storage, segregation, odour additivation in-line during ship discharge, propane and butane in-line mixing etc.

### Terquimsa

Terminales Quimicos SA is a terminal founded in 1970, joint venture of CLH and Vopak Group that operates another terminal in Tarragona besides various liquid bulk terminals all over the world.

Terquimsa offers various services such as storage, mixing, heating, inertization, automatic level control and transhipment of liquid in bulk. The terminal operates mainly with petroleum and chemical products, but can also handle vegetable oils and lubricants.



Figure 16: Terquimsa Terminal.  
Source: <http://www.vopakterquimsa.com>

It contains 49 tanks (43 of carbon steel and 6 of stainless steel) with capacities of 180-20000 m<sup>3</sup>, for a total storage capacity of over 210000 m<sup>3</sup>.

It has access to 4 jetties: 32A, 32B, 32C and 34B, with capacities for vessel discharge/loading through cargo arms or hoses.



### TEPSA

Terminales Petrolíferas SA is a Spanish Group with more than 50 years' experience that has various terminals throughout the country. The TEPESA terminal in Barcelona handles petroleum products, chemicals and biofuels, having a total storage capacity of 353.400 m<sup>3</sup> distributed over 244 shore tanks with capacities between 50 and 18.000 m<sup>3</sup>.

Besides vessel and truck loading/discharge and product storage, Tepsa Terminal offers various services: train access for tank cart loading/discharge, bottled products storage, in-line dilution of phosphoric acid, in-line denaturalization of alcohol etc.

Tepsa operates vessels using loading/discharge arms or hoses from 5 jetties: 32A, 32C, 32D, 32E and 34B, being capable of working with vessels up to 275 m long.



Figure 17: Tepsa Terminal Barcelona.  
Source: [www.portdebarcelona.cat](http://www.portdebarcelona.cat)

### RELISA

RELISA (Receptora de Liquidos SA) is a terminal with over 50 years' experience in reception, handling and subsequent forwarding of bulk liquids, specialized in vegetable oils, fats, latex and molasses, although it also handles biofuels and glycerine.



Figure 18: Relisa Terminal.  
Source: [www.portdebarcelona.cat](http://www.portdebarcelona.cat)

Among the services offered by Relisa we can highlight: reception and delivery of products by ship, truck, train or pipeline, storage in tanks with steam coils and insulation, forwarding products by ship, truck, train or pipeline, loading drums and blanketing with nitrogen. Several storage tanks are equipped with ultrasound monitoring systems that allow its customers to monitor their stocks in real time.

The terminal covers a surface of 27400 m<sup>2</sup> and has a total of 127 tanks lined with epoxy paint or stainless steel, with capacities between 100 and 7500 m<sup>3</sup> each, summing up to a total of more than 200000 m<sup>3</sup> of storage space.

Relisa operates vessels as big as 185 meters in length from 4 jetties: 32C, 32E, 32F and 32G by hose connection, with discharge/load rates between 300-700 m<sup>3</sup>/hour. The truck loading facilities consists in more than 20 bays for loading/unloading. The terminal also has rail connection for simultaneous loading/discharge of up to 20 train tank cars, and can load flexi tanks, container drums etc.

### Tradebe

The hydrocarbon storage facilities of Tradebe terminal (Tradebe Port Services) were created in 2013. Before that year, Ecoimsa Tradebe established itself as the only entity dedicated to reception and treatment of oily residues in the Port of Barcelona. Currently, Tradebe counts on a total storage capacity of 453.000 m<sup>3</sup> distributed over 29 tanks in two inter-connected sites, occupying a total surface of over 60.000 m<sup>2</sup>. One of the sites is adapted for the storage of lighter hydrocarbons such as kerosene and gasoline, while the other is for fuel oil and diesel. The shore tanks have capacities between 5000 to 24.000 m<sup>3</sup>, and can handle other products apart from the one mentioned before, such as biofuels and alcohols (MTBE, ethanol). It offers services such as blending, heating, in-tank and in-line additivation, bubbling and blanketing and has pipeline connections to other terminals from the Port of Barcelona.



*Figure 19: Tradebe Terminal.  
Source: [www.suris.es](http://www.suris.es)*

The terminal works with vessels from 3 jetties: 32E, 32G and 34B. It also shares pipeline systems with the CLH company and is equipped with 5 truck-loading bays.

Apart from liquid bulk storage and handling, Tradebe also offers treatment and management services for port and industrial waste, which are reused as a power source and in other applications. Ecoimsa Tradebe collects oily residues from all types of ships that call the Port of Barcelona, by barge or by truck, and subsequently uses these residues for obtaining thermal and electrical power.

The residues capacities are:

- For Marpol Annex I substances: 80000 mT/year
- For Marpol Annex IV substances: 30000 mT/year
- For Marpol Annex VI: 50000 mT/year
- Slops: 50000 mT/year

### Enagas

Located in the Muelle de la Energia, the Enagas terminal is the oldest regasification plant in Spain and in continental Europe, commissioned in 1969.



Figure 20: Enagas regasification plant.  
Source: <http://www.lngworldnews.com>

Gas is transported in LNG tankers at minus 162 °C in liquid form and is discharged at the regasification plant. LNG is stored in total containment tanks designed for cryogenic conditions, at minus 162 °C and slightly above atmospheric pressure.

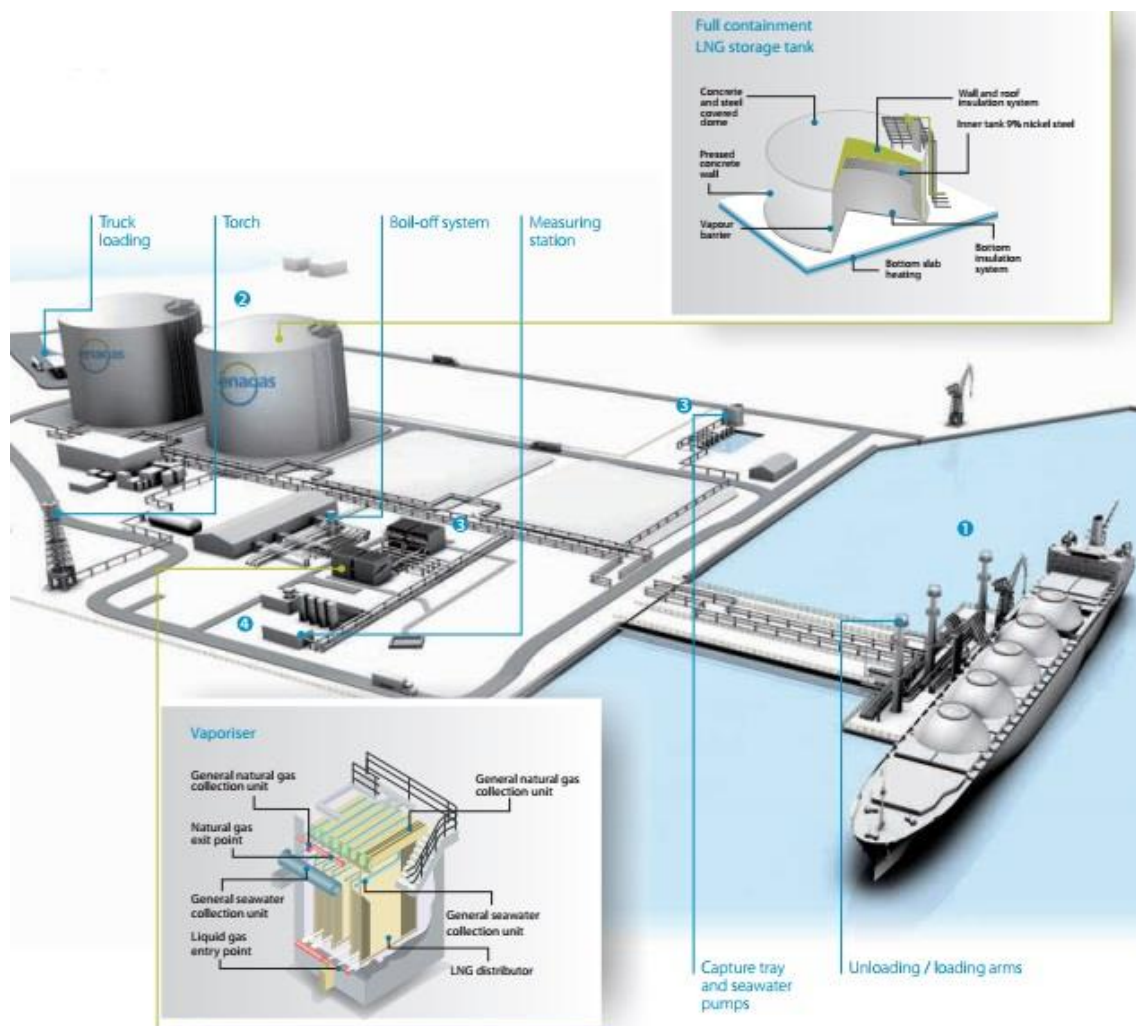


Figure 21: How a LNG terminal works.  
Source: [www.enagas.es](http://www.enagas.es)



The temperature of liquid natural gas is raised above 0 °C through a physical process using saltwater vaporisers, transforming it into gas. The natural gas is metered and odorized so that it can be detected in the event of leaks. It is then injected into the gas pipelines in order to be transported through the network.

Enagas regasification plant currently has 6 tanks with a total LNG storage capacity of 760.000 m<sup>3</sup> and an emission capacity of 1950 m<sup>3</sup>/h (545 GWh/day).

It operates from two jetties that have a maximum capacity of 80.000 m<sup>3</sup> and 266.000 m<sup>3</sup> respectively, and can provide LNG discharge rates ranging from 3000 m<sup>3</sup>/hour for a small vessel and up to 12000 m<sup>3</sup>/hour for larger vessels. The maximum loading rate that can be obtained is 4000 m<sup>3</sup>/hour. The pressure range varies from min. 30 bar to max. 72 bar.

Gas tankers with following characteristics can operate at the Enagas terminal:

	DOCK 1		DOCK 2	
	Maximum vessel	Minimum vessel	Maximum vessel	Minimum vessel
Capacity	87.600 m <sup>3</sup>	34.000 m <sup>3</sup>	266.000 m <sup>3</sup>	69.000 m <sup>3</sup>
LOA	249 m	198 m	345 m	243,34 m
Lpp	237 m	184 m	332 m	230 m
Beam	40 m	26 m	55 m	34 m
Depth	23 m	17,3 m	29 m	21,2 m
Maximum draught	10,64 m	10 m	12 m	10,5 m
Light-water draught	8,9 m	8,85 m	9,7 m	8,2 m
Deadweight tonnage	50.922 TPM	27.234 TPM	130.000 TPM	40.585 TPM
Displacement during loading	≈74.302 tn	≈40.600 tn	≈180.000 tn	≈60.058 tn
Gross register	≈71.469 tn	≈26.951 tn	≈163.922 tn	≈48.454 tn

Table 7: Operating characteristics of Enagas jetties.  
Source: <http://www.enagas.es>

### Meroil

Occupying a total surface of 125.000 m<sup>2</sup> and having a total storage capacity of over 1.000.000 m<sup>3</sup>, Meroil Terminal is the second largest terminal for petroleum products in Spain.

It works with products such as gasoline, gasoil, biodiesel, bioethanol and fuel oil, which can be stored in 45 tanks. The terminal is interconnected through pipelines to other terminals from

the port of Barcelona and to the CLH national distribution network. It has 8 discharge/loading bays for trucks, being able to handle up to 400 trucks per day.



Figure 22: Meroil terminal.  
Source: [www.meroil.es](http://www.meroil.es)

Meroil terminal can load/discharge from tanker vessels as large as 275 meters long, from 4 jetties: 32B, 32F, 32G and 34B, through flexible hoses or hard arms of 8", 10" or 12".

### CLH

Although not actually situated inside the Muelle de la Energia, CLH terminal is interconnected with the other terminals from the Inflammables Wharf through pipelines, having also access to jetty 34B. CLH Terminal is part of the Compania Logistica de Hidrocarburos SA, the most important Spanish company dedicated to the transport of hydrocarbons throughout the Iberian Peninsula and the Balearic Islands, through more than 4000 km of pipelines.

The CLH terminal in Barcelona offers services of reception, storage and distribution of gasoline, gasoil, kerosene, biofuels and marine fuel oil.

The total storage capacity is 476000 m<sup>3</sup>, in 42 tanks.



Figure 23: CLH Terminal.  
Source: [www.interempresas.net](http://www.interempresas.net)

Apart from jetty 34B, CLH terminal can discharge/load tanker vessels from 2 more jetties with following characteristics:

Jetty	Alvarez de la Campa 26A	Alvarez de la Campa 24C
Maximum LOA	230	250
Maximum draft	11,7	14,21
Maximum DWT	66.000	125.000

Table 8: Alvarez de la Campa berth Characteristics

## **CHAPTER 4: BEFORE ARRIVING AT THE PORT**

### **4.1. The Charter Party**

The main purpose of a tanker is loading, transporting and discharging liquid cargo in accordance to the conditions specified in the Charter Party. When chartering the vessel, the owner provides all necessary information concerning the vessel: DWT, service speed, cargo tank capacity, daily fuel consumption, number of grades or products that can be transported and the capacity of different sections, if the vessel has double hull, if it has COW system, Inert Gas, tank protection etc.

The charter party is the main contract that stipulates the rights and obligations between the charterer and the owner. There are various standard charter parties, and big oil companies have their own parties to which articles can be added by the charterer or by the owner.

The ship operator can communicate the voyage orders either directly to the vessel or via the agent, if the vessel is in port.

Contents of a voyage order will include: voyage number, rotation (ports of loading and discharging), name of the cargo, quantity of the cargo, options (+/- quantity or percentage), conditions of discharge (mT/hour, pressure at the manifold, total time of discharge), heating instructions, charter party name/date, laycan (lay days and cancelling days), NOR (notice of readiness) tendering instructions, bunkering, other instructions. On receipt of the voyage orders, the first considerations are if the cargo can be loaded on-board or not and if yes, how much cargo can be loaded.

All substances permissible for carriage on a chemical tanker are listed in a vessel's Procedure and Arrangements (P&A) Manual and approved on behalf of the flag state government the vessel is registered under. If the vessel has been nominated to load a cargo that is not listed in the P&A Manual, this should be notified to the vessel's operator, who will contact with the Class Society to determine whether a note of acceptance or a dispensation is possible for this cargo. The details of the permissible substances to be carried on board are detailed in an attachment to the Certificate of Fitness, issued by the flag state and usually delegated to a Classification society on its behalf. A synonym may be given instead of the original chemical or substance name. Ex: MIK instead of Methyl Isobutyl Ketone, MTBE – Methyl Tertiary-Butyl Ether, Mineral Oil – Crude Oil, Petrelab 550 instead of Alkylbenzene (used by Cepsa) etc.



## 4.2. Stowage planning

### 4.2.1. Cargo compatibility

Compatibility problems with substances already loaded can limit the number of tanks that are fit for carriage. This may be confirmed by reference to a Compatibility Chart, such as the one issued by the US Coast Guard. The USCG also has requirements regarding segregation. The requirements of the IBC and BCH Codes specify that cargoes, residues of cargoes or mixtures containing cargoes which react in a hazardous manner with other cargoes, residues or mixtures shall be segregated from such other cargoes by means of a: cofferdam, void space, cargo pump-room, pump room, empty tank, a tank containing a mutually compatible cargo, or must have separate pumping and piping systems which shall not pass through other cargo tanks containing such cargoes, or have separated tank venting systems. The suitability of a tank coating for carriage of a particular substance can be investigated by referring to the Resistance List issued for that particular material/coating. Certain products, such as esters (acetates etc.) and chlorinated or brominated materials can react with the water from acidic compounds. Although these products are suitable for storage in coated tanks when dry, the presence of water may make them aggressive and unacceptable. Such products must therefore be dry and free from acids and carried in completely dry tanks. Water contamination must be avoided and water content of the cargo should not exceed 0,02%.

### 4.2.2. Previous cargos

The Federation of Oils, Seeds and Fats Associations (FOSFA) is a professional international contract issuing and arbitral body concerned exclusively with the world trade in oilseeds, oils, fats and edible ground nuts and is the major association of its kind in the field. FOSFA was founded in 1971 and currently has over 1100 members in 89 countries. It has an extensive range of standard forms of contracts covering goods, which provide the terms of trade for oilseeds, vegetable and marine oils and fats, refined oils and fats from different origins worldwide and for different methods of transportation or for different terms of trade. Internationally 85% of the global trade in oils and fats is traded under FOSFA contracts.

Previous cargos carried in a ship's tanks can be a possible source of contamination. Despite apparent adequate cleaning, residues can remain trapped in the tank coatings or in areas with difficult access. The FOSFA operational procedures put restrictions on what may have been carried as the immediate previous cargo, or the last two cargoes, or in the case of leaded products, the last three previous cargoes.

A few general restrictions on Cargo Stowage on chemical tankers

- Heated substances should not be loaded adjacent to polymerizing substances
- Heated substances should not be loaded adjacent to highly volatile substances
- Heated substances should not be loaded adjacent to drying substances
- Toxic substances should not be loaded adjacent to edible substances
- Solidifying substances should not be loaded adjacent to ballast or water tanks, unless the tanks are empty or dry
- The quantity of a cargo to be carried in a type 1 chemical tanker should not exceed 1250 m<sup>3</sup> in any one tank.
- The quantity of a cargo to be carried in a type 2 chemical tanker should not exceed 3000 m<sup>3</sup> in any one tank.
- There is no restriction on the amount of cargo to be carried in a tank on a type 3 ship.

During cargo planning, allowance for cargo expansion must be taken into account. The temperature used during calculation should be the maximum temperature that the cargo will reach on passage.

Cargo quantity options. Abbreviations used

MOLOO	More or less Owners Option (expressed as % load)
MOO	More Owners Option
LOO	Less Owners Option
MOLCO	More Or Less Charterers Option
LCO	Less Charterers Option
MCO	More charterers Option
MIN/MAX	Limitations of Quantity of Cargo

#### **4.2.3. Cargo Calculation example**

MT Atlantis Almeria (LOA 109 m, DWT 6400 MT) receives voyage orders to load 6000 MT FAME (Fatty Acid Methyl Ester - biodiesel) 100 MT MOLCO ex Decal Terminal Barcelona. Discharge port is Huelva, Spain.



Figure 24: MT Atlantis Almeria, casting off from the Inflammables Wharf.  
Source: Author's own

Voyage duration is 2,6 days (631 nm at an average speed of 10 knots).

The available quantity for cargo (allowing 3 days voyage + 2 days reserve) can be calculated as follows:

Quantity	Deductibles
120 MT	Stores (constant referenced to Stability Manual)
25 MT	Fresh water consumption for cargo heating purposes (5 MT x 5 days = 25 MT consumption referenced to daily consumption records of engine logbook)
3 MT	Lubes (0,6 MT x 5 days = 3 MT consumption referenced to daily consumption records of engine logbook)
30 MT	Fresh water (6 MT x 5 days = 30 MT consumption referenced to daily consumption records of deck logbook)
10 MT	Potable water (2 MT x 5 days = 10 MT consumption referenced to daily consumption records of deck logbook)
5 MT	Diesel Oil (1 MT x 5 days = 5 MT consumption referenced to daily consumption records of engine logbook)
45 MT	Fuel Oil main engine (9 MT x 5 days = 45 MT consumption referenced to daily consumption records of engine logbook)
20 MT	Fuel Oil for cargo heating (4 MT x 5 days = 20 MT consumption referenced to daily consumption records of engine logbook)
258 MT	TOTAL DEDUCTIONS

6400 MT	Summer DWT
<b>6142 MT</b>	Available for cargo. Therefore, the ordered <b>6000 MT</b> of FAME can be loaded on-board, with the additional <b>100 MT</b> MOLCO capable of being lifted if required.

Table 9: Example of cargo calculation

It is essential to prepare an accurate cargo/ballast plan, so that shear forces and bending moments remain within acceptable limits at all times during cargo operations and while the vessel is at sea. The ship's trim should always be kept within reasonable limits with regards to speed and manoeuvring abilities at sea and as required to meet stripping requirements during cargo operations. It is preferable to have the vessel trimmed by the stern, keeping in mind the need to attain an even keel for arrival at the pilot station. The expected draft on completion of loading has to be calculated, and the value has to correspond to the terminal and jetty's limitation. In the same way, the draft on arrival at the destination port must correspond to the discharge terminal and jetty's limitations.

A large free surface area may be encountered at various stages of cargo and ballast operations on a vessel that doesn't have a centreline bulkhead in the ballast tanks and/or cargo tanks. As a result, the loss of GM due to free surface effects may result in a loss of the vessel's stability. In order to avoid slack tanks, it may be necessary to adjust the order of loading/de-ballasting and the quantity of cargo to be loaded. If loss of stability becomes evident during loading or discharging, all cargo, ballast and bunker operations must be stopped and a plan for restoring positive stability must be prepared. If vessel is at the terminal, it may require disconnection of cargo hoses/arms. It is recommended that no more than 2 pairs of ballast double bottom tanks are to be slack simultaneously. The combination of free surface with a flat bottom can result in generation of wave energy of sufficient power to severely damage internal structures and pipelines.

The movement of liquid inside a cargo tank when the vessel is rolling or pitching in a seaway is called "sloshing". This sloshing can have some negative effects. The slamming effect of the liquid inside the tank may result in serious damage to the piping system and fittings. The free effect of free surface reduces the ship's GM and may lead to loss of stability. Heavy cargoes, with a density of 1,3 – 1,6 that are loaded having a free surface area may damage the cargo deck and bulkheads.

Slack tanks must be avoided wherever possible.

Using specific software, load distribution is checked to assure that efforts are within acceptable limits. The loading plan and cargo distribution into tanks will be discussed with the terminal representative.

### 4.3. Pre-arrival

After signing the charter party, the owner provides the captain with all the necessary information regarding the voyage, port of loading and date, lay-time, window, cargo type, quantity, charterer, shipper, consignee, agent, destination and frequency of the pre-arrival notices, ETA, information regarding drafts, residue disposal etc.

Approximately one week before its arrival at the terminal, the vessel will send daily updates of the ETA. Before arriving at the terminal, the ship must send the following information, through the agents: drafts on arrival, estimated drafts on departure, if vessel is inerted and if IG system is working, details of the connections, manifold, centre height from deck, distance to the side and any other particularity of the vessel.

Also, before arrival, the terminal will communicate to the ship the cargo to be loaded, temperature, drafts, number of tugboats used etc.

The owner, charterer and the vessel are informed of the berth characteristics. A couple of days prior to arrival, the owner and the Captain will start receiving daily updates of the operational prospects: if the vessel is expected to berth on arrival or if it will have to proceed to anchorage, estimated time of the start and completion of operations, number and type of hoses/hard arms used, other operations expected at berth (bunkering, sludge disposal, pre-wash and slop disposal etc.).

In order to obtain the berthing authorization from the Barcelona Harbour Master, the Captain will have to submit the following valid documents (through the ship's agent):

- Certificate of Fitness, with corresponding Appendices that include the products that will be loaded/discharged
- International Oil Pollution Prevention Certificate (IOPP)
- Certificate of Civil Liability for Bunker Pollution
- Certificate of Civil Liability for Oil Pollution
- International Ship Security Certificate (ISPS)
- P&I Certificate
- A plan of the stowage tanks
- A residues declaration, stipulating the quantities of residues (sludge, slops and waste) on board and their discharge plan

Following documents will have to be submitted to the national law enforcement authorities (National Police and Civil Guard):

- Crew List
- A list of stores on board

Apart from the above, if the ship will load or discharge products classified as Dangerous Goods, the Barcelona port Authority will have to issue a Dangerous Good Authorization.

#### **4.4. Tank Cleaning**

When loading a different grade or product than the previous cargo, a thorough tank cleaning is essential for loading and carrying the new product at the required specification.

Tank cleaning can be defined as any operation performed upon a cargo tank for the purpose of improving its physical condition by removal of residues of previous contents. Many products, especially chemical and white products can withstand very little contamination before going off-specification, causing it to be downgraded to a cheaper product, or in extreme cases causing the rejection of cargo.

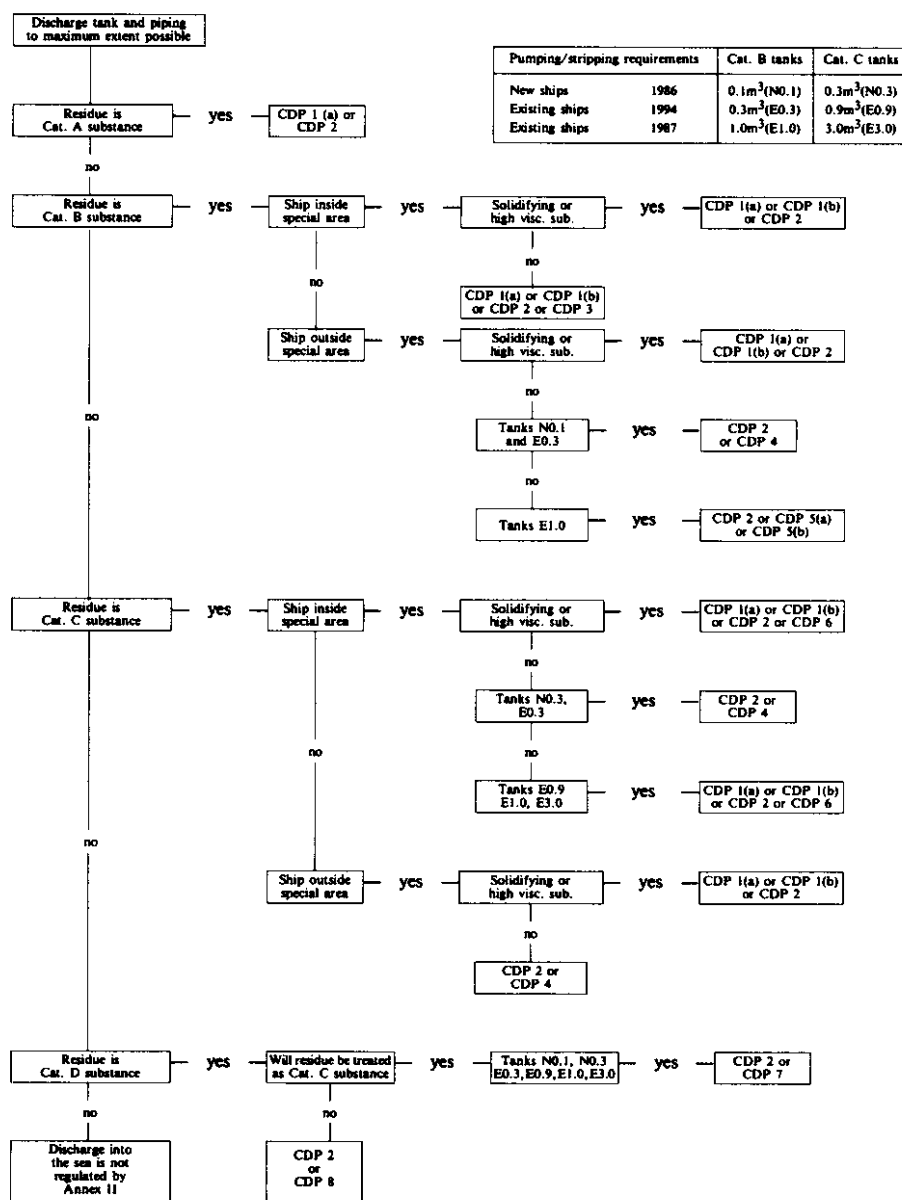
Loading and cargo lines must be cleaned and tested before loading commences. To avoid rejection and losses, the charterer's exemption must be confirmed if cleaning of any tanks has been omitted. This can happen if loading a cargo with the same specification as the previous.

The physical activity of tank cleaning can damage the coatings and expose the steel to dangers of corrosion and rust. On a less sophisticated tanker ship, with unprotected internal steelwork, corrosion can occur whenever water is introduced. A large proportion of accidents on tankers have taken place during tank cleaning operations and while many improvements have been made in equipment, if a ship fails to follow the given procedures a risk still exists.

Tank cleaning should always take place at sea. It is also better for the terminal that a ship arriving to load is already cleaned and ready on arrival, as this reduces the jetty occupancy time.

Cleaning and disposal procedures (CDP) contained within the "P&A Manual" outline the sequence of actions to be taken and essential information to ensure that noxious liquid substances are discharged without threat to the marine environment.

The flow diagram shows a set of questions and actions to be applied. The CDP that are specified in MARPOL Annex II should always be applied.



**Note:** This is a flow diagram giving comprehensive requirements applicable to new and existing ships. The flow diagram for a specific ship should only include parts applicable to that ship.

Figure 25: MARPOL 73/78 Annex II. Addendum A. Cleaning of Cargo tanks and disposal of tank washings.  
Source: <http://statutes.agc.gov.sg>



Cleaning and disposal procedures (CDP)	Sequence of procedures									
	1(a)	1(b)	2	3	4	5(a)	5(b)	6	7	8
Apply prewash in accordance with appendix B and discharge residue to reception facility	×	×								
Apply prewash in accordance with appendix B and transfer residues to slop tank for discharge to sea in accordance with chapter 10, section 10.5 or 10.6						×	×			
Apply subsequent wash of minimum one cycle		×					×			
Apply ventilation procedures in accordance with appendix C			×							
Residue may be retained on board and discharged outside special area				×						
Residue of substances with viscosities <60 mPa.s at the unloading temperature may be retained on board and discharged outside special area. Alternatively, tanks may be prewashed and slops discharged ashore								×		
Dilute residue in cargo tanks with water to obtain residue concentration in mixture of 10% or less										×
Ballast tank or, wash tank to commercial requirements	×			×	×	×		×	×	
Conditions for discharge of ballast/re- sidue/water mixtures other than prewash:										
>12 miles from land	×	×		×	×	×	×	×	×	×
>7 knots ship's speed	×	×		×	×	×	×	×	×	×
>25 metres water depth	×	×		×	×	×	×	×		
Using underwater discharge	×	×		×	×	×	×	×	×	
Ballast added to tank		×					×			
Condition for discharge of ballasts :										
>12 miles from land		×					×			
>25 metres water depth		×					×			
Alternatively, residue/water mixtures may be discharged ashore(N.B.optional not MARPOL requirement)	×	×		×	×	×	×	×	×	×
Any water subsequently introduced into the tank may be discharge into the sea without restrictions	×	×	×	×	×	×	×	×	×	×

Figure 26: MARPOL 73/78 Annex II. Addendum A. Cleaning and Disposal Procedures.  
Source:/puc.overheid.nl

#### 4.4.1. Cleaning methods

The various tank cleaning methods that can be applied depend on the properties of the substances to be loaded, vessel's technical equipment, availability of chemical additives, tank coating and its condition, ambient temperature, seawater temperature, weather conditions, available time, crew experience etc. The methods of cleaning specified in the Tank Cleaning Guide must be reviewed for applicability on-board the vessel. Some operations may be omitted or their duration reduced.



# BP Tank Cleaning Guide

Previous Cargo \ Cargo to be Loaded	Naphtha / Clean Condensates / LDF	Avgas	MTBE/ETBE/Ethanol/Methanol	Leaded Motor Spirit	Unleaded Motor Spirit	Sulphur Free Motor Spirit	Solvents	Jet / Aviation Kerosenes	Kerosenes (undyed)	Kerosenes (dyed)	Gas Oil (undyed)	Gas Oil (dyed)	Sulphur Free Diesel / ULSD	FAME Biodiesel	Crude Oils / Dirty Condensates	Lube Oils	Wax Distillate / Vacuum Gas Oil	Atmospheric Residue	Heavy / Medium Fuel Oil	Low Sulphur Fuel Oil (LSFO / LSWR)	Light Fuel Oil (LFO)
Naphtha/Clean Condensates/LDF ★																					
Avgas																					
MTBE	M	M						M	M	M	M	M	M								
Ethanol/Methanol	M	M						M	M	M	M	M	M								
Leaded Motor Spirit																					
Unleaded Motor Spirit																					
Sulphur Free Motor Spirit ★																					
Solvents ★	PM	PM	PM	PM	PM	PM				PM		PM									
Jet / Aviation Kerosenes	PM	PM		PM	PM	PM				PM		PM									
Kerosenes (undyed)	P	P		P	P	P															
Kerosenes (dyed)	P	P		P	P	P															
Un-dyed Gas Oil	P	P		P	P	P															
Dyed Gas Oil	P	P		P	P	P															
FAME / Biodiesel ★	M	M	M	M	M	M	M			M											
Ultra Low Sulphur Diesel/Gas Oil ★	PM	PM	PM	PM	PM	PM	PM			PM		M									
Sulphur Free Diesel ★	PM	PM	PM	PM	PM	PM	PM														
Crude Oils / Dirty Condensates																					
Lube Oils ★	PM	PM		PM	PM	PM	PM						M			LUB					
Wax Distillate / Vacuum Gas Oil ★	P	P		P	P	P															
Atmospheric Residue ★	P	P		P	P	P															
Heavy / Medium Fuel Oil	PX	PX		PX	PX	P															
Low Sulphur Fuel Oil (LSFO / LSWR)	PX	PX		PX	PX	P															
Light Fuel Oil (LFO)	PX	PX		PX	PX	P															

THIS GUIDE COVERS WHITE OIL CARGOES IN COATED TANKS, AND BLACK OIL / CRUDE CARGOES IN EITHER COATED OR UNCOATED TANKS.

No washing required - strip and drain well  
Refer Notes: 1 & 2

Wash tanks with COLD sea water until tank is clean  
Refer Notes 1, 2 & 3

Wash tanks with HOT sea water until tank is clean.  
Refer Notes 1, 2 & 3

Product NOT to be loaded unless specific instructions have been issued by BP Head Office

P Tanks to be purged to below 2% Hydrocarbon by volume  
Non IG Vessels should be 'Gas Free'

M Tanks to be mopped or educted DRY

X If ROB is less than 0.1%, and purging (if required) is effective, cargo may be loaded directly on top without washing

★ Tanks that have been washed for the carriage of these products must have a final wash with fresh water. Tank and lines are then to be blown and drained free of water.

To ensure minimum grade to grade admixture, tanks to be LUB stripped dry, pump column and deck lines to be blown and drained. Tanks to be visually inspected to ensure min ROB

Notes:

1. Tanks to be stripped dry such that any liquid ROB is confined to the pump well - or better.
2. Pump columns, deck lines, drops etc are to be blown clear and drained free of all product and water.
3. Deck lines, loading drops and cross over lines must be thoroughly washed and drained.
4. MTBE/Methanol/Ethanol (oxygenates) Are water miscible, introduction of water into designated tanks should be avoided.
5. These tank cleaning guidelines are guidelines only and not to be regarded as BP instructions to inspectors

Figure 27: Extract from a tank cleaning guide.  
Source: <http://www.marnav.dk>

The most important decision when tank cleaning is which of the following are to be used:

- Cleaning agent
- Water and cleaning agent
- Ventilation

- Water only
- With fresh or sea water
- With hot or cold water

The wrong decision may lead to a serious error and important financial losses.

Some substances react with water and form insoluble sediments. Drying oils must be cleaned with cold water and semi-drying oils must be cleaned with cold water, or with water that is at the discharge temperature of the oil. In order to prevent the surface drying before cleaning begins, the bulkheads must be flushed on completion of the tank inspection. The tank lids must be closed and tank washing should be commenced at the first opportunity. Non-drying oils should be cleaned with hot water at a temperature of about 78-85°C.

< Low Acid value		High Acid Value >
Cold Water	Cold Water	Hot Water
(clean with cold water)	(clean with cold water or at the discharge temp of the oil)	(clean with hot water at 78-85 C)
<b>Drying Oils</b>	<b>Semi-drying Oils</b>	<b>Non-drying Oils</b>
China Wood Oil	Candle but Oil	Almond Oil
Fish Oil	Corn Oil	Arachis Oil
Hempseed Oil	Cotton Seed Oil	Camphor Oil
Linseed oil	Croton Oil	Canaga Oil
Menhaden Oil	Herring Oil	Cashew Nut Oil
Perilla Oil	Maize Oil	Castor Oil
Soyabean Oil	Poppy Seed Oil	Coconut Oil
Tall Oil	Sesame Oil	Ground nut Oil
Tung Oil	Wheat Oil	Lard Oil
Walnut Oil		Olive Oil
		Palm Oil
		Peanut Oil
		Pine Oil
		Rape Seed Oil
		Tallow Oil
		Whale Oil

Table 10: Classification of vegetable/animal oils

The cleaning of tanks that have contained caustic soda solution 50% is carried out with water at no more than the temperature of the discharged solution, otherwise traces of white crystal sediments will be observed on the tank's bulkheads. These sediments can be removed by wiping by hand with fresh water.

Solidifying substances such as paraffin wax have to be cleaned with hot water at a temperature above 78 °C. Any failure of the boiler or heater should be avoided, as this

substances are soft prior to cleaning, but can become hard as ice if the washing temperature lowers. Before washing, the access to the pump suction well in each tank has to be cleaned, usually using a shovel through the solidified wax. All drop lines must be well steamed.

The tank material and coating resistance must be considered before applying any cleaning agent. Various cleaning methods using agents can be applied.

Butterworthing is a method for cleaning and gas freeing oil tanks by means of high pressure jets of water, either cold or heated. The apparatus consists essentially of double opposed nozzles which rotate slowly about their horizontal and vertical axes, projecting two high pressure streams of water against all inside surfaces of the deck, bulkheads, tank framing and shell plating.

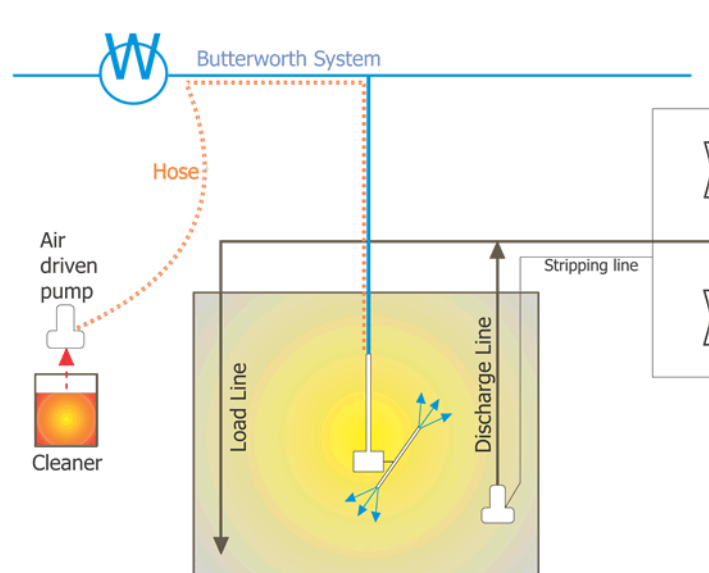


Figure 28: Butterworth cleaning system.  
Source: <http://miracle.chemserve-marine.com>

Butterworthing with a cleaning agent is the most expensive method because it requires the largest volume of cleaning agent to be diluted in the designated tank to achieve the recommended concentration.

Direct application of the cleaning agent is carried out on completion of tank washing. The undiluted cleaning agent can be applied using a brush or spray gun onto the dirty spots, for example the pump's shell. Upon completion of the reaction time, the tank has to be rewashed. Injection of a cleaning agent into washing water is the most cost effective method, as it does not require any special equipment except the supply drum and it can be applied during tank washing. Usually, a single drum of cleaning agent injected for 5 minutes during the washing of each tank is generally sufficient to clean all the tanks on a chemical tanker of 10000 DWT.

The lift method is where the tank is flooded with rinsing water that has cleaning agent placed on the surface. The lift should not exceed 1 metre per hour and vessel rolling should be avoided. When the cleaning agent reaches the top of the tank, the water can be pumped out, taking care to leave the agent behind. The cleaning agent can then be transferred to the next tank which requires cleaning.

Steaming with a cleaning agent is a good way to improve the result of tank cleaning, but safety matters must be kept in mind. An example, steaming with toluene is restricted because of the risk of explosion.

Tank cleaning agents may be corrosive, skin sensitive or toxic.

The four main tank washing atmospheres (where flammable residues of volatile compounds remain) are identified as:

Cold wash: inerted with sufficient oxygen

Cold wash: undefined with precautions including no wash liquid/steam above 60°C and no cleaning additives

Hot Wash: defined as to lean with less than 50% of LEL of flammable gas present, constantly ventilated and measured throughout washing above 60 °C

Hot Wash: defined as over rich, with more than 15% volume flammable content. Not recommended for ship's crew to perform

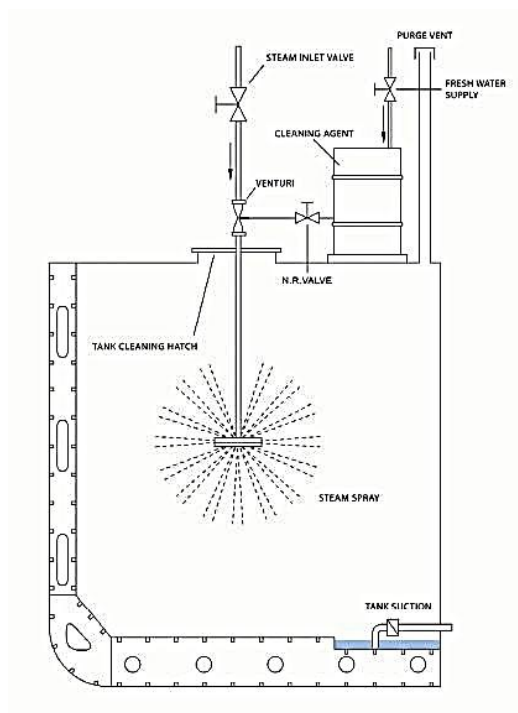


Figure 29: Steam cleaning a tank.  
Source: <http://www.chemicaltankerguide.com>

#### 4.4.2. Cleaning by ventilation

Substances suitable for ventilation are clearly identified in the P&A Manual. Substances with a vapour pressure greater than  $5 \times 10^{-3}$  Pa at 20°C may be simply removed from a cargo tank by ventilation.

Procedure for tank cleaning using ventilation: All pipelines are drained and cleared of any remaining liquid using ventilation equipment. Vessel's trim and list have to be reduced at the minimum possible levels so that the evaporation of cargo residue inside the tanks is enhanced. The ventilation equipment is placed in the tank opening that is nearest to the sump of suction point, such that the jet of air is directed at the tank sump or sump suction pipe. Any obstruction of the air jet on the tank structure has to be avoided. Ventilation is continued until no visible trace of liquid can be observed in the tank.

A tank or pipeline should be purged with inert gas or nitrogen and only a purged tank or pipeline with less than 2% hydrocarbon gas can be ventilated with air.

Steaming is one of the best methods of cleaning non-flammable substances such as chlorides from the tank, as the steam can reach every corner. Steaming for 40-60 minutes is sufficient to freshen the tank and associated lines. The steam can be applied through a line from the manifold or directly into the tank cleaning hatch. The pump in the tank being steamed must be

started, to discharge any condensed water. On completion, tank lids can remain opened and the tank will be free of steam in 20 minutes, being hot with dry surfaces inside, or the tank lids can be closed, and in this case the steam will condense onto the surface of the tank and will make it wet. The latter allows best cleaning for chlorides, but in this case the vessel will need more time for tank drying. The main safety rule is that steam must never be introduced into a tank that has flammable vapours. A tank washing machine or other conductor must never be lowered into a tank containing a mixture of steam and flammable vapour. Some companies restrict steaming, using de-ionized water instead.

Once gas free, any remaining water must be discharged from all cleaned cargo tanks and lines.

Drying the tank is not a concern if the vessel has sufficient time, a dryer and good weather conditions. It is more problematic to dry tanks in wet weather conditions, when the humidity is high. Low humidity inside the tank can be reached if the tank is blown with an appropriate gas, such as nitrogen. The easiest way to dry the tank and reduce humidity is to dry the air before introducing it into the tank. The tank's heating coils, if fitted, can also be used to raise the temperature in the tank, to evaporate water from any surfaces while ventilating the tank with a portable ventilator.

Tank cleaning operations are planned and agreed upon during a meeting of the master, chief engineer, chief officer, pumpman and jetty supervisor (in case vessel is in port). The meeting has to discuss following: any instructions received from the company and shipper, the availability and condition of any necessary equipment, the cleaning procedures to be applied, expected time of cleaning, the readiness of the boiler, pumps and heater, the detailed plan of tank cleaning operations and the crew requirements.

#### **4.4.3. Tank Cleaning machines**

There is a wide range of cleaning devices that can be divided into two categories: fixed and portable machines. Both operate on the same principle: direction of a high pressure fluid jet onto the structure of the tank, dislodging residues that fall onto the bottom. Fluid residue can then be pumped away but solids will remain in the tank and will have to be removed manually if necessary. Portable machines are usually found on smaller product tankers and fixed equipment on larger tankers. The use of fixed equipment in smaller ships, particularly chemical tankers is now more widespread as closed tank operations have become more common.



A portable machine consists of a pair of nozzles and a turbine driven gearbox. The assembly is secured to the end of a high pressure water hose. A fixed tank cleaning machine works on the same principle. Each type of machine is designed to operate at an optimum pressure of 6-10 Bar. The water pressure drives the turbine and gearbox, causing the nozzles to rotate. The nozzles of the tank cleaning machine rotate through  $360^\circ$  in the vertical axis while the main body of the machine rotates through  $360^\circ$  in the horizontal axis. This creates the washing patterns shown in the figure below.

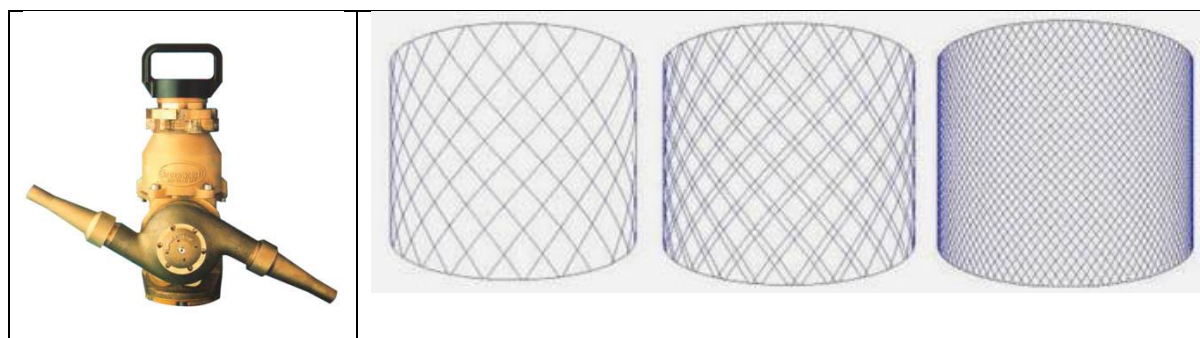


Figure 30: Tank cleaning machine. Tank washing patterns (3 cycles).  
Source: <https://www.butterworth.com/products-bc-ft-tank-cleaning-machine/>

The combined motion of the machine body and the nozzles ensures a fully indexed tank cleaning coverage.

The accumulating charge from the tank washing machine requires continuity with earth to be maintained throughout the periods that the machine is in the tank and while it is lifted in and out before and after washing.

To produce the required coverage pattern the portable machines will normally have a maximum throughput of approx. 25 tonnes/hour, while a fixed machine can provide higher pressure and reach 150 tonnes/hour. A portable machine is easier to maintain but has the disadvantage of a poor jet and requires labour and time to be put into use. A fixed washing machine provides higher pressure and better coverage, but at a higher cost and increased safety hazard through static electricity build-up.

The entire crew is informed prior to commencement of tank cleaning and notices are posted on the exits to the main deck. As a general rule, during tank cleaning no other operations may take place on the cargo deck.

During the entire cleaning process, the pump room should be ventilated, and tanks that are not gas free are to be kept closed. Rinsing of tanks should be conducted without interruption, while the rotation of the cleaning machines and the continuous stripping of the tanks should be regularly checked. Cleaning operations will be suspended if the washing level inside the tanks is rising, and shall be resumed after the tanks are stripped clear. Tank cleaning should

be suspended or the ship's course changed if it is rolling while tank cleaning. This prevents the washing machines striking the tank structure.

In the case of a liquid gas carrier the cleaning medium will always be an inert gas. A gas carrier can achieve a satisfactory cleaning standard by purging its tanks with inert gas.

#### **4.4.4. Particular case for oil tankers: Crude Oil Washing (COW)**

Crude Oil washing (COW) is an internationally accepted method of washing the tanks of a crude oil tanker with crude oil in order to minimize oil pollution risks. These regulations were laid down in Annex I of the 1978 MARPOL convention. Tankers built before 1978 are known as pre-Marpol tankers.

According to MARPOL regulations, all new oil tankers with a deadweight of 20000 tons or more have to be equipped with a crude oil washing system. In order to carry out the crude oil washing, the ship has to be equipped with an inert gas system and the tanks should have been inerted previously. Crude Oil Washing can be carried out both in port or at sea.

Using the crude oil as a cleaning medium uses the solvent action of the lighter hydrocarbon components in the oil, making it more environmentally friendly than when water is used. It washes down any clingage on the internal surfaces of the tank structure and removes sediments from the tank bottom. The solvents break down the heavier deposits in the tank being washed, which are introduced in the cargo being discharged ashore.

Using Oil rather than water, tank corrosion is significantly reduced. Another benefit of COW is the reduction of the volume of cargo residues left in the tank. A typical VLCC with a full load of crude could have 1000-1500 tonnes of oil remaining on board after discharge, before COW. If the ship is crude oil washed, the ROB quantity could be reduced to as little as 200 tonnes. Operations in the discharge port are complex due to the series of operations at the same time: discharge, inertization, COW and ballasting/deballasting. COW is carried out during discharge, not to delay total stay in port.

The ship has to have a Crude Oil Washing manual on board, that indicates the method of cleaning, number of engines used in each tank etc. Provisions in the manual have to be strictly adhered to, any amendment having to be written in the Oil Record Book (ORB). On a tanker that uses water for tank cleaning, the slop quantity at the end of cleaning is about 1% of the total cargo. With COW, this quantity is reduced by 80-90%. Crude Oil Washing also helps reduce internal oxidation of the tank. If COW is carried out, the Captain has to inform the Terminal about the total amount of time needed for COW and has to put warning signs on the bridge, in the engine room, cargo control room, that notify that the tank cleaning lines may



contain oil and that it is prohibited to open the valves of these pipelines by unauthorized personnel. Before arriving in the port, if COW is intended to be carried out, proper closing of the valves situated before the cleaning machine shall be tested. Furthermore, cleaning system has to be pressure tested to check if there are pressure losses in the pipelines or at the valves. The deck circuit has a general manifold from the pumproom throughout the main deck, with branches directed to the tanks.

Usually, fixed cleaning machines are used for COW of tanks. The fixed machines are situated at the lower end of vertical tubes under the deck, and can be programmed to rotate helicoidally following specific patterns or can rotate freely, in an azimuthal pattern in all directions. The cleaning machines can be equipped with one or two nozzles. The working pressure of the fixed machines can be between 8-10 kg/cm<sup>2</sup>. They must be able to direct a continuous jet horizontally over a distance of 30 metres. Inside the tanks equipped with various reinforcements, there can be installed smaller size cleaning machines, for cleaning the zones that are difficult to reach by the main cleaning machine. Tank cleaning can be carried out in 2 ways, depending on the machines being programmable or not. With programmable cleaning machines, initially the superior part of the tank is cleaned (top wash), continuing with cleaning the middle part and the bottom part (bottom wash). For better results when washing the bottom, it is recommended to have a small quantity of crude in order to dissolve the heavy components detached from the machines. At the end of the cleaning cycle, the tanks have to be completely dry. In the case of non-programmable machines, the cycle is continuous until completing the tank.

After completing the cleaning process, the slops containing crude are drained into the aft slop tanks. If clean water ballasting is necessary after crude oil washing, the tanks that will take ballast have to be rinsed with water, and the dirty water will be discharged into the slop tanks, for further decantation.

According to IMO provisions, a total of 25% of the tanks have to be washed with crude, including the ballast tanks, with the purpose of all tanks having been cleaned with crude upon a certain period of time.

The cleaning machines are situated at the end of the short tubes with variable length that leave from the tank ceiling and communicate with the crude oil washing pipelines on deck. Their number depends on the size of the tank and have to cover a certain extension of the horizontal and vertical surfaces of the tanks. The individual remote control equipment for the cleaning machines are situated on deck, on top of the machines they control, or can be portable, to be used for every machine.

The cleaning machines have to be able to clean by direct jet a minimum of 90% of the tank horizontal surface and min. 85% of the vertical surface. This doesn't include small size reinforcements (longitudinal, lateral or bottom). The machines have diagrams that show the

surfaces that are not covered by the direct jet. In some vessels, there are tank zones that are impossible to be reached by fixed cleaning machines. In these cases submerged cleaning machines are installed, to clean the hard for each areas and comply with the regulations.

#### **4.5. Notice of Readiness tendering**

Notice of readiness is issued on arrival at a port to the charterers or their agents, advising arrival, giving the position and time/date and that vessel is awaiting instructions. NOR must be given within the “laycan” period and must be given before lay-time can commence. The NOR must be tendered as stated in the notice clause of the charter party and in most cases will not be accepted until the ship’s readiness has been verified alongside. If mutually agreed between ship and shore, cargo may start in less than 6 hours and freight payments would commence at this time. The NOR is normally in the form of a printed letter, telex fax or e-mail, and includes the vessel’s arrival time, the name and quantity of substances to be loaded/discharged and the arrival draft. If a NOR is not accepted on the first day it was tendered, it should be re-tendered daily thereafter.

To avoid claims caused by the vessel having to load at a continuous low rate, the NOR could state the vessel's readiness to start at the stated rate, and the number of hose connections. The quantity of parcels to load must be declared separately. In the event of the vessel being rejected because it is unacceptable to load, a further NOR must be tendered as soon as the vessel is ready to load.

Should rejection become abnormal, the Master will protect the ship owner’s interest with an “Extension of Right Note of Protest”, issued to the cargo loading principal.

In the event of discharging one parcel and then loading another parcel into the same tank at the same berth, the NOR must be tendered on disconnection of the first parcel hose or upon completion of tank cleaning for the next cargo.

The maximum quantity of cargo as per the voyage instructions must be nominated whenever it is applicable. The ship operator’s acceptance is required if the quantity of a cargo for loading deviates from the quantity stated within the charter party.

The NOR must be addressed to the charterer and can be delivered through the agent. The NOR must be returned to the Master once it has been accepted.

The Charter Party normally states that “lay-time” commences either from a specific number of hours after tendering the NOR or from its acceptance. If such a period is not specified, “lay-time” commences on tendering the NOR.

## CHAPTER 5: MANOEUVRES AND BERTHING IN THE INFLAMMABLES WHARF

As a system of organization of maritime traffic, the port of Barcelona established two access channels, the “South access channel” and the “North access channel”, each with separation devices for the purpose of driving inbound and outbound traffic.

In both channels the method adopted for traffic organization is the same and corresponds to a system of separating opposite traffic streams by means of a central separation line.

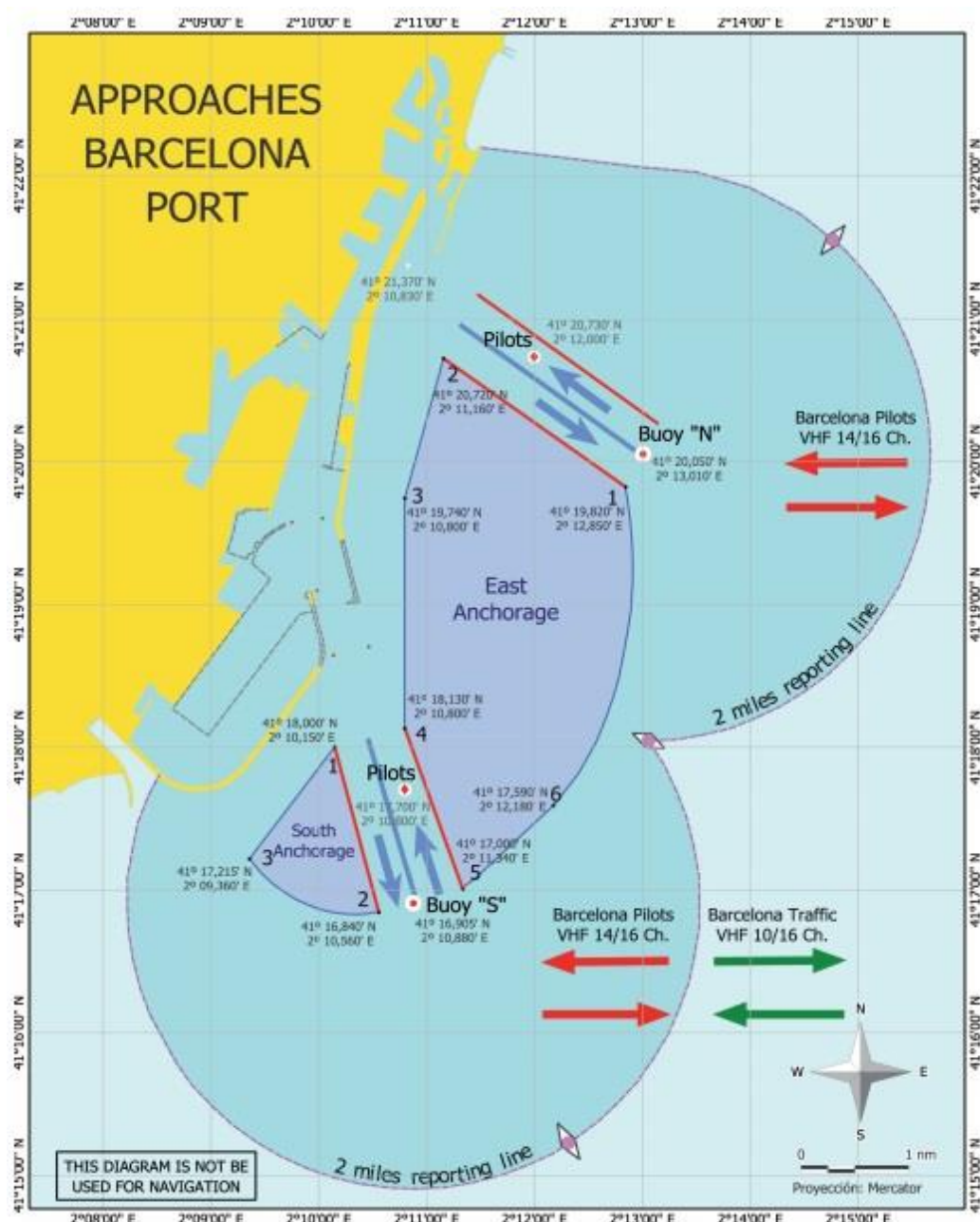


Figure 31: Barcelona Port Approaches.  
Source: [www.portdebarcelona.cat](http://www.portdebarcelona.cat)

Due to the situation of the berths and terminals where they operate, tanker vessels entering the port of Barcelona use exclusively the South Access Channel.

It consists of a two-way traffic separation device for traffic flows separated by a central separation line. The geometric configuration of the channel is almost rectangular. The orientation of the separation line and the western border is  $346^{\circ} / 166^{\circ}$ , although the eastern limit is not exactly parallel, at  $340^{\circ} / 160^{\circ}$ . The channel's inner base has a width of 5 cable lengths, while the outer base has a width of 6,1 cable lengths.

The length of the outer separation line is 1.2 miles, with its southernmost end marked with a buoy marked "S" (Sierra), located in:

$I = 41^{\circ} 16,905' N$

$L = 002^{\circ} 10,880' E$

The buoy is provided with a racon, corresponding to the "B" signal on radars.

The pilot boarding point for vessels entering the port of Barcelona is at the right border of the Channel, with following coordinates:

$I = 41^{\circ} 17,700' N$

$L = 002^{\circ} 10,800' E$

All vessels navigating the North or South Entrance Channel to the port of Barcelona will follow the general direction of the traffic flow indicated and represented in the nautical publications using arrows, unless otherwise instructed by the Service of General Information and Instructions to Ships.

Vessels need to have VHF channel 16 available for permanent listening. Apart from this, communications with the CRCS of Barcelona ("Barcelona Traffic") and with the Service of General Information and Instructions to Ships will also be carried out through the following channels:

- VHF Channel 10 when the vessel is more than 2 miles from the "S" (Sierra) or "N" (November) buoy.
- VHF Channel 14 when the vessel is within the 2 mile radius from the "S" (Sierra) or "N" (November) buoy, as well as in the access channel and in other port waters.

Pilotage is compulsory for all vessels larger than 500 GRT that enter the port of Barcelona. There are a couple of RO-RO ferries engaged in regular passenger and vehicles transport to and from the Balearic islands that are exempted from this obligation.

When going on board, the pilot is informed by the captain of the vessel's characteristics: length, beam, depth, maximum draft, speed, mooring equipment etc.

The operations associated with berthing a ship alongside a berth or jetty are generally required as the ship's responsibility.

A properly moored ship is the most important requirement for safe terminal operations as securing the ship alongside is fundamental in order to prevent any strain on the cargo transfer equipment.

It is the terminal's responsibility to give the arriving ship all necessary information in order to optimize the distribution, heading and number of mooring lines used. It is the master's responsibility to ensure that the ship is moored to the suggested pattern. However, it is always a joint ship/shore effort to ensure that the ship remains secured alongside during operations. A ship's moorings must resist the large number of forces that are exerted on the ship, both environmental and operational. In protected areas such as the Inflammables Wharf, the major sources of environmental force are the wind and current. The magnitude of the wind force acting on a ship is influenced by the velocity of the wind and the area of the ship that is exposed to it. The ship is least affected by wind forces when it is low into the water, for example when it's fully laden.

In similar loading conditions, the force effect of wind is greater on a large vessel than on a smaller vessel, as it has a greater exposed area. Though wind velocity can disturb a ship at berth, it is the sudden increase of force together with a dramatic change of direction that can be most dangerous.

The magnitude of current forces on a ship depends on the velocity of the current, the hull area exposed and the under-keel clearance. The maximum force of current is experienced when the vessel is in a loaded condition and the current is acting directly on the beam.

In light/ballast condition, a vessel will be more exposed to wind forces, whereas in loaded condition it will be more exposed to current forces.

Mooring forces caused by tanker loading or discharge (sinking while loading and rise during discharge) are created by a change in the height of the tanker deck relative to pier. They can be controlled by the deck crew by slacking-off or heaving-in the mooring lines.

A ship moving through the water exerts forces on moored ships. The magnitude of these forces depend on: the under-keel clearance of the moored vessel, the separation distance to



the passing ship, the sizes of the passing ship and of the moored vessel and the speed at which the ship passes the moored vessel.

The interior jetties from the Inflammables Wharf (32A – 32G, 33C) face a large number of passing ships, due to the presence of other terminals in the adjacent wharfs (auto terminals, ferry terminals, general cargo pier etc.). The speed of the passing vessels, however, is generally low, as these ships are carrying out berthing manoeuvres. Ships berthed at exterior jetty 34B are more exposed to forces exerted by passing ships, by virtually being passed by most of the ships that enter the Port of Barcelona through the south entrance (except from the container ships that berth in BEST terminal). They can be affected by large vessels passing by, such as big cruise ships or 8000+ TEU container ships that call to APM Terminal. Most of the passing vessels can have speeds of up to 8 knots when passing this point.

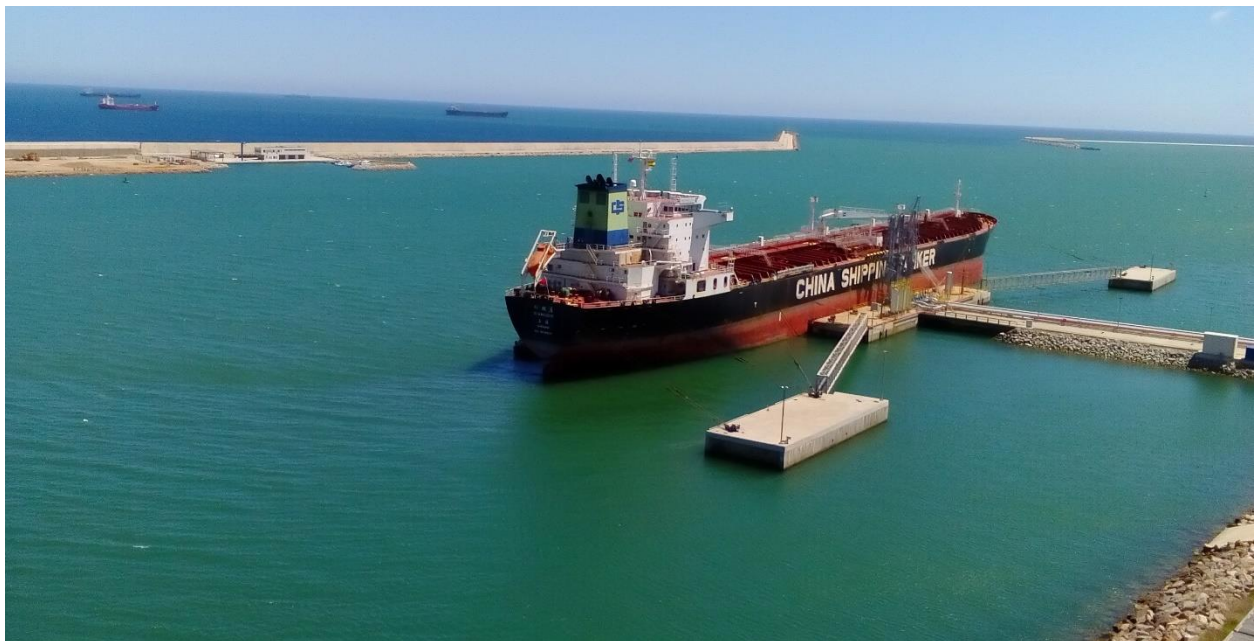


Figure 32: Vessel berthed at Inflammables jetty 34B.  
Source: Author's own

A moored vessel is at its most vulnerable when it has small under-keel clearance, the separation distance between the ships is relatively small, when the passing vessel is of larger size and is travelling at relatively high speed. The most critical moment would occur when the tanker is fully loaded and the under-keel clearance would be minimum.

Load distribution in the mooring lines is affected by several factors: overall mooring pattern, orientation of the mooring lines and elasticity of the mooring lines.

Generally, the mooring pattern should be as symmetrical as possible about the ship's midpoint to ensure a uniform load distribution among the lines. The steeper the orientation of the mooring line, the less effective it is in resisting horizontal loads. Similarly, the larger the horizontal angle between the parallel side of the ship and the mooring line, the less effective

the line is in resisting a longitudinal force. The effect of mooring lines elasticity is often overlooked. When mooring lines of different elasticity are connected at the same point, the stiffer mooring line will always take the greater load stress.

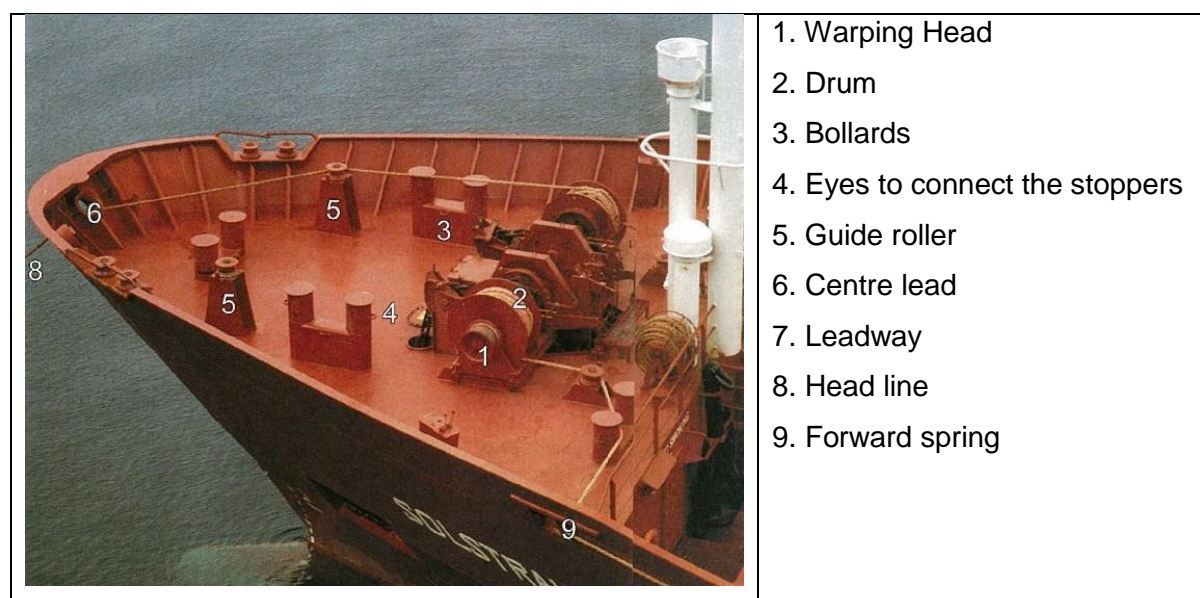


Figure 33: Mooring equipment (bow) of a chemical tanker.  
Source: [www.forshipbuilding.com](http://www.forshipbuilding.com)

Automatic tension winches have been designed so that a specific line tension can be pre-set, allowing the winch to pay out whenever the value is exceeded and then heave in when the line tension falls below this value. Extreme wind or current forces can cause winch release at one end followed by heaving in at the other, allowing the ship to slide along the berth, thus disturbing the perpendicular angle desired for hose or hard arm connection to the manifold. If automatic winches are installed, the winch should be placed in manual brake mode while the vessel is moored alongside.

Loading arms and jetty equipment have operating limits that establish the environmental conditions within which they can operate. Movement of the ship alongside may, in addition to suspending loading/unloading, require disconnection of cargo transfer equipment and the gangway.

Once all mooring lines are made fast, they should be inspected regularly to ensure that all lines are taut and that the ship is hard against the fenders. If the lines are slack or if the ship is lying off any fenders, the appropriate lines should be hove-in immediately to correct the situation. Even though ship may be initially properly moored, changes in weather or freeboard will necessitate tending of the lines to prevent them from being overloaded or going slack. Special attention to mooring lines inspection must be given in conditions such as periods of high loading/discharge rates, when under-keel clearance is low, prior to, during or after the



close passing of other ships. Overload of mooring lines can be evidenced by direct measurement, observation by personnel or by winch slippage.

Vessels use a Docking Aid System, a tool used during docking. This provides real time data on the vessel's position and progress relative to the jetty, measuring distance from the jetty and the speed of approach. Laser docking Aid systems are also a reliable and precise method of measuring vessel approach over the final 200 m to the jetty, with accuracy to 0,1 cm.

Tugs offer assistance for manoeuvring and berthing inside the port. They can also escort tankers or provide rapid response to cover fire-fighting or emergency towing within the port area.

Types of tugs:

- Conventional tugs: generally its propulsion unit is a single screw propeller and a standard rudder. The location of the towing hook, generally fixed amidships, tends to limit the tug manoeuvrability
- Tractor tugs: uses multi-directional propulsion units that consist of controllable pitch rotating blades located below the conning position of the wheelhouse. Offer a high degree of manoeuvrability
- Azimuth stern drive tug: combines the benefits of both conventional tugs and tractor tugs. The main propulsion units are located aft, like a conventional tug



*Figure 34: Vessel unberthing from the Inflammables Wharf, assisted by tug Montfort.  
Source: Author's own*

As per Barcelona port regulation, tug assistance when berthing and unberthing is compulsory in the Inflammables Wharf. Depending on the vessel size and the jetty, it can use 1, 2 or 3 tugs, as per master's and pilot's request.

Vessels will always berth starboardside alongside. This is due to port regulations that stipulate that tanker ships must be prepared at all times to sail as soon as possible in case of an emergency situation. During the tanker's stay in port, the main engine must be functional at all times, in case it needs to be started urgently in the event of an emergency. Therefore, interventions on the main engine that need engine immobilization require special authorization from the Harbour Master.

## **CHAPTER 6: LOADING OPERATIONS**

### **6.1. Shore preparation for loading**

All jetty equipment should be tested prior to the arrival of the vessel alongside. Particular attention must be given to hard arms/hoses and mooring equipment. Once the vessel is alongside, pre-loading check procedure is carried out, verifying that the vessel is securely moored, that all jetty loading valves drains and vents are shut and ensuring that the loading arms/hoses intended for use are drained dry and have blank flanges fitted to both ends. Jetty slop tanks must have been pumped to minimum level.

When connecting loading arms to liquefied gas carriers, the loading arm should be pressure tested with nitrogen, against the vessel's closed manifold valve, to a pressure of approx. 10 Bar. With the loading arms/hoses connected, it is important that they are properly supported. Hoses should be suspended in gentle curves, using a bridle and a sling in the saddle.

The selected shore tanks should have been dipped, checked for water bottoms if applicable and sampled by the laboratory. Some products tend to stratify, so the tank should have been thoroughly mixed before sampling. Loading pumps are checked to ensure they are full of product and vented of air.

If a pipeline system has not been used for some time, a check on its pressure relief system is necessary. Actually, regular monthly checks on relief valve systems are standard operating practice in some terminals.

It may be necessary to use a pipeline for more than one product (ex. gasolines, different grades of lube-oil, fuel-oil etc.) There are numerous ways of clearing and back-filling (ex. Pigging). The system is checked by pressurizing the line to the jetty head and venting off any air. Samples will be taken at various points along the system to check the quality.

Inside the terminal control room, ship/shore radio communication system should be tested and all relevant details from the initial ship/shore meeting must be available, including the start-up rate, the normal rate and the top-off rates of flow.

LPG Carriers require that an adequate supply of nitrogen or inert gas must be available at the jetty head. The plant cold vent system must be available, if required, with particular emphasis on the knock-out drums. Loading lines and pumps should have been cooled down to the required loading temperature and the vapour return system must be operational.

## 6.2. Initial ship/shore meeting

The terminal representative (also referred to as Terminal Supervisor, Head of Operations or Loading Master) is fully conversant with all aspects of the transfer operation and must have the delegated authority to make “on the spot” decisions. Before any cargo transfers begin, it is the Captain’s responsibility to ensure that all his crew are fully aware of their duties and responsibilities.

The Terminal Supervisor will provide following information:

- Details of the cargo to be loaded: temperature, pressure, handling hazards
- Information card, Material safety data sheet (MSDS) of the product
- Brief description of shore equipment and Control: Capacity of pumps, flow control
- Jetty operator’s duties
- Establish normal shut-down procedure, emergency shut-down procedure

## 6.3. Vessel’s preparation for loading

For vessels that arrive inerted (ex. Oil tankers of over 20000 DWT), it will be terminal’s decision whether or not to carry out a tank inspection. If a vessel is asked to open up its tank lids, there would be considerable delay before the vessel could return to an inerted state and ready to load, so the majority of vessels will not de-pressurize. In case of non-inerted product tankers of less than 20000 DWT, should prepare to open all tank lids, tank valves, crossover and master valves, to prove that the internal lines are empty. This can only be carried out safely when the ship has arrived in port.

After having complied with the ship/shore safety checklist, following checks must also be carried out on board:

- Manifold blanks and manifold valves must be opened for inspection
- The ship’s tank vents should be segregated if incompatible cargoes are being loaded

In smaller ships, before a person is allowed to enter the cargo tanks these must be tested for oxygen content levels of 20,9% volume, 1% or less LFL and less than the TLV (Threshold limit value) of toxic gases. This is done by both ship and shore personnel. If a person enters the tank, a responsible ship’s officer should be standing by with breathing apparatus. Where tank entry is not required, the inspection can be carried out using a torch and/or dipping rod. It is the vessel’s responsibility to clearly identify the relevant manifold connection with the product to be loaded through it. This is even more important if more than one type of product is to be loaded

## 6.4. Preload tests

Cargo lines and valves should be pressure tested at least every 6 months and always prior to the vessel entering US waters. The most suitable time to perform the test is during tank cleaning operations. All cargo line ends should be closed with valves or flanges. The line is pressurized with water by the cargo pump and pressurized with compressed air from a portable high pressure test pump with a pressure 1,5 times higher than the working pressure. The pressure must be stable for 15 minutes. The results are recorded in the logbook



Figure 35: Tank heating coils.  
Source: <http://www.test.swiss-ships.ch>

Ships that transport heavy hydrocarbons are equipped with heating matrixes inside the tanks, to maintain the temperature of the cargo within the limits specified in the charter party.

Heating coils (where available) are also pressure tested. They have to be blown dry of liquid and blanked for any voyages in which there is no requirement to heat the cargo. Leakages are indicated if the drain tests show the presence of oil. Pressure testing of heating coils is carried out at 6-8 bar, which is read on a manometer connected to the heating coil exhaust manifold. The pressure is read for approx. minutes. A steady pressure in excess of 3 Bar means that the system is tight.

The free movement of the pressure/vacuum disk/weight in a high velocity relief valve must be ensured. Condensed water is drained through a drain cock. It can be determined if there is any free water inside a vent pipe by tapping it and listening for a ringing sound.

The High Level (98%) and overflow or hi-high level (99,5%) control systems have to be tested before loading. There are two types of test that can be performed: conduction and functional. Conduction tests can be performed with a simple check button on a monitoring panel. The functional test requires two persons to take part. The first will open the cap of the alarm on each tank and pick up the float with a test stick or activate the unit with a magnet, depending on the unit's construction. Audible and visual alarms should result and these can be accepted by the second person in the cargo control room.



Figure 36: High Level Alarm on deck.

Source: <http://www.chemicaltankerguide.com/cargo-loading.html>

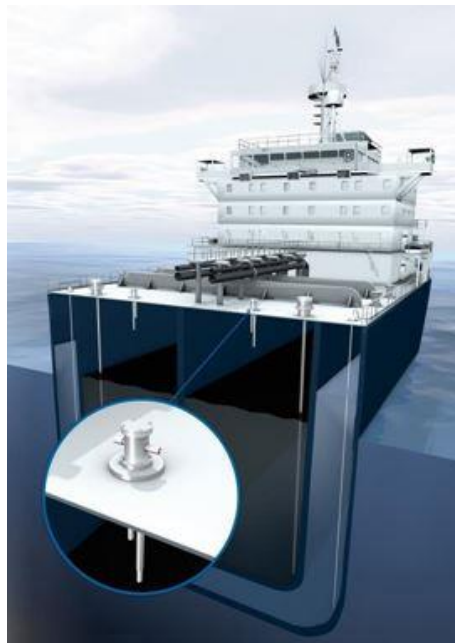


Figure 37: High Level Alarm.

Source: <http://www.api-marine.com/tss-alarm.aspx>

## 6.5. Equipment on board oil tankers and chemical tankers

### 6.5.1. Tanks and pipes in a tanker vessel

The discharge, loading, ballasting and deballasting operations are carried out through a complex system of pipelines and valves. The cargo space of a tanker is divided in such a way

that in any condition of partial loading of one or multiple sections of it, the hull does not suffer excessive efforts and the vessel can maintain the appropriate drafts. Each section of tanks has its corresponding line and cargo pump.

### Conventional system

The conventional piping system on a crude oil tanker is the direct line system. Each line connects with a section of tanks and the ship can load as many different products or grades as the number of sections in which it is divided into, usually 3, separated by means of double valves. The tank lines are mounted above the deck plan, together with the ballast line. These lines are usually provided with double separation valves, allowing the use of the discharge pumps in the other sections. To avoid passing the crude oil through the pumping room, these tanker ships are provided with direct loading lines that connect the deck lines with the bottom piping, one direct load line for each section. The manifolds are usually situated amidships.

### Free flow system

The vessels that employ this system don't have discharge lines to the tanks. Instead of these lines they have valves mounted in the separation bulkheads between tanks. These valves allow the free flow of liquid to the final central tank with the suction pumps. This design allows reducing costs by eliminating the main piping from inside the tanks, leaving only the stripping lines. The rest of the lines are similar to the conventional system. The difference is that loading is carried out through "J" shaped direct load lines that run till the bottom of the tanks.

### Annular system

In this system, the lines from the bottom of the cargo tanks run through the lateral tanks, forming one or more ring shapes, depending on the situation of the pumprooms. The lines on deck or from the pumproom are similar to the ones of other piping systems.

### Product tankers

Tanker vessels designed for the transport of different products are divided in various sections independent from one another, each section having its own piping system and pumproom. The small tankers designed for transporting certain homogenous products, like solvents, the tanks and piping can be made of stainless steel. Some chemical tankers have submerged pumps, deep well pumps in each tank, with piping independent from the deck manifolds. The piping layout of such vessels is complicated, in order to prevent cross-contamination between products.



### Tank types

An independent tank is a cargo-containment unit that is not contiguous with, or part of the hull structure. It is built and installed to eliminate or minimize stressing that results from stressing or motion of the adjacent hull structure. An independent tank is not essential to the structural completeness of the ship's hull and is known as a Type 1 tank.

An integral tank is a cargo-containment area that forms part of the ship's hull and may be stressed in the same manner and by same loads as the contiguous hull structure. It is normally essential to the structural completeness of the ship's hull and is known as a Type 2 tank.

A gravity tank is a tank with a design pressure not greater than a 0,07 MPa at the top of the tank. A gravity tank may be independent or integral. It will be built and tested according to recognized standards and takes into account the temperature of carriage and the relative density of cargo.

A pressure tank is a tank with a design pressure greater than 0,07 MPa. A pressure tank must be an independent tank and should have a configuration that allows the application of pressure-vessel designed criteria of recognized standard.

### Tank Vents

An open tank venting system is a system that during normal operations offers no restrictions, except from friction losses, to the free flow of cargo vapours to and from the cargo tanks.

A controlled tank venting system is a system in which pressure and vacuum-relief valves or pressure/vacuum valves are fitted to each tank to limit the pressure or vacuum in the tank. Controlled tank venting systems fitted in tanks used for cargoes that have a flashpoint lower than 60 °C must be provided with flame arrestors to prevent the passage of flame into the cargo tanks.

### Tank environmental control

Inerting is the process of reduction of the oxygen content in a tank by introducing an inert gas to prevent the developing of a flammable/explosive atmosphere within the cargo tank. A crude oil tanker with cargo tanks having an oxygen content of 8% or less is considered to be inerted. On chemical tankers, the general practice is to use large volumes of compressed nitrogen vapour supplied from the shore, to reduce the oxygen content down to as low as 0,1% by volume.

Padding or blanketing is filling a cargo tank and associated piping systems with a liquid, gas or vapour, which separates the cargo from air. In practice, nitrogen is most often added to a tank that has already been filled with cargo. The main purpose of the pad is to establish a positive pressure on the tank, preventing the ingress of water or air as the tank cools.

A tank is considered Dry when the tank and the associated piping systems are filled with moisture free gas or vapour, with a dew point of -40 °C or below at atmospheric pressure, and then maintained at that condition.

### Pump room

The pump room gathers together in the same place numerous pipelines, valves, pumps and additional equipment for loading and discharging tanker vessels. In crude oil tankers, the pump room is situated aftwards of the cargo tanks, and contains discharge, ballast and exhaust pumps, and the corresponding equipment. The means by which the main pumps are actuated are inside the engine room. In the pumproom we can also find a bilge pumping out system, an oleometer and fire-fighting systems, as well as the discharge system and the ballast system. In the control room of the pump room, on the main deck, there are manometers, thermometers and all the other control equipment, as well as an emergency stop for the pumps, in a place with easy access. Part of the discharge system, there is one suction line for each tank, a master isolation valve, an aspiration valve and a pump filter. Between the isolation and suction valve there's the cross-over piping, interconnecting all the lines, with its isolation valves, so that a pump can suction from each line, if necessary.

The discharge line is provided with discharge valves and non-return valves, and communicates with the deck line and the shore connection through a vertical line. A high transversal connector interconnects with all the discharge lines and corresponding isolation valves, and permits diverting the discharge of one pump to any other deck line, and a deviation or connection piping between the suction and the discharge line, used in older ships for loading through the pump room and taking ballast. The ballast / de-ballast system consists of a ballast pump and suction, loading and discharge pumps, together with a master valve at the inlet of the pump room, filter, opening-closing valve and stripping pump. The cargo suction and ballast lines are completely separated, with an emergency connection between lines carried out through a reel. This reel is painted in red, unmounted and placed in a fixed position, and is only used in case of emergency, if the ballast pump fails and it's necessary to use a main pump to discharge the ballast.

Product tankers can have more pump rooms that divide the tanks in sections that allow transporting different grades of products at the same time. Before entering a pump room, it has to be degasified and the ventilator fans left working as long as anybody is inside the room.



Figure 38: Layout of the pump room of a chemical tanker.  
Source: [www.chemicaltankerguide.com](http://www.chemicaltankerguide.com)

### Valves and expansions

Valves are an essential element of the loading/unloading circuit, ballast/deballast circuit etc., that allow directing the liquid through the pipelines, and can isolate or communicate between sections. There are various types of valves found on tankers.

Master valve: to close a pipeline section that leads to one or more tanks or to the pump room. Can also be found on the deck lines, to shut off the liquid flow to the pump room.

Suction valve: suction valve of the pump; valve that opens or closes the suction of the tanks

Crossover valve: communicates between transversal and longitudinal pipelines, in the bottom circuit or in the pump room.

Bypass valve: communicates between the suction and the discharge line that allows the liquid to return to the suction line without being discharged externally.

Sea valve: for ballast water intake/discharge.

Block valve: isolates one section of the pipelines in order to avoid cross contamination of products.

Non-return/check valve: prevents liquid from returning.

Regulating valve: having at a pre-set pressure value, opens and closes depending on the pressure of the liquid.

Safety valve: has a maximum pressure setting in order to protect pipelines or a device. When the pressure is in excess, the valve opens, letting liquid pass in order to re-establish the pressure balance.

Loading drop valve: allows communication between the lines on deck and the lower lines of the tanks, so that the loading product does not pass through the pump room, with a master valve upstream closing the passage.

Bilge suction valve: for the bilge water suction from the pump room.

By their design, valves can be classified into: butterfly valves, gate valves, sluice valves (in the free flow systems), check valves (used in combination with discharge valves of the pumps), glove valves, ball valves, tap valves, needle valves (for control instruments), control valves, self-regulating valves etc.

The flanges of the shore connection valves that are not connected with the shore lines have to be closed with blind flanges. Under these valves containers have to be placed, to contain the eventual product spills. These trays have their own pipelines and valves for discharging spilled product into a cargo tank.

When completing cargo operations, all valves must be closed, and must remain closed during voyage. They shall only be opened if necessary for transferring cargo between tanks in order to correct vessel trim while at sea. It is very useful to open and close the valves, to check if they work properly. In vessels where valves are opened manually, the flywheels have to be painted in different colours, according to their function. If valves are controlled hydraulically, each valve has a number, controlled from the deck gangway or from the cargo control room. Prior to the start of operations, the entire line circuit where the liquid will pass through has to be checked, to ensure that all valves that have to stay open are opened, and the others closed. During loading, a suction valve will never be closed without opening other from other tank containing the same product, to avoid overpressure that could prevent opening other pressure release valve, especially in the case of gate valves.

Couplings are used in order to absorb the dilatation and the contraction of the pipelines from vessel movements, temperature variations, during cargo operations etc. Dresser couplings are used in big sized pipelines. In vapour pipelines bayonet couplings are used.

### Residues tanks

Residues tanks or slop tanks are a pair of tanks that according to MARPOL regulations need to have a minimum capacity of at least 3% of the vessel's cargo capacity. Normally, slop tanks are situated aftwards of the cargo tanks, behind the lateral tanks. The slop tanks are filled with clean water up to a determined level, and the hydrocarbon residues resulted after tank cleaning are pumped into the portside tank (dirty slops). The two slop tanks are connected through a balance line that allows liquid from the bottom of the dirty slop tank to pass to the superior part of the clean tank, due to gravity.

The hydrocarbon residues from tank cleaning, having a lower density than water, remain floating on the top, and only clean water will pass from the dirty slop tank to the clean tank. In case any residues would pass to the clean tank, these residues would remain floating on the surface of the water, far from the suction pump located on the bottom of the tank. After a period of time that would allow decantation of at least 24 hours, the oily residues form a layer on top

of the water surface. The height of the residues layer is measured with an interface device and the clean water is being discharged. The dirty slops remaining on board shall be discharged in the terminal, or can remain on board to load on top of them.

The residues from the engine room are collected and kept in the sludge tank, to be discharged later on shore.

#### Vapour detection equipment

Ships carrying toxic or flammable products should be equipped with at least two instruments that are designed and calibrated for testing the gases of the products carried. When toxic vapour detection equipment is not available for certain products that require such detection, the ship may be exempted, provided an appropriate entry is made on the International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk.

### **6.5.2. Emergency Equipment**

There should be sufficient respiratory and eye protection for every person on board to use should an emergency escape become necessary. Medical equipment should be readily available.

Following carcinogens require safety precautions when carried on board: benzene, toluene and xylene mixtures, cresols, dichloromethane, ethyl acrylate, styrene, tetrachloroethane, trichloroethane etc.

Tanker vessels are provided with suitably marked decontamination showers and eyewash stations, available on deck in convenient locations. They can operate in all atmospheric conditions. Generally, decontamination stations are activated when a person stands on a base plate or pedal that stops the device when stepping off.

## **6.6. Tanks inspection before loading**

The purpose of the cargo survey is to verify that a product meets certain specifications.

For this inspection to be reliable, it must be carried out by Companies independent to both parties, and specialists in the process and / or product that is subject to inspection.

In the Port of Barcelona there are various Inspection Companies, the majority being local branches of multinational Survey Companies. Some of the Cargo Survey companies working in the port of Barcelona are: SGS, Saybolt, Intertek, Inspectorate Espanola, Comismar, Zurmar, etc. Based on previously established commercial contracts, inspection companies are nominated to carry out cargo surveys by their clients

The Surveyor is responsible for verifying compliance of the product with the specifications and / or regulations, to which it is subject to. In order to carry out these verifications, the Surveyor shall use the procedures defined by the inspection company, which are supported by methods of analysis and international standards of Inspection.

Sampling, inspection and control operations are performed by the Surveyor himself, while a specialized and accredited laboratory that has the appropriate means and equipment will carry out the analysis of the product's characteristics.

When receiving the loading nomination, The Terminal Supervisor (Loading Master) calculates the total quantity of product available and the Surveyor will take samples from the shore tanks. The results of the analysis are introduced in the cargo documentation that will be handled to the vessel upon arrival.

Before loading, all tanks must be inspected and accepted by a Surveyor. The Surveyor inspects that the tanks are clean and without traces of products. Tank history and the vessel experience factor are made ready for the surveyor's investigation by the Chief Officer. Certain shippers require specific information before arrival. This can include cargo operations and equipment carried.

### Wall Wash Test

Tank cleanliness is very important particularly when loading certain products that can go off specification if the slightest trace of contamination is present inside the tank. Some examples include: methanol, ethanol etc.

To confirm a tank's acceptability, several tests can be conducted:

- Hydrocarbon test (or water miscibility)
- Chloride test
- Permanganate fade time test
- Appearance test
- UV test
- Colour test
- Odour test
- Acid wash test
- NVM Test

The sampling agents depend on the tested substance, and can be: methanol, acetone, toluene, ethanol, xylene or other agents.

Before testing, all equipment must be thoroughly cleaned with 3% hydrogen peroxide and 2% hydrochloric solution, followed by de-ionised fresh water and then hydrocarbon free methanol. Then, it will be washed with a tested substance. The person carrying out the test has to wear surgical gloves and plastic shoe covers.

Two types of test should be done by the ship's crew to assess a tank's acceptability before official inspection. These are the hydrocarbon and the chloride test (whichever applicable).

Methanol is one of the most demanding cargos regarding tank cleaning and wall wash testing. The requirement is for a tank with zero water and as near as possible to zero hydrocarbon. Non contaminated methanol dissolves clearly in water so the test for hydrocarbons is developed on the principle that methanol contaminated with hydrocarbon when mixed together with water will create a milky, cloudy liquid that seems like a colloidal emulsion. This discolouration can be measured by a laboratory, giving readings in NTU (nephelometric turbidity units). Readings as little as 0,5 NTU may be required before accepting the tank for loading methanol.

The tests can be carried out by ship's staff prior to the load port Surveyor's test. Any cloudiness will indicate the presence of hydrocarbons. Further cargo surveyor checks are made when there is a level of one foot of liquid loaded inside the tank and finally when full load samples are drawn, especially with a first loading of methanol.

If the vessel has been in a regular dedicated trade of methanol carriage, there is less likelihood of such tests being carried.

The procedure that ship staff carry is as follows. A test sample of hydrocarbon free methanol is rinsed onto the test surface, such as tank wall or other equipment. The rinse should allow at least one metre of wash. The washings are collected into a Nessler tube. A quantity of 15 ml of wall wash liquid is then mixed with 45 ml of distilled water, shaken and allowed to stand for 20 minutes. The contents of the wash liquid mixture are then compared for cloudiness against a clean sample tube of distilled water.

In case of epoxy coated tanks washed with hot water, a wall wash test carried out in a hot tank a short time after cleaning may not give acceptable results, as the porous epoxy coating can create access to the preliminary coating, which may contain solvents.





Figure 39: Wall wash test.

Source: <http://www.tankcleaning.de/4051-Tank-cleaning-result-tests-tankcleaning-guide.html>

The principle of the Chloride test is that chloride salts, when mixed with a silver nitrate solution give a milky, cloudy effect. Distilled water is rinsed onto the tested surface of the tank or equipment and collected in a Nessler tube. The solution is then filtered using a funnel with filter paper placed on the top of another Nessler tube. The tube is filled to 100 ml with distilled water, and five drops of silver nitrate solution are added. After that, the contents are mixed thoroughly and the mixture in the tube is compared with another tube filled with 99 ml of water, 1 ml of standard chloride solution (1 mg chloride per 1 ml) and five drops of the silver nitrate solution.

The Permanganate time test is used to judge the presence of materials subject to oxidation that may be associated with contamination during distribution and to access compliance with a specification. The test is based on the ability of potassium permanganate ( $\text{KMnO}_4$ ) to oxidize hydrocarbon impurities that could be present in the wall wash liquid. If there is a reaction in a neutral solution, the potassium permanganate is reduced and changes its colour from pink-orange to yellow-orange. The more impurities the faster a change in colour occurs.

The UV-Test is used to identify certain hydrocarbons and chemicals. Many hydrocarbons and chemicals have the ability to absorb UV-light when they are exposed to such light. Certain molecular electrons will get excited if exposed to light. This excitation results in absorbance of light which can be measured. Absorbance at a specific wavelength is a measure for concentration of specific compounds. In a special apparatus called Spectrometer a sample (containing hydrocarbons) and a reference sample (containing just a solvent such as methanol) are exposed to a UV light source.

The Acid Wash Test Method is used to determine the presence of Benzene, Toluene, Xylenes, refined Solvent Naphtas, and similar industrial aromatic hydrocarbons. This test is also used for detecting of impurities in methanol. Compounds which cause darkening in the presence of concentrated sulphuric acid due to carbonization can be detected with this test.

## 6.7. Loading sequence

After opening the shore tank valve and with the ship manifold closed, a sample will be taken at the ship's manifold and inspected visually for any visual impurities, water content and colour of the cargo. If the cargo requires wall wash sampling of tanks, apart from checking the sample visually, a wall wash test of sample will be necessary.

If this sample is correct, ship's manifold can be opened and loading can begin. Loading commences very slowly, examining the system both on-board and ashore for leaks. With these checks completed, and having re-checked that product is entering the specified tanks and no others, the loading rate is gradually increased to the previously agreed maximum

Pump stack samples are important when loading cargoes that require wall wash test. This kind of sampling is made in order to ensure that the cargo lines are clean. The sample is taken near the point where the cargo enters the tank. This drain is before the drop valve, but the sample can also be taken from the drain before the discharge valve. The pump stack samples are checked visually for impurities, water content and colour.

In case of sensitive products, such as ethanol, methanol etc., first foot analysis is recommended. Usually if there are impurities in the tank they will tend to stick to the bottom part. The first foot analysis is being carried out after a level of approx. 1 foot of liquid has been loaded in the vessel tank. This correspond to a small volume, less than 5% of the total tank, but covers a big surface of the total tank area, approx. 30%, so if the tank surface is contaminated, it should show in the first foot analysis. This avoids bigger claims if the cargo is damaged after loading into the cargo tank. After the tank has 1 foot of cargo, loading is stopped. The manifold valve, drop valve and discharge valve are closed. After that, the pump is started and the sample is collected from the first available drain on the cargo line.

The sample is then sent for laboratory analysis. Only when the laboratory analysis passes, further loading can be resumed. In case first foot analysis fails, ship staff should inform the owner/charterer immediately, and resampling has to be carried out, ensuring that the bottles are clean and there are no other sources of contamination such as dirty hands. If the second analysis also fails, the off spec first foot cargo would be required to be discharged. If there are differences between the specifications of the manifold sample and the first foot sample, the owner has to bear the costs of the cargo, as well as the delays. Having a tank cleaned to the required standards eliminates the possibility of a failed first foot analysis.

The vessel is fully responsible for cargo operations on board. The duty officer on deck has to make regular checks to ensure that the product is being loaded in the correct tanks and that there are no leaks in the pump room. Every two hours, or at more frequent intervals if smaller parcels are being loaded, details of loading rate, pressure and temperature must be entered

into the log sheet (pumping log). At the same time, vessel confirms with the terminal the amount of product transferred in the last two hours. The amount received by the vessel is particularly important where the pipelines extend for considerable distances underground, as this is one way of determining if there is a possible line leak. The vessel or shore must advise when tank changes are anticipated. Before the time for changeover occurs, the vessel must ensure that the valves on the next tanks to be loaded will open easily. Loaded tanks are re-checked to ensure that there is no seepage through a leaking isolation valve. Slop tanks are checked at frequent intervals. It is possible for a drain valve to be leaking and filling up these tanks.

In case of products that have to be loaded at a certain temperature as per Charter Party, regular temperature checks will be carried out.

Ship and shore operators make periodic checks for possible oil pollution on both sides of the vessel, particularly when the vessel is discharging permanent ballast, clean ballast or heavy weather ballast.

Loaded tanks have to be checked to ensure that valves are closed tight and that the level of cargo remains steady. The loading rate has to be reduced as tanks are topping off, in order to avoid any spillage and to allow topping off in a controlled manner, under the Chief Officer's direction.

The terminal always stops the flow on completion of loading, not the vessel by shutting its manifold valve.

## **6.8. Completion of loading**

When the shore tank is empty, the surveyor certifies it by visually inspecting it. Loading is completed after blowing the line with air or nitrogen. Upon completion of loading, the Surveyor together with the Chief Officer will take two sets of samples from all the tanks loaded with product. One set will be handed to the Captain upon signing a document of samples receipt. After taking the level measurements, the quantity of loaded product will be calculated, and the cargo documents will be completed. The Surveyor is informed about the vessel's draft in order to calculate the vessel's list and trim and the total received quantity using the ship's cargo tank calibration tables provided by the vessel. The values in the tank calibration tables are not always mathematically exact, hence the difference between shore and ship figures. The total received quantity will be reconciled with the shore terminal figures found on the Bill of Lading. The difference between the ship and shore figures must not be in excess of +/- 0,5% of the

cargo. The Vessel Experience Factor (VEF) can be applied to assist in the reduction of the difference between the ship and shore figures. Normally, the ship's figure is calculated using the units found in the ship's tank calibration tables converted in the required units in the B/L. The calculation will be recorded in an Ullage Report, which will include the following information: ship's name, port and berth, drafts, date/time loading commenced, date/time loading was completed, identification of tanks by number, grade of cargo loaded into each tank, observed ullage, trim/list correction, corrected ullage, total observed volume (TOV), free water dip, amount of free water, temperature, gross observed volume (GOV = TOV – free water), temperature, volume correction factor (VCF), gross standard volume (GSV = GOV multiplied by VCF), total calculated volume (GSV + free water). Once the volume calculated, it can be reconciled to a tonnage figure for the Bill of Lading.

### **6.8.1. Bill of Lading**

The Bill of lading serves three main functions:

- It is a conclusive receipt, an acknowledgement that the goods have been loaded
- It contains or evidences the terms of the contract of carriage
- It serves as a document of title to the goods

A Bill of Lading is always negotiable. The three originals and one set of B/L copies are issued at the port of loading. The weight of the loaded cargo is declared as per the shore figures.

A B/L marked "Freight Prepaid" must never be signed without the clear instructions of the Ship Management Company or Operator. Before acceptance of the Statement of the B/L by a Master's signature, following must be checked carefully:

- Cargo destination and weight
- Bill of lading number
- Date of issue (always the date of loading completion)
- Charter party date (as per statement of voyage order)
- Ship's particulars (name, flag, Master's name, etc.)
- Method of payment for freight: freight as per C/P, freight prepaid, collect freight, other
- Correct port of discharge
- Cargo comingling clause

The three B/L originals should be signed personally by the Master. All other copies will be stamped "Copy Non Negotiable".

A blank B/L must never be signed. In special circumstances, on receipt of permission from the ship management company or with the operator's permission, the ship's agent may be authorized to sign the completed B/L on behalf of the Master.

Usually, two sets of cargo documents are carried on-board, the Master's copy and the receiver's copy. The Letter of Protest against the original B/L remains on board for transportation to the receiver.

### **6.8.2. Time Sheet**

A time sheet (TS) is completed for each cargo grade loaded or discharged and all relevant facts and times concerning loading or discharging are recorded. The TS is the basis for lay-time calculations and has to be signed by the shipper, receiver (usually the Loading Master), agent and the Master.

The agent sends these important documents by e-mail/fax to the Ship Management Company or Operator immediately.

### **6.8.3. Loading Set of Cargo Documents**

The various cargo documents to be passed to the receiver in the port of discharge include:

- Cargo quality certificate
- Cargo quantity certificate
- Certificate of origin
- Heating instructions
- Inhibitor certificate
- Cargo Manifest
- Receipt of documents
- Vessel experience factor
- Tank history
- Ullage report
- Sample receipt
- Custom papers

The papers destined for the receiver are given against receipt, either to the Loading Master or the agent in the port of discharge.

### **6.8.4. Cargo discrepancies Loading**

#### Ship's figures less than shore figures

The ship's figures must be rechecked and, if the shortage remains, a Letter of Protest must be issued. In case of the difference exceeding 0,5%, the vessel's operator has to be notified

before signing the B/L and wait to receive clear instructions on the next action, which can be one of the following:

- Notification of the P&I local representative
- Signature of a Letter of Authorization for the Agent, to authorize him to sign the B/L after the vessel's departure
- Signing the B/L endorsed with the operator's remark

#### Ship's figures more than shore figures

Following actions will be done:

- If the difference is more than 0.25%, ship's figures must be rechecked
- The B/L can be signed without any reservation and without any written protest if the difference is less than 0.5%
- If the difference exceeds 0.5%, the vessel's operator must be notified
- Unless a proper order is received from the vessel's operator, a Letter of Protest shouldn't be issued.

#### Short Loading

A Short Loading Protest (SLP) is issued if the quantity of cargo nominated for loading in the NOR is not loaded on-board as per the figures in the B/L. The SLP must be tendered to the shipper via the agent. If an SLP is issued, a report should be made to the Operator. The SLP will not be issued if the vessel is fixed with a LUMPSUM freight unless the Charter Party stipulates a minimum quantity.

#### **6.8.5. Letter of Authorization (LOA)**

The LOA must be issued to the agent if the shore figures and the B/L are not available on-board before departure from the load port. This authorization should be limited to the signature/release of the Bill(s) of Lading when all details including quantity and quality have been approved by the vessel's operator/owner. The LOA should be issued for each grade of cargo to be loaded.

#### **6.8.6. Early departure procedure**

The early departure procedure can be employed when the vessel requires to sail before the final Bill of Lading figure is available, enabling quicker turnaround. Accurate cargo measurement is of fundamental importance in this case. In case the vessel requests early departure procedure before arrival to port, the agent completes the B/L, Cargo Manifest and

all other paperwork in advance, excluding the actual cargo figures. The ship's agent hands the documents to the Captain, who signs and retains the ship's copies and any for the consignee that are to be carried on-board. The agent will return the balance of the signed documents to the supplier, who completes the final cargo figures after loading and sends them by courier, as per the consignee's instructions. After loading has completed, the Captain sends the ship's cargo figures to the supplier. On receipt of the supplier's preliminary gross quantity figures, the Captain compares them as a ship/shore percentage: if the percentage is greater than 99,80% the ship could sail. If the percentage is between 99,50% and 99,80% the ship should recheck its figures. If the percentage is less than 99,50%, the ship should recheck its figures and request the terminal to do the same. Rechecking of figures can be done alongside the berth or at anchorage. After sailing the vessel will receive the final load figures by fax/e-mail.

#### **6.8.7. Disconnecting after loading**

Disconnection of manifolds and hard arms or flexible hoses should be done after completion of the cargo calculations. Safety precautions during disconnections must be respected.



Figure 40: Tanker vessel manifolds.  
Source: <http://www.chemicaltankerguide.com>

The vessel selects a slack tank and leaves the tank and manifold vertical drop valves open. With hard arms, the shore arm commences draining to the jetty slop tank, and by operating the vacuum breaker on the outer arm, allows the contents to flow into the vessel. When using hoses, the hose is raised to the highest elevation, a vent on the manifold is opened, and draining commences. Drip trays should be available for the final disconnection.



## **CHAPTER 7: DISCHARGE OPERATIONS**

### **7.1. Preparation for discharge**

Shore and ship preparation for discharge is similar in most aspects to the preparation for loading. Special precautions must be taken by the terminal when the shore tanks are at a higher elevation than the vessel, to avoid incidents in which the contents of the shore tank could flow back to the ship and causing overflow. Usually, terminals use non-return valves in their import systems.

The discharge plan must be agreed at the initial meeting on-board the ship. On arrival, a responsible ship's officer together with a terminal official and a cargo surveyor will measure and sample the product in the vessel tanks. The ship's officer is responsible for ensuring that all safety regulations relevant to cargo are complied with. On commencing discharge, the vessel will use one pump at minimum rate, while the system is checked for leaks on-board and ashore. When terminal confirms they are receiving the product into the specific tank, then the previously agreed discharge rate may begin. Two-hourly checks on quantities discharged should be compared with the terminal's calculations of receipt. Cargo manifolds assigned for discharging must be properly identified with the labels of the substance(s). The discharging plan, including planned stoppages, maximum pressure, rate of discharging, discharge sequence, emergency procedures, prewash, steaming and blowing must be agreed with the terminal representative.

The Cargo Ballast operation plan must be issued and properly explained to the watch officers and they must formally acknowledge their understanding by signature.

The Notice of readiness procedure is the same as for Loading. The receiver's set of samples from the loading port must be tendered to the receiver against the sample receipt. Samples of the cargo are taken by the receiver's representative before discharge commences. On arrival the Captain will hand all the relevant documents (cargo documents, customs documents of the cargo) to the receiver.

The original Bill of Lading, duly endorsed by the Receiver (the Loading Master on behalf of the receiver) has to be submitted to the Master prior to commencing discharge. Before the start of discharge operations, the consignee will present an Original B/L duly endorsed, through the agent, certifying that he is the correct receiver of the cargo.

If an Original B/L cannot be submitted as the vessel arrives, the Ship Management Company or Operator must be informed immediately and their instructions acted on. However, the cargo

can be discharged against a Letter of Indemnity (LOI). In this case a Charterer's LOI will guarantee to hold the vessel or its owners free of responsibility for the consequences of cargo delivery without an original B/L. Another option is that the cargo could be discharged into a customs bonded storage facility, from which it can be released only on submission of the B/L original or LOI.

A B/L original, produced to the Master by the receiver must be marked with an appropriate note of payment.

## 7.2. Discharging equipment

The vessel's discharge performance is affected by the following:

- Type of cargo pump
- Density and viscosity of the cargo
- Limitations established by the receiver
- Back-pressure from the shore
- Diameter of the shore line
- Length of the shore line
- Elevation of the shore tanks
- Availability of booster pumps ashore and their capacity rate
- Cargo level in the ship's tanks

Loading and discharge movements on board a tanker are carried out by two means: by gravity, taking advantage of the level difference between tanks, and through pumps. The main pump types used in tankers are displacement pumps and centrifugal pumps. The number of pumps and their capacity are proportional to the vessel's deadweight. These pumps are equipped with control instruments and repeaters inside the cargo control room: manometers, thermometers and tachometers. The pressure is measured in  $\text{kg/cm}^2$  and the flow is measured in  $\text{m}^3/\text{hour}$ .

### Displacement pumps

Displacement pumps function by displacement of the liquid inside the pump. Examples: piston pump and screw pump. A pipeline system equipped with displacement pump must have a safety valve and bypass line to protect the discharge line. Piston pumps and screw pumps have excellent suction properties, but any deterioration of the cargo pipework will cause a reduction in the discharge rate.

Displacement pumps are allocated to groups of tanks, normally one pump per group. The suction and discharge valves of a positive displacement pump must always be open before

starting the pump and must remain open until it's stopped. Activation of the overspeed trip of these pumps must be avoided and particular care and attention must be taken when the cargo level in the tank is reduced to the final 0,5 m of liquid. At this point the pump's speed should be reduced.

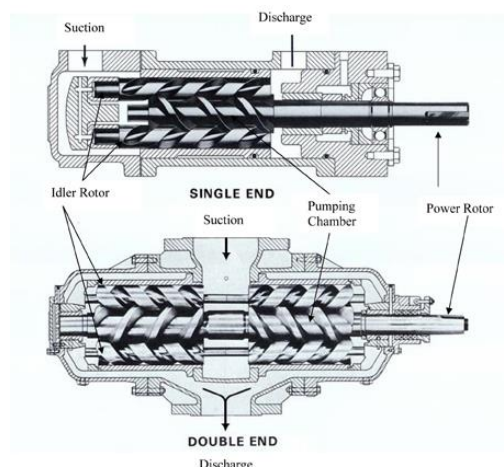


Figure 41: Displacement pump – screw type.  
Source: <http://www.chemicalprocessing.com>

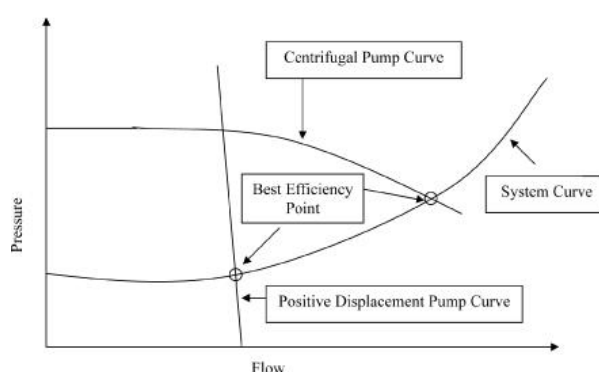


Figure 42: Pump comparison diagram.  
Source: <http://www.chemicalprocessing.com>

### Reciprocating pumps

Reciprocating pumps are positive displacement pumps moved by vapour. They are connected to a valve box and the pumping is carried out through an oscillating movement of a piston inside a cylinder active on both ends: simultaneously suctioning and discharging, opening and closing the corresponding valves inside the box. This effect is generated in both directions of movement of the piston. These pumps reach high pressures and are self-primed, being equipped with shock absorbers to cushion the oscillations in the discharge pipelines and avoid liquid knocks that could damage discharge hoses or arms. These pumps are used for stripping, and when they're unprimed they start hitting, so it's convenient to reduce revolutions

in order to help the liquid reach the suction pumps. When working with viscous liquids, its operation is not efficient.

### Submerged deepwell pumps

Submerged deepwell pumps are used when an individual pump is required in each cargo tank. These pumps are either hydraulically operated or electrically powered. The electric pumps have a motor mounted, that actuates the centrifugal pump on the ceiling of the tank, while the suction tube descends through to the tank bottom, where the drive device is situated. Hydraulic pumps are submerged in the interior of the tank. These pumps are used in some chemical and gas tankers, one pump and line for each tank, ensuring product separation and avoiding cross contamination, at the same time leaving the tanks dry. These types of ships are not provided with a pumproom.

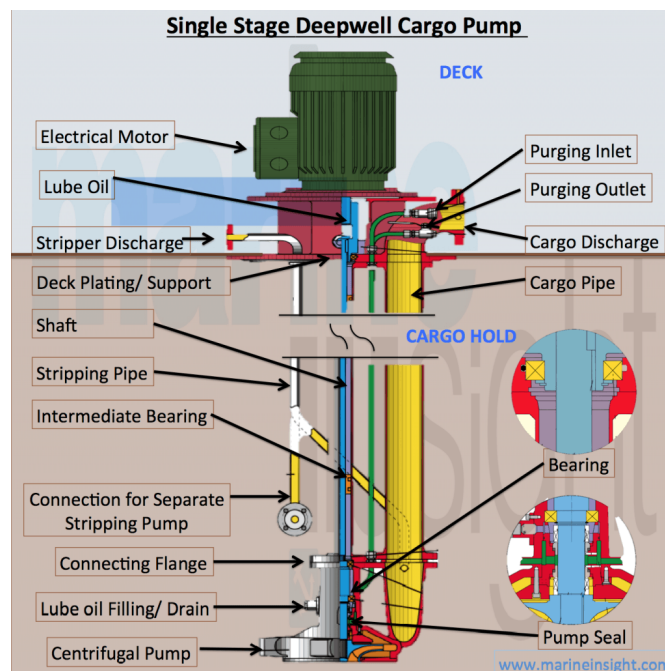


Figure 43: Electrically operated submerged deepwell pump.  
Source: <http://www.marineinsight.com>

Compared to hydraulically driven deepwell pumps, electrical pumps have several advantages:

- Higher system efficiency
- Lower noise levels
- Electrical wiring is easier to install than complicated hydraulics
- Clean external system, no hydraulic leakage
- Less maintenance needed

The pump stack has two pipes. One is the discharge pipe for the cargo and the other is an enclosure for the intermediate drive shaft, shaft bearings and lubricating oil. As the drive shaft is lubricated, the pump can run at high speeds and will not run dry during cargo stripping or tank cleaning operations.

The pumphead is designed with a seal arrangement to segregate the cargo from the lubricating oil. Between the two secondary seals there is an atmospheric drainage chamber, called a “cofferdam”, which acts as a safety barrier between the oil seals and the cargo seals. Any leakage that might occur will be collected in the cofferdam. The cofferdam is connected to the main deck by means of two purge lines. The contents of the cofferdam can be blown out and collected on deck by purging the cofferdam with air or nitrogen.

A portable submersible pump is normally supplied for use as an emergency cargo pump in the event of failure of the main cargo pump. This pump is lowered through a tank cleaning hatch directly into the required tank.

### Centrifugal pumps

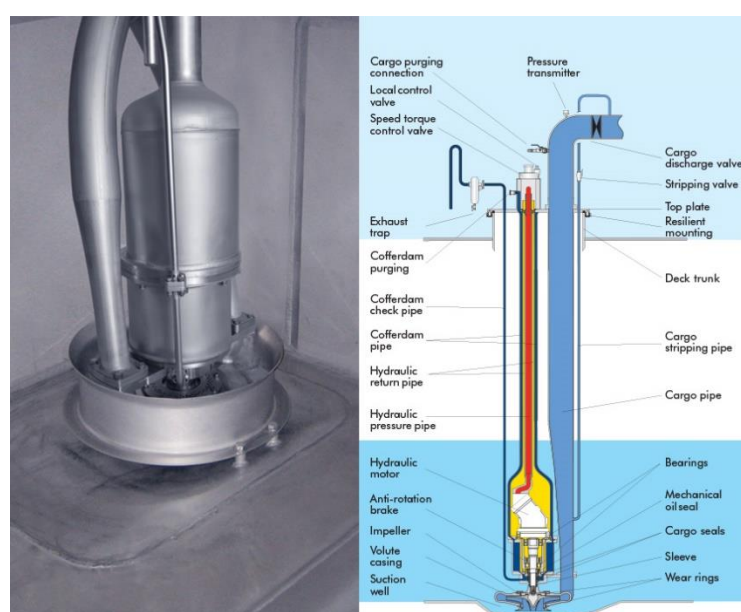


Figure 44: Centrifugal pumps.

Source: [www.framo.com/cargo-pumping-systems/cargo-pumping/submerged-cargo-pumping](http://www.framo.com/cargo-pumping-systems/cargo-pumping/submerged-cargo-pumping)

Kinetic pumps increase the liquid's velocity through the pump. An example is a centrifugal pump, where the rotating impeller's propulsive force creates suction and centrifuges the liquid outwards to the discharge line. An advantage of the centrifugal pumps is the absence of overpressure, but the lack of self-priming capacity and the difficulties when discharging high-viscosity liquids can cause problems.

The flow of the liquid to and from the pump must be matched exactly and this requires the flow on the suction side to be equal or greater than the discharge rate of the pump. When the flow to pump suction falls below the pumping rate, cavitation of the pump will occur, with the possibility of a loss in suction and pump damage.

As centrifugal pumps cannot generate a total vacuum at their suction inlet, only a proportion of the atmospheric pressure can be usefully employed. Therefore, before a pump can operate satisfactorily, a certain pressure must exist at the pump suction inlet.

### Automatic stripping systems

The automatic systems are actuated by the main pumps and it's not necessary to operate any stripping pump. The most common system are the prima vac and the self-stripping system.

The prima vac system consists mainly of a couple of valves mounted on the discharge pipelines, preset at a predetermined pressure and a tube that links the discharge to the suction of the pump. When the discharge pressure drops, the valves close and the liquid is led to the suction of the pump. When it primes again, the discharge pressure rises, the valves open, and the discharge process continues.

The self-stripping system has an aspiration hood mounted after the filter, which contains level sensors. A tube leaves from the upper part of the hood, directed to eductors or vacuum pumps connected by a branch to the atmosphere, with its corresponding valve. In the drive line of the pump, a smaller diameter line with automatic valve creates by-pass to the main discharge valve, connected to the main line before and after this valve. The level sensors installed inside the suction hood command the start or stop of the eductor or vacuum pumps, and the complete opening or closing of the bypass valve simultaneously to the complete closing of the main discharge valve. When the liquid level inside the hood lowers, the eductors or vacuum pumps are started in order to extract the air or gas from inside the hood and make the liquid level rise. At the same time, the main discharge valve is closed and the by-pass valve begins working, continuing to discharge through its smaller diameter line until completion. The opening or closing of this valve is controlled at all times by the level of liquid inside the hood. It is recommended to open the valve of the branch that connects to the atmosphere before the start of discharge, until the aspiration hood is filled with product. After that, the valve can be closed until completion. Eductors do not have mobile parts, and consist of two cone trunks united at their lower surface bases through a short cylinder, where the suction tube enters (Venturi tube). Its working principle is based on Bernoulli's principle on fluid dynamics. They are used for various applications: tank stripping, self-priming of the pumps, on the semi-dry seals of inert gas etc.



### 7.3. Cargo surveys, sampling and calculations before discharge

When receiving the nomination for cargo survey, the inspection company will:

- Request the analysis reports from the Inspection Company that has supervised the cargo loading operations in the port of loading, in order to prepare the file and to verify that the product that has left the port of origin complies with the characteristics and terms agreed upon in the contract
- Prepare the equipment that will be used for taking the samples: bottles, caps etc.
- Keep in contact to the vessel's agent to know the ETA and the berthing and operational prospects

The Cargo survey company is also responsible for the inspection of the shore tanks, to assure that these are appropriate for storing the product discharged from the tanker vessel.

After completing all the briefing procedures with the Chief Officer and Loading Master, the Surveyor shall proceed to carry out the sampling procedures, while the Terminal operator proceeds with connecting the hoses to the ship's manifold. The Surveyor accompanied by the First Officer and another member of the crew proceed to open all tanks transporting the product to be discharged.

Before beginning the sampling process, the Surveyor must verify that there is no product coming out of the tank, as this could cause contamination. For this, a check of the valves of the tank is necessary.

When taking samples manually, the surveyor submerges the probe tape by sliding it until it touches the bottom of the tank. The probe tape must be unwind slowly from the start, submerged so that it makes direct contact metal to metal, in order to avoid possible risks of electrostatic discharge. The tape should remain submerged, touching the bottom of the tank for 5 to 10 seconds. In order to avoid wrong measurements it is necessary to raise the tape very slowly at first. The measurements from the tape are written down.

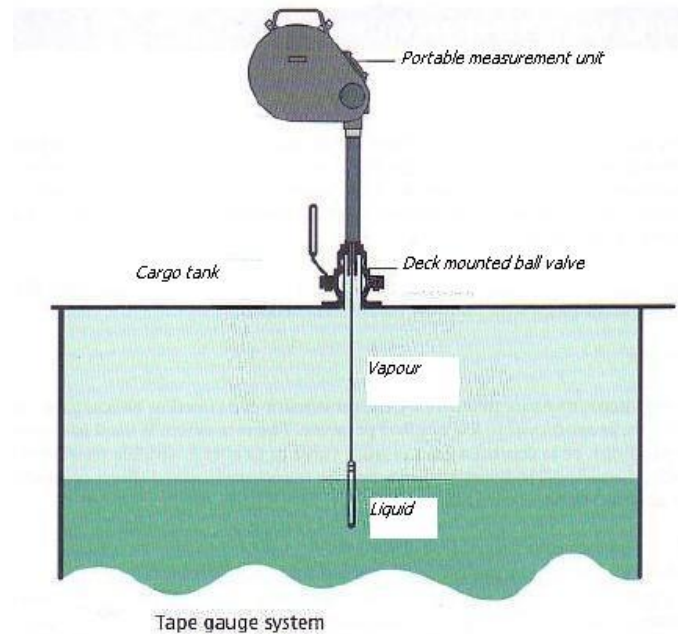


Figure 45: Gauging instrument.  
Source: [www.chemicaltankerguide.com](http://www.chemicaltankerguide.com)

After probing, a thermometer is introduced in order to know the temperature of the product. This is because the volume of petroleum products is always related to its temperature, since it increases upon heating.

The temperature of the product may not be uniform in the same tank, so several temperature readings will be taken at different probe heights.

Once the temperature and volume measurements are completed, the Surveyor continues with sampling. Each element of the sampling process must be clean to such an extent that it does not contaminate the sample. For example, the sample bottle must be clean, dry and free of moisture. For this, the container is rinsed with the same product, without touching the mouth of the container with the hand to avoid ingress of particles. The Surveyor takes all necessary precautions not to contaminate the product. People involved in the sampling process must wear clean latex gloves while sampling.

There are different sampling methods, same as for gauging: open, restricted and closed. For each product, chapter 17 of the IBC Code mentions the gauging-sampling method that should be used.

Open gauging is with a device that makes use of a pipe opening in the tank or tank hatch, potentially exposing the Surveyor to the cargo or its vapour. An example of this is the ullage opening.

Restricted gauging uses a device that penetrates the tank. When in use, this allows a small quantity of cargo vapour or liquid to be exposed to the atmosphere and, when not in use, the

device is completely closed. Its design ensures no dangerous escape from the tank contents (liquid or spray) can take place when the device is opened.

Closed gauging uses a device that penetrates the tank and prevents the release of tank contents. Ex.: float-type systems, electronic probe, magnetic probe and protected sight-glass. Alternatively an indirect device can be used, that does not penetrate the tank shell, independent from the tank (ex. A pipe flow meter).

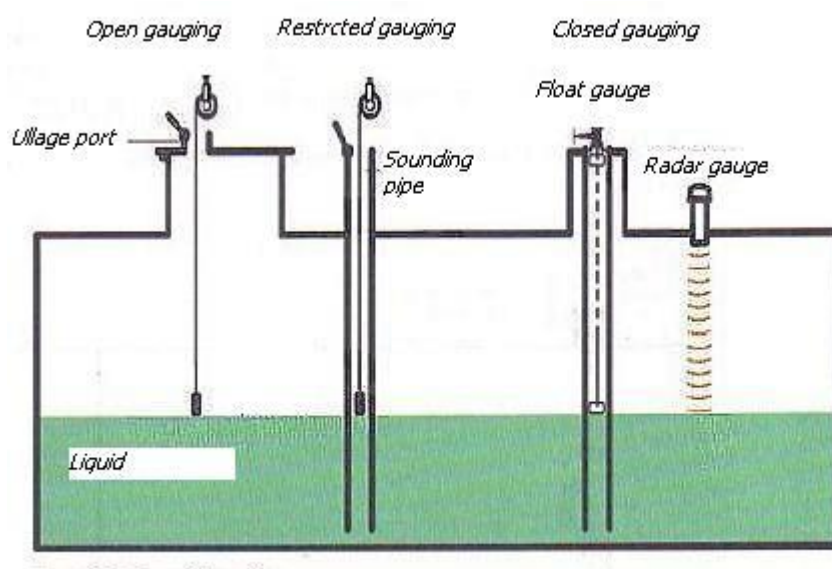


Figure 46: Gauging methods.  
Source: [www.chemicaltankerguide.com](http://www.chemicaltankerguide.com)

Once the sample is obtained, it is labelled so that there will be no confusion of the tank which it corresponds to. In case of any anomaly, the extraction is repeated. The containers used in the sampling are filled up to approximately 80% of their capacity to avoid further stresses due to product dilation.

This operation is repeated for every tank with product to be discharged. When samples are taken at source, two additional samples identical to those analysed are taken, which will be sealed and kept in custody by the Inspection Company in case they may be required for further analysis.

Depending on where they are taken, samples can be stored in different types of containers:

- In case of samples taken when discharging/loading a vessel's tanks, transparent glass bottles of 0,25 / 0,50 / 1 l are used
- For samples taken for clients, transparent glass or plastic bottles can be used, the capacity and type being indicated by the client

Depending on the vessel Operator's policy, the samples are kept on board for a certain period of time. Most policies allow sample disposal after 6 months of discharge, as no claim for cargo

damage can be made upon this period, as per industry practices. It is important to keep records of all sampling activities on board, in a sample log.

When Sampling LPG, samples are taken from LPG tanks using sample bombs. Most LPG carriers have sample points at 25%, 50% and 75% tank levels.

Different methods of calculation for various substances can be applied, but they must be similar for loading and discharging. The calculation method must be agreed with the Surveyor. The range of substance temperatures (port of loading and port of discharge) have to be taken into consideration. Based on the probe obtained and using the calibration tables of the tank, the volume in litres is calculated. It is important to add the litres stored in the pipes, if they exist. An average temperature is calculated based on the temperatures obtained.

#### Calculation with Specific Gravity

The specific gravity (SG) given at the port of loading cannot be used directly with the observed volume of a cargo. It must be first corrected according to the density in the air at the observed temperature, using a correction factor. The resulting density in air will be used to convert the volume of cargo to Metric Tons.

Example:

SG at 20/25 = 0,08250

Correction factor per 1deg C = 0,000081

Observed volume of cargo = 900,000 m<sup>3</sup>

Cargo Temperature = 30 °C

SG at 25/20 = 0,08250

Density at 25 °C in vacuum (0,8250 x 0,9970) = 0,8225

Correction factor for density in air at 25 °C = -0,0011

0,8214

Correct density to observed temperature (30 °C) = -0,000405

25 °C – 30 °C = 5 x (-0,000081)

Density in air at observed temperature = 0,8210

Metric Tonnes = 900 m<sup>3</sup> x 0,8210 = 738,900 MT

### Calculation with density

It must be stated whether an advised density is in vacuum or in air. Density is always given for a specific temperature, either in vacuum or in air.

Following may be received at the loading port:

Density at 20 °C = 0,8605

Correction factor per 1 °C = 0,00042

The density in vacuum must be corrected by subtracting the factor 0,0011

Example:

Density at 20° C (vacuum) = 0,8605

Corr. Factor per 1 °C = 0,00042

Observed volume m<sup>3</sup> = 900,000

Observed temperature °C = 30

Density at 20 °C (vacuum) = 0,8605

Corr. Factor for density in air = -0,0011

Density at 20 °C in air = 0,8594

Correction to observed temperature = 10 x (-0,00042)

Density at observed temperature in air = 0,8552

Conversion to metric tonnes = (900,000 m<sup>3</sup> x 0,8552) = 769,680 MT

### Calculation with API Gravity

Petroleum products and lubricating oils are usually calculated with API Gravity. The API Calculation is based on a measured volume at a given temperature, converted to volume at the standard temperature using the volumetric correction. This corrected value is called Standard Volume. Using the Standard volume and the product density at the standard temperature the mass of the product is determined.

Procedure: The volume and the temperature of the product in a vessel's tanks are measured. The Total Observed Volume (TOV) should be corrected (listing, underlying water, trim etc.).

The corrected volume must then be reduced to the volume at the standard temperature (Gross Standard Volume - GSV). To translate the Observed Volume into the standard volume, should be used the Volume Correction Factor (VCF), which can be found in the ASTM tables.

The obtained value of Standard volume is multiplied by the product's density. This determines the product's mass. The volume Correction Factors are selected from the ASTM tables appropriate to the type of product.

The surveyor will issue an Ullage Report with the calculated quantity. The quantity found will be reconciled against the B/L and the ship figures after loading.

In case of discharge of products that require product analysis, discharge will not commence until analysis is completed, and the results are satisfactory. In case analysis results are not compliant, the process will be repeated. When the Surveyor has all the samples that have to be analysed, the samples are taken to the laboratory. If the analysis results are correct, the Surveyor authorizes the discharge to commence, otherwise he returns to the ship and repeats the sampling operations, taking further precautions to avoid product contamination and sends the new sample to the laboratory so that a new analysis could be performed. If the results of the second analysis are correct, discharge can begin. In case the second analysis is not compliant, the samples loaded in the port of loading are opened and taken to the laboratory to be analysed. While waiting for the result of the analysis, the Surveyor informs the Client of the event and receives the operational instructions regarding that contaminated tank. With the result of the analysis of the origin sample, in case the results are not matching, the Surveyor prepares a Letter of protest, where he presents what has actually happened. The Chief Officer will have to present this Letter of Protest whenever this is requested. The Letter of protest must be signed by the Captain / Chief Officer, who will keep a copy and give another copy to the agent and to the Surveyor. The C/O must present this Letter of protest each time this is requested.

The Surveyor can take two additional samples, one at the vessel's manifold and one just before the connection between the shore hose and the terminal pipeline. If all the samples are correct, discharge is authorized and can begin.

#### **7.4. Discharging sequence**

First, the shore tank valves will be opened. Subsequently, following valves will be opened on board in sequence: tank suction valve, intermediate valve, pumproom master valve, intermediate valves to suction pump, pump valves and all the other valves, leaving only the shore connection valve closed. When the terminal advises that it is ready to receive cargo, the pumps will be started, and when they reach the required pressure, the shore connection valves can be opened.

Every hour, the discharge pressure is noted in the pressure log.

An operator must be present at all times in the berth, to supervise the operations at the berth and check the following: connection and disconnection of hoses, the correct positions of the hoses and absence of liquid losses at the connection, hourly control of pressure values,



supervision of operations and reporting to the Loading Master, access control to the berth, communications between terminal and vessel. During cargo operations, bunkering and loading supplies from shore are usually not permitted. The Operations supervisor inside the terminal controls that the product reaches the shore tank and once the liquid height in the tank is approx. 25 cm he informs the vessel that the pressure can be raised. When there is a sufficient level of product inside the tank, one terminal operator takes a sample from inside the tank and carefully inspects it visually. If the sample is correct, the sample liquid is put back into the tank. When the shore tank is about to be filled, an operator will check that the level inside the tank is at the exact mark where it should be, while the vessel tank valve from the pumproom is being closed gradually. If the shore tank is full and there is still product left in the ship's tank, the shore tank valve is closed, and the valve of the next shore tank is opened. Upon that, the ship's valve can be opened. When the liquid level in the shore tank is getting close to the agreed quantity to be discharged, the Terminal Supervisor informs the vessel to lower the pressure.

The final stage in bulk liquid pumping from a tank or pipeline is called stripping. Stripping of cargo tanks should be performed as per the guidance in the vessel's P&A manual and with regard to the manufacturer's instructions. During tank stripping and line clearing, the ship's list and trim must be maintained within the guidances in the P&A manual.

As the cargo level approaches the bottom of the cargo tank, if left unattended the cargo pump would periodically lose suction through insufficient cargo flow to the pump. This is known as cavitation.

The pump's speed should be reduced, and in this way the discharge capacity will stabilize. The cargo pump will steadily continue to strip the cargo tank. Stripping can be effectively transferred into another cargo tank prior to discharging ashore, resulting in a quick and efficient strip.

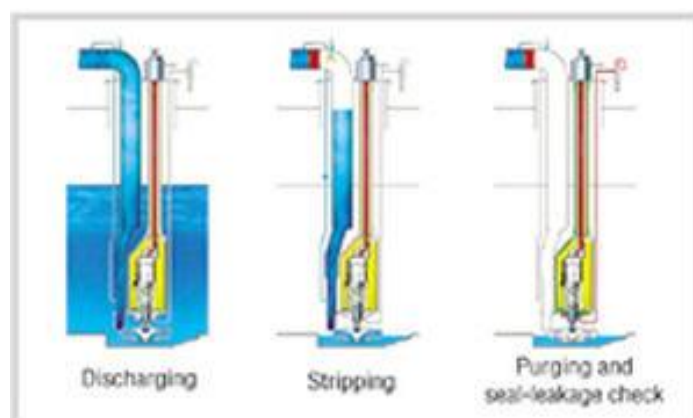


Figure 47: Discharging – stripping - purging.

Source: <http://www.nauticexpo.com/prod/hyundai-marine-engines>

When the cargo tank is empty, the cargo stripping valve has to be opened and the main cargo valve closed. The remaining cargo left in the main cargo pipe is purged by means of inert gas or compressed air, via the stripping pipe into the cargo line on deck. During the purging/stripping procedure the pump should be kept running until the cargo pipe has been purged empty. This procedure guarantees a minimum amount of cargo remaining in the pump well.

After purging the cargo pump and the pressure line up to the discharge valve, the remaining cargo line must be emptied. The compressed air or inert gas should now be admitted into the cargo line. The pressure medium will expand and push the remaining cargo through the stripping connection, close to the cargo pump barrier to the manifold connection. The manifold connection is normally located outboard of the manifold barrier and is equipped with ball valves.

Upon completion of discharge, the shoreline should be blown with nitrogen, pressure, air or steam, to empty the line and safely disconnect. On completion of discharging of any solidifying substances and/or high viscosity substances such as paraffin wax, the ship's lines should be blown with steam into the cargo tanks. The ship's line cleanliness depends on the duration of the steaming.

On completion of discharging the agreed quantity of product, the terminal informs the Surveyor that the product was correctly discharged. The Surveyor comes on board and checks that the vessel's tanks are empty, or that they contain product to the specified level (ROB quantity – Remaining on board). An Empty Tank Certificate or an Ullage Report on completion of discharge is completed and signed by the surveyor. The difference between the ship's figures before discharge and the ROB quantity provides the vessel's discharge figures. This is checked against the total received by the terminal and any difference between shore and ship's figures must be reconciled. At each stage of the cargo operations involving ship and terminal, Letters of Protest will be issued if the figures between the ship and shore are not resolved within the acceptable limits allowed.

While vessel is preparing for hose/arm disconnection, the Surveyor and the Loading Master take samples from the shore tanks, which are taken to the laboratory. The level probes taken are analysed in order to calculate the total quantity of discharged liquid, which will be informed to the client. Meanwhile, the berth operator connects a nitrogen hose to the discharge hose valve, to empty the hose using nitrogen.

For shore pipeline cleaning upon discharge/loading, a special device called PIG is used. This device is inserted in the shore line at the berth by opening the valve that is used when connecting the hose for discharge/loading. It is important that the PIG's diameter and the line's inner diameter are equal. At the terminal end of the line, the PIG receptor valve is opened, as well as the tank entry valve. At the berth end of the pipeline, the PIG housing is connected to the nitrogen system and the nitrogen valve is opened gradually. When the desired pressure is reached, the receptor valve is opened and the PIG device is launched. The operator present at the shore tank will close the tank valve when hearing the noise made by the PIG hitting blind flange of the receptor end. The berth operator closes the nitrogen supply, the PIG housing is then being depressurized and then the blind flange and the PIG device extracted.

Before disconnecting the hoses or arms, the drain taps of the ship's manifold should be drained into fixed or portable drainage trays, with the vent valves of the land lines open. After being disconnected, the manifolds and loading arms or hoses should be covered securely. The contents of the portable dripping trays should be emptied into a slop tank or other container.

At the end of discharge following documents will be issued:

- Time Sheet with all relevant times, from vessel's arrival to estimated time of departure
- Empty tank certificate/Ullage report on completion of discharge
- Pumping Log
- Letters of Protest (if any)

Together with the ullage reports on arrival, the Notice of Readiness and other relevant documents, these will be handed or sent by e-mail by the agent to all concerned parties: vessel's owner, charterer, shipper, receiver, cargo inspectors, cargo brokers etc.

## **7.5. Particular case: Tank prewash**

### ***7.5.1. IMO regulations regarding mandatory prewash***

Prewashing is a preliminary cleaning method carried out to reduce the amount of cargo remaining in the tank and piping system. The prewash does not aim to clean the tank for ballasting or loading purposes.

MARPOL states that: the government of each Party to the convention shall appoint or authorize surveyors who shall execute control of, for instance the unloading and prewash in accordance with control procedures developed by IMO. The surveyors shall as a minimum

endorse in the Cargo Record Book entries of prewash operations. The ship may receive exemptions from mandatory prewash. In such a case, the exemptions shall also be endorsed by the Surveyor. On request of the master, the government of the receiving party may exempt the ship from the requirements of prewash when one of the following occur:

- Unloaded tank is to be loaded with the same substance or with another substance compatible with the previous one and the unloaded tank will not be washed or ballasted prior to loading
- Unloaded tank is neither washed nor ballasted at sea and the tank is prewashed and resulting washings are discharged into a reception facility at another port, provided that it has been confirmed in writing that a reception facility at that port is available and adequate for such a purpose
- The cargo residues will be removed by ventilation

MARPOL's Annex II specifies a mandatory prewash for many substances. For the purpose of the regulations of this Annex, noxious substances are divided into four categories as follows:

Category X: Noxious liquid substances which, if discharged into the sea from tank cleaning or deballasting operations, are deemed to present a major hazard to either marine resources or human health and, therefore, justify the prohibition of the discharge into the marine environment

Category Y: Noxious liquid substances which, if discharged into the sea from tank cleaning or deballasting operations, are deemed to present a hazard to either marine resources or human health or cause harm to amenities or other legitimate uses of the sea and therefore justify a limitation on the quality and quantity of the discharge into the marine environment;

Category Z: Noxious liquid substances which, if discharged into the sea from tank cleaning or deballasting operations, are deemed to present a minor hazard to either marine resources or human health and therefore justify less stringent restrictions on the quality and quantity of the discharge into the marine environment

Other substances: Substances indicated as OS (Other substances) in the pollution category column of chapter 18 of the International Bulk Chemical Code which have been evaluated and found to fall outside category X, Y or Z because they are, at present, considered to present no harm to marine resources, human health, amenities or other legitimate uses of the sea when discharged into the sea from tank cleaning or deballasting operations. The discharge of bilge or ballast water or other residues or mixtures containing only substances referred to as "Other Substances" shall not be subject to any requirements of the Annex.

Category	BCH Ships Constructed before 31/7/1986	Existing IBC Constructed from 31/7/1986 but before 1/1/2007	New Buildings Constructed from 1/1/2007	Ships Other than Chemical Tankers constructed before 1/1/2007
X	Pre Wash Strip to 350 Litres 12 mile 25m water depth 7 knots, en-route	Pre Wash Strip to 150 Litres 12 mile 25m water depth 7 knots, en-route	Pre Wash Strip to 75 Litres 12 mile 25m water depth 7 knots, en-route	Carriage Prohibited
Y	Pre Wash for solidifying for high viscosity substances Strip to 350 Litres 12 mile 25m water depth 7 knots, en-route	Pre Wash for solidifying for high viscosity substances Strip to 150 Litres 12 mile 25m water depth 7 knots, en-route	Pre Wash for solidifying for high viscosity substances Strip to 75 Litres 12 mile 25m water depth 7 knots, en-route	Carriage Prohibited
Z	Strip to 950 Litres 12 mile 25m water depth 7 knots, en-route	Strip to 350 Litres 12 mile 25m water depth 7 knots, en-route	Strip to 75 Litres 12 mile 25m water depth 7 knots, en-route	Strip to Maximum Extent 12 mile 25m water depth 7 knots, en-route
OS	No carriage Requirements	No Carriage Requirements	No Carriage Requirements	
Underwater Discharge Required	Only X and Y cargoes	Only X and Y cargoes	X,Y and Z cargoes	

Figure 48: Prewash requirements for Categories.  
Source: [www.intertanko.com](http://www.intertanko.com)

### 7.5.2. Prewash procedures

#### Procedures for non-solidifying substances without recycling

Tanks are washed by means of rotary jets, operated at sufficiently high water pressure. During washing, the amount of liquid in the tank should be minimized by pumping out slops continuously and promoting flow to the suction point. If this condition cannot be met, the washing procedure has to be repeated three times, with thorough tank stripping between washings.

Substances that have a viscosity equal or greater than 25 mPa at 20 °C should be washed with hot water (temperature at least 60 °C).

After prewashing, the tanks and lines should be thoroughly stripped.

#### Procedures for solidifying substances without recycling

Tanks should be washed as soon as possible after discharge. If possible, tanks should be heated prior to washing. Residues should be removed from hatches and manholes prior to prewash.

Tanks should be washed by means of rotary jets that are operated at a sufficiently high water pressure and that are in locations that ensure all tank surfaces are washed. During washing, the amount of liquid in the tank should be minimized by pumping out slops continuously and promoting flow to the suction point. If this condition cannot be met, the washing procedure has

to be repeated three times, with thorough tank stripping between washings. Tanks should be washed with hot water.

After prewashing the tanks and lines should be thoroughly stripped.

#### Prewash procedures with recycling of Washing Medium

Washing with recycled washing medium may be adopted for the purpose of washing more than one cargo tank. In determining the quantity, the expected amount of residues in the tanks and the properties of the washing medium have to be taken into consideration, and whether any initial rinse or flushing is employed.

The recycled washing medium should only be used for washing tanks that contained the same or a similar substance. All tank surfaces should be washed by means of rotary jets operated at a sufficiently high pressure. The recycling of washing medium may be either within the tank or washed via another tank (ex. a slop tank).

After completing the tank washing with recycling to the extent specified, the washing medium should be discharged, and the tank thoroughly stripped. After that, the tank should be subjected to a rinse, using clean washing medium, with continuous draining and discharge. The rinse should at a minimum cover the tank bottom and be sufficient to flush the pipelines, pump and filter.

The quantities of wash water used in all prewash procedures should not be less than those specified in paragraph 20 or determined according to paragraph 21 of appendix 6 of MARPOL annex II "Standards for procedures and arrangements for the discharge of noxious liquid in bulk".

#### Minimum quantity of water to be used in a prewash

The minimum quantity of water to be used in a prewash is determined by the residual quantity of noxious liquid in the tank, the tank size, the properties, the permitted concentration in any subsequent wash water effluent and the area of operation.

The minimum quantity is given by the following formula:

$$Q = k(15r^{0.8} + 5r^{0.7} \times V/1000) ,$$

Where Q = the required minimum quantity in cubic metres,

r = the residual quantity per tank in cubic metres. The value of r shall be the value demonstrated in the actual stripping efficiency test, but shall not be taken lower than 0,100 m<sup>3</sup> for a tank volume of 500 m<sup>3</sup> and above and 0,040 m<sup>3</sup> for a tank volume of 100 m<sup>3</sup> and



below. For tank sizes between 100 m<sup>3</sup> and 500 m<sup>3</sup> the minimum value of  $r$  allowed to be used in the calculations is obtained by linear interpolation.

For category X substances the value of  $r$  shall either be determined based on stripping tests according to the Manual, observing the lower limits as given above, or be taken to be 0,9 m<sup>3</sup>.

$V$  = tank volume in cubic metres

$K$  = a factor having values as follows:

Category X, non-solidifying, low-viscosity substance,  $k = 1.2$

Category X, solidifying or high-viscosity substance,  $k = 2.4$

Category Y, non-solidifying, low-viscosity substance,  $k = 0.5$

Category Y, solidifying or high-viscosity substance,  $k = 1.0$

The table below is calculated using the formula, with a factor  $k=1$ , and can be used as a reference:

Stripping quantity (m <sup>3</sup> )	Tank volume (m <sup>3</sup> )		
	100	500	3000
≤ 0.04	1.2	2.9	5.4
0.10	2.5	2.9	5.4
0.30	5.9	6.8	12.2
0.90	14.3	16.1	27.7

Table 11: Stripping quantity depending on the tank volume

Verification testing for approval of prewash volumes lower than those given above may be carried out to the satisfaction of the Administration to prove that the requirements of the regulations are met, taking into account the substances the ship is certified to carry. The prewash volume so verified shall be adjusted for other prewash conditions by application of the factor  $k$  as defined above.

In case of mandatory pre-wash the resulting contaminated wash water should always be discharged to shore.

## **CHAPTER 8: OTHER OPERATIONS THAT CAN BE CARRIED OUT AT BERTH**

### **8.1. Bunkering**

Bunkering is a process that requires utmost care and attention, to prevent any kind of fire accident or spill.

The ship operator sends a stem nomination to the bunker supplier, which includes information such as the bunker fuel specification required, quantity to be supplied, place, method etc. The quantity of bunker to be received is decided in consultation with the master. The amount of bunker to be taken depends on the number of days the ship would be at sea before it reaches the next port.

After the vessel receives confirmation of the amount of bunker fuel and the grade to be received, the chief engineer will calculate which tanks are to be filled. It might be required to empty some tanks and transfer the oil from one tank to other. This is required so as to prevent mixing of two oils and prevent incompatibility between the previous oil and the new oil. The crew members that will take part in the bunkering process will have a meeting in which following aspects are discussed: which tanks are to be filled, sequence order of tanks to be filled, how much bunker is to be taken, emergency procedures in case of spills, responsibilities of each officer etc. A bunkering checklist will be made, to be completed during the operation. Before beginning operations, sounding (ullage) of the tanks is taken and recorded, overflow tank is checked to be empty. It is important to place “No smoking” notices in the area and to check that the bunker manifold valves from the opposite side are closed and blanked properly. Bunkering operations to be performed are indicated by presenting the red flag/light on the masthead. Vessel's draft and trim are recorded before starting operations.

The chief officer along with the crew should ensure that the barge is taken alongside safely and a safe means of access is provided to the barge crew. When the bunker barge is secured to the tanker ship, the Bunker Checklist is completed by the two parties, crew members of the barge involved are explained the bunker plan and the paperwork is checked for the fuel's grade and density to correspond to the specification. The ship and the barge agree on the pumping rate and connect the bunker hose to the manifold. All the valves required are opened and checked. After this, the manifold valve can be opened for bunkering. At all times, the barge and the ship have to maintain proper communication.

During the start of the bunker supply the pumping rate is kept low, to check that the oil is coming to the tank whose valve is opened. After confirming the bunker is coming to the proper tank, the pumping rate is increased to the agreed value. The loading rate should be checked

regularly. Generally, filling only is preferred because gauging of more than one tank at a time increases the chances of overflow. The maximum allowable to which tank is filled is 90% and when the tank level is getting close to the maximum level, the barge is informed to reduce the pumping rate so as to top up the tank. When topping-off tanks, the loading rate should be decreased to reduce the possibility of air locks in the tank causing mist carry over through the vents, and to minimize the risk of the supplier not stopping quickly enough. Then, the valve of the other tank can be opened. When changing over from one tank to another, care should be taken to ensure that an excessive back pressure is not put on the hose or loading lines. During bunkering, sounding is taken regularly and more frequently as the level in the tank is getting close to maximum. Many vessels have tank gauges in the control room which show tank level but this can only be reliable if the system is working properly. The temperature of bunker is also checked. Generally the supplier will provide the bunker temperature. A temperature higher than the agreed may lead to shortfall in bunker. Four samples are taken during bunkering. One is kept on-board, one is for the barge, one for analysis and one for port state control. Samples are taken during bunkering with the help of sampling tap at the manifold. On completion of loading, all hoses and lines will be drained to the tank or, if applicable, back to the barge, prior to disconnection. The practice of blowing lines with air into bunker tanks is a common one, but has a high risk of causing a spillage unless the tank is only part full and has sufficient ullage on completion of loading.

After completion of bunkering, draft and trim of the vessel are checked and all bunker tanks are sounded. The bunker volume should be corrected for trim, heel and temperature correction. For each extra degree of temperature, the temperature should be reduced by 0,64 kg/m<sup>3</sup>. The chief engineer will sign the bunker receipt and the amount received. If there is any shortfall, a Letter of protest can be issued against the bunker barge/supplier. After everything is settled, the hose connection can be removed.

The bunker sample is sent to laboratory for analysis. The new bunker will not be used until the report from the laboratory is received.

In the Inflammables Wharf, bunkering operations are generally not permitted during cargo operations, with a few exceptions, depending on the terminal and the product. Therefore, bunkering is carried out upon arrival and berthing, during cargo sampling and analysis or after completion of cargo operations. Regulations allow only bunkering by barge, while the ship is alongside at the jetty.



Figure 49: Greenoil bunker barge in Barcelona.  
Source: [www.shipspotting.com](http://www.shipspotting.com)

The Port of Barcelona is served by 3 companies that supply bunker:

- Repsol Bunker, with tanker Greenoil (GRT 2743, LOA 77 m, DWT 4700)
- Cepsa Bunker, with tankers Spabunker 21 (GRT 2895, LOA 77 m, DWT 4999), Spabunker 41 (1656 GRT, LOA 72 m, DWT 4000)
- Aegean Marine Petroleum, with tankers Ios/Syros (3212 GRT, LOA 90 m, DWT 4620)

## 8.2. Disposal of sludge and bilge water

Oily sludge is residual waste as a result of consuming fuel and is applicable to all types of vessels. On a tanker vessel, the amount of sludge generated is approx. 0,9% of the daily fuel consumption. Bilge waste water is pumped out from the bilge spaces of the machine room and collected and separated by a bilge separator.

As per the regulations of the Port of Barcelona discharge of oily residues is mandatory for all vessels that have sludge and bilge water residues at over 40% of the total residues storage capacity on board.

In the Inflammables Wharf discharge of sludge and bilge water is permitted only by barge and not simultaneously to cargo operations (with some exceptions, depending on the terminal and discharged/loaded product).

Each disposal of sludge/bilge water residues has to be recorded in the ship's Oil Record Book.

## 8.3. Cargo slop disposal

During normal operations of a chemical carrier, the main need to dispose of chemical residues, slops or water contaminated with cargo will arise during or immediately after tank cleaning. Final disposal of slops or wash water should be in accordance with the ship's P&A Manual. Tank washings and slops may be retained on board in a slop tank, or discharged ashore.

In case of mandatory pre-wash the resulting contaminated wash water should always be discharged to shore.

When discharge overboard is permitted, it should only be undertaken when the ship is at sea normally below the waterline through an underwater discharge outlet on the side of the ship away from essential water inlet valves.

Compatibility of various cargo and cleaning chemicals should be considered just as carefully when handling slops as when handling the cargoes themselves. Particular care is needed when washing several tanks which have contained dissimilar cargoes, and compatibility should be taken into account when selecting the destination tank for stripped wash water. The following should be avoided:

- Mixing of slops from Annex I (oil) cargoes with slops from Annex 11 (chemical) cargoes.
- Mixing of slops from incompatible cargoes.
- Mixing of slops from vegetable oils or fats with chemical slops or petroleum oil slops.

If the ship's cargo tanks are used as slop tanks, care should be taken to avoid introducing slops from cargoes which are incompatible with the tank coating. In this regard, some cargoes which are themselves compatible may, when mixed with water, form acids and thus damage a coating, e.g. slops from hydrolytic cargoes in a zinc coated tank.

In the Inflammables Wharf slop disposal is not permitted simultaneously to cargo operations (with a few exceptions, depending on the terminal and product). Slops are normally disposed into trucks at the end of cargo operations.

#### **8.4. Garbage disposal**

Disposal of garbage (domestic waste + oily rags) is compulsory for all vessels that enter the Port of Barcelona. In the inflammables Wharf, garbage disposal is always carried out by barge.

## **CHAPTER 9: SPECIAL PRECAUTIONS DURING CARGO OPERATIONS AND DURING VOYAGE**

### **9.1. Ballasting**

Ballasting or de-ballasting is a process by which sea water is taken in and out of the ship when the ship is at the port or at the sea. The sea water carried by the ship is known as ballast water. Ballasting or de-ballasting can be required during loading or unloading of cargo and when the ship is going for berthing.

The water ballast plan must be strictly followed to avoid any damage to the vessel. The bending moments and shear forces are to be calculated and must not exceed the prescribed limits. The properties of substances in the adjacent cargo tanks should be considered, to avoid solidification or other similar occurrences. Ballast samples must be taken before de-ballasting, to ensure the absence of traces of oil on the surface of the ballast water that is to be discharged overboard. Ballast received in one country should be discharged in open sea and replaced with fresh sea ballast. All information on ballast replacement must be recorded in the deck logbook.

On chemical tankers, for the purpose of stripping the segregated ballast system, eductors are normally installed. On conventional oil tankers, eductors can be installed for stripping the cargo system. The turbulent flow could generate large static electricity accumulation on many chemical liquids.

### **9.2. Inert Gas Systems**

Inert gas produced in a dedicated inert gas generator, by the measured combustion of low sulphur high grade diesel or gas oil, creates a cleaner inert gas than the one produced by boiler up-take or flue gases on conventional tankers. IG generators of up to 15000 m<sup>3</sup>/hour (for larger oil tankers) are in operation today.

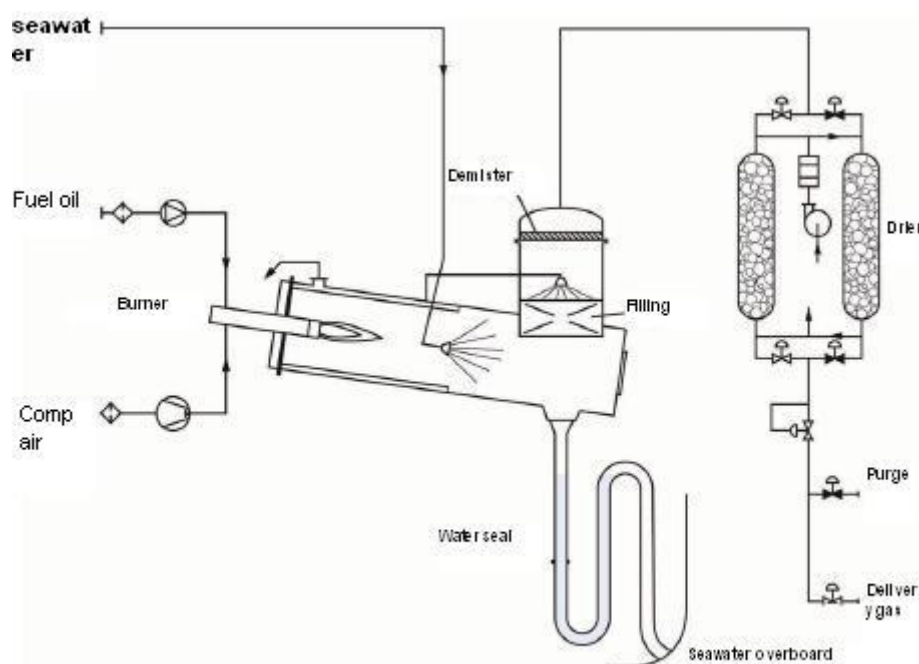


Figure 50: Inert Gas Generator.  
Source: <http://www.chemicaltankerguide.com>

The composition of the inert gas is:

- Carbon dioxide (CO<sub>2</sub>) 15%
- Oxygen (O<sub>2</sub>) 0,5-3%
- Nitrogen (N<sub>2</sub>) 82-85%
- Carbon monoxide (CO) 30 ppm max
- Hydrogen (H) 100 ppm max.
- Sulphur dioxide (SO<sub>2</sub>) 50 ppm max.
- Dew point -18 °C

The oxygen content can be adjusted, but within specific limits. Before the gas can enter the vessel's tanks, it must pass through dryers and coolers that remove excess water vapour. When it is necessary to open the cargo tanks for repairs, inspection or dry-docking, it is essential to reduce the hydrocarbons present in the tanks to a maximum of 2% O<sub>2</sub> volume gas before introducing air into the tanks, and then freeing ready for personnel entry. The use of inert gas is to reduce the hydrocarbon gas content in the tanks and is known as "purging". The oxygen levels in the inerted spaces must be maintained at less than 8% (this figure allows for a safety margin from the level of 11-12% O<sub>2</sub> at which combustion can be supported). Produced inert gas is perfectly acceptable for use during tank cleaning and line blowing when the ship is in the products trade, but it is not suitable for blanketing or padding the majority of chemicals. Such inert gas can contaminate the vapour space above the cargo or leave carbon deposits or acidic formations that are detrimental to the coating on the tank walls and the cargo. Inert



gas produced by combustion will contain approx. 15% CO<sub>2</sub>, which will react with ammonia to produce carbonates. These will form deposits on tank walls and could cause a possible blockage to the internal lines. It may be necessary to purge the inert gas with nitrogen to remove the CO<sub>2</sub> content where low dew points are required (ex. LNG).

The possible Inert Gas generator sources in a tanker can be:

- Combustion gases from the main or auxiliary boilers
- An independent Inert Gas generator
- A gas turbine equipped with an afterburner

In a tank, a final oxygen level of 8% or less will be more easily reached if the oxygen content of the inert gas in the main inert gas line is considerably less than 8%. Ideally, the Inert Gas should not contain oxygen, but this is impossible to achieve in practice. When the combustion gases from a main or auxiliary boiler are used, an oxygen level of less than 5% can generally be obtained, depending on the quality of the combustion control system and on the boiler load.

When a ship is equipped with an independent Inert Gas generator or with a gas turbine plant with afterburner, the oxygen content can be controlled automatically, generally within the range of 1,5% - 2, 5%.

For entering a tank after it has been inerted, the tank should be washed, ventilated and the oxygen confirmed at 20,9% volume, flammable gases at 1% LFL or less and toxics absent or lower than their current TLV.

The tank atmosphere evaluation for tank entry can be made using devices such as an explosimeter, Draeger tubes and oxygen meter. The permissible conditions for issue of an enclosed space entry permit for tank entry are: a completely gas-free condition, with 21% oxygen, less than 1% LEL and below TLV. These readings should be at a minimum, in any position measured in the tank. However, the need to enter a non-gas free tank may occur and safety precautions are to be followed, i.e. the relevant person must be adequately equipped. For LPG carriers, if arriving at the loading port in an inerted condition, there are two options open to the vessel to rid itself of the inert gas atmosphere:

- Connect up to the shore flare system and displace the inerts with product
- Loading a small quantity of the product to be carried and moving outside the harbour limits to prepare the vessel for loading

Tanks should always be inerted, except for the situations when they need to be gas-free for inspection or work.

In order to keep the cargo tanks in a non-flammable condition, the Inert gas generator will be needed to:

- Inert empty cargo tanks.
- Operate during discharging of cargo, ballasting, washing with crude oil and cleaning tanks.
- Purge the tanks before degassing.
- Raise the pressure in the cargo tanks, when necessary, during other stages of the trip.

### 9.3. Heated cargo

Some substances may be identified as solidifying substances or high viscosity substances if their discharge temperature had not reached the temperature required by the Charter Party when the cargo was measured on arrival. Such substances, if heated, can avoid MARPOL's requirements for pre-wash on completion of discharging. These are as follows:

- Cargoes with a melting point of less than 15 °C must be discharged with a temperature of at least 5 °C above melting point. Example: Benzene with a melting point of 4,5 °C should be discharge with a temperature of at least 9,5 °C to avoid prewash requirements
- Cargoes with a melting point equal to or greater than 15 °C are to be discharged with a temperature of at least 10 °C above the melting point. Example: Phenol, with a melting point of 40,9 °C should be discharged with a temperature of at least 50,9 °C to avoid solidification or to be classed as solidifying.

The viscosity at 20 °C and the melting point should be stated on a certificate of quality. The temperature at which the viscosity will be reduced to acceptable limits should also be stated. Heating instructions must be strictly followed in order to avoid the cargo waxing, sedimenting, stratifying, crystallizing, separating or anything else that may damage quality.

The cargo temperature must be measured at least twice a day, in the morning and in the evening. The measured temperature is recorded in a heating log. Any deviation without an immediately apparent reason must be analysed and an attempt to solve the situation has to be made.

The engine room should advise if there is any boiler water loss or increased water consumption as this may indicate a leakage from the heating coils. If there are traces of cargo in the return condensate, this would also indicate leakage in the heating coils. While cargo heating, condensate return water should be periodically drained onto the deck to inspect the

cargo traces for heating coil damages. In this case, the appropriate heating section should be blanked off. Special attention must be given to tanks with a slow rising temperature.

#### **9.4. Nitrogen Blanket Cargo**

Nitrogen blanket cargoes are used to prevent oxidation or moisture from entering into the vapour space of the cargo tank. These should be properly maintained, otherwise the cargo could react with the oxygen, moisture or salts dissolved in the air and go off-specification.

A permanent nitrogen over-pressure must be maintained, and tank pressures have to be checked and recorded daily in the pressure control log. Any loss of nitrogen in the tank should be refilled from the vessel's reserve of nitrogen.

#### **9.5. Cargo recirculation**

Some substances, such as phosphoric acid, must be recirculated during the voyage in order to avoid sediments or deposits in the tank. Occasionally, these sediments can reach 1.5 metres from the tank bottom. Recirculating through a diffuser, drop line or heating line is the best method of prevention.

#### **9.6. Inhibited Cargoes**

In certain circumstances of heat and pressure, some cargo types can become viscous and possibly even solid and dense in nature. This self-reaction can cause some cargoes, in high heat conditions, to begin an exothermic effect, become self-heating and rapidly expand with possible disastrous effects on the ship. As a precaution against this, shippers may add a chemical inhibitor additive to prevent the cargo from bonding within itself. However, one aspect of inhibitors is that they generally require oxygen to activate them and this means that the tank cannot be inerted against fire.

As additive inhibitors are seen as a contamination of cargo at the discharge port, the receiver may require the cargo to be carried with no additive. This is possible in certain short sea temperate climate routes.

There are many inhibitor types, most of which are toxic and need to be handled with care. Due to the different evaporation properties of the inhibitor and of the liquid cargo, solid polymer build-up can occur in the tank ventilators and screens, which must be cleared before suction pumping implodes the tanks.

## 9.7. Cargo tank vapour return systems

For many of the noxious liquid substances carried on a chemical tanker, it is not possible to vent the vapours from the cargo tanks, lines and connections to the atmosphere. Such cargoes are normally classified as Toxic products and are subject to closed loading conditions. This also applies when inerting the cargo lines, tanks and connections with nitrogen from ashore, such as for the carriage of Acetic Acid. If no vapour return line is fitted, the nitrogen would have to be vented into the atmosphere, and the subsequent loss of the inerting nitrogen would represent a huge cost to the terminal.

Some toxic cargoes have a Threshold Limit Value (TLV) so low that any amount released into the atmosphere is hazardous to personnel in the surrounding area. For these cargoes, the crew has to wear protective suits on deck and, while working with cargo access to and from the ship is suspended. MSDS must be checked for each cargo loaded, to ensure that the dangers and restrictions are fully understood.

The vapour return line is a line running from the cargo tank back to the cargo manifold area. Each vapour return line has its own separate manifold, which must be specially marked. This ensures that there is no mistake when connecting the loading line to the vapour return line.

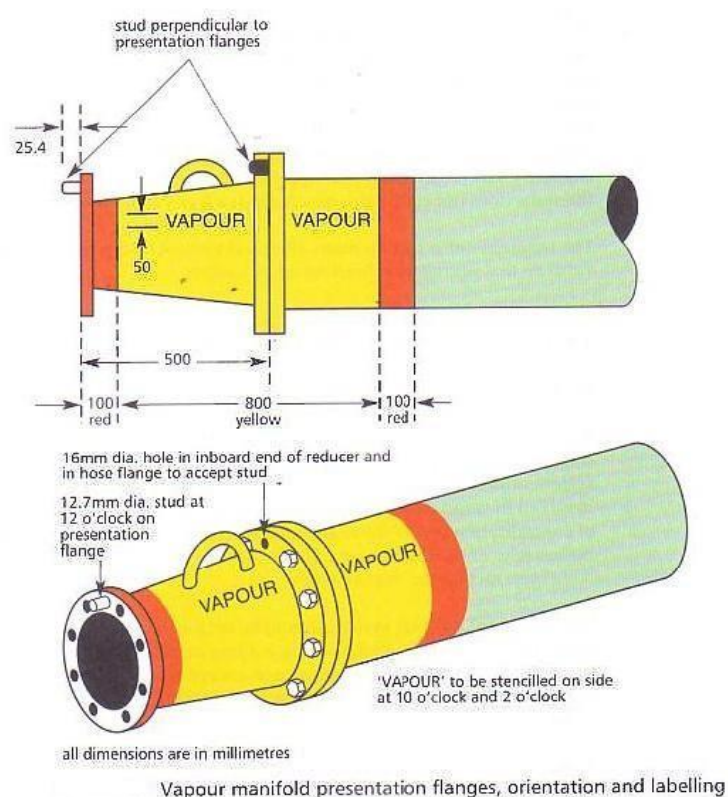


Figure 51: Vapour return line manifold.

Source: <http://www.chemicaltankerguide.com/cargo-tank-venting.html>

There are minimum standards required and must be marked and identified as shown in the figure above. The important item that ensures a cargo line cannot be connected is the stud set at “12 o’clock” on the flange of the manifold and reducer. This must never be removed and must be replaced if damaged. When a shore vapour return hose is presented to the ship for connection, it will have a hole drilled through it at the 12 o’clock position, of a diameter to accommodate the stud.

The IBC Code lays down the requirements needed for a ship to meet the demands of returning the most toxic chemical vapours to shore. It is important that there is a balanced safe pressure between the ship and shore. The tank must be able to evacuate the vapours at a speed fast enough to ensure positive pressure is maintained but low enough to ensure that it is below the set opening pressure of any pressure relief valve in the tank venting system. IMO guidelines recommend not to exceed a tank pressure of 80% of the relief valve setting. To ensure this is met it is very important that there is agreement on the liquid loading rate and the expected pressure at the vapour connection. At no point must liquid be allowed to enter the vapour line as it will reduce the cross-sectional area of the pipeline and so reduce its ability to allow the maximum vapour to flow. The knock-on effect would be a build-up of pressure in the cargo tank.

According to IBC Code requirements, liquid and vapour hoses used for cargo transfer should be compatible with the cargo and suitable for the cargo temperature.

Many toxic products must have separate piping and tank vent systems that are separate from tanks containing non-toxic products.

Chemical tankers able to carry toxic products usually have the cargo system set so that each tank has a complete set of cargo equipment of its own. Each tank has a unique manifold, loading line, cargo pump, vent, vapour return line and vapour return manifold and either heating coils or a heat exchanger. This will provide total independence for the tank and enable a greater flexibility in the cargoes to be carried.

## 9.8. Operational Precautions when Hydrogen Sulphide (H<sub>2</sub>S) is present

Hydrogen Sulphide (H<sub>2</sub>S) is a highly toxic gas that can cause serious injury or fatality at low concentrations. In most instances, but not all, its presence can be predicted and precautions can be taken to ensure safety. There have been a large number of fatalities after single exposures to high concentrations of H<sub>2</sub>S, often in confined spaces. H<sub>2</sub>S is a colourless highly toxic gas, heavier than air. As well as being highly toxic, it is also extremely flammable.

H<sub>2</sub>S is formed and released during the decay of sulphur-containing organic materials or throughout the reduction of sulphates through organic action. It is found in: crude oil, crude oil

derivatives (such as heavy fuel oils, naphtha, bitumens, gas oils), natural gas processing, tanks containing stagnant water, sewerage and wastewater systems.  $H_2S$  is immediately recognised by its characteristic smell of rotten eggs, which may be detected at vapour concentrations as low as 0,01-0,03 ppm. However, as exposure to vapour concentrations in excess of 100 ppm leads to a rapid loss of the sense of smell, this is not a reliable method of recognition. The presence of  $H_2S$  is identified and confirmed by the use of specialist monitoring equipment.

TLV – Threshold Limit Value – is the average concentration under which most people can work consistently for eight hours per day, based on a 40 hour week, with no harmful effects.

STEL – Short Term Exposure Limit – the average concentration for a 15 minute exposure, with a maximum of 4 such exposures per 24 hour period.

Limits  $H_2S$ : TLV 5 ppm, STEL 10 ppm

Continuous checks to ensure that concentrations remain below 5 ppm. If the figure detected is higher than 5 ppm, a risk assessment should be conducted. In recent years, marine regulators have insisted on closed gauging systems to protect both the seafarer and the wider environment.

It should be noted that while the smell of rotten eggs is a good indicator of very small concentrations of  $H_2S$ , it is not reliable as the sense of smell becomes paralysed at relatively low concentrations.

0,01-0,03 ppm – smell of rotten eggs becomes apparent

1-20 ppm – offensive odour, possible nausea

50-100 ppm – eye and respiratory irritation after 1 hour

100-200 ppm – ability to smell completely disappears

200-300 ppm – marked eye and respiratory irritation after 1 hour

500-700 ppm – dizziness, headache, nausea in 15 min, loss of consciousness and possible death after 30-60 min

700-900 ppm – rapid unconsciousness, death a few minutes later

1000-2000 ppm – instant collapse and cessation of breathing

Exposure to  $H_2S$  above 500 ppm for any length of time is potentially lethal. Exposures above 200 ppm can cause potentially fatal lung damage that will take up to 24 hours to appear.

In an oxygen free atmosphere, where  $H_2S$  is present, iron oxide (rust) is converted to iron sulphide. When rapid oxidization occurs, either free sulphur or sulphur dioxide ( $SO_2$ ) is formed. This can be accompanied by the generation of considerable heat, causing individual particles to become incandescent, which can ignite hydrocarbon gases in air.

## 9.10. Static electricity

### Loading into Gas-free/non-gas free tanks

Petroleum liquids are classified as either non-volatile (flashpoint 60 °C or above) or volatile (flashpoint below 60 °C). Before determining how a particular product should be transferred by pumping it is necessary to know if it is an accumulator of static electricity. This will depend on its electrical conductivity.

Non static accumulator oils: These products, whether they are non-volatile or volatile, can be loaded into gas free/non gas free tanks without precautions against static. Examples: fuel oils, heavy diesels and crude oil with an electrical conductivity greater than 50 picosiemens per metre.

Static accumulator oils: A static accumulator oil is defined as having an electrical conductivity of less than 50 picosiemens per metre. When loading static accumulator oils, metallic dipping, ullaging or sampling equipment must not be introduced or remain in the tank either during loading or for 30 minutes after completion. This is to allow for relaxation of the accumulated static charge. Bonded equipment which is grounded to the hull structure, may be used after the 30 minutes stand down. Ropes used must be made of natural and not synthetic fibre. Operational precautions increase for non-inerted tank work. Care has to be taken with the generation of static electricity by liquid turbulence and avoidance of electricity conduction when tank dripping, ullaging and sampling. All liquid flow in petroleum pipelines is turbulent and this turbulence scoops up the inner layer of charged molecules and distributes it throughout the bulk of the petroleum in the pipe, leaving the outer layer in contact with the pipe wall. This means the charged layers are separated, so the petroleum in and emerging from the pipeline becomes charged. Examples of static accumulator oils include distilled petroleum products such as naphthas, kerosene, jet fuel, gasoline, heavy gasoil, lubricants etc.

Steam must not be introduced into any tank until it is confirmed as free of all flammable gases. This is because the ejection of wet steam from the nozzle generates static electricity. Steam must not be used in a tank, compartment or pipe that contains a flammable mixture. Although now an infrequent practice, it is sometimes operationally necessary to introduce steam into a non-gas-free tank, particularly during cleaning operations on chemical tankers.

When liquid CO<sub>2</sub> under pressure is released at a high velocity, rapid evaporation causes cooling. Particles of solid CO<sub>2</sub> may be formed. The solid particles in the cloud of CO<sub>2</sub> may become electrostatically charged and must not be released into a space containing a flammable mixture.



The most important measure to prevent electrostatic hazards is to bond all metal objects together, eliminating the risk of discharge between them. Grounding is accomplished by bonding to the hull, which is naturally earthed through the water. Similar bonding of all conducting metal within a jetty structure allows it to earth to water. However, a difference of electric potential can exist between a ship's hull and the shore pipeline system. This difference is usually only a fraction of a volt but it may be aggravated by the presence of a cathodic protection system for either the ship, jetty or shore pipeline systems.

Hoses used in terminal transfer operations must be continuously bonded and grounded. It is important to note that the cargo transfer piping of the ship must be insulated from the shore side terminal as electrical potential may differ from that of the vessel because of stray current or cathodic protection of the pier. Insulating flanges, joints or sleeves are sometimes used to divide the cargo hoses into electrically isolated halves, on-board and shoreside. Each half is bonded and grounded to its base potential. An all metallic loading/discharge arm provides a very low resistance connection and there is danger of a spark when a high current is suddenly interrupted during connection or disconnection of the arm at tanker manifold. The electrical resistance of the bonded metallic reinforcement of a rubber flexible hose string is greater than that of an all-metallic arm, so the current flow and spark intensity would be much less. However, such sparks could ignite. It is common practice to insert an insulating flange within the length of the arm or at the connection of flexible hose strings to the shore pipeline system. Bonding wires should be incorporated within all water hoses and bonding established between water hoses, the tank washing machine and the cleaning water supply line.

Especially when loading static accumulator oils or when loading in non-inert and non-gas free tanks, precautions against static electricity should be maintained in respect of the loading rate:

- The flow rate during the initial stages of loading into each tank should not exceed 1 m/s
- The maximum flow rate during the main stage of tank loading should not exceed 7 m/s

PIPELINE DIAMETER (inches)	FLOW RATE m <sup>3</sup> /hour (at 1 m/s)	FLOW RATE m <sup>3</sup> /hour (at 7 m/s)
3	17	119
4	29	203
6	66	462
8	114	798
10	180	1260
12	260	1800
14	320	2200
16	420	2900
18	540	3700

Table 12: Flow rates by pipe diameter

Surge pressures produced upstream of a closing valve will become excessive if the valve is closed too quickly. The most vulnerable part of the pipeline system is the ship-to-shore connection and it should be protected while loading by management of the flow of liquid upstream of the connection. Valves in the system are designed and set to close in a minimum time for safety and to avoid damaging surge pressures. The loading rate should never exceed the recommended design flow maximum.

Gas carriers must be capable of emergency shutdown within a maximum period of 30 seconds from initiation. At some terminals, vessel is physically connected to the shore Emergency Shutdown System, using it in preference to its own. In cases where the vessel does not agree to use the shore system, then the effective closing time of the vessel's valves must be obtained and the loading rate adjusted accordingly. Where a system has been isolated for a period of time, any isolation valves should be opened very slowly as a difference in pressure on either side of the valve could cause the same liquid hammer/surge pressure effect.

## **9.11. Pollution prevention**

### **9.11.1. Shipboard Oil or Pollution Emergency Plans (SOPEP)**

According to MARPOL Annex I, all oil tankers of GRT 150 and above has to carry a SOPEP on board. This plan must include:

- Procedure to be followed
- A list of authorities/persons to be contacted
- Detailed descriptions of actions to be taken
- Procedures and point of contact on the ship for co-ordination of action

### **9.11.2. Shipboard Marine Pollution Emergency Plan (SMPEP)**

Since 2003 every carrier of noxious substances in bulk (chemical tanker) of 150 GRT and above is required to carry a SMPEP on board, in accordance with MARPOL Annex II. The SMPEP must be built and approved by a Flag Administration or a recognized organization (Class. society) delegated by the administration.

The SMPEP should have the following:

- written in the languages understood by the Master and officers
- follow the guidelines required by MARPOL Protocol I Article 8
- contain a contact list of authorities or persons in the event of a noxious liquid pollution incident
- contain the actions to be taken to immediately reduce and control the discharge of noxious liquid chemicals
- contain procedures and a point of contact for coordinating shipboard actions with national and local authorities

Where ships are required to carry a SOPEP, they can combine it with the SMPEP.

### **9.12. In case of Emergency**

Whenever required in case of emergency, operations have to be stopped. An emergency situation can be one of the following: fire on board the vessel, fire in the terminal, fire in another vessel berthed in the wharf, fire inside the engine room, mooring line breakage, serious electrical storm, if there is a sudden unexpected rise in pressure etc.

A ship's valve that has pressure in line will not be closed, it is very important to close the shore valve first. In an emergency stop, after closure of the shore valve all the ventilation systems will be closed and after that all the valves of the tanks. If the ship's valve is closed first, the pressure surge generated can break the loading hose/hard arm and this can cause spills or fires. Operations will not be resumed until all checks have been carried out and the event that generated the emergency is solved. Loading hoses or hard arms will also be disconnected, if necessary.

### **9.13. Additional precautions on board tanker vessels**

The main danger is of fire or explosion. In order to reduce the risk of fire, we have to prevent the simultaneous presence of an explosive atmosphere and of an ignition source. In practice, eliminating the two at the same time can be difficult. On deck, in the pumproom and cargo tanks there are often inflammable gases present, so preventing an ignition is essential. In other parts of a tanker, such as the galley, crew quarters and engine rooms, the presence of fires cannot be avoided so it is important to keep away the flammable gases.

Smoking and using matches or lighters is permitted only in the designated places, which usually are the mess room, the cargo office and on deck.

The use of electrical equipment and portable lamps is prohibited on deck, inside the cargo tanks and the adjacent areas, except for when these are gas-free and authorized for hot work interventions.

Lanterns and portable radio transmitters/receivers have to be of the approved type. Portable radios, cameras and computers, as well as other battery-powered devices of unauthorized type must not be used on deck or in other areas where inflammable gases can be present.

The main radio transmitters should not be used if their antennas are located on deck and if there is the risk of an explosive atmosphere. Using the radio equipment during cargo operations could be potentially dangerous, with the exception of the permanent VHF equipment with a power inferior to 1 W.

Before using metalwork tools on a tanker ship outside of the engine or boiler room, the duty officer has to ensure that the atmosphere is gas-free before starting the works.

When wet or soaked with oil, especially vegetable oils, some materials are prone to auto ignition without any external source of heat applied, due to the oxidation of the material. Cotton thread, canvas, cloths, rags or other similar material should not be left on deck, on equipment, pipelines and close to oils, paints etc.

The chimney tube, burner, exhaust tubes and flame protection screens have to be maintained in good conditions, to avoid fire or sparks coming out and falling on deck.

In case of cold weather, the correct operation of the pressure/vacuum valves has to be checked regularly.

The pump room has to be well ventilated to avoid the gas accumulation.

## **CHAPTER 10: CONCLUSIONS**

Currently, about 90% of international trade is carried out through maritime transport, merchant shipping being the lifeblood of the world economy. In the ever-growing nature of maritime cargo transportation, tanker ships, whether oil, chemical tankers, liquefied gas carriers or tankers used for transporting edible oils or beverages, represent the most efficient way to carry large quantities of liquid in bulk over large distances, although it is certain that many cargo ships cause oceanic pollution and degrade the marine environment.

Tankers are one of the most complex type of vessels and are served by a vast network of shore facilities in ports all around the world. In terms of bulk liquid cargo traffic, Barcelona is one of the most important ports in the country, having the advantage of a strategic position close to the border and to the Balearic Islands and benefiting from good railway and road connections to the interior. Given the nature of the local industry, most of the liquid bulk traffic is consists of imports, while transhipments and exports have a smaller share of the total. As the nearby port of Tarragona and its refinery handle all of the crude oil imports in the area, the port Barcelona is mainly an importer of refined petroleum products and other chemical products, with main trade partners being the European Union and the Middle East. An important share is represented by the edible oils used in the food industry, cosmetics and pharmaceutical industry, the vast majority being imported from the Far East. Exports share a relatively small percentage of the total, consisting basically in petroleum products for the Balearic Islands (fuel-oil, kerosene, gasoil and gasoline) and for other European countries.

It is worth mentioning that in recent years in the local production and subsequent export of bio-fuels (biodiesel, bioethanol etc.) has increased significantly. Biodiesel is produced from oils and fats using trans-esterification and is currently the most common biofuel in Europe. Export is done using tanker ships, with the main destination being the EU. Encouraging the use of biofuels as an alternative to fossil fuels can be one of the numerous ways through which we can achieve a better environmental sustainability.

One of the characteristics of the Inflammables Wharf is that except for the liquefied gas terminal, that has its own jetty, all of the other berths are shared between two or more terminals, with installations designed for loading and discharging specific products. Traffic congestion has been an issue in the Inflammables Wharf on various occasions, berthing

preference being normally granted according to the time of arrival at roads, on a first-arrived-first-berthed policy as long as the conditions at adjacent jetties would allow berthing a tanker at the jetty where it has to operate. Due to the restrictions of the interior berths and to the small distance between them, it is often impossible to have vessels berthed simultaneously at two adjacent interior berths (32 A-G), especially when it comes to vessels longer than 120 m. In order to address to the traffic problem and to the increase in the storage capacity of the terminals, jetty 34B was inaugurated in 2011, this exterior berth being at that time the berth with the deepest draft in all of the western Mediterranean ports. It has a maximum draft of 15,90 metres and can operate tankers up to 275 m in length and 175.000 tons of displacement. But this berth is sometimes not sufficient, due to the limitations of the interior jetties and to the increasing number of larger tanker ships calling to the Inflammables Wharf. On the long run, this can become a problem as carriers could choose operating their tankers in other ports and terminals that are not that affected by traffic congestions and that can accommodate bigger ships.

Therefore, an improvement is highly necessary, the creation of a new exterior jetty being essential for keeping pace with the increasingly busy tanker vessel traffic and the development of the storage capacities of the existing terminals. This new berth should have at least the same characteristics as jetty 34B (maximum draft of 15,90 m, maximum LOA 275 m, displacement of 175.000 tons), being able to handle ships as large as Suez-max tankers dedicated to the transport of refined petroleum products, but also smaller vessels, thus relieving the sometimes congested vessel traffic inside the Inflammables Wharf. It should be connected to all the liquid bulk terminals and it should be able to handle a large variety of products, from refined petroleum to edible oils.

The construction of a new exterior jetty in the Inflammables Wharf (jetty 34C, adjacent to 34B to the south) is a future development that has been thoroughly discussed and analysed lately by the Port Authority, being a priority for the following years.

From a personal point of view, I can truly say that I've always been fascinated by tankers, by their complexity and by the mere fact that they can carry liquids by sea and other waterways. The whole operation of loading or discharging a liquid product is complex and has its own particularities depending on the product, a fact that I find really captivating.

I was very fortunate to have the opportunity to gain a hands-on experience in the vast world that is the tanker shipping business, by working in a shipping agency dedicated to customized services for tankers in the Port of Barcelona. During this practical experience I learned about how a tanker operates in port, about the actors involved and their role in the process.

A shipping agency is just a small part of the chain involved in a tanker's operation, that can include parties such as: vessel's owner, crew, charterer, shipper, receiver of goods, shipping brokers, terminals, cargo surveyors, class inspectors and technicians, Port Authority, Harbour Master, local authorities etc. Tanker ship agencies are working in a very competitive sector, therefore dedication and state-of-the-art 24-hours services are essential in order to stay in business. As a tanker vessel agent, the main responsibilities I had included preparing the necessary documentation for the vessel arrival and dealing with the local authorities (Harbour Master, Barcelona Port Authority, Immigration Police etc.) and organizing all aspects of the vessel's call while informing all parts involved in the process: vessel's owners, charterers, shippers and receivers of the cargo, terminals and cargo inspectors. Updates were sent on a daily basis, often more times per day when changes occurred, regarding estimated times of arrival and completion, berthing prospects and details of the operations to be carried out, which could include bunkering, residues disposal, tank prewash etc. As the characteristics of the Inflammables Wharf could sometimes incur restrictions on a ship's berthing due to the actual scenario at the jetties, it is essential to be aware of these changes and to keep all parties informed, as any delay is important and potentially costly. Another task of the vessel agent is preparing some of the Cargo documents for loading (which include preparing the Bill of Lading, where precision is essential when it comes to total quantities loaded), discharge and connected operations, such as the mandatory prewash.

Through this Master's Thesis I intended to write a brief operating guide of a tanker in port, describing most aspects connected to the vessel's operations in a chronological order, from voyage planning until vessel sailing, and how it applies to the Port of Barcelona, to the best of my knowledge gained from my personal experience. The procedure was presented both from shore as well as from the vessel's point of view, with special emphasis on the operating procedures on board. I never had the chance to sail on board a tanker, therefore this study really helped me understand the processes on-board during voyage and in port, and the responsibilities of everyone involved. My initial formation is in engineering, hence I also have a keen interest in vessel structural characteristics and in the design and operation of the equipment used for discharge, loading and other cargo-related procedures, both on board and inside the terminals.

Although at the present time my career path has brought me in the exciting container shipping business, more exactly in a terminal from where I can see the Inflammables Wharf from the other side of the water, I can honestly say that tankers and everything related to them will always be of high interest to me.



## CHAPTER 11: GLOSSARY

API Gravity – Specific gravity defined as per the standards of the American Petroleum Institute

Aromatics – Group of hydrocarbons that contain benzene. They are called “aromatics” due to their pleasant or aromatic smell. They have a relatively high density and are good solvents

BCH Code – The IMO code for the Construction and Equipment of ships Carrying dangerous Chemicals in bulk, applied for ships built before 1<sup>st</sup> July 1986

Bill of Lading – Negotiable document that serves as an acknowledgement that the goods have been loaded, contains or evidences the terms of the contract of carriage and serves as a document of title to the goods

Charter Party – Contract in the shipping industry that stipulates the rights and obligations between the charterer and the owner

Cost Insurance Freight (CIF) – This is a contract, based on the discharge port, where the seller must pay all the costs including insurance and the freight/carriage charge to transport the cargo to the discharge port. Risk passed from the seller to the buyer when cargo passed the ship's manifold.

Certificate of Fitness (COF) – A certificate issued by a flag administration confirming that the structure, equipment, fittings, arrangements and materials used in the constructions of a tanker are in compliance with the relevant IMO Chemical Codes. The certification may be issued by approved classification societies on behalf of an administration.

Corrosives – Substances that cause severe damage when in contact with living tissue or, in the case of leakage, will materially damage or even destroy other freight or the means of transport.

COW – Crude Oil Washing – A method of cleaning out the tanks on a crude oil tanker, using the crude oil itself

Diesel oil – Combustibles used in diesel motor and compression engines

Evaporation – The process of changing from liquid into vapour. It is usual to refer to such vapours as gases. Some chemical tankers have high evaporation capabilities and they can release vapours that are dangerously flammable, toxic or corrosive.

**Expansion** – Most substance expand when heated. Evaporation causes rapid expansion. Combustion of vapour causes heating and even greater expansion. If the expansion is contained, inside a tank for example, then pressure may increase further and possibly cause an explosion.

**Explosion-proof equipment** – Equipment or apparatus that will withstand, without damage and in accordance to its prescribed rating, any explosion of a flammable gas to which it may be subjected to under practical operating conditions and which will prevent the transmission of flame to the surrounding atmosphere.

**Flame arrestor** – a device used to arrest the passage of flame in a pipeline.

**Flammable** – something that can be set on fire. Inflammable has the same meaning. It is the vapour that burns, not the liquid. The easier a combustible liquid evaporates, the easier it can be ignited. Danger increases according to how readily a product evaporates into air.

**Flammable Limits** – it is possible to have a mixture containing so little (too lean) or so much (too rich) flammable vapour that it cannot be ignited. Mixtures that have reached these strengths are outside the flammable limits.

**Flammable Range** – The flammable range of a mixture which is the range between its flammable limits, can vary greatly depending on the chemical structure of the particular substance. The flammable range of some chemicals is much broader than petroleum. Flammable limits and flammable range are sometimes referred to as Explosive limits and Explosive Range.

**Flash point** – The flash point is the lowest temperature at which a liquid will evaporate enough fluid to form a combustible concentration of gas. The flash point is an indication of how easily a product may burn. Some products evaporate very rapidly and produce plenty of gas at normal atmospheric pressures and temperatures, and have low flash points. Gasoline is an example. Vapour is nearly always present. A hot enough spark can set it on fire. A hot surface like a heating element or warm machine can ignite products with low flash points.

**Free on Board (FOB)** - The seller covers all costs and risks until the cargo passes the ship's manifold, then it becomes the responsibility of the buyer. From that point the buyer must cover all carriage and insurance costs to the discharge port.

**IBC Code** – The IMO International Code for the Construction and Equipment of ships carrying Dangerous Chemicals in bulk. Applies to vessels built after 1st of July 1986.

**Ignition point/auto-ignition point** – The minimum temperature required to ignite a gas or vapour in air without a spark or flame being present. This can be an important factor with less volatile

liquids, which could be in contact with a heated surface above their ignition point. It is also important to ensure that waste material is never heated to its ignition point temperature.

**Inerting** – The process of introducing an inert gas into an empty cargo tank for the purpose of preventing a flammable/explosive atmosphere from developing. A cargo tank with an oxygen content of 8% or less is considered an inerted cargo tank. On chemical tankers, the general practice is to use large volumes of compressed nitrogen supplied from the shore.

**Inhibitor** – a substance used to prevent or retard cargo deterioration or a potentially hazardous chemical self-reaction, such as polymerization. These have a defined lifespan of several days.

**Letter of Indemnity (LOI)** – often used when transporting goods by ship, it protects the shipping company against any claims that may arise from the issue of a clean Bill of Lading

**Liquid expansion** – Liquids, as well as vapours, expand with heat. Some cargoes have the potential to expand to the point where they could over fill a tank and rupture pipelines when the ship travels into hot climate.

**Liquid droplet mist** – Volatile liquids, sprayed from a leaking pump or pipe, may form a mist of droplets that, in the presence of oxygen, can be very dangerous.

**Loading Master** – Person in charge from the terminal who supervises the movement of liquid bulk products between tanker ships and terminal while the vessel is berthed at dock

**Long Ton** – equal to 1,01605 metric tons

**Mixtures** – A combustible vapour may burn if it is mixed with air and supplied with enough energy such as a spark.

**Non-volatile** – Liquids that evaporate less rapidly. Those with a flash point of over 60 C are classed as non-volatile. An example is heavy diesel oil.

**Noxious liquids** – Chemicals that may be toxic or hazardous.

**On board quantity (OBQ)** – This is the total quantity of product in the cargo tanks and ship's lines and pumps on-board ship before loading commence.

**Operator** – The manager of all the operational matters of the ship

**Padding or Blanketing** – Filling a cargo tank and associated piping systems with a liquid, gas or vapour which separates the cargo from air. In practice, nitrogen is most often added to a tank that has already been filled with cargo. The principal purpose of the pad is to establish a positive pressure on the tank, preventing the ingress of water or air as the tank cools.

Petroleum – a general term that is used for crude oil and the products in all forms they are refined from it.

Polymerization – the phenomenon where the molecules of a particular compound link together into a larger unit called a polymer. Polymerization may occur spontaneously with no outside influence, or it may occur if the compound is heated or if a catalyst or impurity is added. Polymerization may be dangerous under some circumstances, but it can be delayed or controlled by the addition of inhibitors.

Relative Vapour density – The relative weight of the vapour compared to the weight of an equal column of air at standard conditions of temperature and pressure.

Remaining on board (ROB) – The quantity of product that remains on board in the tanks, ship's lines and pumps after discharge has been completed

Safety Data Sheet – A document in accordance with the IMO codes and usually from the manufacturer of the cargo, which contains necessary information about the properties of the chemical for its safe carriage as a cargo. (Also MSDS – Material Safety Data Sheet)

Ship Management Company – Refers to the company that manages the relevant vessel.

Slack tank – Tank half full.

Solubility – The ability of one substance (solid, liquid or gas) to blend uniformly with another. Solubility is usually understood as the maximum weight of substance which will dissolve in water in the presence of undissolved substances.

Sounding (or innage) – The measurement of the height of liquid from the bottom of the tank

Specific gravity: the ratio between the weight of a substance at 60° F and the weight of the same volume of water at 60° F

Surveyor – Inspector from specialised 3<sup>rd</sup> party company, in charge of ullaging, sampling operations and cargo calculations

Threshold Limit Value – The time weighted average concentration of a substance to which workers may be repeatedly exposed, for a normal 8 hour working day and 40 hour working week, day after day, without adverse effect.

Total Observed volume (TOV) – Total volume of liquid cargo measured at the observed temperature

Total Calculated Volume (TCV) – Volume of product calculated at ambient temperature

Ullage – The measurement of the space above a liquid from the measurement point to the top of the tank.

U.S barrels – 42 US gallons =158,985 litres

Vapour pressure – The pressure exerted by the vapour above the liquid at a given temperature

Vessel Load Ratio – Ratio of the TCV of product measured after loading, minus the OBQ divided by the shore TCV load figure

Vessel Experience Factor (VEF) – The adjusted mean value of VLRs obtained after several cargoes

Viscosity – The property of a liquid which determines its resistance to flow

Volatile – Liquids that evaporate readily. For example, clean white petroleum products.

Volume Correction factor (VCF) – This corrects the volume of liquid cargo to the standard reference temperature using product density and temperature.

West Texas Intermediate (WTI) – A grade of crude oil used as a benchmark in oil pricing

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## ANNEX A: TANKER BILL OF LADING

## TANKER BILL OF LADING B/L No: MTF166020

Shipped on board in apparent good order and condition by (shipper) PT. WILMAR NABATI INDONESIA  
GEDUNG B.B.G LANTAI 9 JL. PUTRI HILAU NO.10  
KESAWAN, MEDAN BARAT  
MEDAN, SUMATERA UTARA 20111

on board the tanker MT MTM FAIRFIELD V60 at the port of GRESIK, INDONESIA

whereof CAPT. NGWE WYNN is the Master, to be delivered to the port of LIVERPOOL

Consignee/Order of: TO ORDER

Notify: WILMAR TRADING PTE LTD  
56 NEIL ROAD SINGAPORE 088830

A quantity in bulk said by the shipper to be:	QUANTITY
COMMODITY	(BEST TONS/BARRELS/GALLONS)
(NAME OF PRODUCT)	
PALM FATTY ACID DISTILLATE IN BULK (GMP+)	4000 MT

"CLEAN ON BOARD" (DATED 14<sup>TH</sup> JANUARY 2016)  
 "FREIGHT PREPAID"  
 OCEAN STOWAGE NUMBER : 3P, 3S, 8P, 8S, 9S

**THIRD ORIGINAL**

"THIS SHIPMENT OF 4000 METRIC TONS WAS LOADED ON BOARD THE VESSEL AS PART OF ONE ORIGINAL LOT OF 6008.200 METRIC TONS STOWED IN 20,000 BARRIS, WITH NO SEGREGATION AS TO PARCELS FOR THE WHOLE SHIPMENT. 3 SETS OF BILL OF LADING HAVE BEEN ISSUED, FOR WHICH THE VESSEL IS RELIEVED FROM ALL RESPONSIBILITIES TO THE EXTENT IT WOULD BE IF ONE SET ONLY WOULD HAVE BEEN ISSUED. THE VESSEL UNDERTAKES TO DELIVER ONLY THAT PORTION OF THE CARGO ACTUALLY LOADED, WHICH IS REPRESENTED BY THE PERCENTAGE THAT THE TOTAL AMOUNT SPECIFIED IN THE BILL(S) OF LADING BEARS TO THE TOTAL OF THE COMMINGLING SHIPMENT DELIVERED AT DESTINATION. NEITHER THE VESSEL NOR THE OWNERS ASSUME ANY RESPONSIBILITY FOR THE CONSEQUENCES OF SUCH COMMINGLING NOR FOR THE SEPARATION THEREOF AT THE TIME OF DELIVERY."

The quantity, measurement, weight, gauge, nature and value and actual condition of the cargo unknown to the Vessel and the Master, to be delivered at the port of discharge or so near thereto as the Vessel can safely get, always afloat upon prior payment of freight as agreed.

This shipment is carried under and pursuant to the terms of the Charter dated 12.03.2015 (Month/Day/Year) at SINGAPORE between MTM TRADING LLC AS DISPOSONT OWNER and WILMAR TRADING PTE LTD as Charterer, and all the terms whatsoever of the said Charter except the rate and payment of freight specified therein apply to and govern the rights of the parties concerned in this shipment. Copy of the Charter may be obtained from the Shipper or Charterer. The freight is earned concurrent with loading, ship and/or cargo lost, or not lost or abandoned.

The Owner shall have an absolute lien on the cargo for all freight, demurrage, detention and costs/expenses including attorney's fees, of recovering the same, which lien shall continue after delivery of the cargo into the possession of the Charterer, or of the holders of any bills of lading covering the same, or of any storage bills. In the event the Charter party is not sufficiently incorporated above, any and all disputes arising out of this bill are to be arbitrated in London or New York, at Owner's/Carrier's option, subject to the Exemption 84 arbitration clause.

If this Bill of lading is a document of title in which the Carriage of Goods by Sea Act of the United States, approved April 16, 1936 or similar legislation giving statutory effect to the International convention for the Unification of Certain Rules relating to Bills of lading at Brussels of August 25, 1924, applies by reason of the port of loading or discharge being in territory in which the said Act or other similar legislation is in force, this Bill of Lading shall have effect subject to the provisions of the said Act or other similar legislation, as the case may be, which shall be deemed incorporated herein, and nothing herein contained shall be deemed a surrender by the carrier of any of its rights or immunities or an increase of any of its responsibilities or liabilities under said Act or other similar legislation. If any term of this Bill of Lading is repugnant to the said Act or other similar legislation as so incorporated, such terms shall be void to that extent but no further. The contract of carriage evidenced by this Bill of Lading is between the shipper, consignee and/or owner of the cargo and the owner or demise charterer of the vessel named herein to carry the cargo described above. It is understood and agreed that, other than said shipowner or demise charterer, no person, firm or corporation or other legal entity whatsoever, is or shall be deemed to be liable with respect to the shipment as carrier, bailee or otherwise in contract or in tort. If, however, it shall be adjudged that any other than said shipowner or demise charterer is carrier or bailee of said shipment or under any responsibility with respect thereto, all limitations of or exonerations from liability and all defenses provided by law or by the terms of the contract of carriage shall be available to such other.

In Witness Whereof, the Master has signed THREE (3) ORIGINALS Bills of Lading of this tenor and date, one of which being accomplished, the others will be void.

Dated at GRESIK, INDONESIA this 14<sup>TH</sup> day of JANUARY 2016

  
 PT. PELAYAN BUKIT BARU JAYA  
 AS AGENT SIGNED FOR AND ON BEHALF OF MASTER  
 (CAPT. NGWE WYNN)

## ANNEX B: SET OF DISCHARGE CARGO DOCUMENTS



Paseo de Colón, 2, 3ª planta (Ed. Cervantes)  
08002 BARCELONA (Spain)  
Phone: 34-93-295 44 80 - Fax Agency: 34-93-310 11 29  
Fax Adm: 34-93-310 27 07  
Telex: 51955 Chart E  
E-mail: barcelona@ibericamaritima.com  
E-mail: operations.bcn@ibericamaritima.com  
http://www.ibericamaritima.com

### TANKER STATEMENT OF FACTS

Vessel:	MT MTM PENANG -VOY10	Port/Berth:	BARCELONA 32C
Arrived from:	BIZERTE	Sailed to:	GIBRALTAR
Arrival draft:	F 6,7m      A 7,7m	Sailing draft:	F 4,70m      A 6,00m
CP Date:	09/12/2015 WILMAR TRADING	Terminal:	RELISA
Commodity:	PALM FATTY ACID DISTILLATE		
Weight:	7010,219 MT	Ship's figure:	7.007,994 MT
Stowage:	3W, 5S, 7W, 8P, 9S		
Load.port:	Dumai, Indonesia		

	Day	Date	Time
Vessel arrived at roads / Free pratique given	Thursday,	25/02/2016	12.30 hrs
Notice of readiness tendered		25/02/2016	12.30 hrs
Dropped anchor		25/02/2016	12.30 hrs
Weighted anchor		25/02/2016	15.50 hrs
Pilot on board		25/02/2016	16.24 hrs
First line ashore		25/02/2016	17.18 hrs
All fast		25/02/2016	18.00 hrs
Gangway down		25/02/2016	18.06 hrs
Surveyor on board		25/02/2016	18.30 hrs
Notice of readiness accepted		25/02/2016	19.30 hrs
Ullages and calculations completed		25/02/2016	21.36 hrs
Hose connected	1x6"	25/02/2016	20.42 hrs
Commenced discharge		25/02/2016	21.42 hrs
Completed discharge	Saturday,	27/02/2016	04:36 hrs
Tanks inspected & passed/calculations completed		27/02/2016	01:42 hrs
Hose disconnected		27/02/2016	02:15 hrs
Cargo documents on board		27/02/2016	02:30 hrs
Pilot ordered		27/02/2016	hrs
Vessel sailing		27/02/2016	hrs

#### Remarks:

Upon ship's arrival she had drop the anchor due to berth occupied by MT SOUND OF SEA

Cargo was discharges through 1 Flexible line of 6 inches into RELISA Terminal

From 0536 hrs to 0606 hrs on 26/02/2016 stopped discharge to re-connect hose on board

MT MTM PENANG

Master/Ch. Off.

FOR RELISA ONLY

RELISA

Terminal

IBERICA MARITIMA

Ship's Agents



**MTM TRADING LLC**

**VESSEL TIME SHEET / STATEMENT OF FACTS (SOF)**

Date:	27/FEBRUARY/2016		Operation (Ld/Dch):		DISCHARGING		Charterer:		WILMAR TRADING	
Vessel:	MTM PENANG		Port:		BARCELONA, SPAIN		Berth:		32 C	
Voy No.:	1016		Grade:		PFAD		Cargo No.:		B/L Quantity:	
Stowage:	3W, 5S, 7W, 8P, 9S								7010.219 MT	
							Slip Quantity			
DRAFT:	Arrival:		Sailing:		TUGS:		Arrival		Sailing	
Forward:	6.70 M		4.70 M				2 TUG		2 TUG	
Aft:	7.70 M		6.00 M							
Mean:	7.20 M		5.35 M							
									Other	

[illegible]

**Signatures:**

2. Mastent/LANG

Page 1 of 1 MASTER

FOR RECEIPT ONLY  
SIGNED ON BEHALF  
OF F.S.B.

## Surveyor

Only for receipt, without any  
Prejudice, for passing on to  
Terminal, as Agent Rep

SOF 0130 -- Ver 0 -- 06/15/13

MTM TRADING LLC



## NOTICE OF READINESS

Vessel:	MTM PENANG	Voy No.:	10/15	Port:	BARCELONA, SPAIN
Arrival Date:	25 FEBRUARY 2016	Arrival Time:	1000 LT		

TO: LOADING MASTER, AGENT OR TO WHOM SOEVER IT MAY CONCERNI herewith tender you the SINGAPORE (Flag of vessel) flagged vessel,M/T MTM PENANG of which I am the MasterAs being ready in all respects to DISCHARGING her cargo of PFAD1/PFAD2/PFAD3

Quantity: PFAD1-3970.119 MT//  
PFAD 2-1910.052 MT//  
PFAD 3- 1130.048 MT

Stowage: 3P/3S, 5S, 7P/7S, 8P, 9SThis notice is tendered this day of 25<sup>th</sup> FEBRUARY 2016 at 1230 hrs local time while

the vessel is lying at

VESSEL ANCHORED AT EASTERN ANCHORAGE ,  
BARCELONA

This notice is tendered in accordance with all terms, conditions, and exceptions of the governing charter party.

Master's Signature: [Signature]  
CAPT AJEY ARVIND GHARURE  
 MASTER

ACCEPTED:  
 Time/Date: 25-02-2016 19:30h  
 For Charterer: [Signature]  
 Signature: [Signature]  
 Name Printed: K. ALVIRA  
 Representing: ACCEPTED BY RELISA

AS PER CHARTER PARTY  
 ACCORDING THE DISCHARGE/LOADING  
 PLAN ACCEPTED FOR THE VESSEL

NOR 0070 - Ver 0 - 06/15/13



MTM TRADING LLC

ULLAGE REPORT (CHEMICALS)

Vessel: MTM PENANG Voy No.: 10118 Date: 25-Feb-18 Load/Disch: DISCHARGING Charterer: WILLMAR  
 Port: BARCELONA Birth: 32 C Grade: Distillate Cargo No.: 01 S.G. at 71°C: 0.8539  
 Pico Telly Add

DRAFT Forward 6.70 M Aft 7.70 M Mean: 7.20 M

TANK NO.	OBSERVED ULLAGE	TRIMLIST CORRECTION	CORRECTED ULLAGE	OBSERVED VOLUME	VCF	TANK TEMP. °C	S.G. AT TANK TEMP.	NET VOLUME M3	NET QUANTITY MT
1P									
1S									
2P									
2S									
3P									
3S	1.140	0.034	1.174	1327.236		69.0	0.85483		1147.753
4P									
4S									
5P	1.210	0.013	1.223	635.129		69.0	0.85480		547.550
5S									
6P									
6S									
7P									
7S	1.450	0.034	1.484	1398.254		71.0	0.85390		1147.435
8P	1.370	0.034	1.404	1312.523		71.0	0.85390		1133.889
8S									
9P									
9S									
STOPP SLOPS									
TOTALS				4601.061					3976.547
						Ship Figure MT	Shore Figure MT	ShoShore DIF	% Difference
						3976.547	3976.119	6.528	0.16%

Remarks: 1. UTI SERIAL NO. - 85581 / 2. ULLAGES TAKEN IN SLIGHT SWELL / 3. DENSITY USED AS PER CHART PROVIDED BY LONING MASTER

SIGNED ON BEHALF OF  
 MTM PENANG  
 Ch Officer *[Signature]* Terminal Rep *[Signature]*  
 SIGNATURES  
 CHIEF OFFICER



## MTM TRADING LLC

## ULLAGE REPORT (CHEMICALS)

Vessel: MTM PENANG Voy No.: 1016 Date: 25-Feb-16 Load/Disch: DAICHANG Charterer: WILMAR  
 Port: BARCELONA Berth: 32 C Grade: PALMISTRY ACID DISTILLATE Cargo No.: 2 S.G. at 15°C: 0.9539

DRAFT Forward 6.70 M Aft 7.70 M Mean: 7.20 M

TANK NO.	OBSERVED ULLAGE	TRIMLIST CORRECTION	CORRECTED ULLAGE	OBSERVED VOLUME	VCF	TANK TEMP. °C	S.G. AT TANK TEMP.	NET VOLUME M3	NET QUANTITY MT
11P									
11S									
20P									
20S									
30P	2.740	0.034	2.774	1145.512		68.0	0.95480	960.839	
30S									
40P									
40S									
50P									
50S									
60P									
60S									
70P									
70S									
80P									
80S									
90P	2.120	0.032	2.152	1055.462		71.0	0.95390	920.453	
90S									
SLOP P									
SLOP S									
TOTALS				2210.974					1841.091
Remarks: 1. UTI SERIAL NO. - 5038N / 2. ULLAGES TAKEN IN SLIGHT SWELL / 3. DENSITY USED AS PER CHART PROVIDED BY LOADING MASTER									
Ship Figure MT Shore Figure MT Slop Shore Disb									
1911.091 1910.052 1.036									% Difference 0.06%

SIGNATURES Ch Officer [Signature] MTM PENANG  
 Surveyor [Signature] Terminal Rep  
 Chief Officer [Signature]





MTM TRADING LLC

ULLAGE REPORT (CHEMICALS)

Vessel: MTM PENANG Voy No.: 1015 Date: 25 Feb-15 Load/Disch: DISCHARGING Charterer: WILMAR  
 Port: BARCELONA Berth: 32 C Grade: ACID DISTILLATE Cargo No.: 01 B S.G. at 70C: 0.8643

DRAFT Forward 5.70 M Aft: 7.70 M Mean: 7.20 M

TANK NO.	OBSERVED ULLAGE	TRIMLIST CORRECTION	CORRECTED ULLAGE	OBSERVED VOLUME	VCF	TANK TEMP. C	S.G. AT TANK TEMP.	NET VOLUME NO	NET QUANTITY MT
1P									
1S									
2P									
2S									
3P									
3S									
4P									
4S									
5P									
5S									
6P									
6S									
7P	1.731	0.035	1.766	1296.143		70.0	0.86430		1120.256
7S									
8P									
8S									
9P									
9S									
SLOP P									
SLOP S									
TOTALS				1296.143					1120.256
Remarks: 1. UTM SERIAL NO - 46384 / 2. ULLAGES TAKEN IN SLIGHT SWELL / 3. DENSITY USED AS PER CHART PROVIDED BY LOADING MASTER									
									Ship Figure MT Shore Figure M Ship/Shore Diff % Difference
									1120.256 1120.048 -0.792 -0.87%

SIGNATURES  
 Ch Officer: MTM PENANG  
 Chief Officer: BEHALF OF  
 Surveyor: SIGNED ON  
 Terminal Rep: F.S.B.

MTM TRADING LLC



## EMPTY TANK CERTIFICATE

Date:	27-FEBRUARY-2016				
Vessel:	MTM PENANG	Port :	BARCELONA, SPAIN	Berth:	32 C
Voy No.:	10/16	Grade:	PFAD	Cargo No.:	01 & 02

I, the undersigned, have inspected the following cargo tank(s), pump(s), and line(s):  
 3P,3S,5S,7P,7S, 8P,9S

After discharging and have found them empty.

Inspector's signature:

Inspector's name printed:

CARLOS CASADO

Representing:

FLOKSTRA SURVEY BUREAU

Empty Tk Cert 0100 - Ver 9 - 06/15/13



# FLOKSTRA SURVEY BUREAU B.V.

INDEPENDENT MARINE & CARGO SURVEYORS

FOSFA member - NOFOTA recognized superintendent

## Ullage-Report :

Reference : F16-1267A

**Vessel** "MTM Penang" V.10  
**Cargo** Palm Fatty Acid Distillate

**Port** Barcelona  
**Date** 25/02/2016

Measurements taken from : UTI-device

Density		Table loading port			
Corr.factor		Table loading port			
TANKS :	ULL./SOUND.	TEMP. :	LITERS :	DENSITY :	M.TONS :
3P	2,774	69,0	1.145,512	0,86480	990,639
9S	2,152	71,0	1.065,462	0,86390	920,453
		TOTAL :	2.210,974	TOTAL :	1.911,092
Ship's figures are approximate and not for official weight determination					
Draft Fwd: 6,70		Aft: 7,70		List: NIL	

All work is carried out under the standard trading conditions of the national association of cargo superintendents and surveyors - copies available on request.

FOR ULLAGES & TEMP. ONLY

MTM PENANG

CHIEF OFFICER





**FLOKSTRA SURVEY BUREAU B.V.**  
INDEPENDENT MARINE & CARGO SURVEYORS  
POSFA member - NOFOTA recognized superintendent

Ullage-Report :

Reference : F16-1267B

Vessel "MTM Penang" V.10 Port Barcelona  
Cargo Palm Fatty Acid Distillate Date 25/02/2016

Measurements taken from : UTI-device

Density Corr.factor		Table loading port Table loading port			
TANKS :	ULL./SOUND.	TEMP. :	LITERS :	DENSITY :	M.TONS :
7P	1,766	70,0	1,296,143	0,86430	1.120,256
		TOTAL :	1.296,143	TOTAL :	1.120,256
Ship's figures are approximate and not for official weight determination					
Draft Fwd:	6,70	Aft :	7,70	List :	NIL

All work is carried out under the standard testing conditions of the national association of cargo superintendents and surveyors - copies available on request



FOR ULLAGES &amp; Temp ONLY

MTM PENANG

  
CHIEF OFFICER



# FLOKSTRA SURVEY BUREAU B.V.

INDEPENDENT MARINE & CARGO SURVEYORS

POSPA member - NOFOTA recognized superintendent

Ullage-Report :

Reference : F16-1267C

Vessel "MTM Penang" V.10  
Cargo Palm Fatty Acid Distillate

Port Barcelona  
Date 25/02/2016

Measurements taken from : UTI-device

Density	Table loading port				
Corr.factor	Table loading port				
TANKS :	ULL./SOUND.	TEMP. :	LITERS :	DENSITY :	M.TONS :
3S	1,174	69,0	1.327,235	0,86480	1.147,793
5S	1,223	69,0	633,129	0,86480	547,530
7S	1,484	71,0	1.328,204	0,86390	1.147,435
8P	1,404	71,0	1.312,523	0,86390	1.133,889
		TOTAL :	4.601,091	TOTAL :	3.976,647
Ship's figures are approximate and not for official weight determination					
Draft Fwd:	6,70	Aft :	7,70	List :	NIL

All work is carried out under the standard loading conditions of the national association of cargo superintendants and surveyors - copies available on request



FOR ULLAGES & TEMP. ONLY

MTM PENANG

CHIEF OFFICER



## FLOKSTRA SURVEY BUREAU B.V.

INDEPENDENT MARINE & CARGO SURVEYORS

POSPA member - NOPOTA recognized superintendent

### TANK INSPECTION CERTIFICATE

**VESSEL :** "MTM Penang" V.10  
**CARGO :** Palm Fatty Acid Distillate  
**REF :** F16-1267A

**PORT :** Barcelona  
**DATE :** 27 Feb 2016

**Re: M/T :** "MTM Penang" V.10  
**Quantity :** 1.910,052  
**Stowage :** 3P-9S

We the undersigned herewith declare that after discharge of above cargo the  
ship's tank No. **3P-9S** was found to be

EMPTY

EMPTY

On behalf of  
**Flokstra Survey Bureau B.V.**

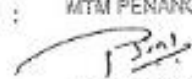
Surveyor: **Carlos Casado**

Signature: 

**Master/Chief officer**

Name: **PARVIZNOOR SIN SH**

Sign. : **MTM PENANG**

  
**CHIEF OFFICER**

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# FLOKSTRA SURVEY BUREAU B.V.

INDEPENDENT MARINE & CARGO SURVEYORS

FOSFA member - NOFOTA recognized superintendent

## TANK INSPECTION CERTIFICATE

**VESSEL:** "MTM Penang" V.10  
**CARGO:** Palm Fatty Acid Distillate  
**REF:** F16-1267B

**PORT:** Barcelona  
**DATE:** 27/FEB/2016

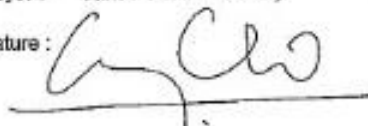
**Re: M/T:** "MTM Penang" V.10  
**Quantity:** 1.130,048  
**Stowage:** 7P

We the undersigned herewith declare that after discharge of above cargo the  
 ship's tank No. **7P** was found to be

**EMPTY**

On behalf of  
**Flokstra Survey Bureau B.V.**

Surveyor: Carlos Casado Custey

Signature: 

**Master/Chief officer**

Name: **PARVINDER SINGH**

Sign: **MTM PENANG**

  
**CHIEF OFFICER**

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## FLOKSTRA SURVEY BUREAU B.V.

INDEPENDENT MARINE & CARGO SURVEYORS

FOSFA member - NOFOTA recognized superintendent

### TANK INSPECTION CERTIFICATE

**VESSEL:** "MTM Penang" V.10  
**CARGO:** Palm Fatty Acid Distillate  
**REF:** F16-1267C

**PORT:** Barcelona  
**DATE:** 27 Feb 2016

**Re: M/T:** "MTM Penang" V.10  
**Quantity:** 3.970,119  
**Stowage:** 3S-6S-7S-8P

We the undersigned herewith declare that after discharge of above cargo the  
ship's tank No. **3S-6S-7S-8P** was found to be

**EMPTY**

On behalf of  
**Flokstra Survey Bureau B.V.**

Surveyor: Carlos Casado Custey

Signature:

**Master/Chief officer**

Name: **JARUINDER SINGH**

Sign.: MTM PENANG

  
**CHIEF OFFICER**

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## MTM TRADING LLC



## LETTER OF PROTEST (LOP)

Date:	27-FEB-2016	Charter Party Date:	09-DEC-2015	Charterer:	WILMAR TRADING
Vessel:	MTM PENANG	Port:	BARCELONA, SPAIN	Berth:	32 C
Voy No.:	10/16	Grade:	PALM FATTY ACID DISTILLATE	Cargo No.:	01 & 02
Stowage:	3P,3S,5S,7P,7S,8P,9S				

TO: Shipper(s) and/or Receiver(s) and/or Terminal rep(s) and or Surveyor(s)

On behalf of the Vessel, Owners, Operators, Managers, and any other concerned parties, I hereby protest against the delays caused by you to my vessel as noted below. I hereby hold you responsible for all delays, time lost, costs, and consequences and reserve the right to revert to this matter in the future.

PHASE OF CARGO OPERATION During ☐ Before ☐ After ☒ Loading ☐ Discharge ☒

☒ The vessel is capable of connecting 7 x 6" hoses/lines to its manifold and handling 1 grades simultaneously, but only 1 x 6" hose(s)/line(s) was provided by terminal.

☒ The vessel is capable of a rate of 1000 m3 per hour, but the terminal restricted the rate to less than this amount at an average rate of only 265 mt per hour was achieved.

☐ The vessel is capable of maintaining a discharge pressure of \_\_\_\_\_ bars, but the receiving facility restricted the pressure to less than this at \_\_\_\_\_ bars.

☐ The cargo operation was delayed due waiting for shippers' cargo surveyor attendance/readiness. Delays occurred from \_\_\_\_\_ to \_\_\_\_\_.

☐ The cargo operation was delayed due waiting for terminal and/or barge and/or shore readiness. Delays occurred from \_\_\_\_\_ to \_\_\_\_\_.

☒ The cargo operation was delayed due to berth congestion. The intended berth was occupied by Other vessel from 25-Feb-2016 / 1230 LT to 25-Feb-2016 / 1550 LT awaiting at Anchorage

☐ Stops and/or rate reductions requested by shore

☐ Protest is noted due to shippers, and/or receivers and/or terminal reps and/or surveyors refusing to sign cargo documents.

Signatures:

Master

Surveyor \_\_\_\_\_

Only for use by Terminal Rep  
Prejudice, for passing to  
Terminal, as agents only

☐ Further protest is noted due to Shipper(s) and/or Receiver(s) and/or Terminal rep(s) and or Surveyor(s) Refusing to Sign this protest.

The Master may amend the LOP to better suit the particular situation being presented.

LOP 0000/0100- Ver 0-05/15/01



**FLOKSTRA SURVEY BUREAU B.V.**  
INDEPENDENT MARINE & CARGO SURVEYORS  
FOSFA member - NOPOTA recognized superintendent

**LETTER OF PROTEST**

To the Master/Chief Officer,

Port  
Date

Barcelona

27 FEB 2016

re: M/T "MTM Panang" V.10  
Arrived 25/02/2016  
At Reusa  
Quantity 1.910,052  
Cargo Palm Fatty Acid Distillate  
Stowage 3P-9S  
Ref.: F16-1267A

Dear Sir,

On behalf on our principals we hold you responsible for the following fact(s) and all consequences which may arise due to or caused by the mentioned fact(s):

Difference between B/L figures and arrival figures:

B/L figures	1.910,052 kilos
Ship's arrival figures	1.911,092 kilos
Difference	<u>1,040 kilos</u>

Difference between loading and arrival figures

Ship's loading figures	1.896,392 kilos
Ship's arrival figures	1.911,092 kilos
Difference	<u>14,700 kilos</u>

Difference between B/L figures and prov.outturn

B/L figures	1.910,052 kilos
Provisional outturn	1.891,192 kilos
Difference	<u>- 18,860 kilos</u>

High / Low temperature not in accordance with the heating instructions.

Temp.acc. heating instructions	degrees C
Temp.at arrival / discharge	degrees C
Temp.during ship's voyage	degrees C

Flokstra Survey Bureau B.V.

Surveyor: Carlos Casado Custey

Signature:

Master / Chief Officer

Name: CAPT. A. ARVED CHARPURE

Signature:

FOR RECEIPT ONLY

MTM PENDING

MASTER



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# FLOKSTRA SURVEY BUREAU B.V.

INDEPENDENT MARINE & CARGO SURVEYORS

FOSFA member - NOFOTA recognized superintendent

## LETTER OF PROTEST

To the Master/Chief Officer,

Port  
Date

Barcelona

27 Feb 2016

re: M/T "MTM Penang" V.10  
Arrived 25/02/2016  
At Rellao  
Quantity 1.130,048  
Cargo Palm Fatty Acid Distillate  
Stowage 7P  
Ref.: F16-1267B

Dear Sir,

On behalf on our principals we hold you responsible for the following fact(s) and all consequences which may arise due to or caused by the mentioned fact(s):

### Difference between B/L figures and arrival figures:

B/L figures	1.130,048 kilos
Ship's arrival figures	1.120,256 kilos
Difference	-9,792 kilos

### Difference between loading and arrival figures

Ship's loading figures	1.116,683 kilos
Ship's arrival figures	1.120,256 kilos
Difference	3,573 kilos

### Difference between B/L figures and prov.outturn

B/L figures	1.130,048 kilos
Provisional outturn	1118,890 kilos
Difference	-11,158 kilos

### High / Low temperature not in accordance with the heating instructions.

Temp.acc. heating instructions	degrees C
Temp.at arrival / discharge	degrees C
Temp.during ship's voyage	degrees C

Flokstra Survey Bureau B.V.

Surveyor: Carlos Casado Custey

Signature:

Master / Chief Officer

Name: CAPT. AJEY ARVIND CHARPUR

Signature: FOR R. CHARPUR

MTM PENANG

MASTER



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# FLOKSTRA SURVEY BUREAU B.V.

INDEPENDENT MARINE & CARGO SURVEYORS

FOSFA member - NOPOTA recognized superintendent

## LETTER OF PROTEST

To the Master/Chief Officer,

Port *Barcelona*

Date *27 Feb 2016*

re: M/T *"MTM Penang" V.10*  
 Arrived *25/02/2016*  
 At *Relisa*  
 Quantity *3.970,119*  
 Cargo *Palm Fatty Acid Distillate*  
 Stowage *3S-5S-7S-8P*  
 Ref.: *F16-1287C*

Dear Sir,

On behalf on our principals we hold you responsible for the following fact(s) and all consequences which may arise due to or caused by the mentioned fact(s) :

*Difference between B/L figures and arrival figures :*

B/L figures	3.970,119 kilos
Ship's arrival figures	3.976,647 kilos
Difference	<u>6,528</u> kilos

*Difference between loading and arrival figures*

Ship's loading figures	3.968,816 kilos
Ship's arrival figures	3.976,647 kilos
Difference	<u>17,831</u> kilos

*Difference between B/L figures and prov.outturn*

B/L figures	3.970,119 kilos
Provisional outturn	3.930,918 kilos
Difference	<u>- 39,201</u> kilos

*High / Low temperature not in accordance with the heating instructions.*

Temp.acc. heating instructions	degrees C
Temp.at arrival / discharge	degrees C
Temp.during ship's voyage	degrees C

Flokstra Survey Bureau B.V.

Surveyor: *Carlos Casado Custey*

Signature: 

Master / Chief Officer

Name: *CAPT. AJEY ARVEND GNARPURE*

Signature: *For Reception*  


MASTER



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## MTM TRADING LLC



## HOURLY RATE/PRESSURE LOG

Vessel:	M. T. MIM PENANG		Port:	BARCELONA, SPAIN		Berth:	32 C	
Voy No.:	10/16	Grade:	PFAD		Cargo No.:	01 & 02	Quantity:	7010.219 MT
Stowage:	3W, 5S, 7W, 8P & 9S					Operation (Ld/Dch):		DISCHARGING
Number and size of hoses supplied:			1 x 6"					
Number and size of shore lines:			1 x 8"					
Shore Restrictions:			7 BAR MAX PRESSURE AT MANIFOLD					
Expected Load / Dch Rate (mt/hr):			330 MT / HR					

Date	Time	Rate (mt/hr)	Manifold Pressure (Bars)	Comments
25-02-2016	2142		0.5	Commenced discharging from 3P & 9S
25-02-2016	2200	261	7.0	
25-02-2016	2300	265	7.0	
25-02-2016	2400	293	7.0	
26-02-2016	0100	273	7.0	
26-02-2016	0200	275	7.0	
26-02-2016	0300	278	7.0	
26-02-2016	0400	274	7.0	0400 Commenced stripping and squeezing 3P & 9S COT
26-02-2016	0500	111	3.0	
26-02-2016	0600	56	1.0	0536 Completed stripping and squeezing 3P & 9S COT
26-02-2016	0700	195	5.0	0606 Commenced discharging from 3S, 5S, 7W & 8P COT
26-02-2016	0800	305	7.0	
26-02-2016	0900	316	7.0	
26-02-2016	1000	340	7.0	
26-02-2016	1100	264	7.0	
26-02-2016	1200	272	7.0	1218 Completed stripping and squeezing 5S
26-02-2016	1300	297	7.0	
26-02-2016	1400	323	7.0	
26-02-2016	1500	325	7.0	
26-02-2016	1600	326	7.0	1612 Completed Stripping & Squeezing 3S
26-02-2016	1700	212	7.0	1736 Completed Stripping & Squeezing 8P
26-02-2016	1800	238	7.0	
26-02-2016	1900	231	7.0	
26-02-2016	2000	273	7.0	
26-02-2016	2100	270	7.0	
26-02-2016	2200	285	7.0	
26-02-2016	2300	236	6.0	2348 : Completed Stripping & Squeezing 7P
26-02-2016	2400	186	6.0	
27-02-2016	0100	117	3.0	0136 : Completed Discharging

Remarks (additional notes for delays &amp; details of LOI's):

Signatures:  
Master/Ch officer

MTM PENANG

  
CHIEF OFFICER

Surveyor

FOR RECEIPT ONLY  
SIGNED ON BEHALF  
OF: E.S.B. LO

Only for Terminal use  
without any  
Prejudice to parties  
Terminal, as agents only

Page 1 of 1

Rate &amp; Press Log 0100 - Ver 0 - 06/15/13

## ANNEX C: MANDATORY PREWASH DOCUMENTS (MT OTHELLO)

Othello is to discharge in Barcelona the following cargoes :

Cargo	IBC Name	IMO	UN No	USCG	Marpol	Quantity MT	Prewash/Slops Quantity
IPA	Isopropyl Alcohol	3	1219	20	Z	1000.274	N/A
MEK	Methyl Ethyl Ketone	3	1193	18	Z	407.062	N/A
DINP	Dialkyl (C9-C10) Phthalates	N/A	N/A	34	Y	802.306	Yes
DIDP	Dialkyl (C7-C13) Phthalates	N/A	N/A	34	X	553.109	Yes

The prewash will be conducted following Marpol Annex II Appendix 6. DINP and DIDP will both be considered as high viscosity at the unloading temperature (> 50 mPa.s, as stated in the MSDS of DIDP and on the BL of DINP).

As stated in B.20 of the foresaid appendix, the minimum quantity of water to be used for prewash will be 12.9 cbm (see attachment for calculation details and formula).

The fix tank cleaning machine consumption is 10 cbm/hr at 10 bars, the complete cycle in prewash mode is 3 min. To obtain the foresaid quantity, 2 machines running per tank, the running times are to be the following:

1P – 8 min, 75 – 9 min, 3P – 22 min.

This after the water reached a temperature of at least 60 deg C to fulfil Marpol regulation. Regarding USCG compatibility chart, the slops of those two cargoes can be mixed.

Attachment 1 - Page 5

## OTHELLO LXOD

Products	CAT	Taskgroups	Footnotes
Cycloheptene	X	1	3
Cyclohexene	Y	1	3
Cyclohexanol	Y	1	3
Cyclohexanone	Z	1	3, 4
Cyclohexanone, Cyclohexanol mixture	Y	1	3
Cyclohexyl acetate	Y	1	3
Cyclohexaniline	Y	1	3, 4
1,3-Cyclopentadiene dimer (mixture)	Y	1	3
Cyclopentadiene	Y	1	3
Cyclopentane	Y	1	3
p-Cymene	Y	1	3
Decahydronaphthalene	Y	1	3
Decanoic acid	X	1	3
Decene	X	1	3
Decyl alcohol (all isomers)	Y	1	3
Decyl/Dodecyl/Tetradecyl alcohol mixture	Y	1	3, 7, 20
Decylacetylenedihydrothiophene dioxide	X	1	3
Di-(2-ethylhexyl) adipate	Y	1	3
Di-(2-ethylhexyl) phosphoric acid	Y	1	3
Dioctyl alcohol	Z	1	3
Dioctyl (C7-C13) alkylates	X	1	3 <i>DIDP</i>
Dioctyl (C8-C9) diphenylamines	Z	1	3
Dioctyl (C9-C10) alkylates	Y	1	3 <i>DINP</i>
Dioctyl thiophosphates sodium salt solution	Y	1	3, 7, 20
Dioctyl hydrogen phosphonate	Y	1	3
Dioctyl phthalate	X	1	3
Dioctyl sebacate	Y	1	3, 7
Dioctylamine	Y	1	3
3,4-Dichloro-1-butene	Y	1	3, 4, 20
Dichlorobenzene (all isomers)	X	1	3
1,1-Dichloroethane	Z	1	3, 4
Dichloroethyl ether	Y	1	3, 4
1,8-Dichlorooctene	Y	1	3
2,2-Dichloroisopropyl ether	Y	1	3, 4, 20
Dichloromethane	Y	1	3
2,4-Dichlorophenol	Y	1	3, 4
2,4-Dichlorophenoxyacetic acid, diethanolamine salt solution	Y	1	3
2,4-Dichlorophenoxyacetic acid, diethylamine salt solution (70% or less)	Y	1	3
2,4-Dichlorophenoxyacetic acid, triisopropanolamine salt solution	Y	1	3
1,1-Dichloropropane	Y	1	3, 20
1,2-Dichloropropane	Y	1	3, 20
Dichloropropene/Dichloropropene mixtures	X	1	3, 20

Created by FORBOL

2014-07-15

## DINP-DIDP

## Minimum water for prewash (cbm)

Formula=  $Q=k((15R^{0.8})+(5R^{0.7}) * V/1000))$

Q= Minimum water needed for prewash

R= Residual quantity per tank in cbm

$V$  = Volume of the tank

K<sub>ONP</sub>= Factor

K <sub>cliff</sub> = Factor	2.4
-----------------------------	-----

K=1,2 Category X, non-solidifying, low-viscosity substance

K=2,4 Category X, solidifying or high-viscosity substance

K=0,5 Category Y, non-solidifying, low-viscosity substance

K=1	Category Y, solidifying or high-viscosity substance
-----	---

R Shall not be taken lower than 0.1m<sup>3</sup> for a tank volume of 500m<sup>3</sup>

R Shall not be taken above than 0.04m3 for a tank volume <100m3

For Category X the value of  $r$  shall either be determined based on stripping tests according to the Manual, observing the lower limits as given above, or be taken to be 0.9m<sup>2</sup>

Tank	Volume	R	Min water
Exemple	100	0.1	2.5

	Tank	Volume	R	Min water
DINP	1P	339.098	0.1	2.7
DINP	7S	565.65	0.1	2.9
DIDP	3P	654.484	0.1	7.3
	Total			12.9

STORAGE PLAN - OTRILLO									
VOYAGE: Nieuwpoort-Harterdam/Tees Sea Sands					VOT: 12/16				
					Depth: 6.64 Force: 6.67 Midi: 6.70 Aft: 6.70				
No	Grade	System	From-To	Ship MT	Days	Volume	MADEPOL	USCG	IMO
1	Hexane		Antwerp-to-Gibraltar	204,000	0.8688	808,047	Y	8	1208
2	Methyl Ethyl Ketone		Antwerp-Barcelona	428,000	0.8190	508,864	Z	18	1182
3	Methyl Ethyl Ketone 2		Antwerp-to-Gibraltar	238,000	0.8190	199,074	Z	18	1182
4	IPA		Antwerp-Barcelona	304,000	0.7858	1,275,596	Z	20	1182
5	Diisobutyl Phosphate		Antwerp-Barcelona	800,000	0.9729	822,284	Y	34	0
6	Diisobutyl Phosphate		Antwerp-Barcelona	550,000	0.9653	569,653	X	34	0
7	Methyl Ethyl Ketone 3		Antwerp-Gibraltar	530,000	0.8190	672,580	Z	18	1182
8	2 Ethyl Hexanol		Antwerp - La Goulette	900,000	0.8266	692,427	Y	20	1191
9	Croton(Naphyl) CE		Antwerp - La Goulette	6,000	0.8726	9,000	X	30	2296
10									
Totals:				4,125,000		4,906,764			
Master: M. van Leeuwen					Chief Mate: F. Gredanay				
					2nd Mate: J. Johnson				
					3rd Mate: L. Hoffman				



Page 2 of 4

☒ 1 Yes ☐ 0 No ☐ 2 Not applicable

3.2 On completion of stripping cargo lines were blown out with:

Air ☒ 1 Nitrogen ☐ 0 Inert gas ☐ 2  
 Duration 5-8 min Pressure 7 bar  
 Air/Nitrogen/inert gas was supplied from:  
 Shore ☐ 0 Ship ☒ 1  
 An inert gas generator is on board ☒ 1 Nitrogen storage 0 cylinders ☒ 1

I. Results (Test medium: water)

I.1 Residue Quantities

Tank No.	Total volume [m <sup>3</sup> ]	Sounding at test begin [cm]	Trim [max.3°]	List [max.1°]	Remaining quantities [t]				
					Section	Entrapped areas tank bottom	Cargo pump	Piping up to manifold	Total
1 P	1		1.00	0	1	1	0	2	4
1 S	1		1.00	0	2	2	0	2	6
2 P	1		1.00	0	0.5	2	0	8	10.5
2 S	1		1.00	0	1	2	0	4	7
3 P	1		1.00	0	0.5	1	0	1	2.5
3 S	1		1.00	0	2	1	0	5	8
4 P	1		1.00	0	1	1	0	6	8
4 S	1		1.00	0	3	6	0	3	11
5 P	1		1.00	0	2	2	0	20	24
5 S	1		1.00	0	1	2	0	2	5

2 Stripping Time 25-30 min

Remarks:

The duration of line blowing of each cargo tank is 5-8 min

The duration of Automatic superstripping of each cargo tank is 22-25 min

Minors



Page 2 of 4

☒ 1 Yes
 ☐ 0 No
 ☐ 2 Not applicable

3.2 On completion of stripping cargo lines were blown out with:

Air ☒ 1 Nitrogen ☐ 0 Inert gas ☐ 2  
 Duration 5-8 min Pressure 7 bar  
 Air/Nitrogen/inert gas was supplied from:  
 Shore ☐ 0 Ship ☒ 1  
 An inert gas generator is on board ☒ 1 Nitrogen storage 8 cylinders ☒ 1

4. Results (Test medium: water)

4.1 Residue Quantities

Tank No.	Total volume [m <sup>3</sup> ]	Sounding at test begin [cm]	Trim [max.3°]	List [max.1°]	Remaining quantities [t]				Total
					Suction	Entrapped areas tank bottom	Cargo pump	Piping up to manifold	
6 P	1		1.00	0	1	2	0	3	6
6 S	1		1.00	0	0.5	10	0	0.5	11
7 P	1		1.00	0	1	1	0	18	20
7 S	1		1.05	0	1	3	0	2.5	6.5

4.2 Stripping Time 25-30 min

Remarks:

The duration of line blowing of each cargo tank is 5-8 min

The duration of Automatic superstripping of each cargo tank is 22-25 min

Valves: 0014050708 Eamir Osman *[Signature]*