BASIC TRAINING FOR OIL AND CHEMICAL TANKER CARGO OPERATIONS

Purpose of this Training course :

The purpose of this course is to enhance the capabilities of shipboard personnel who sail on specialized carriers such as tankers. It is not the intention of the course to compartmentalize the trainee's way of thinking in terms of tanker operation. The idea is to make him/her aware of the specialization of operations specific to an oil and chemical tanker and sensitize him/her towards the responsibilities that s/he will face on such a vessel.

This course is meant for officers and ratings assigned basic duties and responsibilities related to cargo or cargo equipment on board oil and chemical tankers. By successfully completing this course, the aforementioned shipboard personnel will fulfill the mandatory minimum requirements of Regulation V/1-1 of STCW 1978, as amended.

1. BASIC KNOWLEDGE OF TANKERS

1.1 Classification of Tankers:

Fig. 1.1.A: Tanker Ship

Classification of Tankers on the basis of Type

1. Oil Tankers: Oil tankers, as their name suggests carry oil and it's by products. Oil tanker however, is a generic terminology and includes not only crude oil but also petrol, gasoline, kerosene and paraffin. Oil tankers are further sub-divided into two main types: product tankers and crude tankers:

– **Product tankers** are used to transport the above mentioned petroleum based chemicals

– **Crude tankers** are specifically used to transport crude oil from the excavation site to the crude oil refining industrial plant

2. LNG Carrier: The LNG Carriers are those tanker ships that are used to cargo LNG or Liquefied Natural Gas. These types of tankers require careful and delicate handling owing to the precariousness of the material they carry. Statistically speaking, there are around 193 LNG tankers that are currently under operation.

Fig. 1.1.B: LNG carrier Gaselys

3. Chemical Tankers: Chemical tankers are those cargo tankers which transport chemicals in various forms. Chemical tankers are specifically designed in order to maintain the consistency of the chemicals they carry aboard them. These tanker ships are applied with coatings of certain substances that help in the easy identification of the chemicals that need to be transported.

Fig. 1.1.C: Tanker ship Stolt Emerald

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 fertiliser 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.

Fig. 1.1. D: Oil tanker Heather Knutsen

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.

Classification of Tankers on the basis of Size

Some of the tankers shipping varieties in this category are as follows:

1. VLCC: Known as Very Large Crude Carriers, these tankers have a cargo carrying capacity of 2, 50,000 tons.

Fig. 1.1. E: VLCC Sirius Star

2. ULCC: They are known as Ultra Large Crude Carriers and have a cargo hauling capacitance range up to 5, 00,000 tons.

3. Panamax: The largest Tanker that can pass through the Panama Canal is known as the Panamax. The cargo tankers which cannot be classified under this category owing to their size are known as the Post-Panamax tankers.

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 1,20,000 tonnes.

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.

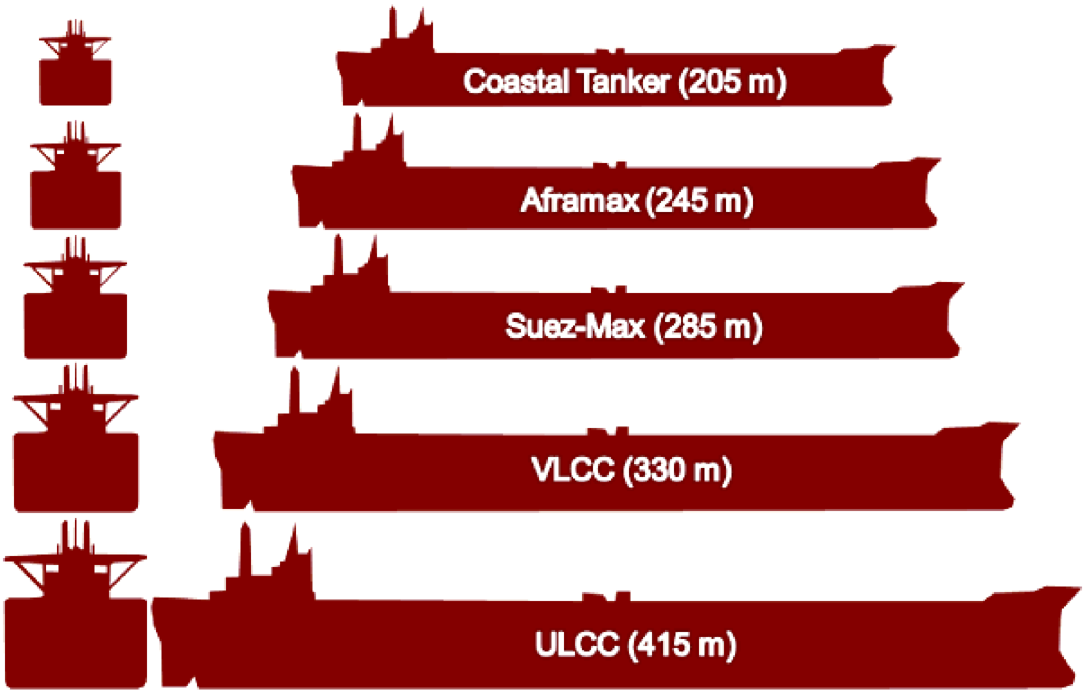


Fig. 1.1. F: Tanker ship size

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.

1.2 Basic Knowledge of Ship arrangements of an Oil Tanker

Oil tankers can be divided into fore part, tank area and after part.Means must be provided to keep spills away from the accommodation. SBT contribute towards the protection of the marine environment . There are requirements with respect to number and minimum capacity of slop tanks, oil tanker's cargo system the stripping system. Not all tankers have separate stripping system . Steam heating coils are generally used for heating cargo tanks. The operating principle of different level gauges the operating principle of portable oil/water interface detector. General Modern civilization is very largely dependent on the products of oil and vast quantities are transported throughout the world.

The invention of modern synthetic materials has engendered growing trade in sophisticated chemicals and these are now being carried in quite large quantities in bulk liquid carriers, whereas they used to be carried in very small quantities and were subject to the recommendations in the IMDG code. The carriage of oil product cargoes is dealt with first, then chemical cargoes and liquefied gas cargoes are considered. Oil is carried in bulk by specially designed ships.

A large proportion of this trade consists of the transportation of crude oil, but refined products are also carried in considerable quantities and include fuel oil, diesel oil, gas oil, kerosene, gasoline and lubricating oils. The design of a tanker must take into account the particular trade for which it is intended. A high rate of loading and discharging is desirable; pumping capacity and size of pipelines being important in this respect. The safety factor must be borne in mind with the provision of a fire smothering installation and the provision of cofferdams at the ends of cargo spaces, ventilating pipes to tanks, etc. Ships intended for the carriage of heavy oils would have steam heating coils fitted in tanks.

The cargo space is generally divided into three sections athwartships by means of two longitudinal bulkheads and into individual tanks by transverse bulkheads. The maximum length of an oil tank is 20%L (L is length of vessel) and there is at least one wash bulkhead if the length of the tank exceeds 10%L or 15 m. Tanks are generally numbered from forward, each number having port, centre and starboard compartments. Pump rooms are often located aft so that power may easily be supplied to the pumps from the engine room, but ships designed to carry many grades of oil at once may he fitted with two pump rooms placed so as to divide the cargo space into three sections. The system of pipelines used in a tanker is such that great flexibility is possible in the method of loading or discharging, and different parcels of cargo may be completely isolated from one another during loading and subsequently during discharge. In some cases a small, separate line is used for stripping the last few inches of oil from each tank.

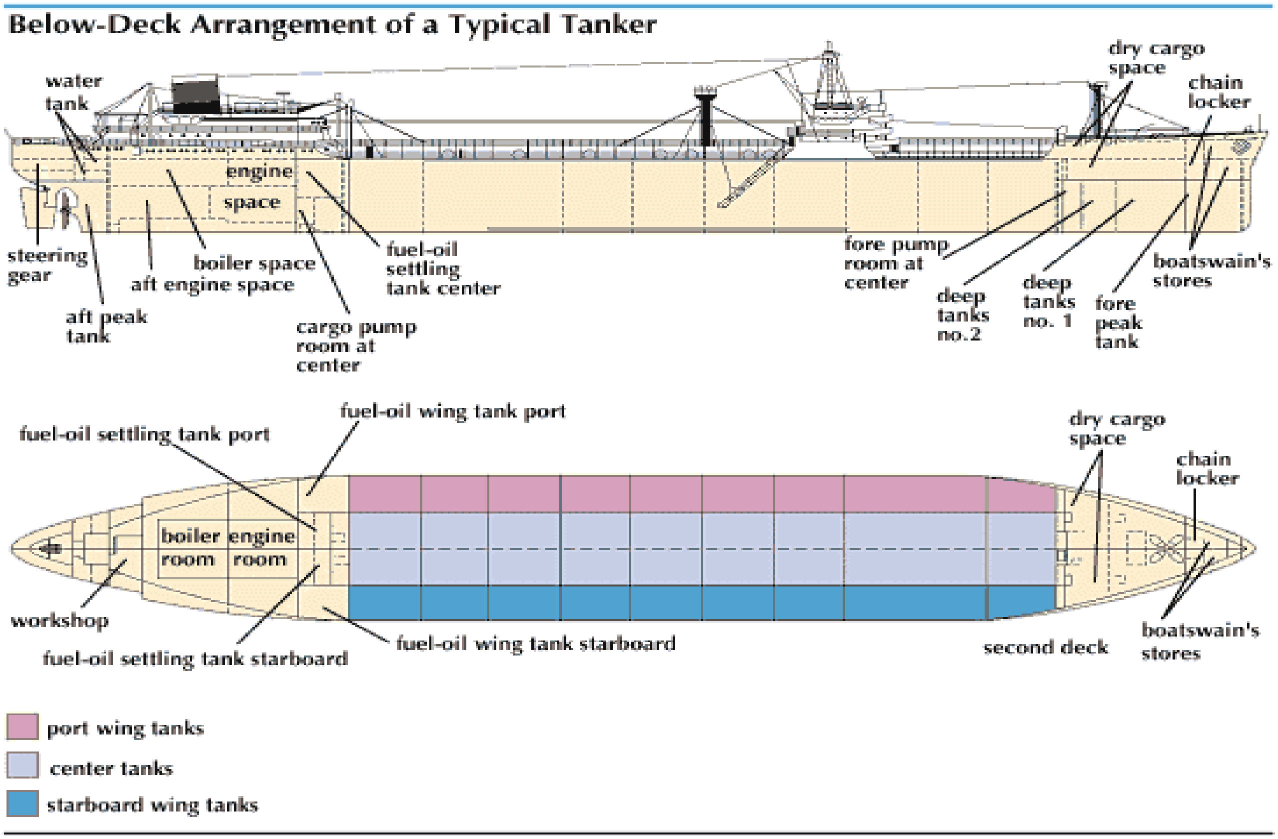


Fig. 1.2.: Basic Deck Arrangements of a Typical Tanker

1.3 Basic Knoeledge of Ship arrangements of a Chemical tanker

A chemical tanker is a type of tanker ship designed to transport chemicals in bulk.

As defined in MARPOL Annex I, chemical tanker means a ship constructed or adapted for carrying in bulk any liquid product listed in chapter 17 of the International Bulk Chemical Code. As well as industrial chemicals and clean petroleum products, such ships also often carry other types of sensitive cargo which require a high standard of tank cleaning, such as palm oil, vegetable oils, tallow, caustic soda and methanol.

Oceangoing chemical tankers range from 5,000 tonnes deadweight (DWT) to 35,000 DWT in size, which is smaller than the average size of other tanker types due to the specialized nature of their cargo and the size restrictions of the port terminals where they call to load and discharge.

COLLOQUIAL TERM	*M.E. TERM*
fore end	forward
after end	aft
midships part	amidships
right side	starboard s.
left side	port s.
in front of	before / forward of
behind	abaft / aft of
across (the ship)	athwartships
from stem to stern	fore and aft

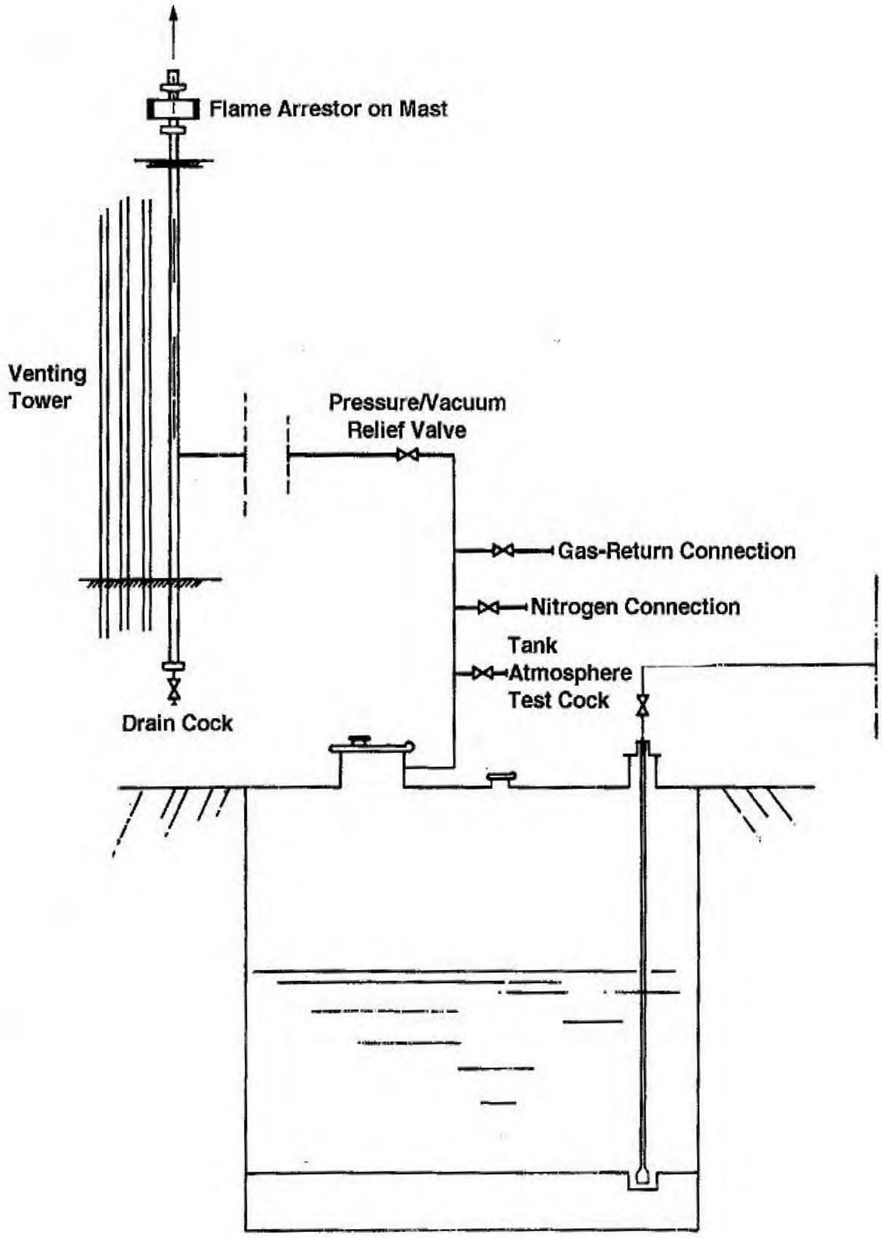
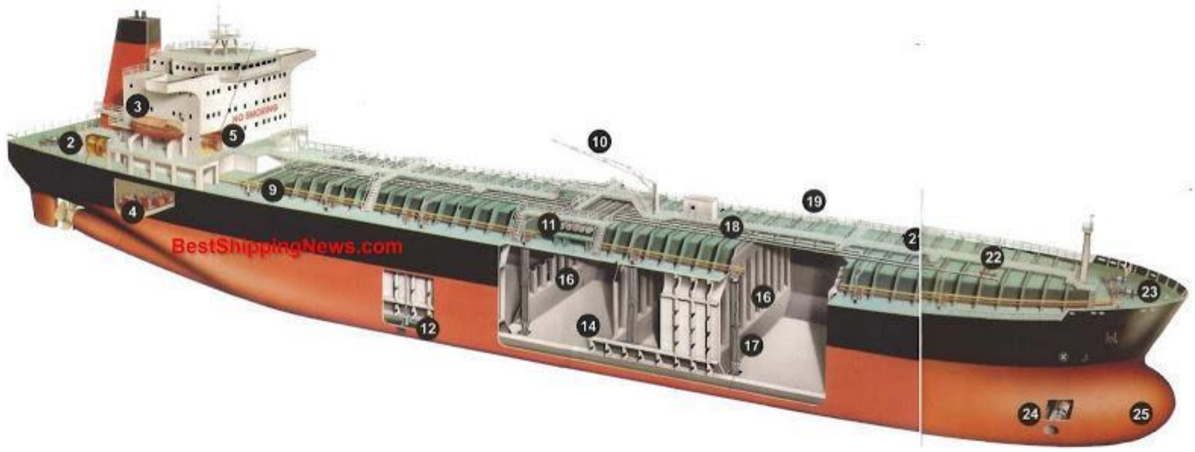


Fig. 1.3.A: Arrangements of a Chemical Tanker

Chemical tankers normally have a series of separate cargo tanks which are either coated with specialized coatings such as phenolic epoxy or zinc paint, or made from stainless steel. The coating or cargo tank material determines what types of cargo a particular tank can carry: stainless steel tanks are required for aggressive acid cargoes such as sulfuric and phosphoric acid, while 'easier' cargoes — such as vegetable oil — can be carried in epoxy coated tanks. The coating or tank material also influences how quickly tanks can be cleaned. Typically, ships with stainless steel tanks can carry a wider range of cargoes and can clean more quickly between one cargo and another, which justifies the additional cost of their construction.



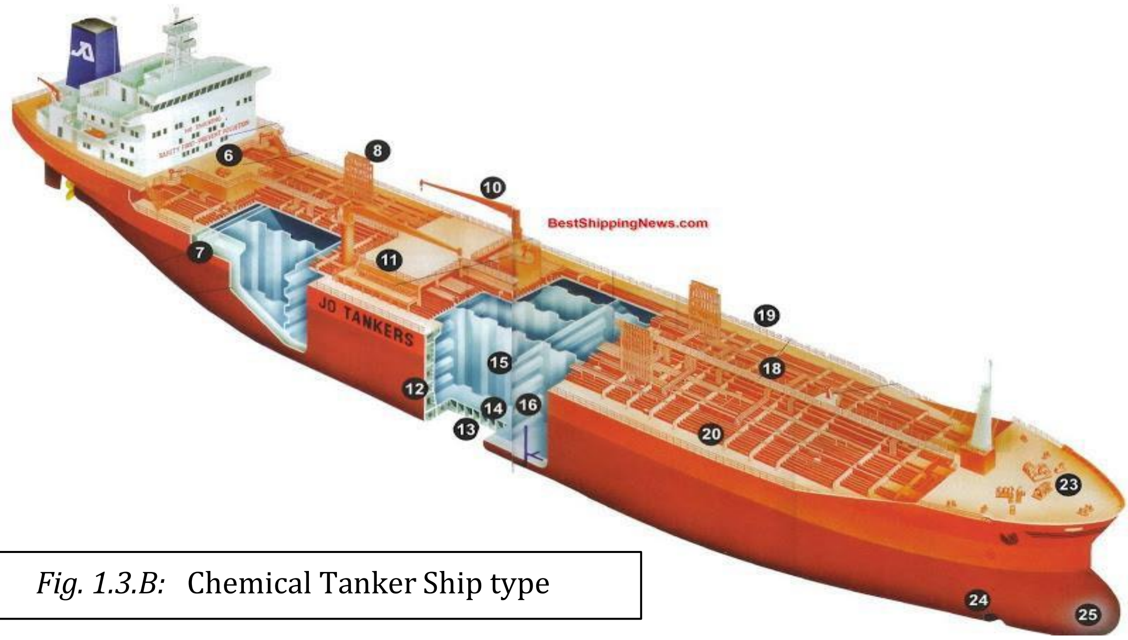


Fig. 1.3.B: Chemical Tanker Ship type

1. Balanced rudder with conventional propeller
2. Auxiliary unit
3. Lifeboat in gravity davits
4. Hydraulic prime mover
5. Cargo control room
6. Tank heating / tankwash room
7. Cofferdam, empty space between two tanks
8. Vent pipes with pressure-vacuum valves
9. Hydraulic high pressure oil-and return lines for anchor and mooring gear,
10. Hose crane
11. Manifold
12. Wing tank in double hull
13. Double bottom tank
14. Tanktop
15. Longitudinal vertically corrugated bulkhead
16. Transverse horizontally corrugated bulkhead
17. Cargo pump
18. Catwalk
19. Railing
20. Deck longitudinals
21. Deck transverses
22. Cargo heater
23. Forecastle deck with anchor-and mooring gear
24. Bow thruster
25. Bulbous bow

Type 1 tank configuration

Type 2 tank configuration

Type 3 tank configuration

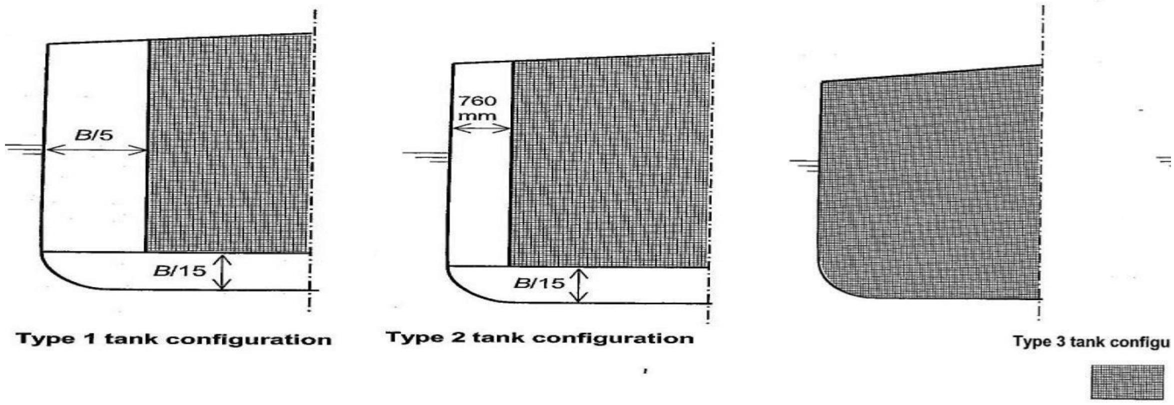


Fig. 1.3.C: Chemical Tanker Ship type configuration as per IBC Code

Note: IBC Code requirements for:

Ship Type 1 each tank capacity not more than 1250 m3;

Ship Type 2 each tank capacity not more than 3000 m3;

Ship Type 3 each tank capacity not regulated.

In general, ships carrying chemicals in bulk are classed into three types:

1. A 'Type 1' ship is a chemical tanker intended to transport of the IBC Code products with very severe environmental and safety hazards which require maximum preventive measures to preclude an escape of such cargo.

2. A 'Type 2' ship is a chemical tanker intended to transport of the IBC Code products with appreciably severe environmental and safety hazards which require significant preventive measures to preclude an escape of such cargo.

3. A 'Type 3' ship is a chemical tanker intended to transport of the IBC Code products with sufficiently severe environmental and safety hazards which require a moderate degree of containment to increase survival capability in a damaged condition.

1.4 Pmnps and Eductors

A pump is used to move liquids from lower pressure to higher pressure.

PUMPS

Positive Displacement pump:
Reciprocating Pump
Screw pump
Gear pump
Piston pump
Ram type pump
Vane pump

Dynamic pressure pumps:
Centrifugalpumps
Axial flow pumps
Submersible pump
Centrifugal-axial (mixed) pump.

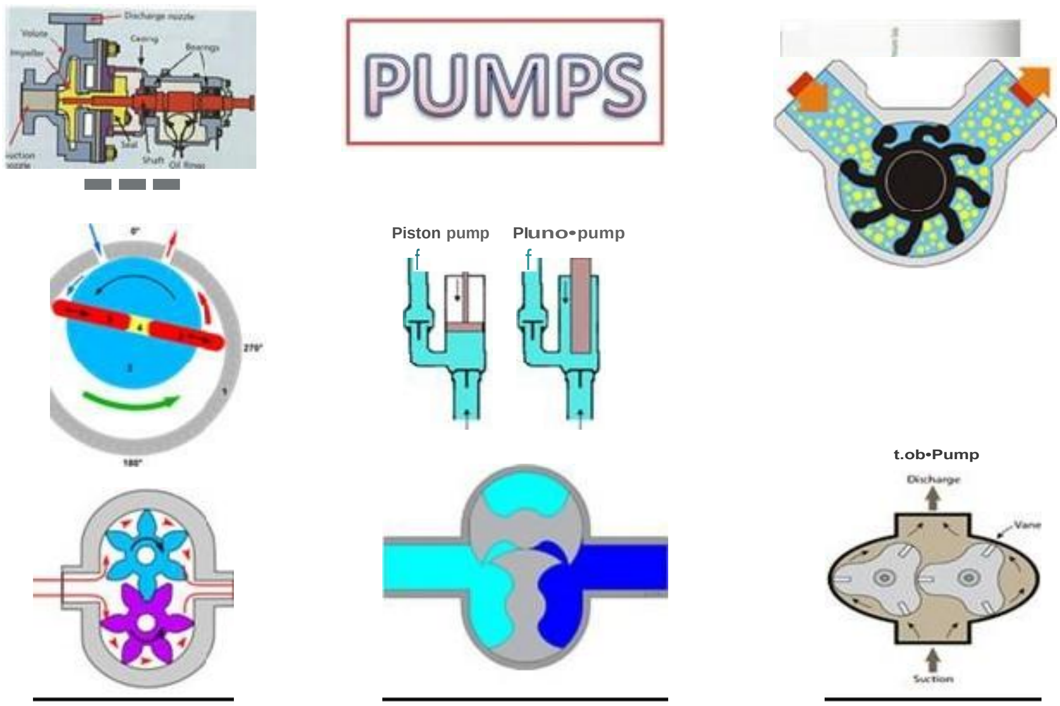


Fig.1.4.A. Pumps

Cargo and ballast pumps for chemical tankers

The function of any pump is to transfer liquid from one point to another and this involves the use of piping. Such a transfer in a tanker can be divided into two parts:-

1. The movement of liquid from the tank to the pump. This is a function of the pump and its installation design. These factors are beyond the control of the ship provided the design ratings of the pump are maintained.

2. The onward movement of the liquid from the pump to its destination. This is an area where the efficient operation of the pumps is essential if optimum results are to be obtained.

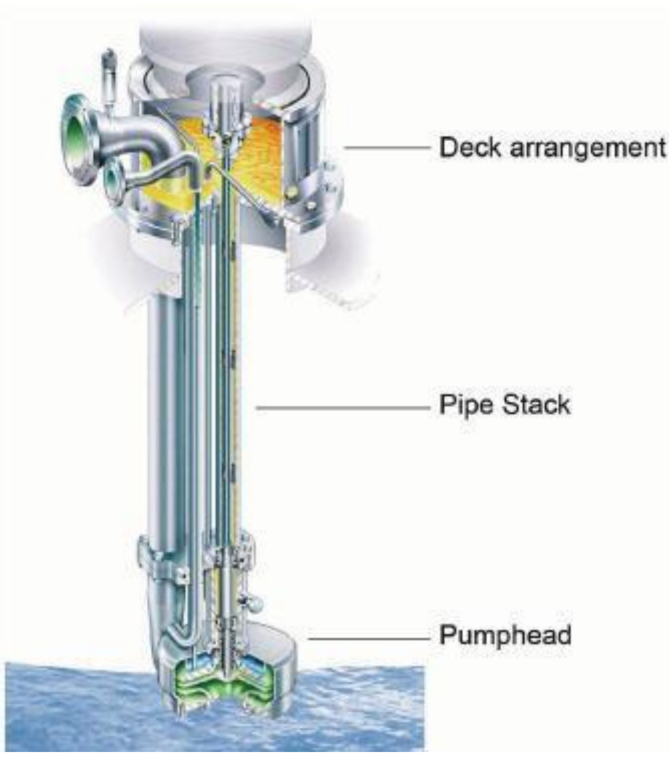


Fig. 1.4. B: Submerged pump

The major factors influencing pumping performance are discussed below. The flow of 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. Where the flow to the pump suction falls below the pumping rate cavitation will occur with the possibility of loss of suction and pump damage.

Centrifugal pumps do not suck liquids. The only factors which cause liquid to flow to the pump are:-

- Pressure acting on the surface of the liquid.
- The height of the liquid level in the tank in relation to the pump suction.

Since no centrifugal pump can generate a total vacuum at its 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 and this is known as the required Net Positive Suction Head.

Centrifugal Pumps

CENTRIFUGAL pump is basically a kinetic pump which increases the flow when through the pump—it centrifuges the liquid into the discharge line.

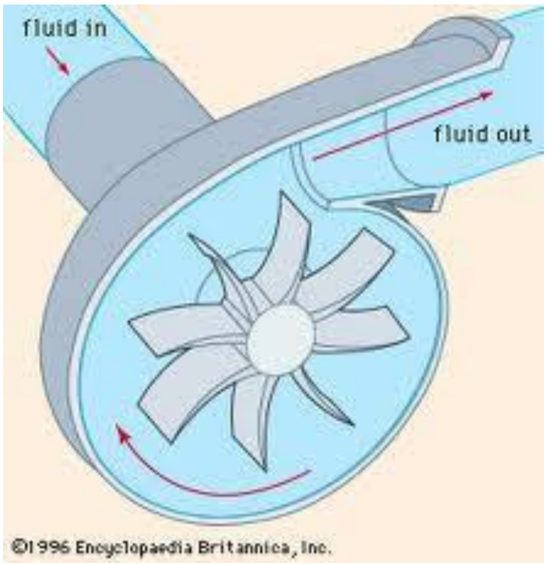


Fig. 1.4. C. Centrifugal Pumps

If the flow into the pump suction is less than the delivery the pump will cavitate causing gassing and loss of suction. They are resistable to solids in cargo. The big disadvantage is its inability to evacuate air/ gas from its casing. The pump casing must be filled with liquid before starting—the pump must be stopped to do this. When the impeller starts to turn the liquid is driven to the periphery of the housing by centrifugal forces. This results in a positive pressure on the outside of the impeller and a negative pressure in the centre.

The centrifugal pump has for many years been the most suitable pump where a high pumping capacity is the most important factor. The size and cost of such a pump does not increase in proportion with the throughput, as it is not a positive displacement pump. It requires either the provision of ancillary self-priming equipment for the removal of air in the system or a separate stripping system.

In a centrifugal pump the motive force is provided by a rotating impeller which takes its suction at its center and centrifuges the pumped liquid outwards to the casing discharge. The head generated is dependent on the diameter, blade angle and speed of rotation of the impeller. Flow rate is affected by the pressure in the discharge system and can fall to zero. Reverse flow through the pump can occur if a non-return valve is not fitted and operational on the discharge side of the pump.

The correct and efficient use of centrifugal pumps requires the observance of certain basic operating principles. Guidance on these principles is given here however, as manufacturers may incorporate special design features to meet operational requirements, the information given here must be read in conjunction with the manufacturers operating instructions and on board procedures organised.

The basic characteristics of a centrifugal pump are:-

- Throughput varies with speed.
- Head varies as speed squared.
- Power required varies as speed cubed.

These relationships are subject to appreciable variation caused by the system in which the pump operates.

Positive Displacement Pump

Unlike the centrifugal pump, the positive displacement pumps used in dedicated stripping systems are capable of a low suction pressure and the ability to pick-up suction without external priming. This type of pump includes steam reciprocating pumps and ‘screw’ type pumps. Both types are now mainly used for stripping tanks or as specialised cargo pumps.

The suction and discharge valves of a positive displacement pump must always be open before starting the pump and must remain open until the pump is stopped. These pumps must not be operated in excess of their design speed and particular care must be taken to avoid these pumps overspeeding when they lose suction. Pressure relief devices must be checked at regular intervals to ensure their correct operation.

Fig. 1.4. D: Hydraulic submerged pump

Submerged Pumps

Submerged pumps are relatively common on chemical carriers. This type of pump is usually powered hydraulically or electrically and provides for a pump located in each tank. Manufacturer's instructions must be complied with for efficient operation of these pumps.

Submersible pumps are purged, using inert gas (ship's IG or nitrogen) or air, as a means of checking for seal condition and tightness. The pumps must be purged before and after every loading/discharging/tank cleaning operation and the appropriate record form completed.

If the purging records indicate a deviation from the manufacturer's recommended parameters, such as pump cofferdam is blocked or excessive seal leakage being detected, the management office is to be notified and appropriate corrective action is to be taken at the first opportunity.

Portable Submersible (Emergency) Pump

Portable submersible pumps, are provided on chemical ships and other specialised liquid cargo carriers, for discharging cargo in the event of a main cargo pump failure. The pumps are usually hydraulically driven and lowered directly into the tank generally through a tank cleaning hatch.

All necessary safety precautions relevant to the actual cargo being handled are to be observed and permission obtained from the local port authorities before operations are commenced. It is a good practice to shutdown the hydraulic oil pressure system before connecting and disconnecting hydraulic hoses of portable hydraulic driven emergency pumps.

Use of Eductors

Eductors may be used for ballast stripping purposes. To strip efficiently, an eductor used for tank cleaning operations should have a capacity of about twice the rate of liquid being introduced to the tanks.

• Eductors are always to be operated at or near their design driving pressure as, in general, lower driving pressures will considerably reduce eductor efficiency. Higher back pressures in the system than the eductor was designed for can also reduce suction capacity.

• The eductor drive liquid must always be flowing before the suction valve is opened to prevent back flow of the driving liquid to the tank suction.

• When shutting down an eductor the suction valve is to remain open until the eductor is stopped to prevent the eductor drawing a vacuum on the suction line.

• If, during use, the eductor driving pressure falls below the required operating pressure, the eductor suction valve is to be closed to prevent backflow of the driving liquid. The tank suction must not be used to prevent backflow as the suction pipework is not designed for such high operating pressures.

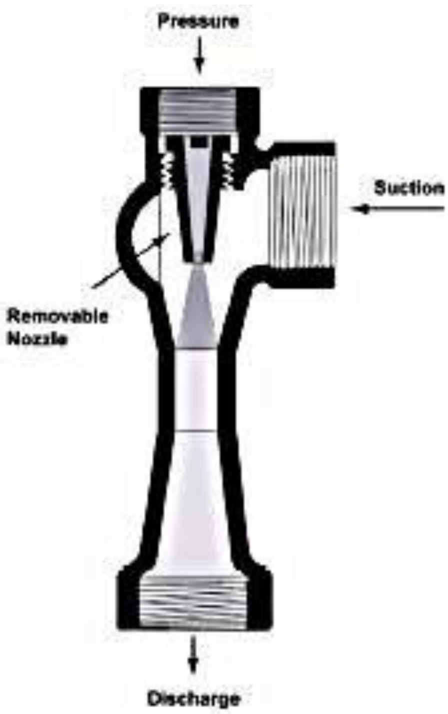


Fig. 1.4. E: Water jet eductors

Recommendations

High melting point cargoes such as Phenol, Palm fatty acid distillates lauric and Stearic acid has inherent property to form lumps of cargo. It is therefore recommended to turn the cargo pumps at regular intervals during the voyage and prior to discharge in order to avoid any last minute surprises. All the lines to be then blown back to the cargo tanks.

The danger of frozen valves, pressure/vacuum in the tanks to be monitored during loading, voyage and discharge. In the event if any of the pumps are found frozen, deployment of portable Framo pump should not be considered without a proper risk assessment and office permission.

1.5 Cargo Heating System

Steam Heating On Chemical Tankers

All chemicals carried at sea are heated by hot water and not steam.

The tank heating coils at exit point of tank , must contain hot water not steam. The temperature of water in the coils is adjusted by the return valve from tank . The steam inlet valve to tank must be 100% open always .

Fig. 1.5. A: Heating arrangements of a Chemical Tanker

Heating is done to

- Reduce viscosity. Viscosity is measured in centistokes. Water is one cst. As the temp rises viscosity reduces at the rate of 2% per degree.

- Reduce pour point. Pour point is 3 degrees over temperature were liquid coagulates.

- Reduce cloud point. Cloudpoint is the temp where cystallised solids forms inside liquid and settles on bulkheads.

- Avoid crystallization. Some cargoes like Caustic Soda require heating to avoid crystallisation.

- Avoid freezing of cargo. Some cargoes like Cyclohexane require heat to avoid freezing.

- To avoid pre-wash at discharge port. Heating may also be required in order to comply with MARPOL regulation for prewash (Phenol will have to be prewashed if dischg berth temp is below MP plus 10 deg.

- To increase the water solubility. For example Phenol is soluble in water at a temp of 60 degrees.

- To reduce unpumpables at tank sump.

- To reduce delivery pressure of the ships centrifugal deepwell pumps.

- To avoid claims from the charterers who want a particular voyage and discharge heat. Under heating and over heating will both result in claims from charterers.

- To reduce clingage. Clingage does not include the tank bottom

For tank heating coil system the size of the main return line is smaller than that of the steam inlet line. Because the return line is supposed to contain water only, while the main inlet line is supposed to contain steam only. For the steam winches the case is opposite, the return line is bigger as it contains expanded steam.

From the engine room boiler steam arrives on deck through the main inlet steam pipe. Before it enters the deck it has to pass through a PCV or pressure control valve of 1 bar to 7 bar range. There will be a small bypass line around this valve for initial warming prior starting. This bypass must be operated for at least 45 minutes on a small chemical tanker, before the PCV is opened. Heating must be started slowly to reduce thermal stresses.

When not in use the steam coils should be full of fresh water-unless the cargo is water reactive in which case it must be blown dry and blanked.

For initial starting the PCV is put at 1 kg and then slowly increased. Open all drain cocks in the steam inlet line till water is ejected and steam comes out.

Only water should return to engine room through the return line – otherwise it is a huge waste of money. This is one of the energy conservation items. This water must be pure and should not contain any cargo. There is an *inspection chamber (called siphoning drum)* where the first one hour of return water must be monitored. On a chemical tanker you can view through a glass port to check for floating insoluble cargoes, get the odor from the vent to check for volatile soluble cargoes, and drain from the bottom to check for sediments or high SG insoluble chemicals.

When carrying heating cargoes the return siphoning drum content must be inspected daily check for any traces of cargo—if any are found then the heating coils must be drained individually to find out the culprit. This coil can then be blanked off. The drain valves and siphoning drum must be checked twice daily for ingress of cargo.

Heating of tank is regulated also by the number of active coils from inlet manifold. Temperature of return line has to be taken regularly to find out if you are over heating or under heating. Centre Tanks with double skin has to be heated less than wing tanks who have a cold interface with ballast.

It Is Important To Know How To Stop Heating. Or You Destroy The Heating System. The Idea Is To Avoid Trapping High Pressure Steam Which On Cooling Will Cause A High Vacuum Build Up . This Will Cause Corrosive / Explosive/ Toxic Chemicals To Be Sucked Into The Coils .

- First close the inlet valve . Then open drain cock in front of the return valve. Then close return valve.

- One single leaking coil can contaminate other clean coils via the return manifold. Steam blow contents must always be checked for pH.

- If steam heating coils fail -in an emergency, use adjacent heat including live steam in ballast water around the tank. When no heating is done temp usually drops 1-2 deg C a day.

- When you heat raise the temp to 5 to 6 deg a day---NOT MORE. Many cargoes perish due to indiscriminate overheating . Too high temp causes unacceptable VP or chemical/ physical change which can be permanent. When veg/ animal oils are overheated Carbon Monoxide is formed which can affect the sweeping party. Overheating luboils can cause oxidation of cargo and colour off spec. Overheating Molasses cause thermal decomposition and total destruction.

- Make sure cargo is at the discharge heat four days prior arrival. To expedite the process, remove cold ballast interface.

- The heating coils of tanks not required to be heated must be blanked on both entrance and exit and log entry made. In order to avoid confusion, heating coils should only be used when a cargo requires heating. Any other cargoes on board should have their coils blanked on both the inlet and return side. This is also of paramount importance if the cargo is inhibited, subject to polymerisation (Styrene Monomer), or has a violent reaction water (Sulphuric acid) etc.

- Tanks which require heating must be pressure tested prior loading and log entry made. If the coils leak –you cannot load unless permanent repairs with proper stainless steel welding is done by chief engineer.

- If a heated valve is tight allow it to cool. If you force it , you damage it.

Some ships have deck mounted heat exchangers –Framo pump discharges into a heater at about 60 bars.

The two methods for testing steam coils on board are:

1. Hydraulic testing using water

2. Steam pressure testing

It is possible to carry out pneumatic testing (air), but this method is considered unreliable and will NOT be considered suitable for meeting company standards, and is NOT to be used.

1. Hydraulic testing using water

Hydraulic testing of heating coils is time consuming and cannot be carried out in all tanks on a regular basis. The hydraulic testing of heating coils must be carried out, by ship's engineers, once a year. or as dictated by the company. It is recommended that tank tests are staggered so they are not all due at the same time. Hydraulic testing must also be done by chief engineer after any permanent repairs have been made to the heating coils. The results of all hydraulic tests must be recorded in the log book and the planned maintenance system.

Steam testing of coils is to be carried out before the loading of every heated cargo as a policy.

Thermal oil heating coils are to be hydraulic tested, using oil, every two years. If defects occur, then the coils must be tested annually. The coils must also be tested after any repairs.

All coils must be hydraulically tested when they have been replaced following disassembly for coating work. etc. In a docking situation this should be done before leaving the yard. If this is impossible, then testing should be scheduled for as soon as it is practical.

Any cargo damage due to steam coil leak or ingress into steam coils is un acceptable to us, it is considered as personal failure.

For cold hydraulic testing use Graco pump and a 200 litre FW drum to pressurise to 12 kg. Do not forget to inspect the riser piping. Testing must be done coil by coil. Also check for loose nuts from steam coil clamps.

It is the more severe of the two test methods due to the fact that when using steam, heat expansion can cause small leaks to seal, and also higher pressure (1.5 times) than working pressure can be used.

When carrying out hydraulic testing, it is important that the tank is completely dry , and cold water ballast interface at the tank bottom is removed. This will make the detection of very small leaks much more easier—any water at the bottom means a leak.

Install blanks to provide the required test boundary. Connect the hydraulic test pump to the coils and install a suitable pressure gauge. Fill the coils with good fresh water. Build up the pressure in the coils to 1.5 times their maximum rated working pressure. Close the hydraulic pump valve to prevent pressure drop. Monitor the pressure of at least 30 minutes, without additional pumping. If a leak is indicated by a pressure drop, then the entire system must be checked until the leak is found.

After 30 minutes, the coils are to be thoroughly examined. The thorough examination must include a very close visual inspection and also feeling by hand under the coils in order to detect any pinhole leaks. Such pinhole leaks may not be indicated by a pressure drop on the manometer and can also be very hard to detect by the eye.

Repair and properly document all leaks detected. Repeat the test procedure after repair.

2. Steam pressure testing

The testing of coils using steam pressure from the ship's boiler:

Misleading results can be obtained from steam testing due to steam condensation in the coils if the test is not properly conducted as described below. The maximum maximum boiler pressure is to be used. The coils to be tested should be exhausted to atmosphere until live steam is issuing from the return. Close the return against the steam. The steam pressure must be held for 30 minutes prior to inspecting.

Another 2 in one (DUAL) method is with return valve closed; open the steam inlet at 7 kg. This will then give an easy hydraulic test on coil due to trapped condensate in line. Inspect the coil for water leaks. Following the above, return valve to be opened and steam allowed to flow through the coil via the steam trap. After 30 minutes have elapsed, coils to be inspected for leaks. By shining a torch light along the coil, escaping steam will be highlighted.

If a leak is detected and a section of piping has to be repaired, a proper hydraulic test should be carried out after the repair is completed as a policy. Install blanks to provide the required test boundary, i.e. isolate only the coil to be tested.

When carrying out visual inspections for leaks, look closely for signs of corrosion. Corrosion leaks may require further close examination of the coils to determine the amount of damage. Bad corrosion may mean the whole section may have to be cropped and renewed. All corrosion problems are to be reported to the chemical operator immediately.

Heating coils not in use must be steam pressure tested every 3 months and its results must be recorded. If heating is not to be done the coils must be blanked—and log entry made

If the Master is unable to comply with the charterers heating instructions he must inform the chemical operator well in advance. Make sure that there is enough bunkers on board to run the boiler.

Under no circumstances should cargo exceeding tank lining resistance tables temperatures be accepted for loading. Be aware of the maximum cargo temperature stipulated in the charter party.

It is the responsibility and duty of chief officer to take the temperature twice daily—the critical heating log must be signed by him daily without fail—signature must not be postponed to the next day. A signed copy must be hung in CCR bulkhead for Chief engineer to monitor.

The steam valves of wing tanks and forward tanks are usually opened more. The % of the return valve opened must be entered in the log column.

The Chief engineer must log down daily the bunkers used in boiler solely for heating cargo.

Heated cargo temps must be taken at 3 levels inside tanks. As the cargo is discharged, the steam heating into the tank must be reduced. Heated cargoes must be stripped immediately. IT MUST NOT BE POSTPONED.

There must be an action plan (as part of the pre-load pre-dischg meeting) to melt solidifying cargoes from inside the pipelines and to prevent valves from getting frozen in place. If steam hoses have to be used the crew must use PPE and heat resistant gloves.. Steam must be applied at the underside of the pipes. It is more effective to use hot water on a burlap lagged pipes , especially at bends.

If the pump impeller is frozen steaming into empty DB via sounding pipe can be considered—but inform the chemical operator first.

Before discharging a high MP cargo consider recirculating the cargo before opening the tank delivery valve and the manifold valve.

Thermal Oil Heating on Chemical Tankers

What is Thermal Oil?

Thermal oils are heat transfer fluids that transfer the heat from one hot source to another process. This could be from a combustion chamber or from any exothermic process. The main application is in fluid phase heat transfer.

They are available in chemically different forms as:

- Synthetic Oil, which are aromatic compounds.
- Petroleum based oils, which are paraffin's.
- Synthetic glycol based fluids.

Thermal oils are available in a wide range of specifications to suit the needs of various processes. Currently available thermal oils have a maximum temperature limit of around 400 °C. There are Thermal oils that are in use in Cryogenic fields up to -100 °C.

- **Steam vs. Thermal Oil**

A heat transfer medium is required where direct heating of a process is not practically possible.

Steam was the prime choice as a heat transfer medium. The advantages of steam were the availability, low cost of water, with no environmental issues.

Effective Heat transfer by steam uses the latent heat. The saturation pressure dictates the temperature at which heat transfer takes place. To obtain higher temperatures the pressures have to be higher. For 350 °C, you will require a pressure of 180 bar. This will require higher thickness for the heat exchangers tubes. This increases the weight and thermal stresses and will require special manufacturing techniques. All this leads to higher cost.

- Thermal oil scores on this point. Even at temperatures of 350 °C, the pressure requirements are just sufficient to overcome the system pressure drops. This also decreases the pumping cost.

The system is simple in that it requires only a pump, an expansion and storage tank and the heat exchangers. A steam system on the other hand requires demineralized makeup water supply, drains, traps, safety valves, chemical additions and blow downs.

Using thermal oils eliminates all these complications along with issues of corrosion, scaling, fouling, and deposits in the heat transfer areas.

This is why thermal oil finds many uses in the process industry. All this leads to considerable reduction in cost.

Unlike steam, thermal oils also find use in applications where the temperatures are below zero °C.

- **Thermal Oil Heaters**

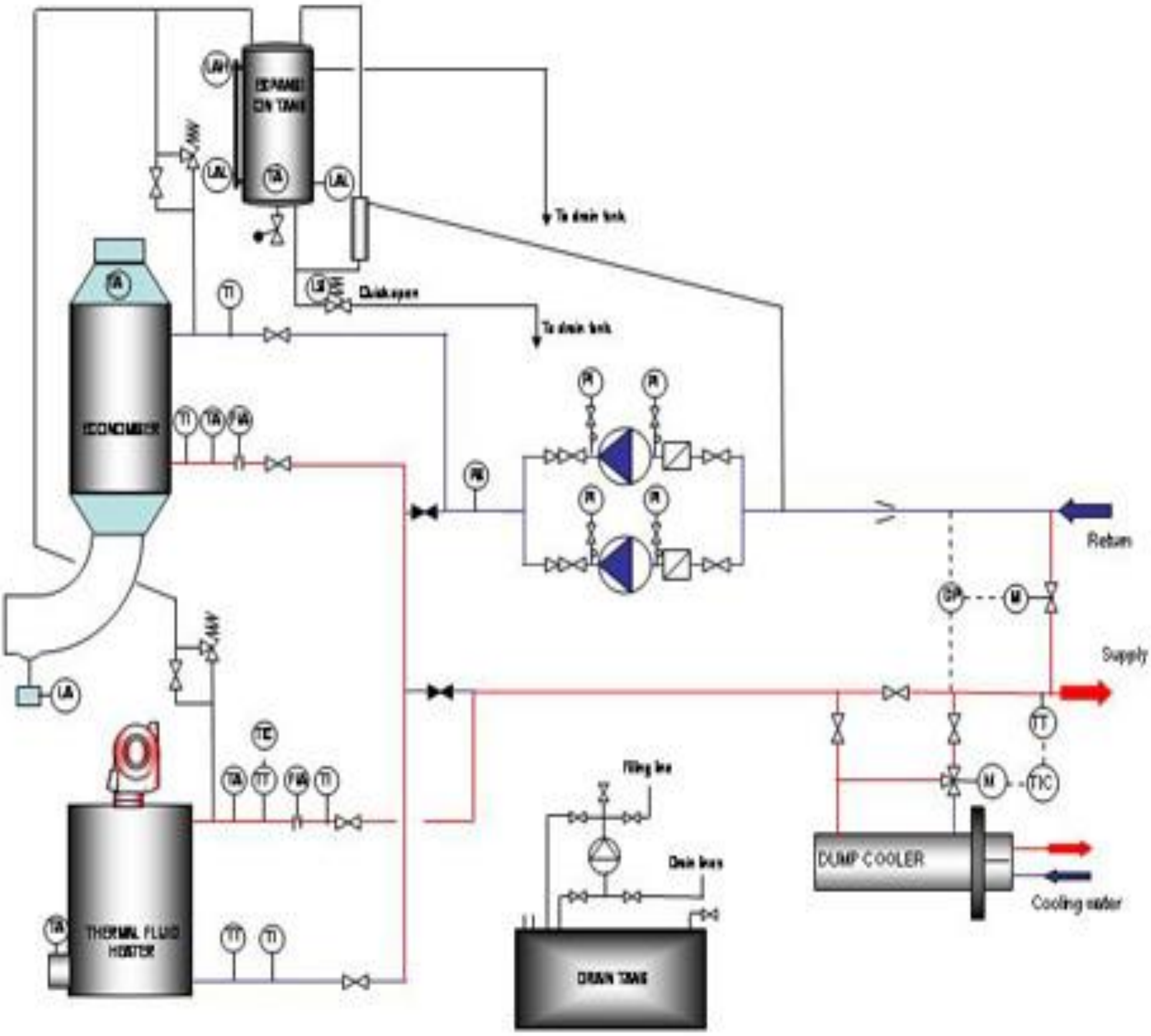
Thermal oil heaters functionally are similar to steam boilers. The combustion chamber that burns fuel oil, bio fuel, coal or any other fuel with all necessary safety devices is the same. Since there is, no evaporation the oil passes through simple heater coils placed in the radiant or convection zones. The oil pumped through these coils heats up and flows to the process heat exchanger. The cooler oil returns to a tank and then back to the pump. An expansion tank takes care of the thermal expansion. The tanks have provisions to prevent the oxidation and vaporization of the oil.

Marine applications use very compact heaters with helical coils.

Heaters downstream of gas turbines or diesel engines can function as heat recovery systems for use in suitable downstream process.

Thermal Oil Boiler with Oil / Gas Burner

Electrical Heated Thermal Oil Boiler



- **Applications of Thermal Oil**
  Thermal oil finds use in a wide range of industrial applications.
  - This is in use the oil gas and chemical industry for almost thirty years and is part of many chemical reactions.
  - Storage and transportation of items like asphalt, which have low solidification temperatures, use thermal oil heaters . This is especially suitable for marine transportation of these materials.
  - Solar Thermal systems or Concentrating Solar Power (CSP) use thermal oils as a heat storage medium. This allows the power plants to produce power even when there is no sunshine.
  - Heating Biodiesel for transesterification, paper and board manufacturing, and noble metal extraction also makes use of this.
  - Thermal oil finds use in large scale baking and frying in industrial kitchens. The high and even temperatures that are possible help in retaining taste.
  - Industrial laundries are converting to the use of thermal oils instead of steam for most of the applications.

- **Specifications of Thermal Oil**
  Thermal oils are available in a wide range of specifications. Different manufacturers produce different oils under different brand names. Different specifications suit various needs of the process and applications. Some of the commonly used brands are
  - Therminol from Solutia Inc.
  - Dowtherm from Dow Chemical Co.
  - Exceltherm from Radco Industries Inc.
  - Paratherm from Paratherm Corp.

  The most important characteristic is the maximum temperature of service. The oil is thermally stable till this temperature. It should be borne in mind that the cost increases exponentially with increase in the maximum temperature limit. Currently the thermal oils are available up to 400 °C. Oils are also available for cryogenic applications up to -100 °C.

  Apart from the temperature other characteristics that determine which type or brand of fluid to be used are the
  - Heat transfer co-efficient.
  - Pumpability. Serviceability.
  - Environmental issues including toxicity, shipping restrictions and disposal methods.
  - Oxidation and degradation potential.

- **Problems /Drawbacks with Thermal Oil**
  As with any system, thermal oil heaters too have their share of problems.

    - Sudden trips or unplanned shutdowns of the system may cause the oil to overheat.
    - Overheating causes degradation of the oil and will form sludge.
    - This will necessitate cleaning and replenishing the oil.
    - Leaks especially in the combustion area can cause fire hazards.
    - Valves, gaskets and packings should be suitable for thermal oil use.
    - Piping and supports design has to take care of thermal expansion and thermal fatigue. Because this is low pressure application theses are sometimes not taken care of.
- As manufacturers develop and produce thermal oils with higher temperature limits and specifications industry is finding increasing applications, improving energy efficiency and reducing cost.

1.6 Inert Gas System

Inert gas systems for chemical tankers

- Preventing flammable tank atmospheres

In the context of chemical tanker operations and chemical cargoes, an inert gas system may have three distinct uses: preventing a fire, preventing a chemical reaction or maintaining cargo quality.

Flammable gases normally encountered in chemical tankers cannot bum in an atmosphere which is deficient in oxygen, and an inert gas is understood to be a gas used to produce such an atmosphere by displacing air.

SOLAS specifies the standards necessary to do this.

It may be achieved by using either nitrogen or oil fired flue gas, with a portable or fixed piping arrangement to supply the inert gas to the cargo tanks and, if applicable, the places surrounding the cargo tanks. Mandatory safety requirements for tank atmosphere control are given in the IBC Code; for example the system must be able to compensate for normal transportation losses and maintain an overpressure of at least 0.07 bar gauge at all times.

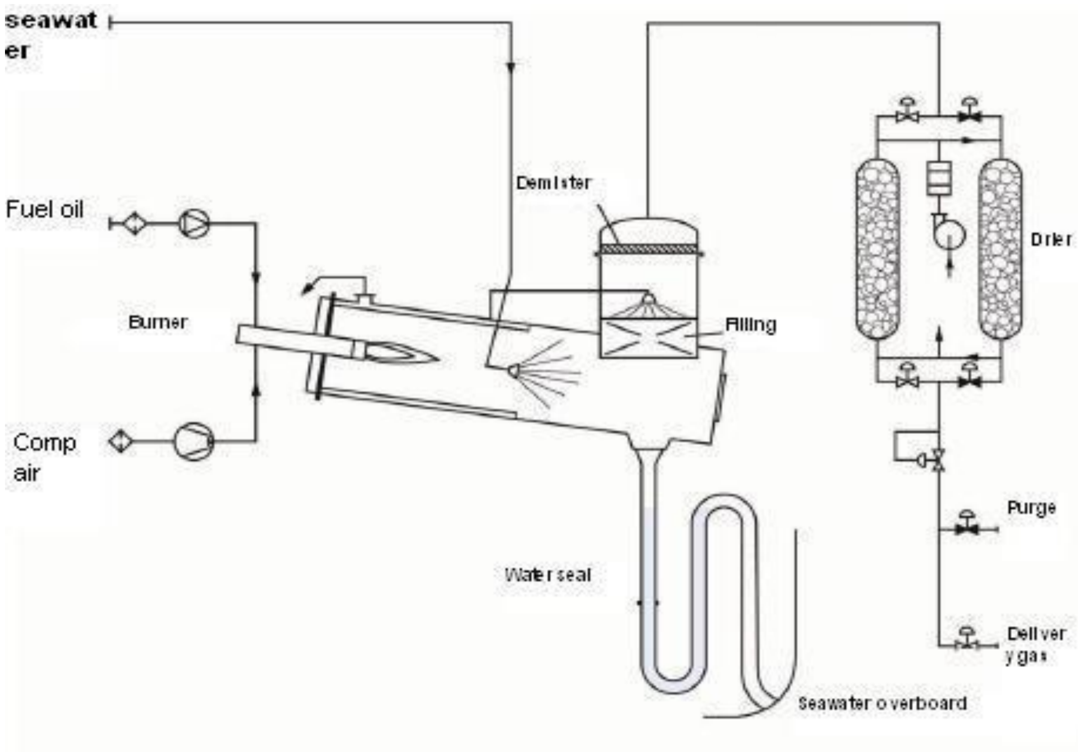


Fig. 1.6. A: Inert gas generator

There are several types of inert gas systems that can be used on chemical carriers.

The most common are:

1. stored compressed nitrogen;
2. stored liquid nitrogen;
3. Gaseous nitrogen supplied from shore;
4. Nitrogen generators using pressure swing adsorption (PSA);
5. Nitrogen generators using membrane separation;
6. Oil fired inert gas generators.

There are occasions when inerting is not appropriate for safety reasons, because exclusion of oxygen could create hazardous situations with a number of chemicals when shipped in monomer form. Such chemicals (e.g. acrylic acid, styrene and vinyl acetate) have added inhibitors to prevent polymerisation, during transportation.

In order to be effective, the inhibitors require the presence of oxygen dissolved in the monomer, and that oxygen is obtained from the air in the ullage space. Inhibited monomers must therefore be carried in tanks where the atmosphere has an oxygen level sufficient for the inhibitor to fulfil its purpose.

Requirement of nitrogen used as inert gas on chemical tankers

Most nitrogen used as inert gas on chemical tankers is not used for safety reasons but for cargo quality control. Shippers often have their own special requirements to ensure cargo quality, which can require inert gas of extreme purity, and may specify that nitrogen for initial inerting of cargo systems prior to loading a cargo will be supplied from the loading terminal.

Smaller amounts of pure nitrogen can come from compressed or liquid nitrogen containers stored on board, and refilled from shore when required, but a very high quality can be produced on board by nitrogen generators based on membrane separation, or swing adsorption generators.

When using an oil fired inert gas generator, an oxygen level of less than 5% can generally be obtained, depending on the quality of combustion control and the load on the boiler. The gas must be cooled and scrubbed with water to remove soot and sulphur acids before being supplied to the cargo tanks.

But certain cargoes, for instance chemically reactive cargoes, are sensitive to oxygen concentrations as low as 2.0% by volume.

Some cargoes react with carbon dioxide in flue gases. Other cargoes are highly sensitive to moisture, or are liable to discoloration. For these reasons oil fired flue gas systems are rarely used on chemical carriers when carrying chemical cargoes, because demands for strict control of atmosphere standards cannot be met. The following is an indication of potential problems that may occur:

- acid catalysed hydrolysis (e.g. with esters, acetates or acrylates);
- acid catalysed polymerisation (e.g. with allyl chloride);
- formation of carbonates (e.g. with amines);
- increased acidity (e.g. contamination of toluene and xylene by carbon dioxide);
- reaction with water (e.g. with acetone or ethanol);
- de-activation of polymerisation inhibitors (e.g. with vinyl acetate)

Pressure swing Adsorption (PSA) nitrogen generators

Adsorption is a process in which a substance, usually a gas, accumulates on the surface of a solid to form a very thin film. Pressure swing adsorption plants work on the principle that the major constituents of air - nitrogen and oxygen - are adsorbed to a different extent when passed over a carbon-molecular sieve material.

The amount of each gas adsorbed depends on the time of exposure. If the system is adjusted correctly, the sieve adsorbs most of the oxygen in the air, allowing the nitrogen to pass through and be collected.

The oxygen can then be desorbed (returned to a gas) and exhausted to atmosphere, thereby regenerating the sieve.

To give a continuous nitrogen flow, PSA plants are fitted with two or more interconnected pressurised vessels (called beds) which contain the molecular sieve material.

Air is compressed by an oil-free compressor and passed over one set of beds that are adsorbing while the other set of beds is desorbing. During the production cycle, therefore, the plant will vent an oxygen-rich waste, which must be exhausted to a safe area.

In addition to nitrogen and oxygen, the carbon-molecular sieve material also adsorbs a number of other gases, among them carbon dioxide and water vapour.

In normal circumstances the carbon dioxide content in air is very small, so the presence of carbon dioxide has negligible effect on the plant operation and any carbon dioxide adsorbed is ejected with the waste gases during the desorption cycle.

A number of proprietary sieve materials are water sensitive, and the compressed air must be passed through a dryer to remove most of the atmospheric humidity before passing over the beds. In marine service, the air inlet to the PSA beds must always be protected from spray.

The gas produced by the PSA process may have an oxygen content varying between 0. 1 % and 2% by volume depending on the flow rate. Typical plants produce gas with a dewpoint lower than -50'C and a carbon dioxide content of less than 2ppm by volume.

Membrane separation nitrogen generators

Membrane units are based on the fact that different gases permeate at different rates through the walls of a thin, hollow membrane.

The 'slow' gases are methane, nitrogen and carbon monoxide, the 'medium' gases are argon and oxygen, and the 'fast' gases are water vapour, hydrogen and carbon dioxide.

The fact that the two main components of air, nitrogen and oxygen, have different permeation rates means they can be separated. The fact that water vapour permeates quickly means that the nitrogen produced is also very dry.

The membrane unit is made up from bundles of thin hollow fibres which give a large wall area for separation. The membrane bundles are enclosed in pressure vessel pipes of about 100 to 200 millimetres diameter; several of these bundles may be arranged in parallel.

Clean compressed air is passed into these bundles where the oxygen and water molecules are removed. The membranes are heat-sensitive and it may be necessary to cool the compressed air before it enters the bundles.

The efficiency of the separation depends on the flow rate through the membranes; a control valve is used to regulate the flow and thereby the oxygen content. The flow is adjusted to give nitrogen of the purity required - typically with an oxygen content variable between 0.1% and 2% by volume, with water and carbon dioxide contents below 5ppm. Oxygen enriched air is vented as a waste gas, which must be exhausted to a safe area.

Oil fired inert gas generators

Oil fired inert gas is generally acceptable for use with petroleum products but it has been found that the quality of the inert gas generated by this type of system is not suitable for use with many chemical products, because it can affect the cargo quality.

It is therefore recommended that when inerting or padding is required by the IBC Code for a particular cargo, nitrogen is used to inert or pad that cargo unless the shipper or supplier has stated that oil fired inert gas is acceptable for such purposes.
The basic principle of oil fired plants is that the oxygen content of the air is converted to carbon dioxide by combustion of oil while the nitrogen content remains largely unchanged.

The oil fuel is burnt in a combustion chamber and the combustion (or flue) gas is passed through a water tower (or scrubber) to cool it and remove most of the sulphur dioxide, particulates and impurities. This requires contact between the flue gas and large quantities of sea water.

The gas may then be dried by being passed either through a cooler or an alumina bed dryer (or even both). Chemical tankers are usually fitted with two non-return valves in series as an equivalent to a deck water seal, thereby avoiding the risk of water carry over into the cargo. As a further safeguard against backflow, there is usually an isolating valve or a spool piece at each branch connection.

The inert gas produced by oil fired generators depends on the quality of the fuel oil and the efficiency of the combustion and scrubbing processes. These factors influence, for example, the amount of sulphides in the inert gas produced - which is why the sulphur content of the fuel is limited in the plant specification. Likewise, inefficient combustion can cause soot, which clogs the scrubber and, in particular, the dryer system, thereby producing wet and dirty inert gas.

If the plant is efficiently burning good quality fuel, the inert gas can be expected to have approximately the following composition:

Carbon dioxide	15%
Oxygen	1.0%
Carbon monoxide	0.1%
Oxides of nitrogen	120ppm
Hydrogen	100ppm
Sulphur dioxide and sulphur trioxide	120ppm
Nitrogen Balance	
Dewpoint	-25'C

1.7 Cargo Measurement Systems

Cargo control and measurement instruments -Liquid level gauges for tankers

The accuracy required of chemical carrier level gauges is high because of the nature and value of the cargo. To limit personnel exposure to chemicals or their vapours while cargo is being handled, or during carriage at sea, the IBC Code specifies three methods of gauging the level of a liquid in a tank - open, restricted or closed - according to the health hazard of the product. Many chemical cargoes may not be gauged by manual dipping because to do so requires an opening to the atmosphere during operation. The use of completely closed gauging systems is necessary, so that no vapour is emitted.

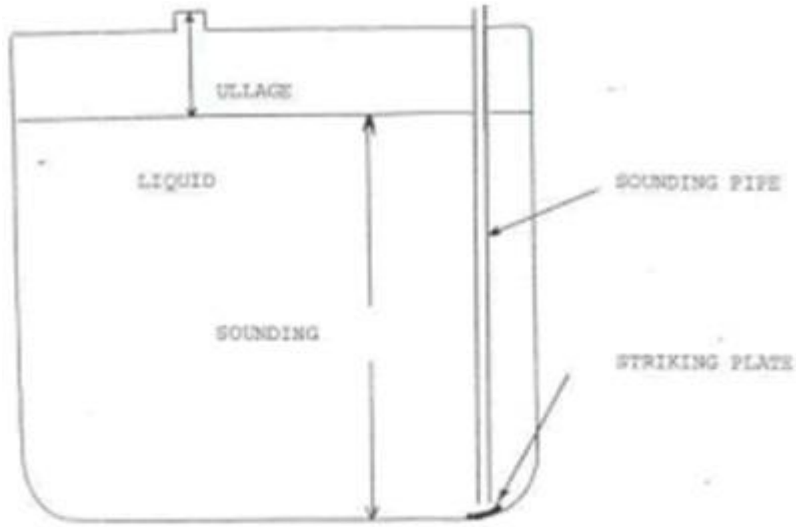
Examples of closed systems are float gauges or radar systems. Indirect measuring methods such as flow metering may also be used.

Many more chemicals, although still hazardous, do not require quite such rigorous controls, and restricted gauging accepts that a very small amount of vapour may escape during gauging, An example is using a sounding pipe that reaches right into the liquid. Virtually all toxic cargoes require either restricted gauging or closed gauging.

However, other cargoes can be gauged through openings in the ullage space. This is called open gauging.

Ullage. This is a measurement of space between the surface of liquid in a tank and the top of the tank inner surface.

Ship's ullage tables are drawn up, based on the internal volume of a tank measured from some reference point, e.g., the lip of an "ullage" hole. The reverse of ullage is sounding. This is the depth of liquid in a tank measured from the liquid surface to some reference point at the bottom of the tank "Sounding tables" may complement or replace "ullage tables".



This expression covers the free space left in the tanks after loading liquids in bulk. In oil tankers, ullage is left in order to leave room for expansion when the oil is heated to a higher temperature before discharge. Oil can also expand with atmospheric temperature changes so that oil tanks are customarily loaded to 98 per cent capacity.

Float gauges

These are closed gauges, and consist of a float which rises vertically on the liquid. It is attached by a tape to an indicating device for local reading, with provision for a drive mechanism for remote read-out. Particular attention is drawn to the following:

i) floats should be secured when at sea, except briefly during measurement of tank contents. If the float remains unsecured at sea it will almost certainly be damaged due to sloshing of the cargo;

ii) remote and local readings should be compared frequently to determine discrepancies;

iii) readings may need to be corrected to allow for tape and tank expansion or contraction, and ship trim and heel. Tables are normally provided for this purpose;

iv) tapes should be checked regularly for free vertical movement of the float, and if damaged, should be replaced. Particular care is necessary with the rewind mechanisms which are carefully balanced: if obstructed, the gauge readings will be inaccurate;

v) when tapes are renewed, or a gauge reassembled after maintenance, allowance should be made for the level at which the float begins to lift. Manufacturer's instructions should be consulted;

vi) parts should be securely assembled: special care is necessary with tape-to-float and tape-to-reel attachments.

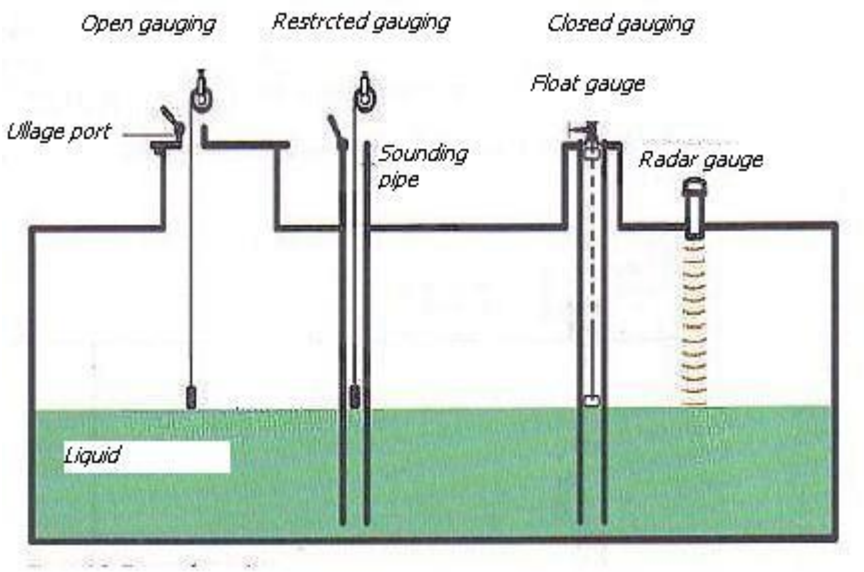


Figure : Types of gauging

Procedures for Measurement-Closed and Restricted

When vessels are fitted with vapor control valves, portable electronic gauging equipment can be used to measure free water, petroleum liquid levels, and temperature. It may also be used for measuring liquid ROB/OBQ. Special PMUs and/or techniques may be used for taking samples and for measuring non-liquid ROB/OBQ. Use of this equipment requires observance of safety procedures outlined in the International Safety Guide for Oil Tankers and Terminals, (ISGOTT), the International Maritime Organization (IMO), Inert Gas Systems (IGS), and other applicable International Chamber of Shipping, the

Oil Companies International Marine Forum (OCIMF) publications and manufacturer's instructions.

Prior to boarding a vessel equipped with VCVs, attempt to determine the manufacturer and size of the VCVs so that compatible equipment or adapters can be taken on board.

In addition, before gauging, verify that:

a. All cargo operations have been stopped, and no cargo is being transferred.

b. The IGS pressure in the cargo tanks has been lowered sufficiently to minimize vapor loss.

c. The gauging equipment has been calibrated and the calibration/verification log reviewed.

d. The equipment is free of breaks, kinks, and signs of wear which might affect measurement accuracy.

e. The equipment is suitably clean for the product to be measured. I.e. all numbers and graduations on the tape are legible.

f. The batteries are charged (replace if necessary).

It may be noted that for best accuracy, trim and list should be eliminated. When both conditions exist; every effort should be made to eliminate at least one condition, preferably list. Conditions of trim and list must be noted and corrections made for their affect on measurements and or volumes.

2. PHYSICAL AND CHEMICAL PROPERTIES OF OIL AND CHEMICALS

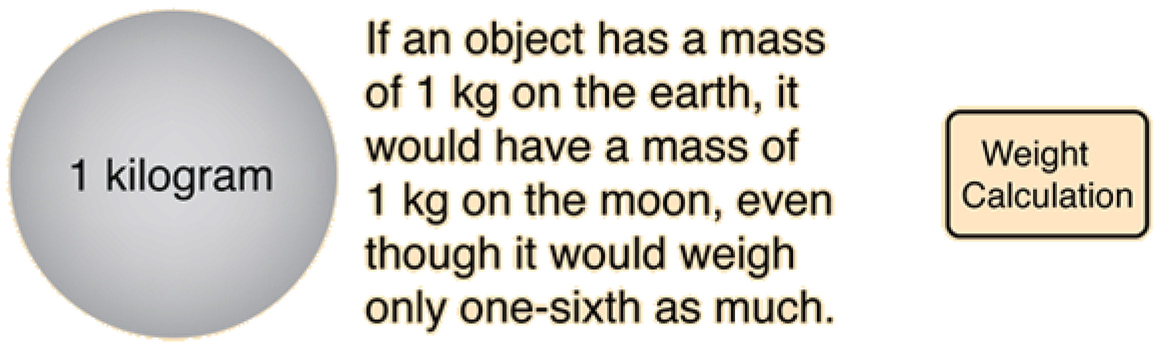
2.1 Basic physics

System International de Units (SI system of units) In earlier days, many system of units were followed to measure physical quantities. The British system of foot–pound–second or fps system, the Gaussian system of centimetre – gram – second or cgs system, the metre–kilogram – second or the mks system were the three 17 systems commonly followed.

Mass and Weight

The mass of an object is a fundamental property of the object; a numerical measure of its inertia; a fundamental measure of the amount of matter in the object. Definitions of mass often seem circular because it is such a fundamental quantity that it is hard to define in terms of something else. All mechanical quantities can be defined in terms of mass, length, and time. The usual symbol for mass is m and its SI unit is the kilogram. While the mass is normally considered to be an unchanging property of an object, at speeds approaching the speed of light one must consider the increase in the relativistic mass.

The weight of an object is the force of gravity on the object and may be defined as the mass times the acceleration of gravity, $w = mg$. Since the weight is a force, its SI unit is the newton. Density is mass/volume.



2.2 Basic Chemistry, Chemical Elements and groups

Bonds and Molecules

An atom stabilizes by bonding with another atom in order to fill out its outer set of electrons in its shell. When two atoms of the same chemical element bond together they form a diatonic molecule. When two atoms of different chemical elements bond, they form a chemical compound. Atoms are held together because there is an electrostatic attractive force between the two atoms. Energy is required for the chemical reaction to bond atoms. This energy becomes potential chemical energy that is stored in a molecule or chemical compound. For example, combining two atoms of hydrogen forms a hydrogen molecule, H_2.

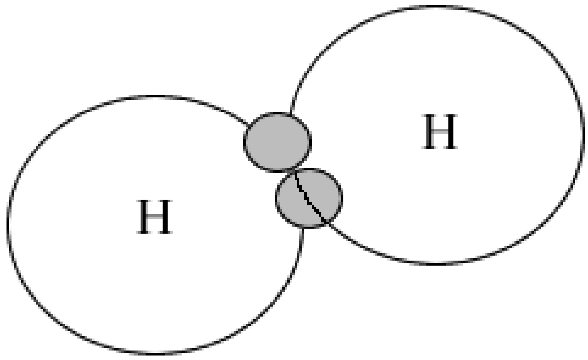


Fig. 2.2.A: Hydrogen becomes chemically stable by sharing an electron with another hydrogen atom.

Combining a hydrogen molecule consisting of two atoms with one oxygen atom forms the compound we know as water. H_2O.

Bonds are formed in two ways:

- Gain or lose an electron from the valence shell; called an ionic attraction.
- Share one or more electrons in the valence shell; called a covalent bond.

Atoms bond together using a range of ionic and covalence bonds.

There are three major chemical bonds.

- **Ionic bond**. Transfer electrons from one atom to another atom. An atom becomes unbalanced when it gains or loses an electron. The reation that creates table salt from sodium and chlorine causes an ionic bond between these atoms.

- **Covalent bond**. Atoms share electrons in their valence shell. The shared electron orbits the nucleus of both atoms. A covalent bond is the strongest bond and the most commonly found in organisms.
- **Hydrogen bond**. A hydrogen bond forms a weak, temporary bond that serves as a bridge between either different molecules or portions of the same molecule. For example, two water molecules are physically combined using a hydrogen bond.

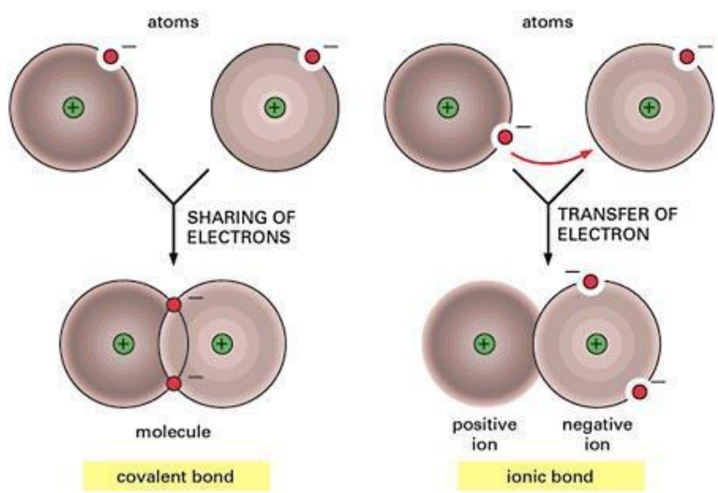


Fig. 2.2.B: Covalent Bond and Ionic bond

Compounds

What Are Molecular Formulas?

Atoms are seldom solitary in nature. They tend to combine with other atoms to create compounds, also known as molecules.

Common examples of molecules include water, carbon dioxide, and ammonia.

Molecules are typically represented by molecular formulas which list the number and type of atoms found in the molecule. Listed are the molecular formulas of some of the most common water treatment chemicals below.

Common Name	Chemical Name	Formula
	Aluminum hydroxide	$Al(OH)_3$
Filter alum	Aluminum sulfate	$Al_2(SO_4)_3$ * $14H_2O$
Ammonia gas, Ammonia	Ammonia	NH_3
Ammonia	Ammonium hydroxide	NH_4OH
	Calcium bicarbonate	$Ca(HCO_3)_2$
Limestone	Calcium carbonate	$CaCO_3$
Hydrated lime	Calcium hydroxide	$Ca(OH)_2$
HTH	Calcium hypochlorite	$Ca(OCl)$
Quick lime	Calcium oxide	CaO
Chloride of lime	Calcium oxychloride	$CaOCl_2$
Gypsum	Calcium sulfate	$CaSO_4$
Dry ice	Carbon dioxide	CO_2
	Carbonic acid	H_2CO_3
Liquid chlorine	Chlorine	Cl_2
	Chlorine dioxide	ClO_2
Blue vitriol	Cupric sulfate	$CuSO_4$ * $5H_2O$
	Dichloramine	$NHCl_2$
Ferrichlor, Chloride of Iron	Ferric chloride	$FeCl_3$ * $6H_2O$
Muriatic acid	Hydrochloric acid	HCl
	Hypochlorous acid	$HOCl$
	Methane	CH_4
	Monochloramine	NH_2Cl
	Nitrogen trichloride	NCl_3
Soda	Sodium bicarbonate	$NaHCO_3$
Soda ash	Sodium carbonate	Na_2CO_3
Salt	Sodium chloride	$NaCl$
Lye, Caustic soda	Sodium hydroxide	$NaOH$
	Sodium phosphate	Na_3PO_4 * $12H_2O$
Oil of vitriol, Vitriol	Sulfuric acid	H_2SO_4
Water	Water	H_2O

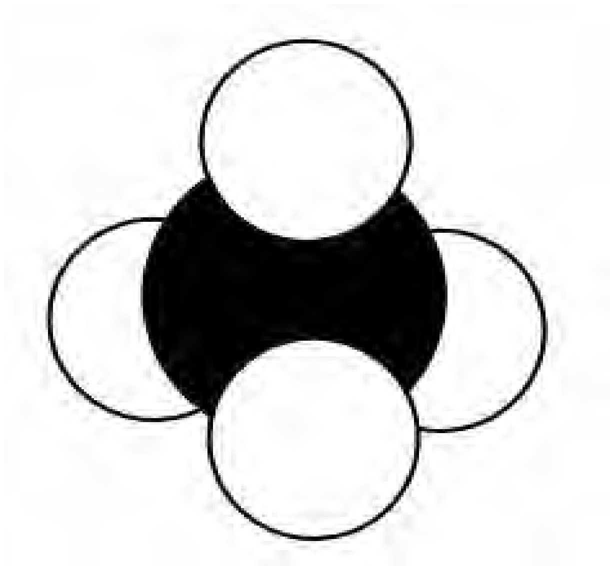


Fig. 2.2.C: Methane Molecule CH4

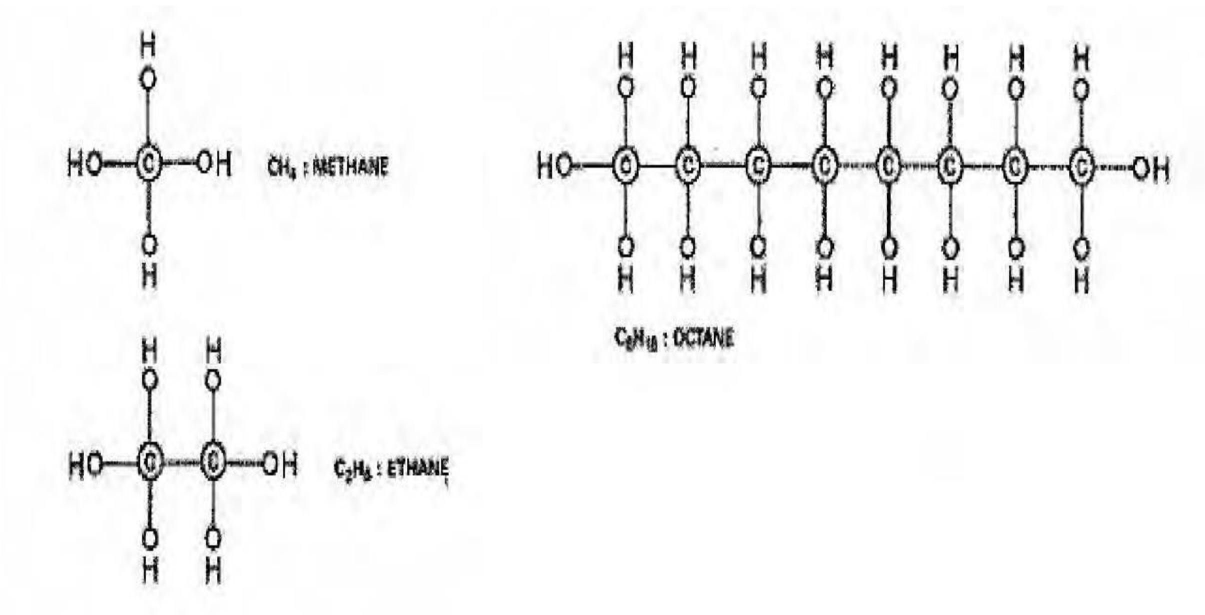
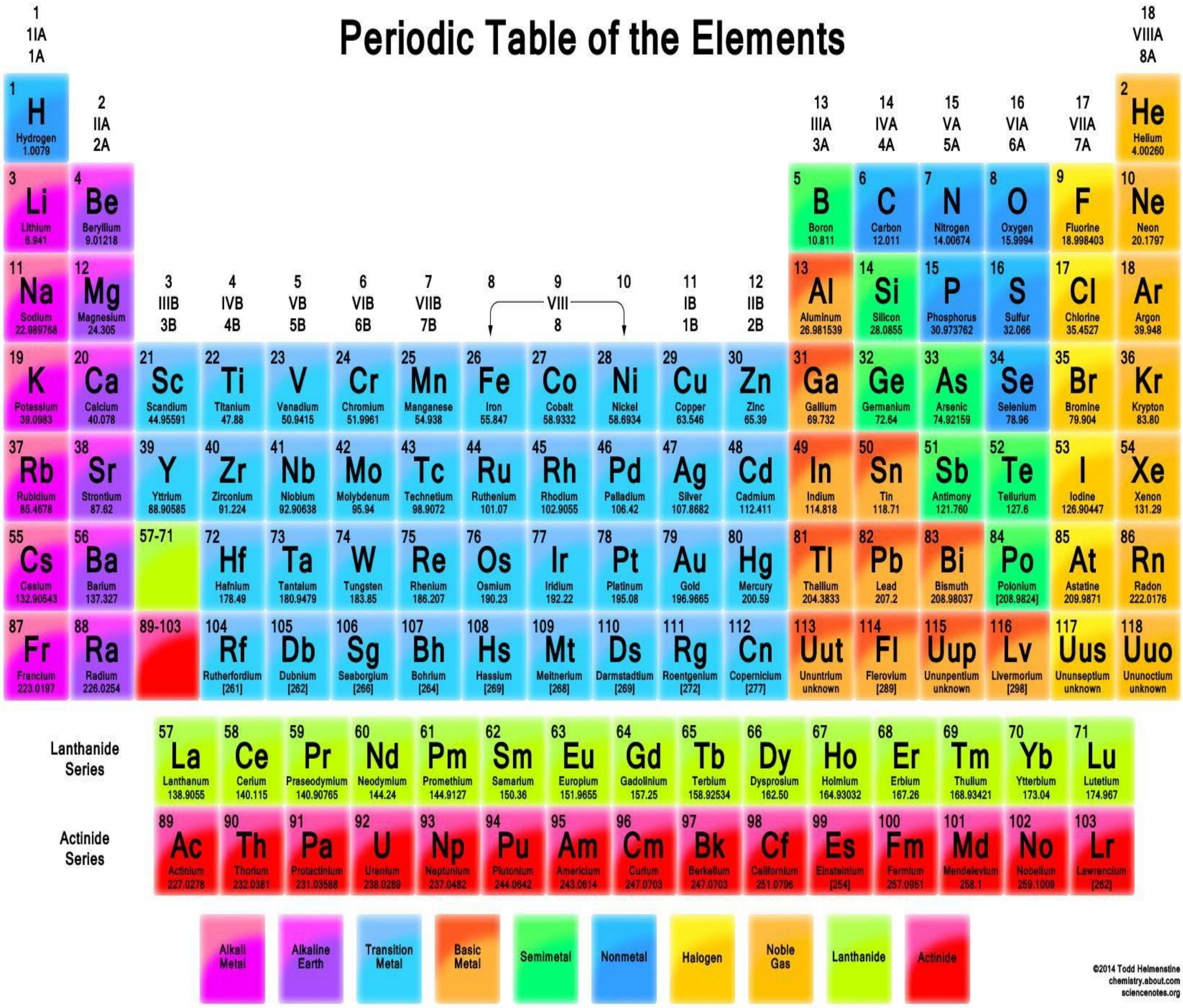


Fig. 2.2.D: Schematic representation of hydrocarbon molecules

Periodic Table of Groups of Elements

One reason the periodic table of the elements is so useful is because it is a means of arranging elements according to their similar properties. There are multiple ways of grouping the elements, but they are commonly divided into metals, semimetals, and nonmetals. You'll find more specific groups, like transition metals, rare earths, alkali metals, alkaline earths, halogens, and noble gases. Click on an element to read about the chemical and physical properties of the group to which that element belongs.



2.3 Physical properties of oil and Chemicals carried in bulk

Physical properties of various noxious liquid chemicals carried at Sea Specific Gravity (Density)

Tanks on a Chemical Tanker are normally designed to load cargoes of a higher specific gravity than an oil tanker. Very often the design strength differs between groups of tanks on the same ship.

The information with regards to tank strengthening is normally found on the Certificate of Class and Fitness, and the Master must be familiar with this lay-out and the restrictions that may be imposed on loading high gravity cargoes. Especially important is the risk of slack loading a tank as this can cause excessive sloshing in the tank that may cause damage to the tank structure and/or its equipment. Equally important is the danger of exceeding the tank's design weight capacity.

Flash Point

The flash point of a liquid is the lowest temperature at which the liquid will give off sufficient vapour to form a flammable gas mixture with air, near the surface of the liquid.

Auto Ignition Temperature

The auto ignition temperature of a solid, liquid or gas is the lowest temperature at which it requires to be raised to support self combustion.

Flammable / Explosive Limits

The flammable (explosive limits) are the minimum and maximum concentrations of flammable gas or vapour in air between which ignition can occur.

The Minimum vapour concentration is known as:

The Lower Flammable Limit LFL

The Lower Explosive Limit LEL

The maximum vapour concentration is known as:

The Upper Flammable Limit UFL

The Upper Explosive Limit UEL

Vapour pressure/Boiling point

Vapour of every liquid exerts a certain vapour pressure at any given temperature called the vapour pressure. The liquid will boil when the vapour pressure equals the external atmospheric pressure. In a closed ship tank, however, the liquid will boil when the vapour pressure equals the atmosphere pressure plus the pressure setting of the P/V valve. The tanks and vent systems are designed to withstand this pressure, plus the hydrostatic pressure of the cargo.

True vapour pressure (TVP)

The true vapour pressure of a liquid is the absolute pressure exerted by the gas produced by evaporation from a liquid when gas and liquid are in equilibrium at the prevailing temperature. Boiling Point The temperature at which the vapour pressure of a liquid equals that of the atmosphere above its surface; this temperature varies with pressure.

Freezing point/Melting Point

Most liquids have a defined freezing point, sometimes described as the melting point. Some products, like lube oil additives, vegetable and animal oils, polyoils etc do not have a defined freezing point, but rather a freezing (melting) range or none at all. The product's viscosity is instead used as a measurement for the products liquidity or handling characteristics. Products with a freezing point higher than the outside temperature in which the ship is trading will need to be heated in order to remain liquid.

Ship's structure and equipment normally have limitations on high heat. Exceeding this limitation could damage the tanks or their structure. High heat will also reduce steel strength, and the risk of cracking will increase. Caution should be exercised when carrying high heat products as non-insulated lines and vents may freeze and clog the systems. Not insulated cargo lines used for high heat products pose a safety hazard as they may cause severe burns if touched.

Adjacent tanks temperature limitation to be monitored. MARPOL Annex II requirements for solidifying substances discharge temperature to be complied (in consultation with shippers). Prewash may be required if discharge temperature as per Annex II cannot be complied with. The cargo tank vapours pressure to be monitored carefully in freezing weather conditions to monitor blockage of PV vent lines.

Solidifying/non-solidifying

Solidifying Substance means a noxious liquid substance which:

1) In the case of a substance with a melting point of less than 15°C which is at a temperature of less than 5°C above its melting point at the time of unloading; or

2) In the case of a substances with a melting point of equal to or greater than 15°C which is at a temperature of less than 10°C above its melting point at the time of unloading.

Non-solidifying Substance means a noxious liquid substance, which is not a Solidifying Substance.

Pour Point

The pour point of a liquid is the lowest temperature at which the liquid will flow. It should be noted that cargo with thixotropic properties (the properties of showing a temporary reduction in viscosity when shaken or stirred) can be pumped at temperatures well below its pour point, but at very restricted rates.

Viscosity

Viscosity is a measure of a liquid's ability to flow and is usually determined by measuring the time required for a fixed volume to flow under gravity through a thin tube at a fixed temperature. As the temperature of the liquid increases its viscosity decreases and therefore it flows more readily. It can also be described as a measure of the internal friction of a liquid. The distinction between viscosity and pour point should be made clear. Oil ceases to flow below its pour point temperature when the wax content solidifies.

A viscosity measurement of a liquid depends upon the internal resistance of the liquid to flow. For a simple liquid this internal resistance varies with the temperature in a predictable and regular way. However, when oil approaches its pour point the rate at which viscosity increases as temperature falls accelerates until sufficient wax has precipitated to solidify the product.

Viscosity is important as regards the pumpability of a product. Centrifugal and deepwell pumps are acceptable for the majority of cargoes but high-viscosity products such as bitumen or molasses are more suited for pumping with positive displacement pumps. High-Viscosity Substance means a noxious liquid substance in Category X or Y with a viscosity equal to or greater than 50 mPa.s at the unloading temperature.Low-Viscosity Substance means a noxious liquid substance, which is not a High-Viscosity Substance. MARPOL Annex II requirement for high viscosity substances are to be complied with.

Electrostatic charging

Certain cargoes are known as static accumulators, and become electrostatically charged when handled. They can accumulate enough charge to release a spark that could ignite a flammable tank atmosphere.

Cubic expansion

All liquids will expand as temperature rises, or contract when temperature decreases. Sufficient space must be allocated in the tank to facilitate any cubic expansion or contraction expected during the voyage.

Vent line systems must be checked for operation at regular intervals, as malfunction could cause structural damages because of changes in the liquid's volume. For calculating maximum intake, the density at 35`C is used for non heating cargoes and the density at maximum discharge temperature for heated cargo is used. The volume at these temperatures should not exceed 98% of cargo tank maximum volume. Allowances should also be made for load density and IBC Code requirements.

Vapour density

Vapour density is expressed relative to density of air. Many chemical cargo vapours are heavier than air, caution must be exercised during loading and any other cargo operation, as vapour concentrations may accumulate and be trapped in certain deck areas. (If cargo tanks are incorrectly cleaned vapour may remain in the bottom of the tank).

Solubility

Solubility is expressed in many different ways; yes, no, slight, as a percentage or totally and in this connection only with water. Most non-soluble chemicals are lighter than water and will float on top; others like the chlorinated solvents are heavier and will sink to the bottom. This latter condition may cause a safety risk in drip trays and even in cargo tanks where they may be trapped under water in pump wells, and pose a danger even if the tank atmosphere is tested safe for entry.

Colour

Colour is the comparison between a sample of product and standard colours measured under closely controlled conditions. The colour of clean products is one of the more common causes of cargo rejection or downgrading. This is generally caused by loading a light-colored product without adequate preparation into a tank that last carried a darker product. Most of the lube oils and white-water white products show quite readily the traces of prior darker lube oils or residual products, and because of this trait, it is most important that the tank cleaning instructions are closely followed and proper line cleaning carried out.

3. KNOWLEDGE AND UNDERSTANDING OF TANKER SAFETY CULTURE AND SAFETY MANAGEMENT

Self Checklist for Company Safety Management System

IMO Company ID. No.: ____________ **Number of relevant employees who carry out or have responsibility to the SMS of the Company ashore.** [ ]

Company Name: ____________ **Type of Audit** ________ **Record No.** ________

Company Address: ____________ **Country:** ________

Designated Person(s): ____________ **Tel.:** ________ **Fax:** ________

Date of Checking: ________ **Checked by:** ________ **E-mail:** ________

Title & Latest Revision Date of Manual: ____________ **Website:** ________

Note:
(1) This Checklist indicates items to be included at least in the samples at self checking.
(2) In principle, the verification over the Company's implementation of SMS should be made comprehensively for the past one year. However, in the Renewal, the verification over the Company's implementation of SMS should be extended to include the reports issued by the external audits, PSC or marine casualties, and the company's investigation and analysis conducted in response to them, for the past five years.

(1) Items to be checked prior to audit

Items to be checked	*CHK*	*Remarks*
1-1 Changes of ships under management		As for new acquisition, a copy of owner's report to the Administration as required in ISM Code 3.1 to be available.
If there are any SMC of ships left from the Company's management, the SMC should be returned to ClassNK Head Office for "Termination of ISM registration".		
1-2 Changes in Company's name/address		If Additional Audit has not yet started, an Additional audit for changes shall be applied to the ClassNK Local Office.
1-3 Confirmation of ship types covered by DOC		If any ship type no longer exists under management for more than 1 year, rewrite of DOC shall be requested at next Audit.
1-4 Confirmation of ship flags covered by DOC		If no ship under management remains with any Flag, the DOC of same Flag shall be returned at next Audit.
1-5 Confirmation of reporting to Flag States		A copy of owner's report to the Administration as required in ISM Code 3.1 to be confirmed, for every ship.

(2) Items to be confirmed prior to audit

Type of ship*	Flag & number of ships under management	Type of ship*	Flag & number of ships under management
Oil Tanker		Bulk Carrier r**	
Chemical Tanker		Other Cargo Ship	
Gas Carrier		Passenger Ship	
* Refer to SOLAS IX/1 & 2		** Dry cargo ships assigned with "ESP" within the Class Notation	
Active Crew nationality			
Masters		Chief Engineers	
Deck Officers		Engineers	
Deck Ratings		Engine Ratings	
Radio Operators		Cooks	
Language	Manual, Procedures and Instructions	Working Language Onboard	

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Fig. 3.0.A: Safety Management checklist

Certificates

- Certificates issued to a Company Certificates, that may be issued to a Company, are as follows;

(i) DOC: A full-term Certificate issued under the authority of the Flag State Government.

- DOC

DOC(s) shall be issued to a Company by the Flag State Government or the Head Office of Class NK under the authority of the Flag State Government, upon successful completion of an Initial Audit after at least three months implementation of its SMS at the Company and of at least one ship of each ship type managed under the SMS. Therefore, when a Company manages a plural flag fleet, a plural number of DOCs shall be issued.

The period of validity of a DOC, issued after Initial Audit, shall be five years from the last date of the Audit subject to annual audit. As for Renewal Audit, when the same is completed within three months before the expiry date of an existing DOC, the period of validity of the new DOC shall be five years from the next day of the expiry date of the existing DOC.

When the Renewal Audit is completed more than three months before the expiry of an existing DOC, the new DOC shall be valid from the date of completion of the Renewal Audit for a period of five years. DOCs shall be endorsed upon the successful completion of an Annual Audit.

The original of DOCs shall be kept at the Company and a copy of the DOC, relevant to the ship and endorsed for the annual audit, shall be placed on board of each ship covered by the SMS.

(ii) SMC

A SMC shall be issued to a ship, which is managed by a Company who is in possession of DOC or Short-term DOC (not Interim DOC) relevant to the Flag State, by the Flag State Government or the Head Office of ClassNK under the authority of the Flag State Government upon successful completion of an Initial Audit, after at least three months implementation of its SMS on the ship.

The period of validity of a SMC, issued after Initial Audit, shall be five years from the last date of the Audit, subject to an intermediate audit carried out between the second and third anniversary date. As for Renewal Audit, when the same is completed within three months before the expiry date of the existing SMC, the period of validity of the new SMC shall be five years from the next day of the expiry date of the existing SMC.

When the Renewal Audit is completed more than three months before the expiry date of existing SMC, the new SMC shall be valid from the date of completion of Renewal Audit for a period of five years. A SMC shall be endorsed upon the successful completion of an Intermediate Audit.

The original of the SMC shall be placed on board and a copy of the SMC shall be kept by the Company.

(iii) Audit

Purposes of Audit

Purposes of audits are to verify compliance of with the requirements of the ISM Code and, through the verification, to support and encourage Companies in achieving safety management objectives, which are: (1) to provide for safe practices in ship operation and a safe working environment; (2) to establish safeguards against all identified risks; and (3) to continuously improve the safety-management skills of personnel ashore and aboard.

- Handling of a Certificate

When a Non-conformity is found

- When a Major Non-conformity (MNC) is found When an MNC is found, no Certificate may be issued nor be endorsed. However, if the MNC is corrected or downgraded to DNC during the audit, DOC/SMC shall be issued or be endorsed. In this case, however the certificate shall become invalid, unless an Additional Audit is undertaken within three months, at the Company or onboard, to verify effective actions have been taken

- When Non-conformities (NC) are found When NCs are found, a Certificate may be issued or be endorsed, provided the submission of a Corrective Action Plan within two weeks is agreed, which indicates a schedule not exceeding three months. In this case, the Certificate shall become invalid if the Corrective Action Plan is not submitted within two weeks. Otherwise, please be advised that, in cases of Audit for issuing an Interim DOC or Interim SMC, Certificates shall not be issued when a NC is found.

4.1 HAZARDS

4.1.1 Health hazard

Substance that is carcinogen, corrosive, irritant, toxic, or can damage eyes, lungs, mucous membranes, or skin, or which produces acute or chronic health effects.

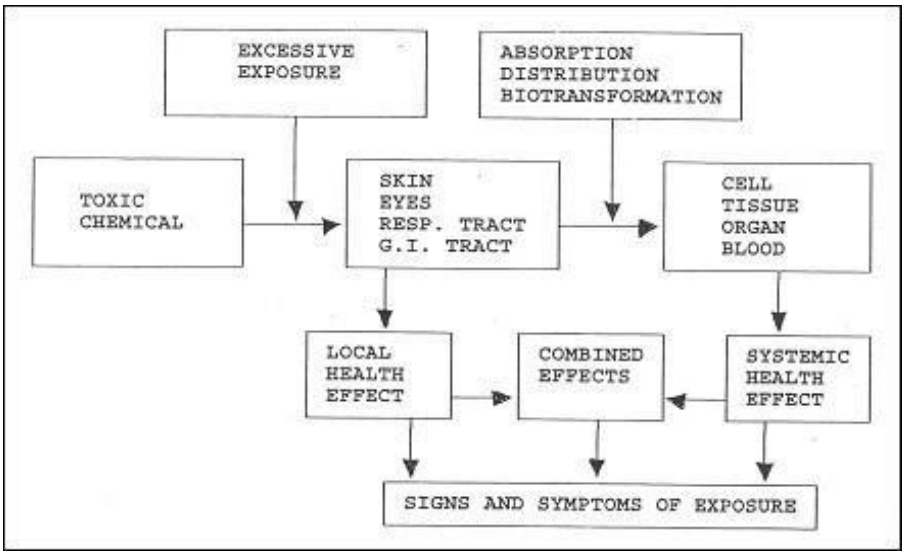


Fig. 4.1.1.A: Health Hazards

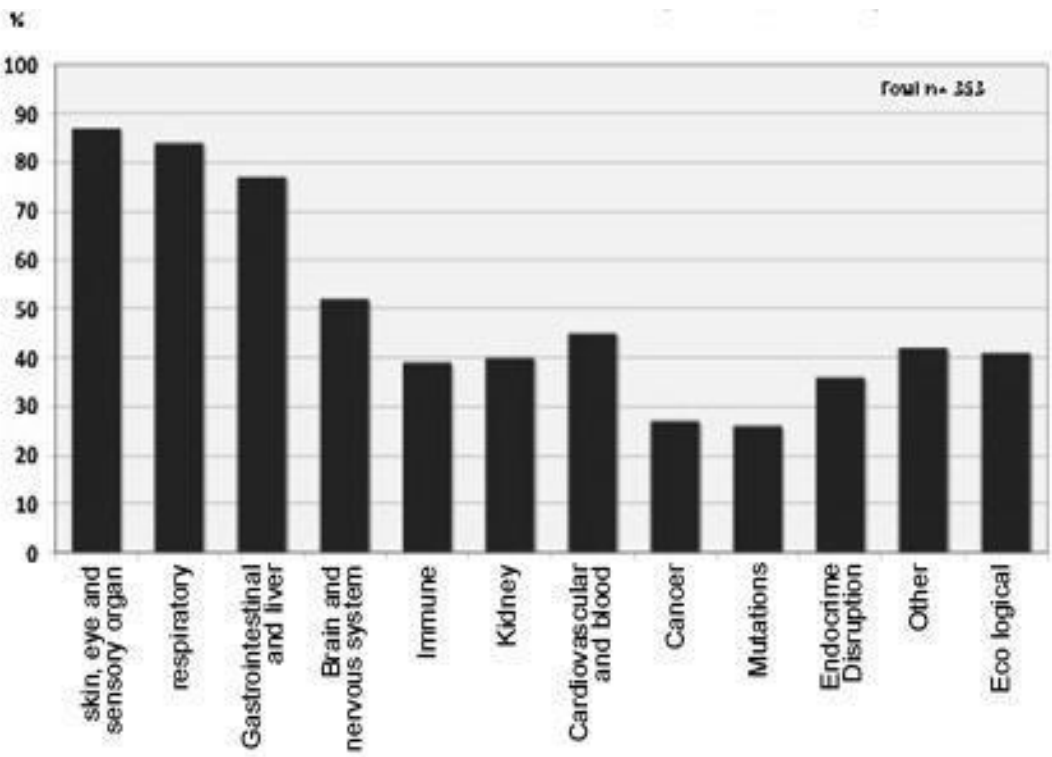


Fig. 4.1.1.B: Health Hazards in percentage of exposures to oil and Chemicals

4.1.2 Environmental Health

What Is Environmental Health?

The word 'health' brings many things to mind. Maintaining good health involves eating right, exercising, vaccinations against diseases and visiting your doctor regularly. Your health describes how well your body is functioning and your quality of life.

We can also appreciate health in a broader sense. Environmental health involves understanding the impacts of environmental and human-made hazards and protecting human health and ecological systems against these hazards. This includes studying the impacts of human-made chemicals on wildlife or human health, as well as how the environment influences the spread of diseases.

Types of Environmental Hazards

We face countless environmental hazards every day. To better understand them, we can think of them as falling into four categories: physical, chemical, biological and cultural.

1. **Physical hazards** are physical processes that occur naturally in the environment. These include natural disaster events such as earthquakes, tornadoes, volcanoes, blizzards, landslides and droughts. Not all physical hazards are discrete events - some are ongoing, like ultraviolet radiation. UV radiation is considered a hazard because it damages DNA and can cause human health issues like skin cancer and cataracts.

2. **Chemical hazards** can be both natural and human-made chemicals in the environment. Human-made chemical hazards include many of the synthetic chemicals we produce, like disinfectants, pesticides and plastics. Some chemical hazards occur naturally in the environment, like the heavy metals lead and mercury. Some organisms even produce natural chemicals that are an environmental hazard, such as the compounds in peanuts and dairy that cause allergic reactions in humans.

3. **Biological hazards** come from ecological interactions between organisms. Viruses, bacterial infections, malaria and tuberculosis are all examples of biological hazards. When these pathogens and diseases are transferred between organisms, it's called an infectious disease. We suffer from these diseases and pathogens because we're being parasitized by another organism, which, while hazardous, is also a natural process.

4. **Cultural hazards**, also known as social hazards, result from your location, socioeconomic status, occupation and behavioral choices. For example, smoking cigarettes is hazardous to your health, and this is a behavioral choice. If you live in a neighborhood with lots of crime, this is a hazard based on your location. Similarly, your diet, exercise habits and primary mode of transportation all influence your health and the health of the environment around you.

4.1.3 Reactivity Hazards

Chemical reactivity hazards still exist even if a plant doesn't intentionally run chemical reactions. Chemical reactivity hazards can be manifest through:

- Materials which become chemically unstable for a variety of reasons,
- Intended chemical reactions that get out of control for a variety of reasons
- Unintended chemical reactions that take place due to accidental mixing of chemicals that are normally separate

4.1.4 Corrosion Hazards

Corrosives include acids, alkalis (bases or caustics) and halogens. A corrosive material is a reactive compound or solution that produces a destructive chemical change in the material upon which it is acting. Upon contact, a corrosive material may destroy metals, body tissues, plastics and other materials.

Those corrosive solutions that have the greatest concentration of hydrogen ions (H) are the strongest acids, while those that have the greatest concentration of hydroxyl ions (OH) are the strongest bases. The measure of acidity and basicity is pH: strong acids have a low pH (maximum 1), while strong bases have a high pH (maximum 14). Neutrality is given the pH of 7.

Examples of common corrosives include:

- Acids - hydrochloric acid, nitric acid, sulphuric acid
- Bases - potassium hydroxide, sodium hydroxide (caustic soda)
- Halogens - chlorine, bromine

4.1.5 Explosion and Flammability Hazards

The danger of explosion exists when flammable materials are mixed with air, when they can form an explosive mixture. This can occur during storage, movement, process, production and manufacture of such flammable materials.

The primary requirement is for the operator to prevent conditions where a flammable mixture is released to the atmosphere. However, as there is some risk of such a situation taking place, special measures need to be taken in respect of electrical and non-electrical apparatus, to prevent the possible ignition of flammable or explosive atmospheres. The employment of these measures should safeguard both the plant (or installation) and more importantly human life, as ignition can only occur when both a flammable atmosphere and the means for an ignition exist simultaneously.

Such ignition may occur following an arc, spark or hot surface during the use of electrically powered equipment. It should also be recognized that non-electrical equipment may also be the source of ignition

In addition ignition could also be initiated by frictional sparking and electrostatic action. Arcs can result from the discharge of stored energy or from switching contacts. Hot surfaces sufficient to cause ignition can arise from electrical enclosures or components.

Other sources of ignition energy are open flame, stray electric currents, lightning, compression, engine exhausts, heat from chemical reactions, spontaneous combustion, friction or heat from mechanical equipment & heat from the sun.

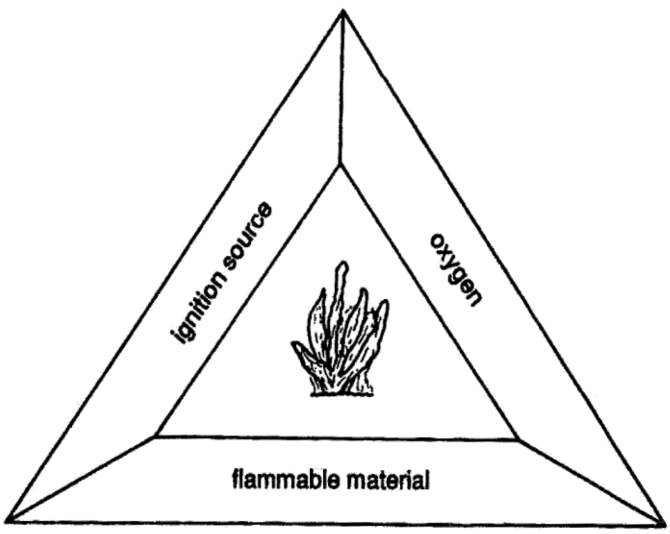


Fig. 4.1.5. A.: The Fire Triangle

The three ingredients which together will give rise to an explosion taking place :-

a. Flammable material
b. Air and
c. Ignition source

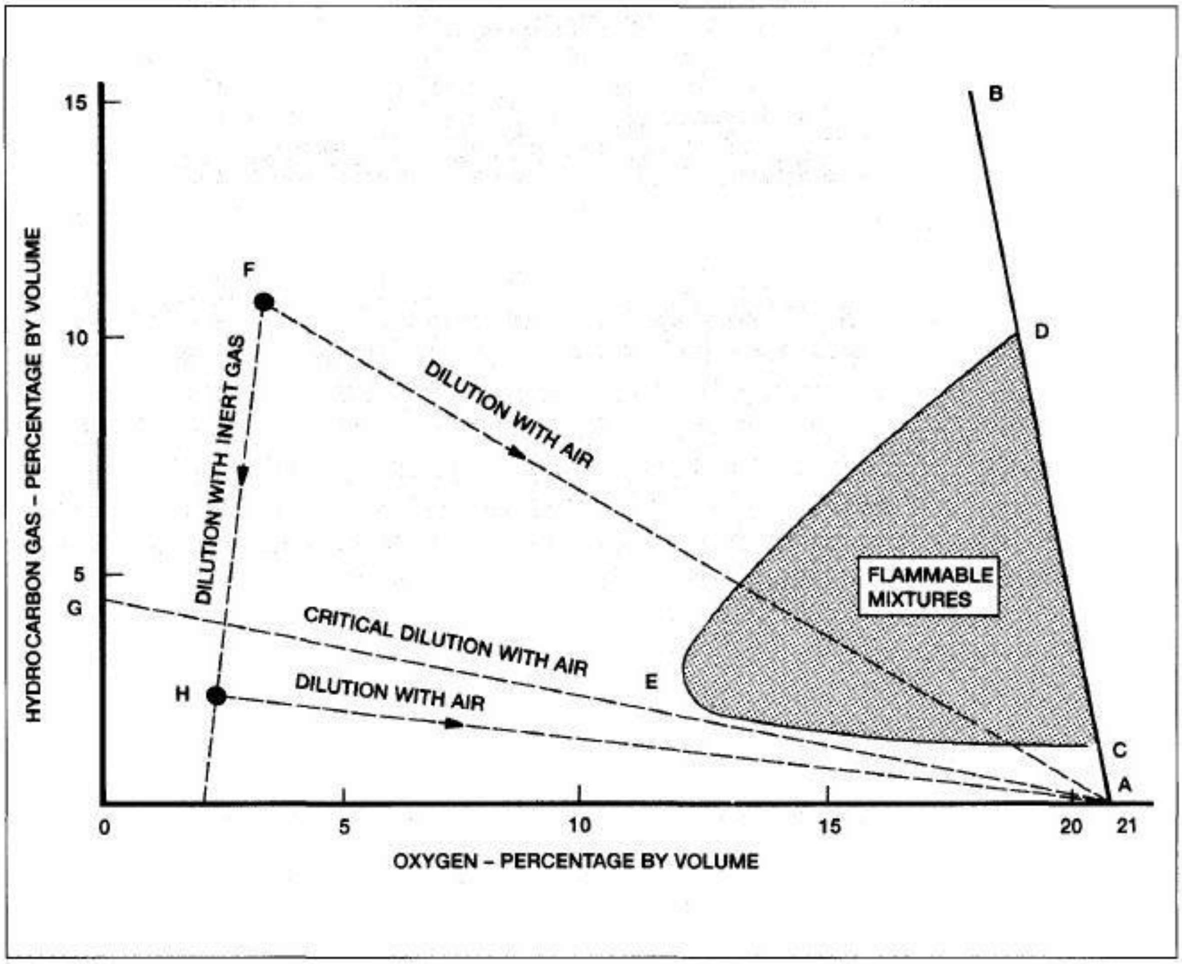


Fig. 4.1.5.B. : Flammability diagram

4.1.6 Sources of Ignition, including electrostatic hazards

Static electricity is a common source of ignition leading to fire and explosion in process industries. Electrostatic charge is developed due to relative motion between two dissimilar substances during various operations which may dissipate to earth or less charged objects resulting in a spark leading to fire, explosion, detonation and loss of plant, property and personnel. Various aspects for evaluation of a process plant for electrostatic hazard and providing adequate safety measures are outlined in this paper.

Electrostatic Phenomenon

Static charge generates from movement of electrons when two dissimilar substances come into close contact and then separate. Transfer of electrons occurs across the interface when two surfaces are in contact usually leading to line-ups of opposite electrical charges on two adjacent substances, at the boundary between them. Magnitude and polarity of charge being function of areas of contact surfaces, type of materials, surface temperature and separation velocity. Separation of two layers with opposite charges leads to potential difference.

Electrical conductivity of material determines time required for charge to become neutralised and separation rate decides time available for discharge. Atmosphere is ionised if field strength exceeds a critical level, which may lead to discharge to some nearby earthed or less charged object as complete spark (responsible for majority of industrial fires and explosions) or partial breakdown- corona discharge depending on configuration of two surfaces acting as capacitor and field strength.

4.1.7 Toxicity hazards

Toxic materials can cause serious health effects in an exposed individual. The degree of hazard associated with any toxic material is related to the exact material you are exposed to, concentration of the material, the route into the body and the amount absorbed by the body (the dose). Individual susceptibility of the user also plays a role.

The health effects may occur immediately or the effects may be delayed. Health effects that occur immediately after a single exposure are called acute effects. In other cases, health effects will not occur until some point after the exposure. This is called a chronic effect. A chronic effect may occur hours, days, months or even years after exposure. Generally, acute effects are caused by a single, relatively high exposure. Chronic effects tend to occur over a longer period of time and involve lower exposures (e.g., exposure to a smaller amount over time). Some toxic materials can have both acute and chronic health effects.

4.1.8 Vapour leaks and Clouds

Behaviour of LNG in the cargo tanks - Dispersal of vented cargo vapours
When loaded in the cargo tanks, the pressure of the vapour phase is maintained substantially constant, slightly above atmospheric pressure.

The external heat passing through the tank insulation generates convection currents within the bulk cargo, causing heated LNG to rise to the surface where it vaporizes.

The heat necessary for vaporization comes from the LNG, and as long as the vapour is continuously removed by maintaining the pressure as substantially constant, the LNG remains at its boiling temperature. If the vapour pressure is reduced by removing more vapour that is generated, the LNG temperature will decrease. In order to make up the equilibrium pressure corresponding to its temperature, the vaporization of LNG is accelerated, resulting in an increase heat transfer from LNG to vapour.

Cargo vapour, whether toxic or flammable, should be vented to atmosphere with extreme caution, taking account of regulations and weather conditions.

If the temperature of the vented vapour is below atmospheric dew point, clouds of condensed water vapour will form. Condensed water vapour (fog) is heavier than air whereas the cargo vapour may or may not be heavier than air, depending on temperature. The cargo vapour cloud is likely to be oxygen deficient, and should only be entered by personnel wearing breathing apparatus. Furthermore, it should never be assumed that the cargo vapour is contained entirely within the boundaries of the visible water vapour cloud.

If the cargo vapour is heavier than air it may accumulate on deck and enter accommodation spaces. Standard precautions should therefore be observed. In some cases it may be possible to heat vapour before venting to reduce its density and assist dispersion. If such facilities are provided they should be used.

Any cargo vapour, whether toxic or flammable, is to be vented to atmosphere with extreme caution, taking account of regulations and weather conditions. In some cases venting may be prohibited.

If the vapour vented is at a temperature below the atmospheric dewpoint clouds of water vapour will form and these are heavier than air. The cargo vapour may or may not be heavier than air, depending on temperature. It is never to be assumed that the cargo vapour is contained entirely within the boundaries of the water vapour cloud. The cargo vapour cloud is likely to be Oxygen deficient and is only to be entered by personnel wearing breathing apparatus.

Void spaces / duct keels and pipe tunnels

Because of restricted natural ventilation these spaces may be oxygen deficient. In addition, they are adjacent to cargo holds and ballast tanks, so both hydrocarbon vapour and inert gas may leak into them. It must be recognised that the rescue of an unconscious or injured person may be very difficult. Hydrocarbon vapours may also be released from adjacent cargo tanks due to leaks in pipelines or hairline cracks in the tank structure. It is therefore essential that checks are made of these spaces for the presence of hydrocarbons.

Some ships will be equipped with automatic detectors and recording devices for this purpose. Ships that do not have such equipment must carry our manual checks at least weekly and the results recorded in the table within the deck log book.

Where the Classification Society rules do not require the permanent lighting systems in these spaces to be isolated during gas trading, the following procedures are to be complied with in order to eliminate the hazards that could result from damaged flame proof fittings.

The space must be tested and proven gas free, before the lights are switched on.

The mechanical ventilation system is to be in operation before the lights are switched on, and must remain in operation until after the lights are switched off.

There are four different types of control for cargo tanks, as follows:

1. Inerting

2. Padding

3. Drying

4. Ventilation

4.2 BASIC KNOWLEDGE OF HAZARD CONTROLS

4.2.1 Inerting, water padding, drying agents and monitoring Techniques

1. **Inerting** - by filling the cargo tank and associated piping systems and, where specified in Section 15, the spaces surrounding the cargo tanks, with a gas or vapour which will not support combustion and which will not react with the cargo, and maintaining that condition.

2. **Padding** - by filling the cargo tank and associated piping systems with a liquid, gas or vapour which separates the cargo from the air, and maintaining that condition.

3. **Drying** - by filling the cargo tank and associated piping systems with moisture-free gas or vapour with a dewpoint of –40 °C or below at atmospheric pressure, and maintaining that condition.

4.2.2 Anti- static measures

Sources of static electricity and how to eliminate ?

Loading of bulk liquid chemicals in a ships tank involved static electricity hazards. Controlling the main reasons of static electrical fields generators can eliminate potentials threats.

Splashing and spraying of static accumulators should generally be avoided, as they lead to the formation of charged mists or foams. A charged mist can be ignited even if the temperature does not reach the flash point: so splash filling and spraying are a danger even with relatively high flash point cargoes.

Filling of a ship's tank should normally be through a pipeline which ends near the bottom of the tank so that, in the early stages of loading, the liquid is gently laid on the bottom. When the rising liquid covers the pipeline outlet, turbulence in the tank is considerably reduced and fewer static charges are generated.

- **Safe pumping rate**

The faster the liquid flows through the pipeline to the ship's tank, the higher is the electrostatic charging. To avoid excessive turbulence within a static accumulator cargo, the velocity of liquid entering a tank should be very low until the inlet is well covered . Low velocity also limits any mixing with water that might be present in the tank bottom.

After the inlet has been submerged, the flow velocity may be increased, but it should still minimise turbulence and avoid breaking the liquid surface.

- **Presence of water**

Most static accumulators are not miscible with water. The presence of water produces two sources of static electricity. First, friction occurs at the surface of the water droplets dispersed within the cargo liquid, so far more static charges are generated than if the cargo liquid did not contain the water. Second, the charged droplets settle through the liquid and gather at an interface, producing a high voltage at the liquid surface. This process may continue even after tank filling has ceased.

- **Gas bubbling up through the filled tank**

After loading, pipelines are often blown through using air, nitrogen or other gases. When the gas enters the tank from the bottom it will rise through the liquid in small bubbles, generating a high voltage at the surface. If it is necessary to blow through after loading a static accumulator, the amount of gas allowed to enter the ship's tank should be kept to a practical minimum.

- **Relaxation time downstream of filters**

Micropore filters made of paper, cloth, felt, chamois or a metal grid, particularly if deep and thick, are prolific generators of electrostatic charges. Strainers such as perforated metal baskets are not. The liquid is highly charged when it leaves the filter in the loading line. For such charge to be relaxed, the liquid has to flow quietly in the pipeline for some time, before entering the ship's tank.

Practical experience has shown that 30 seconds is sufficient. Filters are usually located ashore so the transit time is adequate, but if the distance between the filter and the ship's tank is not great enough, either the flow rate should be reduced, or the pipe length increased or its diameter enlarged, or a relaxation tank should be provided in between the filter and the storage tank.

- **Unearthed conductors**

A conductor having no electrical contact with earth can become charged and rise in voltage through induction (without physical transfer of charges) and collection (with physical transfer). An unearthed conductor floating on the surface of a charged liquid actually collects charges from it. A conductor located in a charged mist becomes charged to approximately the same voltage as the mist, even though it cannot collect any charge.

In summary, a rise in voltage is possible without charge transfer to an unearthed conductor. If a spark then jumps between the unearthed conductor and an earthed metal surface all the energy the former has accumulated flows instantly into the spark, which therefore has a higher chance of being incendive.

Avoiding the presence of unearthed conductors in ships' tanks is of fundamental importance to prevent incendive sparks, because they provide the electrode from which a spark can jump. The following are examples of unearthed conductors which might be present inside a ship's tank:

• thin metal scraps, including rust: they do not float, but can be buoyed up by charged foam;

• a metal coupling at the end of a non-conductive cargo hose used for filling the tank;

• a metal rod or the tube on a gas sampling meter;

• a metal sampling can or thermometer holder lowered on a non-conductive rope;

• a tank washing machine on the end of a hose having a broken bonding cable, particularly when the hose is empty;

• dropped tools falling through a tank filled with a charged mist from water washing: the mist might be invisible.

- **Projections and probes in tanks**

Tanks are sometimes equipped with sounding pipes which extend down from underdeck towards the liquid surface. Other examples of projections and probes are high level alarms, spraying nozzles and fixed tank washing machines.

If the liquid being loaded is at a high surface voltage, an incendive brush discharge to an unbonded projection may take place. The need to avoid such a situation will have been taken into account during the design of fixed projections inside a cargo tank, and all requirements for safety as to materials of construction, earthing, insulation and static electricity generation will have been checked while the ship was being built.

It is important that any routine servicing should be performed in accordance with manufacturer's instructions, but no on board modifications to the equipment itself should be contemplated.

- **Gauging and sampling of tanks**

Whilst loading a static accumulator cargo,- conductive objects which are not bonded to the ship's structure such as metal sampling cans, gauge tapes and thermometers should not be lowered into a tank.

A period of 30 minutes should elapse after filling has stopped for the charge to be relaxed before any unbonded metallic or other conductive equipment is introduced. A metal sounding rod, suspended on a rope, will not be earthed.

The metal becomes charged when it is immersed in the charged liquid and, when it is then lifted, a metal to metal spark may jump between the rod and the rim of the tank opening, with a high probability of being incendive. If the surface voltage of the liquid is very high, it is possible to get an incendive brush discharge to the equipment when it first approaches the surface of the liquid during lowering.

Completely non-conductive equipment could in theory be used, but in practice it is difficult to ensure that such material remains non-conductive because it is habitually exposed to dirt and moisture. It is therefore better strictly to observe the waiting time in all cases.

The restriction of this waiting time may be avoided only if the gauging and sampling equipment is lowered inside a sounding pipe that extends all the way down and is connected to the bottom of the tank, because the voltage inside the sounding pipe is small. It is important to note that a shorter sounding pipe is not safe.

- **Washing of tanks**

During tank washing, a charged mist is produced and is present throughout the space. Such mist persists for a few hours after washing has come to an end. If an unearthed conductor is lowered into the charged mist, it becomes charged to a voltage which may be high enough for an incendive spark to jump to some part of the tank structure.

The limitations on water flow rate per nozzle, per machine and per tank have been established by extensive research, and should not be exceeded. If the water contains cleaning additives or is recycled, or the washing medium is other than clean water, washing should be conducted in a non-flammable atmosphere:

i.e. the tank should be made inert. The practical aspects of tank washing are therefore important to observe.

- **Steaming**

Steam issuing from a nozzle will generate a mist of charged water droplets. Therefore steam should never be injected into a tank that may contain a flammable atmosphere.

- **Bonding and earthing**

A spark cannot jump between two conductors which are either electrically bonded together or both earthed, because they are kept at the same voltage.

Effective bonding is achieved by connecting a metal cable between objects. The cable is sometimes permanently fixed to one conductor and bolted or clamped to the other. At the removable end, contact should be metal to metal and care should be taken to make sure paint, dirt or rust does not hamper it.

The cable should be strong enough to have good resistance to wear and tear.

Bonding and earthing cables should be inspected periodically and their resistance checked with a meter. Many hoses used in marine operations are made electrically conductive. A pair of flanges bolted together can be relied upon for being electrically continuous, as can flexible joints of metal loading arms, so bonding or jumping wires around them are not needed.

A different electrical phenomenon is experienced when a tanker is connected to a shore installation by a conductive hose or a metal loading arm. Ship, hose, dock and water form the elements of a battery and a large current can flow through the low resistance hose, even if the voltage difference between ship and shore is small. But this is not static electricity.

When the hose is disconnected the current is suddenly interrupted and an electrical arc can be formed between the flanges. There is a risk of igniting a flammable atmosphere existing at the manifold. To prevent such a hazard, the ship has to be insulated from the shore pipeline by means of an insulating flange or a length of non-conductive hose. This keeps the circuit of the battery open, and prevents a spark. However, there is no need to connect a tanker to the dock by a bonding cable, since both are earthed by the water.

4.2.3 Ventilation

DNV Rules on Ventilation Systems within the Cargo Area Outside the Cargo Tanks

- Any ducting used for the ventilation of hazardous spaces shall be separate from that used for the ventilation of non-hazardous spaces. Ventilation systems within the cargo area shall be independent of other ventilation systems.

- Air inlets for hazardous enclosed spaces shall be taken from areas which, in the absence of the considered inlet, would be non-hazardous. Air inlets for non-hazardous enclosed spaces shall be taken from non-hazardous areas at least 1.5 m from the boundaries of any hazardous area. Where the inlet duct passes through a more hazardous space, the duct shall have over-pressure relative to this space, unless mechanical integrity and gas-tightness of the duct will ensure that gases will not leak into it.

- Air outlets from non-hazardous spaces shall be located outside hazardous areas.

- Air outlets from hazardous enclosed spaces shall be located in an open area which, in the absence of the considered outlet, would be of the same or lesser hazard than the ventilated space.

- Ventilation ducts for spaces within the cargo area are not to be led through non-hazardous spaces.

- Non-hazardous enclosed spaces shall be arranged with ventilation of the overpressure type. Hazardous spaces shall have ventilation with under-pressure relative to the adjacent less hazardous spaces.

- Starters for fans for ventilation of gas-safe spaces within the cargo area shall be located outside this area or on open deck. If electric motors are installed in such spaces, the ventilation capacity shall be large enough to prevent the temperature limits from being exceeded, taking into account the heat generated by the electric motors.

- Wire mesh protection screens of not more than 13 mm square mesh shall be fitted in outside openings of ventilation ducts. For ducts where fans are installed, protection screens are also to be fitted inside of the fan to prevent the entrance of objects into the fan housing

- Spare parts for fans shall be carried onboard. Normally wear parts for one motor and one impeller is required for each type of fan serving spaces in the cargo area.

Fans serving hazardous spaces

- Electric fan motors shall not be installed in ventilation ducts for hazardous spaces unless the motor is certified for the same hazard zone as the space served.

- Fans shall be designed with the least possible risk for spark generation.

- Minimum safety clearances between the casing and rotating parts shall be such as to prevent any friction with each other. In no case is the radial air gap between the impeller and the casing to be less than 0.1 of the diameter of the impeller shaft in way of the bearing, but not less than 2 mm. It need not be more than 13 mm.

- The parts of the rotating body and of the casing shall be made of materials which are recognised as being spark proof, and they shall have antistatic properties. Furthermore, the installation on board of the ventilation units shall be such as to ensure the safe bonding to the hull of the units themselves. Resistance between any point on the surface of the unit and the hull, shall not be greater than 106 Ohm. The following combinations of materials and clearances used in way of the impeller and duct are considered to be none-sparking:

- impellers and/or housing of non-metallic material, due regard being paid to the elimination of static electricity

- impellers and housings of non-ferrous metals :

- impellers of aluminium alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non- ferrous materials is fitted in way of the impeller, due regard being paid to static electricity and corrosion between ring and housing

- impellers and housing of austenitic stainless steel

- any combination of ferrous (including austenitic stainless steel) impellers and housing with not less than 13 mm tip design clearance.

- Any combination of an aluminium or magnesium alloy fixed or rotating component, and a ferrous fixed or rotating

4.2.4 Chemical cargoes segregation and compatibility

Why segregation?

In the case of two or more liquid chemical cargoes which react with one another in a hazardous manner, segregation must be done The product data sheets, together with the BCH/IBC Codes are to be studies carefully to determine the compatibility restrictions when carrying different groups of cargoes.

Regarding slops reacting with each other in a hazardous manner, these must not be collected in the same slop tank nor transferred through the same pipes.

Compatibility with Water / Stowage of Heated Cargoes

Some chemical cargoes are not compatible and may even be reactive with water therefore, due consideration is necessary to avoid stowage of such cargoes adjacent to the water ballast tanks. It is also a requirement that the heating coils are to be blown through, cleaned and blanked off, or thermal oil used as a heating medium.

It is recommended that a cargo to be heated is not stowed adjacent to cargoes which have a low boiling point because the excess evaporation will result in consequent cargo loss and possible vapour hazards. As a safe margin, the maximum temperature of the heated cargo must be 10°C below the boiling point of the unheated cargo.

Heated cargoes must never be stowed adjacent to self-reactive cargoes since excess heating of self-reactive cargoes will shorten the life of the stabilising inhibitor in which the following items are shown must be given by the shipper, or the manufacturer of the cargoes.

- Name and amount of inhibitor added;
- Date inhibitor was added and the length of its effectiveness;
- The action to be taken should the length of the voyage exceed the effective lifetime of the inhibitor;

The Company and Charterers must be informed immediately if a product inhibitor certificate is not made available.

Compatibility with the Coatings of the Cargo Tanks

The suitability of the coating of tanks for loading various chemicals and products must be checked against the paint manufacturer's data sheets before cargoes are assigned to tanks. Also temperature limits imposed by the relevant coatings are not to be exceeded.

Epoxy coatings are capable of absorption of certain chemicals, which could later be released resulting in contamination of future cargoes and possible safety hazards. Similarly "metal pick-up" form recently applied zinc coatings could contaminate sensitive cargoes.

Edible Oils Compatibility

Toxic chemicals, as defined in the BCH/IBC Code, must not be carried as the last cargo immediately prior to edible oils or stowed in adjacent tanks sharing common bulkheads with tanks containing edible oils. Likewise, lengths of pipeline serving tanks containing such toxic products must never run through tanks containing edible oils and vice versa.

The FOSFA(Federation of Oils, Seeds and Fats Associations) International "Operation Procedure for Ocean Carriers of Oil and Fats for Edible and Oleao-Chemical Use" requires that the immediate previous cargo for the tanks, lines and pump system designated to load and fats must have been on the FOSFA International "List of Accepted Previous Cargoes or not on the FOSFA International "List of Banned Previous Cargoes" currently in force whichever is appropriate.

4.2.5 Cargo Inhibition

Procedure for carriage of inhibited flammable chemical products in cargo tanks

Why chemical inhibitor is required ?

In certain conditions of heat, pressure and in the presence of Oxygen, some chemical cargo types can become viscous and possibly solid and dense in nature.

This self reaction can cause some cargoes , especially in the presence of high temperatures and Oxygen, to begin an exothermic reaction, becoming self heating and rapidly expanding which may result in possibly disastrous consequences for the vessel.

As a precaution against this, a chemical inhibitor may be added to prevent the cargo from bonding with itself, however, one aspect of inhibitors is that they sometimes require Oxygen to activate them and this means that the tank cannot be inerted. When such a situation exists, the management Office must be contacted. See IBC code regarding carriage of inhibited flammable products in cargo tanks of more than 3000m3 and using inerting.

There are many inhibitor types, most of which are toxic and need to be handled with care. Usually the inhibitor is added by the Terminal personnel during the loading programme.

Fig. 4.2.5.A : Chemical tanker cargo pipelines

Shippers of inhibited cargoes must advise the vessel (and present an inhibitor certificate onboard prior to loading) of the quantity of inhibitor added, the hazards of the inhibitor, the time validity of the inhibitor, the temperature parameters within which the inhibitor will work and the emergency actions should these be exceeded. Masters are to check that the Inhibitor validity is sufficient for the voyage length.

The vapour of the cargo will not necessarily contain inhibitor as the two liquids will have differing evaporation properties. Therefore, it is possible for some solid polymer build-up to occur in the tank vents / screens, these must be verified as clear during voyage and prior to commencing discharge in order to prevent the possibility of damage from under pressure being created in the tanks during the discharge.

The temperature of inhibited cargoes must be checked and recorded daily in order to be able to note any abnormal rise that may indicate either inhibitor failure and/or polymerisation. Notice of any rise or excessive temperatures should be notified immediately to the Management Office with a request for the action to be taken.

Inhibited cargoes often need the presence of some oxygen in the tank atmosphere in order to permit the inhibitor to work properly. The minimum level of oxygen is usually stated on the inhibitor certificate but, as a general rule, a cargo containing an inhibitor that needs oxygen should not be carried in an inerted tank.

If nitrogen is bubbled through an inhibited cargo (such as when compressed nitrogen is used to clear the cargo hose after loading) the nitrogen will deplete the oxygen dissolved in the liquid, thereby requiring the inhibitor to take oxygen from the atmosphere. It is possible that excessive nitrogen used for blowing through might linger in the ullage space.

4.2.6 Importance of cargo compatibility

Guide to compatibility of chemicals

The Guide is based in part upon information provided to the Coast Guard by the National Academy of Sciences - U.S. Coast Guard Advisory Committee on Hazardous Materials and represents the latest information available to the Coast Guard on chemical compatibility.

The accidental mixing of one chemical cargo with another can in some cases be expected to result in a vigorous and hazardous chemical reaction. The generation of toxic gases, the heating, overflow, and rupture of cargo tanks, and fire and explosion are possible consequences of such reactions.

The purpose of the Compatibility Chart is to show chemical combinations believed to be dangerously reactive in the case of accidental mixing. It should be recognized, however, that the Chart provides a broad grouping of chemicals with an extensive variety of possible binary combinations. Although one group, generally speaking, can be considered dangerously reactive with another group where an “X” appears on the Chart, there may exist between the groups some combinations which would not dangerously react. The Chart should therefore not be used as an infallible guide. It is offered as an aid in the safe loading of bulk chemical cargoes, with the recommendation that proper safeguards be taken to avoid accidental mixing of binary mixtures for which an “X” appears on the Chart. Proper safeguards would include consideration of such factors as avoidance of the use of common cargo and vent lines and carriage in adjacent tanks having a common bulkhead.

The following procedure explains how the Guide should be used in determining compatibility information:

(1) Determine the reactivity group of a particular product by referring to the alphabetical list in Table 7.1.

(1) Enter the Chart with the reactivity group. Proceed across the page. An "X" indicates a reactivity group that forms an unsafe combination with the product in question.

For example, crotonaldehyde is listed in Table 7.1 as belonging in Group 19 (Aldehydes) and also has a notation, (2), which is explained in the footnotes to Table 7.1. The Compatibility Chart shows that chemicals in group 19 should be segregated from sulfuric and nitric acids, caustics, ammonia, and all types of amines (aliphatic, alkanol, and aromatic). Footnote (2), refers the user to Table 7.3 where exceptions to the Compatibility Chart are listed. Here, crotonaldehyde is listed as also being incompatible with Group 1, non-oxidizing acids.

It is recognized that there are wide variations in the reaction rates of individual chemicals within the broad groupings shown reactive by the Compatibility Chart. Some individual materials in one group will react violently with some of the materials in another group and cause great hazard; others will react slowly, or not at all. Accordingly, a useful addition to the Guide would be the identification of specific materials which might not follow the characteristic reactivities of the rest of the materials in its Group. A few such combinations are listed in Table 7.3; as other exceptions to the Chart become known, they will be listed in subsequent revisions of this manual.

FIGURE 1 – COMPATIBILITY CHART

[X indicates incompatible groups]

CARGO COMPATIBILITY	1. NON-OXIDIZING MINERAL ACIDS	2. SULFURIC ACID	3. NITRIC ACID	4. ORGANIC ACIDS	5. CAUSTICS	6. AMMONIA	7. ALIPHATIC AMINES	8. ALKANOLAMINES	9. AROMATIC AMINES	10. AMIDES	11. ORGANIC ANHYDRIDES	12. ISOCYANATES	13. VINYL ACETATE	14. ACRYLATES	15. SUBSTITUTED ALLYLS	16. ALKYLENE OXIDES	17. EPICHLOROHYDRINS	18. KETONES	19. ALDEHYDES	20. ALCOHOLS, GLYCOLS	21. PHENOLS, CRESOLS	22. CAPROLACTAM SOLUTION		
1. NON-OXIDIZING MINERAL ACIDS		X			X	X	X	X	X	X	X	X	X			X	X							1
2. SULFURIC ACID	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		2
3. NITRIC ACID		X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			3
4. ORGANIC ACIDS		X			X	X	X	X				X				X	X							4
5. CAUSTICS	X	X	X	X							X	X				X	X		X	X	X	X		5
6. AMMONIA	X	X	X	X						X	X	X	X			X	X		X					6
7. ALIPHATIC AMINES	X	X	X	X							X	X	X	X	X	X	X	X	X	X	X	X		7
8. ALKANOLAMINES	X	X	X	X							X	X	X	X	X	X	X		X					8
9. AROMATIC AMINES	X	X	X								X	X							X					9
10. AMIDES	X	X	X			X						X									X			10
11. ORGANIC ANHYDRIDES	X	X	X		X	X	X	X	X															11
12. ISOCYANATES	X	X	X	X	X	X	X	X	X	X										X		X		12
13. VINYL ACETATE	X	X	X			X	X	X																13
14. ACRYLATES		X	X				X	X																14
15. SUBSTITUTED ALLYLS		X	X				X	X																15
16. ALKYLENE OXIDES	X	X	X	X	X	X	X	X																16
17. EPICHLOROHYDRIN	X	X	X	X	X	X	X	X																17
18. KETONES		X	X				X																	18
19. ALDEHYDES		X	X		X	X	X	X	X															19
20. ALCOHOLS, GLYCOLS		X	X		X		X					X												20
21. PHENOLS, CRESOLS		X	X		X		X			X														21
22. CAPROLACTAM SOLUTION		X			X		X					X												22
30. OLEFINS		X	X																					30
31. PARAFFINS																								31
32. AROMATIC HYDROCARBONS			X																					32
33. MISCELLANEOUS HYDROCARBON MIXTURES			X																					33
34. ESTERS		X	X																					34
35. VINYL HALIDES			X																			X		35
36. HALOGENATED HYDROCARBONS																								36
37. NITRILES		X																						37
38. CARBON DISULFIDE							X	X																38
39. SULFOLANE																								39
40. GLYCOL ETHERS		X										X												40
41. ETHERS		X	X																					41
42. NITROCOMPOUNDS					X	X	X	X	X															42
43. MISCELLANEOUS WATER SOLUTIONS		X										X												43
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22		

4.2.7. Atmospheric Control

Preparing a cargo tank atmosphere

Ship checks prior to loading: For some cargoes the IBC Code requires vapour spaces within cargo tanks to have specially controlled atmospheres, principally when the cargo is either air reactive resulting in a hazardous situation, or has a low auto-ignition temperature, or has a wide flammability range.

The correct atmosphere in a tank, can be established either inerting to prevent the formation of flammable mixtures of cargo vapour and air, or padding to prevent chemical reaction between oxygen and the cargo. It may also be necessary to reduce the humidity (dewpoint) of the atmosphere within the cargo system.

The extent of atmosphere control to protect the quality of the cargo will normally be specified by the cargo shippers. Some cargoes are extremely sensitive to commercial contamination or discoloration, and for quality control reasons are carried under a blanket of nitrogen that is very pure and which must often be obtained from shore.

4.2.8 Gas Testing

Gas Detection Equipment

Gas detection equipment is required for ensuring spaces are safe for entry, work or other operations. Their uses include the detection of:

a) Cargo vapour in air, inert gas or the vapour of another cargo.

b) Concentrations of gas in or near the flammable range.

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

d) Toxic gases

Personnel must fully understand the purpose and limitations of vapour detection equipment, whether fixed or portable.

Maintenance records for all gas detection equipment onboard are to be maintained by the Chief Officer . Onboard calibration records and shore records are to be maintained together for each meter and are to be updated on each occasion that the instrument is tested or checked. The importance of careful calibration cannot be over emphasised as the gas detection or analysing equipment will only give accurate readings if calibration is carried out strictly in compliance with the manufacturer's instructions and using the correct calibration gases. Where calibration is carried out ashore or by shore technicians, a certificate is to be issued and retained onboard.

Instruments must always be checked, zeroed and spanned where applicable before every use as per the manufacturer's instructions.

Where calibration is required by the manufacturer's instructions to be carried out ashore or by shore technicians, this must be recorded within the vessel's PMS and all certification issued. In such circumstances at least one unit for each measurement function should remain onboard available for use at all times. Where calibration is carried out ashore or by shore technicians, a certificate is to be issued and retained onboard.

Any equipment not fully operational and/or in good condition, including perished hoses, leaking aspiration bulbs and out-of-date calibration gases or Draeger tubes should be withdrawn from service and reported to the management office.
Hoses used with portable gas instruments must be of sufficient length, appropriate to the full depth of the tank or space being tested. Long hoses must clearly marked at least every 5 meters so that the user can assess the level of the hose in the space.

Where the atmosphere testing equipment is not of a uniform manufacture with identical hose fittings, a suitable system is to be created to identify and match the correct hoses with the correct equipment. Hoses compatible with the equipment should be stowed in the same location as the equipment.

Oxygen Analysers

All ships are supplied with a portable oxygen analyser. This equipment is supplied for use in checking that spaces to be entered have been properly ventilated. It is also to be used on Tankers, Gas Ships and Chemical Carriers to check that the atmosphere of inerted tanks remains below 7%.

Two tests should be carried out on the instrument prior to use and a permanent record of readings kept on board.

(a) Zero Adjustment

This is done by using an oxygen-free gas, such as Nitrogen or Carbon Dioxide. Equipment is supplied for this test. Note that CO_2 is paramagnetic and therefore may not give a zero reading on certain instruments.

(b) Span Adjustment

This must be done in FRESH AIR and the instrument carefully checked that the reading has stabilized at 21% before the atmosphere of any space is tested.

The maker’s instructions for the particular instrument should be followed carefully to ensure that calibration procedures are correctly carried out. Calibration checks must be carried out every two months.

Explosimeter

The Explosimeter is the name normally associated with the instrument for measuring hydrocarbon gas in air at concentrations below the Lower Flammable Limit. Its full name is a Catalytic Filament Combustible Gas Indicator.

A full understanding of the construction and principle of an Explosimeter is essential for its safe and efficient use and it is essential that any person using this instrument carefully studies the operating manual. There is also a detailed explanation in the ISGOTT carried on tankers.

The Explosimeter measures from 0 to 100% of the Lower Explosive Limit (1.4% by volume). If the gas to air mixture is above the upper explosive limit (6% by volume) the meter reading will initially rise to give a reading of 100% or above, but will rapidly fall towards zero because the mixture of gas and air in the combustion chamber is too `rich' to sustain combustion.

The meter must therefore be constantly observed for this phenomenon, as an apparently safe reading may be obtained when the atmosphere is in fact highly dangerous.

Calibration checks must be carried out at two monthly intervals and when a filament has been changed in accordance with manufacturers’ instructions. Note that, in general, an explosimeter may be calibrated by different gases. It is essential that the correct gas is used otherwise an error may result. Explosimeters will not read hydrocarbon levels in an inert atmosphere.

Tankscope

Although similar to the Explosimeter, the `Tankscope' (or Non-Catalytic Heated Filament Gas Indicator) measures hydrocarbons in an inert atmosphere. It indicates their presence as a percentage proportion of the whole atmosphere. The instrument is especially useful during purging with inert gas. It will indicate when the proportion of hydrocarbons has fallen to a level whereby the atmosphere will remain below the Lower Explosive Limit (LEL) on the introduction of fresh air. Calibration checks must be carried out at two monthly intervals.

Toxic Gas Detectors

These detectors measure relatively low concentrations of toxic gases. Such gases may include Carbon Monoxide or Hydrogen Sulphide.

The type of instrument will normally require a special attachment or tube which the gas is aspirated through. It is necessary to know in advance what gas is expected in order to choose the correct detection tube. The readings are to be compared with the occupational exposure limits or threshold value limits. A minimum list of tube types required for specific vessels is included at the end of this section however additional tubes must be carried appropriate to the hazards identified within the MSDS for the cargo carried.

Combined Function Meters

There are certain instruments which have a combination of functions. Examples of some equipment which may be carried are:

1. Draeger Combiwarn: this instrument measures and monitors flammable vapours as a percentage of LEL in the range of 0 - 50% LEL. It also measures oxygen concentrations. This instrument can be preset to give audible and visual alarms at specific levels.

2. Digiflam 2000: this combines the functions of the Tankscope and an Oxygen meter, its main use being the monitoring of COW and Inert Gas operations.

3. Exotox 40: this is supplied specifically for the use in testing and monitoring the atmosphere of enclosed spaces. It combines the functions of an Oxygen monitor, and Explosimeter and a toxic gas monitor for either Carbon monoxide or Hydrogen sulphide. It provides continuous monitoring of all three functions and has visual and audible alarms.

As with all other instruments the manufacturer’s instructions regarding operation and calibration must be followed at all times.

Personal Monitoring Meters

Some instruments can be carried in a pocket such as a Personal Oxygen Meter, used for entry into enclosed spaces. Such instruments are intended only as a personal monitor and will give an audible and visual alarm if the Oxygen content falls below its preset level.

As monitors, they are not designed (and therefore not to be used) for testing the atmosphere for oxygen or other gases.

A vessel carrying H2S cargo must maintain sufficient supply of personal meters to ensure all persons working in the gas-zone are provided with detection equipment.

Zero and alarm checks are to be made before each use.

Sample Lines

The material and condition of sample lines can affect the accuracy of gas measurements. Sample tubing which is cracked or blocked or which has become contaminated with oil or other substances may seriously affect instrument readings.

The tubing must always be checked before and during use and if necessary be cleaned or replaced. It is also important to realise the length of tubing and compare to the meter manufacturer's instructions as to the number of aspirations per metre length. If this is not done there is a danger that the sample gas may not reach the meter sensor and therefore give a false reading.

4.2.9 Understanding of information on a Material Safety

Requirement of Material Safety Data Sheets (MSDS) for chemical cargoes carried at sea

MSDS are very important and useful sources of information relating to the chemical compound being shipped. A MSDS should be supplied by the manufacturer, supplier or shipper for each type of cargo before being loaded. If these are unavailable then the office must be advised for further instruction before loading the cargo and a Letter of Protest issued.

Fig. 4.2.9.A: MSDS

The MSDS for the products being carried must be displayed prominently onboard the vessel and all crew briefed in order that all crew members are familiar with the properties and handling of the cargoes onboard.

The data sheets comprise of different sections and the layout may differ slightly from supplier to supplier however the information contained within them is basically the same and can be summarised as follows:

1. Identification of Substance. This will include the trade name and manufacturer.
2. Composition and Formula.
3. Principal Hazards (e.g. toxic, carcinogenic etc)
4. First Aid Measures
5. Fire-fighting Measures
6. Accidental Release Measures
7. Handling and Storage
8. Exposure Controls and Personal Protection (this will include the likes

of threshold limit values and details of PPE)

9. Physical & Chemical Properties

10. Stability & Reactivity

11. Toxicological Information

12. Ecological Information

13. Disposal Considerations

14. Transport Information (e.g. UN numbers)

15. Further Information

It is extremely important that the MSDS is specific to the actual cargo product being loaded, and not a generic one, in order to establish all the cargo's components. Once received, it is to be read and fully understood as the health and safety of those working with the cargo and others is dependent on the safe handling and suitable precautions of the chemical in question.

Cargo control and measurement instruments onboard chemical tankers

In order to maintain a proper control of the tank atmosphere and to check the effectiveness of gas freeing, especially prior to tank entry, several different gas measuring instruments need to be available for use. Which one to use will depend upon the type of atmosphere being measured. Tank atmosphere sampling lines should be in all respects suitable for and impervious to the gases present, and should be resistant to the effects of hot wash water. Instruments themselves should be used in accordance with the manufacturers' instructions .

Much of the monitoring and measurement during cargo operations on chemical tankers remains reliant on human interpretation of information, and subsequent decisions are made on the basis of training and experience. Those factors will continue to be fundamental to safe carriage of chemicals by sea. Modern measurement instrumentation has achieved an improved flow of information at a consistent standard, and modern control technology permits exact management of operations.

However, in order to be able safely to take full advantage of the gains available, there is a need to understand the capability of the instruments and, equally, their limitations. The best source of detailed information about a particular system can be found in the manufacturer's advice, in particular regarding calibration or maintenance requirements.

It has been reported that on numerous occasion vessels have loaded chemical cargoes without appropriate Draeger tubes or Antidotes for the cargo. It is Master’s responsibility to procure these items as soon as the cargo is fixed . The appropriate tubes and antidote are to be procured before cargo is loaded on board. A wide range of instrumentation may be fitted on a modern chemical tanker. Only an outline is given here, providing guidance on the safe and efficient operation of the equipment.

5. SAFETY

5.1 Function and Proper use of gas - measuring instruments

List Of Instruments:

Oxygen Analysers

Explosimeter

Tankscope

Toxic Gas Detectors

Combined Function Meters

Personal Monitoring Meters

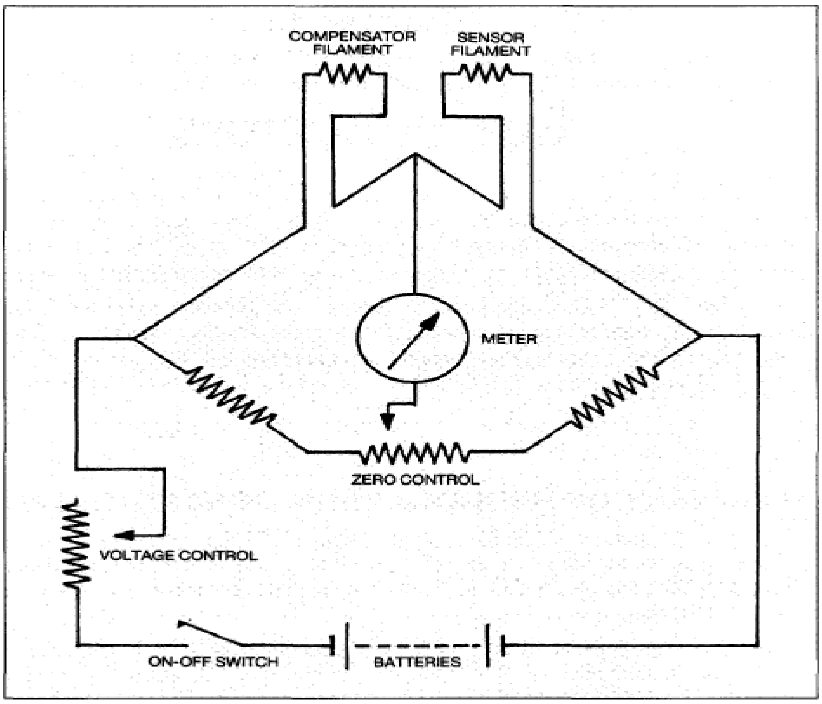


Fig. 5.1: A Circuit diagram of a Tankscope

5.2 Proper Use Of Safety Equipment And Protective Devices Including:

5.2.1 Breathing apparatus and tank evacuating equipment

Safety equipment and related considerations for modern chemical tankers

Ventilation requirement in cargo handling spaces - Chemical tanker procedure:

Spaces normally entered during cargo-handling operations - Cargo pump-rooms and other closed spaces which contain cargo-handling equipment and similar spaces in which work is performed on the cargo should be fitted with mechanical ventilation systems which should be capable of being controlled from outside such spaces. Provision should be made to ventilate such spaces prior to entering the compartment and operating the equipment.

Mechanical ventilation systems

(i) Mechanical ventilation inlets and outlets should be arranged to ensure sufficient air movement through this space to avoid the accumulation of toxic and/or flammable vapours (taking into account their vapour densities) and to ensure sufficient oxygen to provide a safe working environment, but in no case should the ventilation system have a capacity of less than 30 changes of air per hour, based upon the total volume of the space.

(ii) Ventilation systems should be permanent and should normally be of the extraction type. Extraction from above and below the floor plates should be possible. In rooms housing motors driving cargo pumps, the ventilation should be of the positive-pressure type.

(iii) Ventilation exhaust ducts from gas-dangerous spaces should discharge upwards in locations at least 10 m in the horizontal direction from ventilation intakes and openings to accommodation, service and controlstation spaces and other gas-safe spaces,

(iv) Ventilation intakes should be so arranged as to minimize the possibility of recycling hazardous vapours from any ventilation discharge opening.

(v) Ventilation ducts should not be led through engine-rooms, accommodation, working spaces or other similar spaces.

(vi) Ventilation fans should be approved by the Administration for operation in explosive atmospheres when flammable cargoes are carried aboard the ship.

Spaces not normally entered

Double bottom; cofferdams, duct keels, pipe tunnels, spaces containing cargo tanks and other spaces where cargo may accumulate should be capable of being ventilated to ensure sufficient air to avoid the accumulation of toxic and/ or flammable vapours and to ensure sufficient oxygen to provide a safe environment prior to entry. Where a permanent ventilation system is not provided for such spaces, approved portable means of mechanical ventilation should be provided.

It should also be borne in mind that in all cases the advice given may be subject to local or national regulations, and that terminal operators have their own safety procedures which could affect cargo handling operations and the measures to be adopted in emergencies. The master and all personnel must be aware of and comply with those regulations and procedures. Their existence will be highlighted by the use of the Ship/Shore Safety Checklist which, together with its guidelines for completion, remains a fundamental part of establishing safe conditions for transport by sea of chemicals in bulk.

Safety precautions Inert gas is practically non-toxic provided that combustion has been good, but of course after its use, there will be a lack of oxygen in cargo tanks. Oil vapor may also be present. Should it become necessary to enter a tank which has been inerted, the tank should be washed and gas-freed. After this, entry should not be permitted until a test of the tank atmosphere shows that there is adequate oxygen and that the concentrate of cargo vapor and carbon monoxide, if combustion has been imperfect, has been reduced to a non-toxic level. Before anyone enters such a tank the inert gas system should be checked to make sure that inert gas cannot accidentally be introduced into the tank while persons are inside.

5.2.2 Protective clothing and equipment

Tanker Safety Equipment and Protective Clothings

I. Breathing Apparatus

2. Compressed Air Breathing Apparatus (CABA)

3. Explosimeter

4. Oxygen Indicator

5. Combustible Gas Indicator

6. Special Gas Indicator (Toxic)

7. Rescue Equipment

a. Lifeline

b. Harness

c. Breathing Apparatus

d. Single sheave swivel blocks

8. Protective Clothings

a. Cover-all

b. Rubber boots .

c. Safety helmets

d. Safety goggles

e. Rubber gloves

f. Woolen bonnet

Fig. 5.2.2.A: A Protective Clothing

Main Personal Protective Equipment (PPE) Used Onboard Ship

Safety of self and co-workers is the prime priority kept in mind by a professional seafarer while working onboard ship. All shipping companies ensure that their crew follow personal safety procedures and rules for all the operation carried onboard ships.

To achieve utmost safety on board ship, the basic step is to make sure that everybody wears their personal protective equipments made for different types of jobs carried out on ship.

Following are the basic personal protective equipments (PPE) that are always present onboard a ship to ensure safety of the working crew:

1) Protective Clothing: Protective clothing is a coverall which protects the body of the crew member from hazardous substance like hot oil, water, welding spark etc. It is popularly known as “dangri “or “boiler suit”.

2) Helmet: The most important part of the human body is the head. It needs utmost protection which is provided by a hard plastic helmet on the ship. A chin strap is also provided with the helmet which keeps the helmet on place when there is a trip or fall.

3) Safety Shoes: Maximum of the internal space of the ship is utilized by cargo and machinery, which is made of hard metal and which make it clumsy for crew to walk around. Safety shoes ensure that nothing happens to the crew member’s feet while working or walking onboard.

4) Safety Hand gloves: Different types of hand gloves are provided onboard ship. All these are used in operations wherein it becomes imperative to protect ones hands. Some of the gloves provided are heat resistant gloves to work on hot surface, cotton gloves for normal operation, welding gloves, chemical gloves etc.

5) Goggles: Eyes are the most sensitive part of the human body and in daily operations on ship chances are very high for having an eye injury. Protective glass or goggles are used for eye protection, whereas welding goggles are used for welding operation which protects the eyes from high intensity spark.

6) Ear Muff/plug: Engine room of the ship produces 110-120 db of sound which is very high for human ears. Even few minutes of exposure can lead to head ache, irritation and sometimes partial or full hearing loss. An ear muff or ear plug is used on board ship which dampens the noise to a bearable decibel value.

7) Safety harness: Routine ship operation includes maintenance and painting of high and elevated surfaces which require crew members to reach areas that are not easily accessible. To avoid a fall from such heightened area, safety harness is used. Safety harness is donned by the operator at one end and tied at a strong point on the other end.

8) Face mask: Working on insulation surface, painting or carbon cleaning involves minor hazardous particles which are harmful for human body if inhaled directly. To avoid this, face mask are provided which acts as shield from hazardous particle.

9) Chemical suit: Use of chemicals onboard ship is very frequent and some chemicals are very dangerous when they come in direct contact with human skin. A chemical suit is worn to avoid such situations.

10) Welding shield: Welding is a very common operation onboard ship for structural repairs. A welder is provided with welding shield or mask which protects the eyes from coming in direct contact with ultraviolet rays of the spark of the weld.

Fig. 5.2.2.B: Welding Shield

5.2.3 Resuscitators

Failure to observe these precautions and the content of this manual may result in inefficient ventilation of the patient or damage to this device.

1. Warnings

- Keep away from smoke, open flames, oil and grease.
- Don't use the Resuscitator in a toxic or hazardous atmosphere.
- Never override the Pressure Relief Valve unless medical and professional assessment indicates the necessity;
- lung rupture may occur.

2. Cautions

Use of resuscitators by qualified medical and emergency personnel only trained in pulmonary ventilation and advanced cardiac life support techniques.

Control the effectiveness of ventilation by watching and observing the movements of the patient's chest while listening for expiratory flow from the patient valve.

Switch to mouth-to-mouth ventilation immediately if efficient ventilation cannot be obtained with the device. It should be in safe condition when using high oxygen concentration.

Most parts can be easily disassembled and replaced by the operator. Do not disassemble the Pressure Relief Valve and PEEP Valve (available as optional accessory) as they might be damaged. Always check all parts of the resuscitator and assemble them correctly before use.

3. Introduction

The Silicone Manual Resuscitators are for use as a device for artificial ventilation and cardiopulmonary resuscitation. They are used to ventilate apneic patients or used for spontaneously breathing patients to augment ventilation and/or oxygen delivery.

When connected to an oxygen supply source, the Silicone Manual Resuscitator delivers supplemental oxygen.

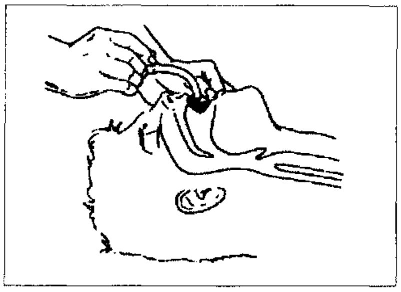
The oxygen concentration delivered by the resuscitator depends on the oxygen supply flow rate, tidal volume, ventilation frequency and operator technique.

The resuscitators are made of 1a polycarbonate and silicone material, they are latex-free.

The Silicone Manual Resuscitator is equipped with a Pressure Relief Valve which vents the excess air to atmosphere if the pressure exceeds 40 ± 5 mm H20. The Pressure Relief Valve may be overridden by the operator if a higher delivery of pressure is required.

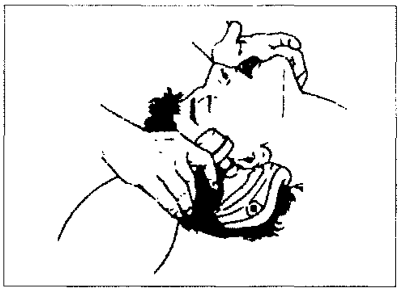
It is easy to disassemble and assemble all the parts of the resuscitator for cleaning and sterilizing.

4. Operating instructions



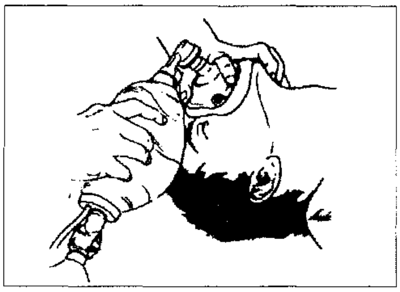
Step 1

Place victim on back.
Clean off foreign materials from patient's mouth and the airway.



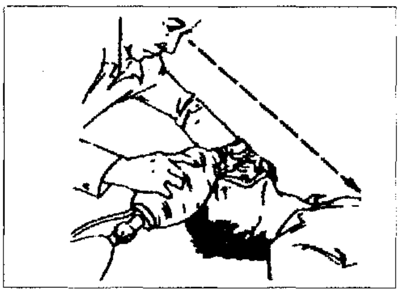
Step 2
Let the patient face upwards. Insert an oropharyngeal airway (if available) to open the patient's mouth to prevent the tongue from occluding patient's airway.

The operator stands behind the patient's head, extends the head backwards, pulls patient's chin upwards and lets the chin forward to the operator to open the airway.



Step 3
Apply the mask to the patient's mouth and nose and hold it tightly to achieve a tight seal.

Before using a resuscitator it is very important to thoroughly train the correct application of the face mask



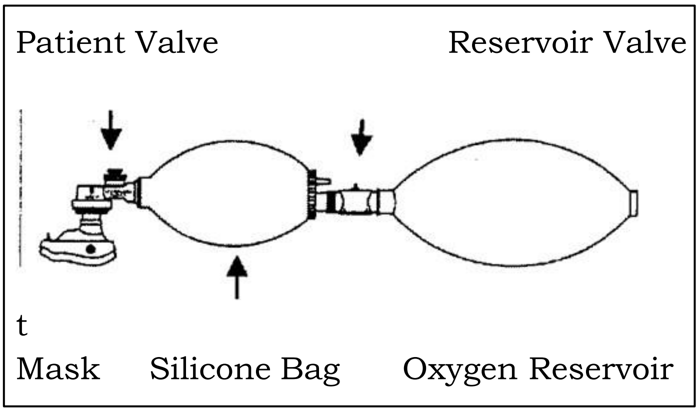
Step 4
Then squeeze the bag and release the bag abruptly.
Recommended ventilation frequency: Adult: 12- 15 BPM
Child: 14- 20 BPM

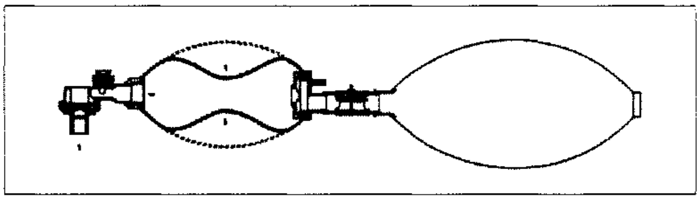
Correct ventilation frequency may vary which should be decided upon on-site
CPR professionals..

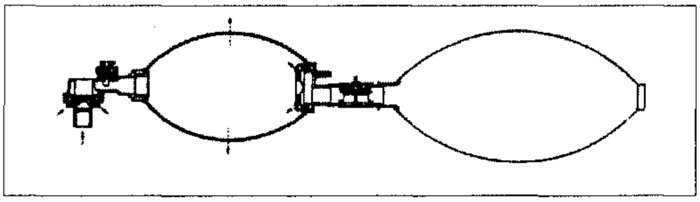
Check and make sure that the ventilation is properly functioning. Procedures as follows:

- Observe rises and falls of the patient's chest.
- Check the colour of patient's lips and face through the transparent part of the mask.
- Check the Patient Valve to determine if it is working properly through the transparent housing of the valve.
- Check if the interior of the mask is being fogged during expiration.
- Release the bag abruptly and listen to the expiratory flow from the Patient Valve.
- If the patient vomits during mask ventilation, clear the patient's airway and freely squeeze the bag for a few times to assure no obstruction before resuming ventilation.

5. Principles of Operation



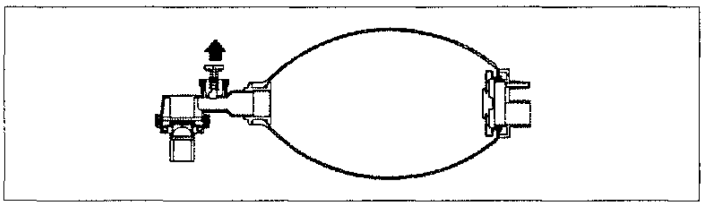


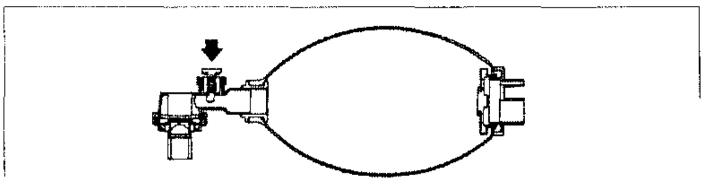


Inspiration
By squeezing the silicone bag air/gas is delivered to the patient through Patient Valve. Excess pressure is relea• sed through the Patient Valve.

Exhalation
Exhalation starts when the silicone bag is releasing. Exhaled air from patient is delivered out of the Patient Valve. Air/gas is refilling the silicone bag through Intake Valve and Reservoir Valve.

Pressure Relief Valve
The Silicone Manual Resuscitators are equipped with a Patient Valve which contains a Pressure Relief Valve that is set to be opened at 40 ± 5 mm H20.





In some cases the Pressure Relief Valve can be overrid• den to generate higher pressure. Please refer to para• graph 1 "Warnings".

- Turn and unlock the Pressure Relief Valve. Press and hold the button during ventilation to close the valve for temporary use.
- push the button down and turn to lock and override the Pressure Relief Valve.

- Turn and unlock the Pressure Relief Valve. Press and hold the button during ventilation to close the valve for temporary use.

- For permanent operating without pressure limiting, push the button down and turn to lock and override the Pressure Relief Valve.

6. Performance

Stroke volume

	INFANT	CHILD	ADULT
Measured volume of resuscitator (ml)	240	500	1600
Measured volume of reservoir bag (ml)	600	2600	2600
Stroke volume (ml)	175	360	900
Maximum stroke rate (BPM)	180 +	168	92

Oxygen supply with or without Oxygen Reservoir

Optimal oxygen concentration for certain ventilation is capable when supplying oxygen source. Connect Reservoir Valve and Oxygen Reservoir to the Resuscitator. Connect oxygen supply tubing (not supplied with the resuscitator) between the regulated gas source and the oxygen reservoir inlet. Adjust gas flow so that the reservoir expands completeley during the delivery of the breath and nearly collapses when the bag refills.

Oxygen concentration

	INFANT	CHILD	ADULT	ADULT	ADULT
02 flow (LPM)	4	10	3	5	10
Operating rate (BPM)	30	20	12	12	12
Tidal volume (ml)	40	250	500	500	500
without Reservoir(%)	85	70	34	47	70
with Reservoir(%)	100	100	68	85	100

Testing Condition: Compliance 0.02 l/cmH20

Resistance 20 cmH20

I:E ratio: 1:2

If supplemental oxygen is not to be used, remove the oxygen reservoir and reservoir valve.

Failure to do so will affect the refill rate and maximum frequency capabilities.

Oxygen supply with or without Oxygen Reservoir

Optimal oxygen concentration for certain ventilation is capable when supplying oxygen source. Connect Reservoir Valve and Oxygen Reservoir to the Resuscitator. Connect oxygen supply tubing (not supplied with the resuscitator) between the regulated gas source and the oxygen reservoir inlet. Adjust gas flow so that the reservoir expands completeley during the delivery of the breath and nearly collapses when the bag refills.

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Operating rate	30	20	12	12	12
Tidal volume (ml)	40	250	500	500	500
without	85	70	34	47	70
with	100	100	68	85	100

Testing Condition: Compliance 0.02 l/cmH20

Resistance 20 cmH20

I:E ratio: 1:2

If supplemental oxygen is not to be used, remove the oxygen reservoir and reservoir valve.

Failure to do so will affect the refill rate and maximum frequency capabilities.

7. Recommended Functional Test

The Silicone Manual Resuscitator should be tested when first using the new resuscitator

After cleaning and sterilizing

After any new parts have been fitted

Monthly, if the resuscitator is not frequently used.

Resuscitator

1. Connect a 1.5 to 2 liter breathing bag to the patient connector. Squeeze and release the resuscitator several times and check that the test bag fills. During continued ventilation expansion and relaxation of the test bag must be visible.

2. Squeeze the resuscitator and hold. In this way a positive pressure should be created, which remains in the test bag until the resuscitator is released.

3. Close the patient connector with one finger and compress the bag firmly to check tightness and proper valve fitting.

Oxygen reservoir bag attachment (if used)

1. Supply a gas flow of 3 liter/min. to the oxygen inlet. Close the outlet with one hand. The bag should now fill in approx. 20 seconds.

2. Close off the flow. Squeeze the bag and check that the gas is easily vented into the ambient air via the spill valve slots.

Pressure Relief Valve (pressure limitation if used)

1. Connect the patient connection port to a 0 - 100 mm H20 manometer.

2. Squeeze the bag to pass air through the pressure-limiting system (Pressure Relief Valve).

3. The pressure at the patient connection port shall not exceed 4.5 kPa (= 45 cm H20).

8. Cleaning, Disinfection and Sterilization

The Silicone Manual Resuscitator should be cleaned and sterilized:

• When first using the new Resuscitator between patients

Whenever the Resuscitator becomes contaminated every 24 hours of use with the same patient.

Carry out cleaning and sterilization as follows:

1. Disassemble the Resuscitator and Mask.

CAUTION: Do not disassemble the Pressure Relief Valve and PEEP Valve (optional accessory); these parts can be cleaned assembled. Damage on these parts may occur when disassembling.

CAUTION: Do not disassemble Oxygen Reservoir and it's connector; permanent damage and tearing may occur.

2. Wash all parts of the Resuscitator thoroughly in clean water using mild detergent. Make sure that the detergent is suitable to the material of the Resuscitator. Rinse all parts in clean water to remove remaining detergent and let the parts dry.

3. Sterilize the components using one of the following methods:

- boiling for 10 minutes (not Oxygen Reservoir)

- Autoclaving not to exceed 122 ^{0}C(not Oxygen Reservoir)

- ethylene oxide gas (all parts)

- liquid sterilization (all parts); please ensure that the disinfectant is suitable for the materials that have got to be sterilized and rinse thoroughly with water after sterilization.

1. Dry all components thoroughly after sterilization.

2. Inspect all components and replace if necessary.

3. Reassemble the Resuscitator.

4. Before use, test the Resuscitator as described in Recommended Functional Test.

Cleaning, Disinfection or Sterilization X =	Manual washing	Automatic dishwasher	Heating up and boiling for 10	Chemical disinfectan	
Bag	X	X	X	X	X
Patient Valve	X	X	X	X	X
Intake Valve	X	X	X	X	X
Masks	X	X	X	X	X
02-Reservoir	X			*X*	

5.2.4 rescue and escape equipment

EEBD

An Emergency Escape Breathing Device (EEBD) is an important life saving appliance which is used for escaping an area with hazardous conditions such as may be fire, smoke, poisonous gases etc. All cargo ships and passenger vessels must carry EEBD at different locations, complying with amendments of chapter -3 of Fire system safety code (FSSC). It is important to understand the construction and working of EEBD before buying one.

Fig. 5.2.4.A: Stretcher

Stretcher

The last thing any mariner would want to get involved in is an accident on ship, keeping in mind lack of proper medical facilities present onboard. But still accidents are prone to happen as ship is a complicated floating structure with several machineries, moving equipment's, and compact spaces.

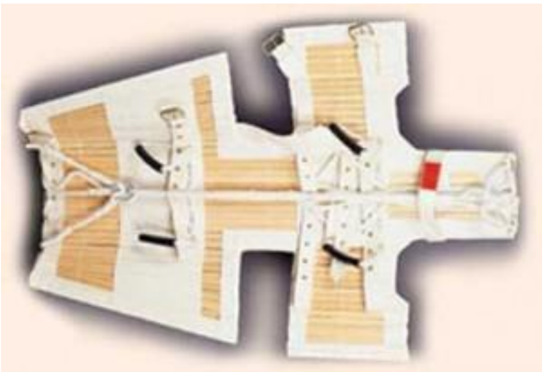


Fig. 5.2.4.B: Stretcher

If an accident occurs on a ship, the life of the person greatly depends on the time taken to remove the person from the site of accident and transfer him to the ship's hospital room, where the first aid and other medical procedures can be carried out. There are several medical equipment's available on board and the Neil Robertson stretcher is the most commonly used one on board ships.

Neil Roberts on Stretcher

The Neil Robertson stretcher is designed for removing an injured person from spaces wherein access, doors, or hatches are too small to permit the use of regular stretchers. Spaces such as engine-room spaces, Cargo holds, Pump rooms, Boiler room etc. are few examples of such compact spaces on ship.

The Neil Robertson stretcher is made of flexible semi rigid canvas and can be folded easily when not in use or during accessing small spaces.

The stretcher is provided with strong straps which when firmly wrapped around the victim, give strong support to hold the person with almost negligible movement with respect to stretcher, which is very important when rescuing or transferring injured person.

The stretcher straps are such made that when tied up over the victim, it covers the person in mummy-fashion, giving sufficient support.

Self-Contained Breathing Apparatus (SCBA)

A self-contained breathing apparatus is used when extremely toxic chemicals are present, in an oxygen-deficient atmosphere, or when the contaminant or concentration is not known. SCBA's are also typically used in emergency situations.

SCBA's consist of a bottle (tank or cylinder), carrying assembly, gauge, safety valve, and a full face piece. The bottle is equipped with an alarm to warn the wearer when air in the tank is getting low (about 25% of the tank air remains). Some SCBA's operate in an open-circuit mode; that is, the exhaled air is vented to the atmosphere and not rebreathed. Other SCBA's operate in a closed-circuit mode where exhaled air is filtered before it is rebreathed.

SCBA's differ by manufacturer and type. You must be trained in the manufacturer's instructions and inspection procedures before using any SCBA Also, only a certified person may conduct technical repair operations on the unit.

Fig. 5.2.4.C: Entering enclosed space with SCBA

Shock-Absorbing Full Body Harness

The inclusion of shock-absorbing systems has now been part of fall protection for over 20 years. As their name suggests, they are designed to absorb energy that is created as the body falls towards the ground under that almighty force - gravity. The 'shock' of the fall is reduced with an energy-dissipating system that starts to take up energy applied to it over 200 kg of force. Under the Australia/New Zealand design standard AS/NZS1891.1, this must not allow the body to receive a force exceeding 6 kN (kilo Newtons - a measure of force named after the famous scientist Sir Isaac Newton).

Fig. 5.2.4.D: Shock-Absorbing Full Body Harness

5.3. Basic knowledge of safe working practices and procedures in accordance with legislation and industry guidelines relevant to oil and chemical tankers

5.3.1 Precautions to be taken when entering enclosed spaces

A ship is a complex structure from inside with several small and enclosed spaces. Many of these enclosed spaces are used for installing some machinery or for storing machine parts or workshop equipments. A ship has a matrix of pipelines which runs through each of its parts, including enclosed spaces.

But that is not the point of discussion here. An enclosed place can be used for several reasons; however, the main issue arises when one has to enter these enclosed places in order to do some repairing work or for cleaning purposes.

Because of zero ventilation, these enclosed places generate and store toxic gases which are either produced from chemicals stored in the place or leakage from pipelines. If a person enters such place without taking precaution, he or she may suffer unconsciousness and sometimes even death.

In order to prevent such unfortunate circumstances there is a proper procedure that needs to be followed for safety and wellness of the person entering the enclosed space.

Procedure for Entering an Enclosed Space

The following are the points that need to be followed before entering an enclosed space:

- Risk assessment to be carried out by a competent officer as enclosed or confined space entry is deficient in oxygen, making it a potential life hazard.
- A list of work to be done should be made for the ease of assessment for e.g. if welding to be carried out or some pipe replacement etc. This helps in carrying out the work quickly and easily.
- Risk assessment also needs to be carried out. Risk assessment includes what work to be done, rescue operation etc.
- Potential hazards are to be identified such as presence of toxic gases.
- Opening and securing has to be done and precaution should be taken to check if the opening of enclosed space is pressurized or not.

- All fire hazard possibilities should be minimized if hot work is to be carried out. This can be done by emptying the fuel tank or chemical tank nearby the hot work place.
- The confined space has to be well ventilated before entering.
- The space has to be checked for oxygen content and other gas content with the help of oxygen analyzer and gas detector.
- The oxygen content should read 20% by volume. Percentage less than that is not acceptable and more time for ventilation should be given in such circumstances.
- Enough lighting and illumination should be present in the enclosed space before entering.
- A proper permit to work has to be filled out and checklist to be checked so as to prevent any accident which can endanger life.
- Permit to work is to be valid only for a certain time period. If time period expires then again new permit is to be issued and checklist is to be filled out.
- Permit to work has to be checked and permitted by the Master of the ship in order to work in confined space.
- Proper signs and Men at work sign boards should be provided at required places so that person should not start any equipment, machinery or any operation in the confined space endangering life of the people working.
- Duty officer has to be informed before entering the enclosed space.
- The checklist has to be signed by the person involved in entry and also by a competent officer.
- One person always has to be kept standby to communicate with the person inside the space.
- The person may also carry a life line with him inside.
- The person should carry oxygen analyzer with him inside the enclosed space and it should be on all the time to monitor the oxygen content. As soon as level drops, the analyzer should sound alarm and the space should be evacuated quickly without any delay.
- No source of ignition has to be taken inside unless the Master or competent officer is satisfied.

• The number of persons entering should be constrained to the adequate number of persons who are actually needed inside for work.

• The rescue and resuscitation equipment are to be present outside the confined space. Rescue equipment includes breathing air apparatus and spare charge bottles.

• Means of hoisting an incapacitated person should be available.

• After finishing the work and when the person is out of the enclosed space, the after work checklist has to be filled.

• The permit to work has to be closed after this

The above mentioned procedure is extremely important to entering an enclosed space. These points are imperative to risk any crew member's life while entering a confined space.

Cargo tanks and other enclosed spaces entry precautions onboard chemical tankers

Entry into an enclosed space that is not in normal daily use, great care should be taken to create and maintain safe working conditions, even if the duration of the work is to be short. Many fatalities in enclosed spaces have resulted from entering such spaces without proper supervision or adherence to agreed procedures. In almost every case the fatality would have been avoided if the simple guidance in this section had been followed.

The rapid rescue of personnel who have collapsed in an enclosed space presents particular risk. It is a human reaction to go to the aid of a colleague in difficulties, but far too many additional deaths have occurred from impulsive or ill-prepared rescue attempts.

The normal oxygen level in fresh air is 21% by volume . Uncontaminated air with a slightly lower oxygen concentration can be breathed for some minutes before the effects become apparent. If the oxygen supply to the brain is depleted, victims will feel dizzy and have headaches before losing consciousness. This is particularly dangerous because they may not recognise that they are in danger or be capable of finding the way out of the space. They therefore become a risk to themselves and others. There is a danger of permanent brain damage after only four minutes in a very oxygen-deficient space. A successful rescue depends upon the victim being resuscitated in the shortest possible time.

Ensuring a safe atmosphere

When an enclosed space is left closed and unventilated for any length of time, the internal atmosphere may become unsafe to human life, either because it contains insufficient oxygen, or because it contains contaminants, or both. The oxygen content can be reduced naturally by the process of rusting or other oxidising, which absorbs oxygen from the air, or by the presence of inert gas. Contamination can come from sources such as stores. Decomposition of animal and vegetable oils and fats, a process known as putrefaction (or going off), can seriously deplete the oxygen content and evolve toxic gases, making proper ventilation of the space necessary prior to entry.

However, it is possible that an oxygen deficiency is due to the air in the space being mixed with a contaminant such as cargo vapour. Cargo vapour or inert gas should always be anticipated in cargo tanks, and leakage into adjacent enclosed spaces separated from cargo tanks by a single gas-tight bulkhead should be suspected. Similarly, cargo vapour or inert gas should be suspected in any space containing cargo handling or inert gas equipment.

It is therefore vital that nobody ever enters an enclosed space without breathing apparatus until it has been confirmed that the atmosphere is safe and will remain so. As a general rule, enclosed spaces should not be entered unless it is absolutely necessary. Suitable notices should be prominently displayed to warn and inform personnel about the dangers of entering enclosed spaces. Instructions should clearly explain the precautions to be taken when entering tanks or other enclosed spaces, and listing any restrictions placed upon the permitted work. Company procedures should be such that the instructions are followed.

On some ships, there is no door or hatch restricting passage from a pump-room into a duct keel. In these circumstances, the duct keel can be regarded as being ventilated by the pump-room extractor fans. Nevertheless, entry of personnel into the duct keel should be subject to a strict safety procedure involving prior notification to a responsible person.

Preparations prior allowing personnel into enclosed spaces

Prior to allowing personnel to enter an enclosed space, an entry permit should be issued. It is recommended that it should be signed by the master or a responsible officer expressly delegated by him.

The entry permit should contain a clear indication as to its maximum period of validity (which should not exceed a normal working day), and the maximum time the space can be left unattended (which should not exceed four hours). It is critical to ensure that while personnel are within a space the levels of oxygen and any contaminants are frequently checked, and are within safe limits. If there is any doubt, suitable breathing apparatus and personal protective equipment should be worn, including a lifeline if practicable.

The responsible officer should confirm that:

• The space has been thoroughly ventilated by natural or mechanical means to remove any toxic or flammable gases, and to-ensure an adequate level of oxygen throughout the space.

• All personnel entering the space are properly trained in enclosed space entry procedures, and are familiar with safety and emergency procedures; they should be aware of the ship's procedure for issuing an enclosed space entry permit.

• A trained crew member is standing by at the entrance.

• A reliable system of communication has been established and is understood both by those entering the space and by the crew member standing by at the entrance.

• The appropriate officer of the watch on the bridge or in the cargo control room or in the engine room is aware of the enclosed-space entry operations.

• Rescue procedures are in place.

• Rescue equipment (including lifelines and harnesses) and breathing apparatus are readily available, and resuscitation equipment is prepared.

The rescue procedures should clearly set out how to raise the alarm and summon assistance. Access to the space concerned, deployment of reserve equipment and communication between the emergency party and command centre should also be arranged.

In the event of emergency, under no circumstances should an attending crew member enter the space before help has arrived and the situation has been evaluated, to ensure the safety of those carrying out rescue operations.

How to test the environment prior entry ?

Before the space is entered it should be thoroughly ventilated. The time necessary to ensure thorough ventilation depends upon the size of the space, the capacity of the system used, the level of contamination and the efficiency of the ventilation system. Once the space has been ventilated, the atmosphere should be checked as follows:

• The oxygen content should be sampled with a suitable and reliable detector: 21% oxygen is required for entry. The principle of measuring the oxygen level in an enclosed space, and interpretation of the figure obtained, must be thoroughly understood. The content of the world's air is constant at 21% life-sustaining oxygen, and 79% other gases which are breathable but do not themselves sustain life. Therefore, confirming that the oxygen level in a compartment is 21% ensures that there is no major component of the atmosphere that is not air. Nevertheless, this may not exclude trace volumes of toxic vapours.

• If a flammable cargo vapour may be present, a combustible gas indicator should also be used. A content as low as practicable, but never more than 1% LFL, is required for entry.

• If a toxic gas may be present, the correct toxic gas detector should be used to check that the level is below the safe operational exposure limit, depending on the nature of the previous contents of the space.

Ventilation should be stopped about 10 minutes before tests are made and not restarted until the tests are completed. Sampling the atmosphere may require the use of breathing apparatus. A number of samples from different locations may have to be taken before the air in the whole space can be judged safe. Readings should be taken at several levels - top, middle and bottom. Suspected vapours which have a relative vapour density greater than that of air will be found at the bottom of any space, and those that have a relative vapour density less than that of air will be found at the top of a space. Vapour will also tend to remain where the ventilating airflow is least effective.

Sampling and measurement should be done by personnel trained in use of the equipment, and sufficiently knowledgeable to understand the results obtained. It is vital that the correct instruments are used. A combustible gas indicator will not measure an oxygen deficiency, nor indicate the presence of toxic gas or the presence of flammable vapour in inert gas. All atmosphere testing equipment used should be of an approved type. It must be correctly maintained, prepared for use in accordance with the manufacturer's guidance, and regularly check-tested against standard samples.

Even after a space has been made gas free and found to contain a respirable atmosphere, local pockets of gas should always be suspected. Cargo residues may be trapped in tank coatings or in residual scale. Generation of vapour should always be considered possible, even after loose scale has been removed. Hence a person moving around to different areas of a tank or compartment, or descending to the lower part after work in the upper part, should remain alert to the possible need for further tests to be made.

Prior entering in a contaminated cargo tank

Unless all necessary safety precautions can be followed, spaces should only be entered by personnel wearing breathing apparatus, appropriate protection against exposure to flammable, toxic or corrosive cargo vapours and, if practicable, a lifeline. In chemical tankers, operational entry into cargo tanks may be required before the atmosphere is certified as safe. A documented system should exist to ensure safety throughout any operation when entry of a contaminated cargo tank, or one suspected of being contaminated, is necessary.

5.3.2 Precautions to be taken before and during maintenance in gas dangerous areas

Hot work

No hot work must be undertaken inside a compartment until it has been cleaned and ventilated. Tests of the atmosphere in the compartment should indicate 21% oxygen content by volume, flammable vapour as low as possible but not more than 1% LFL, and that the compartment is free from toxic gases. It is important to continue ventilation during hot work.

No hot work should be undertaken on the open deck unless the area is free from flammable vapour and all compartments (including deck tanks) within a specified radius around the working area have been washed and freed of flammable vapour and/or inerted. Company or national regulations may give guidance on this distance. If no guidance is available, then the advice in ISGOTT should be taken into account.

All sludge, cargo-impregnated scale, sediment or other material likely to give off flammable or toxic vapour, especially when heated, should be removed from an area of at least 10 metres around all hot work. All combustible material such as insulation should either be removed or protected from heat.

Adjacent compartments should either be cleaned and gas freed to hot work standard, or freed of cargo vapour to not more than 1% LFL and kept inerted, or completely filled with water. No hot work should be undertaken in a compartment beneath a deck tank in use.

Care should be taken to ensure that no release of flammable vapour or liquid can occur from non-adjacent compartments that are not gas free.

An adjacent fuel oil bunker tank may be considered safe if tests using a combustible gas indicator give a reading of not more than 1% LFL in the ullage space of the bunker tank, and no heat transfer through the bulkhead of the bunker tank will be caused by the hot work. No hot work should be carried out on bulkheads of bunker tanks that are in use.

All pipelines interconnecting with cargo spaces should be flushed, drained, vented and isolated from the compartment or deck area where hot work will take place.

Hot work on pipelines and valves should only be permitted when the item needing repair has been isolated from the system by cold work, and the remaining system blanked off. The item to be worked on should be cleaned and gas freed to a standard that is safe for hot work, regardless of whether or not it is removed from the hazardous cargo area.

All other operations utilising the cargo or ballast system should be stopped before hot work is undertaken, and throughout the duration of the hot work. If hot work is interrupted for any reason for an extended period, hot work should not be resumed until all precautions have been rechecked and a new hot work permit has been issued.

5.3.3 Safety measures for hot and cold work

Safe Work Permits

Certain safeguards that normally protect the worker may have to be removed when repair or maintenance work is performed. When this occurs, the hazards involved need to be identified and a safe work system developed to eliminate or control these hazards A safe work permit is document that identifies the work to be done, the hazard(s) involved, and the precautions to be taken. It ensures that all hazards and precautions have been considered before work begins. Safe work permits should always be used when work is performed by an outside agency or employer.

What is a safe work permit?

A safe work permit is a written record that authorizes specific work, at a specific work location, for a specific time period. Permits are used for controlling and co-ordinating work to establish and maintain safe working conditions. They ensure that all foreseeable hazards have been considered and that the appropriate precautions are defined and carried out in the correct sequence. The permit is an agreement between the issuer and the receiver that documents the conditions, preparations, precautions, and limitations that need to be clearly understood before work begins.

5.3.4 Electrical Safety Precautions

1. Provide protective clothing, personal protective equipment, and other protective equipment needed to protect employees from potential arc flash and shock hazards identified in the analysis.

2. Provide training to create qualified employees capable of understanding the purpose/function of the electrical heat tracing, its electrical power supply/control equipment, and how to recognize and avoid the hazards associated with its operation and maintenance.

3. Treat all electrical conductors and circuit parts as though they are energized until they are placed in an electrically safe work condition by doing the following:

• Identify the circuit or equipment to be de-energized and all possible sources of electrical energy supplies to the specific circuit or equipment.

• Interrupt the load currents appropriately, and then open the circuit disconnecting device(s).

• Visually verify, where possible, that the appropriated circuit disconnecting device is indeed open.

• Apply lockout/tagout devices according to a documented and established procedure.

• Test for absence of voltage with an approved voltmeter (where the voltmeter is tested on a known circuit voltage prior to and immediately following application).

• Ground the phase conductors or circuit parts before touching them where the possibility of induced voltages or stored electrical energy exists.

• Apply ground-connecting devices rated for the available fault duty where the conductors or circuit parts being de-energized could possible contact other exposed energized conductors or circuit parts.

Ensure insulation mats are provided at all the switch board and junction boxes.

Ensure the workers use certified high voltage gloves.

5.4 Basic knowledge of First Aid with reference to a Material Safety Data Sheet (MSDS)

The Material Safety Data Sheets (MSDSs)

The material safety data sheet or "MSDS" is an important source of information for the worker at the worksite. It is one of the three basic elements of the WHMIS(Workplace Hazardous Materials Information System) right-to-know-system.

The MSDS includes the following: relevant technical information on the substance; a list of its hazardous ingredients, (*if it's a mixture*); chemical hazard data, control measures such as proper engineering controls and personal protective equipment; instructions in accident prevention while using the substance, specific handling, storage and disposal procedures; and emergency procedures to follow in the event of an accident.

The information provided is expected to be comprehensive and must include what can reasonably be expected to be known about the material and the hazards it may present. MSDS's from different companies may not look the same but they should contain the same basic information.

The following pages include the various sections of a MSDS for acetone as well as explanation of the corresponding relevant technical information. The order in which sections appear on a MSDS may vary from one supplier to another, but the content of each section is specified by the legislation.

Each section of a MSDS must be filled in, even if it only states: "not determined" or "not applicable".

- Section 1 - Material Indentification
- Section 2 - Hazardous Ingredients
- Section 3 - Physical Data
- Section 4 - Fire and Explosion Data
- Section 5 - Reactivity Data
- Section 6 - Health Hazard Data
- Section 7 - First Aid Measures
- Section 8 - Preventative Measures
- Section 9 - Storage and Handling

- Section 10 - Spill Clean-up and Waste Disposal
- Preparation Date

First Aid Measures

The First Aid Measures section describes actions to be taken immediately in case you are accidentally exposed to the material. The purpose of first aid is to minimize injury and future disability. In serious cases, first aid may be necessary to keep the victim alive.

First aid information needs to be known before you start working with the material. There is no time to find and read the MSDS during an emergency. First aid procedures should be periodically reviewed, especially by employees trained to give first aid. All employees should know the location of the facilities and equipment for providing first aid; for example, the eyewash fountains, safety showers and first aid kits.

When medical treatment is necessary, send the MSDS, if it is readily available, to the emergency facility with the victim. If the MSDS is not available, you should send the material's label or a labelled container of the material, if it is small enough. Emergency medical responders need to know what the material is and what First Aid Measures have been recommended and used. Occasionally, the MSDS has additional instructions (or a Note to Physician) which may be useful to the emergency doctor.

6. FIRE SAFETY AND FIRE FIGHTING OPERATIONS

6.1 Oil and chemical tanker fire response organization and action to be taken

On any vessel, especially Oil and Chemical Tankers, emergencies may have catastrophic consequences, unless proper action is taken. Actions therefore, must be prompt, timely and adequate. Any fire drills carried out with shore establishments shall be taken positively and the Master must take full advantage of this situation to learn from the exercise, a de-briefing of the crew must be carried out and lessons learnt from such drills pointed out.

Fig 6.1.A: Fire Safety- Fire drill on a ship

General Guidelines for Emergency Response

All members of the technical staff must know all the ship emergency codes in detail. All members of the crew should receive appropriate training in accordance with their role at the time of emergency. On board passengers must be told about the possible dangers because otherwise the general public starts panicking.

An understanding of the effects on the behavior of the ship of wind, current, shallow water, banks, and narrow channels is equally important so that the technical staff does the wise thing at the time of emergency. Closing of the watertight doors, fire doors, valves, scuppers, side-scuttles, skylights, portholes, and other similar openings in the ship is very important so that ocean water does not enter inside the ship.

In case of abandoning the ship, all the passengers must be rescued first using life jackets and life boats, or shifting them to another ship. The staff members should be the last ones to leave the ship and that even only after ensuring that no one is left on the abandoned ship. Modern ships are equipped with hi-tech and advanced life saving tools and with the help of mobile communication devices, or can easily contact off-shore rescue teams.

Structure and Function of Emergency Response Teams

The basic structure of any emergency team will usually comprise four sub-groups.

- The Command Center
- The Emergency Team
- The Back Up Squad
- The Technical Team

Different sub-groups will do different tasks and coordinate with the other sub-groups.

Functions of Emergency Team groups:

- **The Command Center**

The command center will be located on bridge. The master is to take responsibility for the overall safety and navigation of the ship. All communications will be performed from here to the different teams as well as shore. A log must be maintained of all events.

- **The Emergency Team**

The Emergency Team will have the front line job of tackling the emergency. In general the chief officer will lead the team for the emergency on deck while the 2nd engineer will take charge for engine room emergencies. The duties of each person will have to be laid down and practiced for every emergency so as to avoid duplication, confusion, and chaos.

- **The Support Team**

The Support Team is to provide first aid and prepare the lifeboats for lowering. Should the above two function not be required, they should assist as directed.

- **The Technical Team**

The Technical, or Engineer's, Team will maintain the propulsion and maneuvering capability of the ship and auxiliary services as far as is possible in the circumstances.

6.2 Fire hazards associated with cargo handling and transportation of hazardous and noxious liquids in bulk

Fire hazards associated with cargo handling and transportation of hazardous and noxious liquids in bulk

The fire hazards associated with Noxious Liquid substances (NLS) are: - Some cargoes give out oxygen when on fire, thereby supporting the fire.

- Some chemical fires, the source of ignition may be heat from a reaction within the cargo itself or through mixing with other chemicals.

- Chemicals miscible in fire will render normal foam useless. For such chemicals alcohol resistant or dual-purpose foam shall be used.

- Some chemicals are miscible in water and hence their presence may not be recognized.

Some chemicals are heavier than water and insoluble in water. These may be smothered using water.

- Some chemicals evolve large volumes of toxic vapours when heated.

- Some chemicals have a low auto-ignition temperature. There is a risk of re-ignition of these chemicals

6.3 Firefighting agents used to extinguish oil and chemical fires

Commonly used firefighting agents are:

- Water is the most common cooling agent. This is largely because water possesses very good heat absorbing qualities and is available in ample quantities at terminals and on ships. However, it is not suited for direct extinguishing of an oil/chemical fire.

- Foam is an aggregation of small bubbles, of lower specific gravity than oil or water, which flows across the surface of a burning liquid and forms a coherent smothering blanket. It will also reduce the surface temperature of the liquid by the absorption of some heat.

- Carbon dioxide is an excellent smothering agent for extinguishing fires, when used in conditions where it will not be widely diffused. Carbon dioxide is therefore effective in enclosed areas such as machinery spaces, pump rooms and electrical switch rooms where it can penetrate into places that cannot be reached by other means.

- Dry chemical powder is discharged from an extinguisher or from a fixed installation as a free flowing cloud. It is most effective in dealing with a fire resulting from an oil spill on a jetty or on the deck of a chemical tanker and can also be used in confined spaces. It is especially useful on burning liquids escaping from leaking pipelines and joints

- Alcohol-resistant foam extinguishing agents possess low-expansion properties and are adaptable to various low expansion foam generators. Alcohol-resistant foam extinguishing agents may be used in chemical tankers where water-soluble flammable liquids such as alcohol, ester, ether, aldehyde, ketone, and organic acids.

6.4 Firefighting agents used to extinguish chemical fires and its compatibility with chemical cargoes

The firefighting agents used to extinguish chemical fires must be compatible with the chemical cargoes , in that it must not react with the cargoes to form hazardous vapours and reactants. The foam used should also be of AR-AFFF foam (Alcohol-Resistant Aqueous Film Forming Foam).

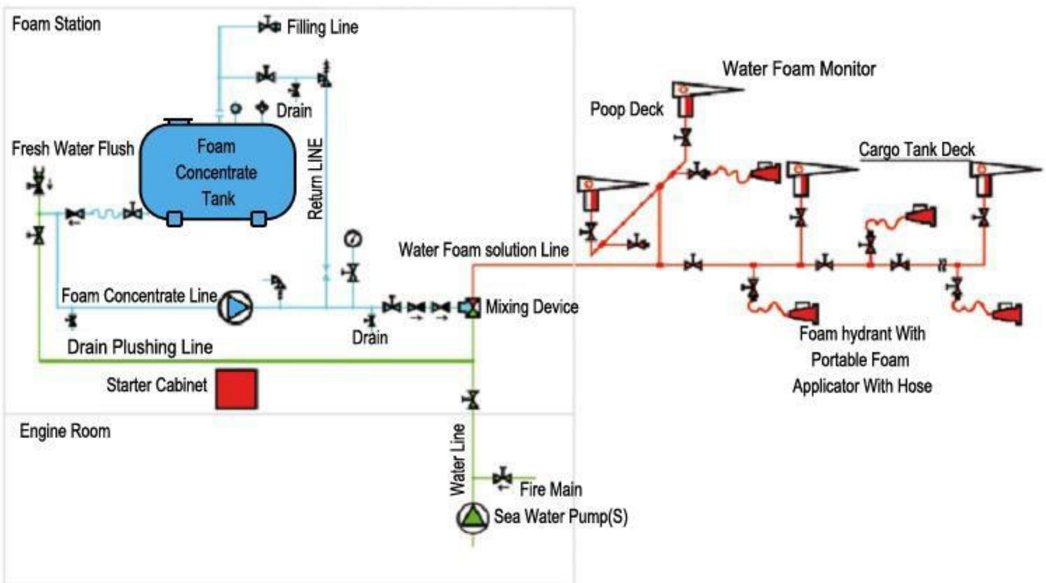
Alcohol Resistant-Aqueous Film Forming Foam (AR-AFFF) : Alcohol-resistant foam extinguishing agents may be used in chemical tankers where water soluble flammable liquids for example alcohol, ester, ether, aldehyde, ketone, and organic acids are carried as cargo.

Chemical Foam

Chemical foam is formed by mixing together a solution of an alkali (usually sodium bicarbonate), an acid (usually aluminum sulfate), water and a stabilizer. The stabilizer is added to make the foam tenacious and long-lived. When these chemicals react, they form a foam or froth of bubbles filled with carbon dioxide gas. The carbon dioxide in the bubbles has little or no extinguishing value. Its only purpose is to inflate the bubbles. From 7 to 16 volumes of foam are produced for each volume of water. Premixed foam powders may also be stored in cans and introduced into the water during firefighting operations. For this, a device called a foam hopper is used. Or, the two chemicals may be premixed with water to form an aluminum sulfate solution and a sodium bicarbonate solution.

6.5 fixed fire fighting foam operations

The layout of fixed foam installation All foam systems consist of a water supply, foam liquid storage, a proportioning device and a distribution system. The water supply pump(s) provide(s) a certain capacity of seawater to the deck foam system, and is/are supplied by the ship's fire pumps. The foam liquid is stored in a tank. The tank must be complete with vent, contents gauge, and access manhole. The foam is delivered via a high pressure foam liquid pump to the automatic foam liquid proportionator, which will accurately proportionate foam liquid at 3% to 6% to the seawater flow, irrespective of flow rate or pressure. For satisfactory operation of the proportionator, foam liquid must be supplied with a minimum pressure of at least 10 meters head higher than the inlet water pressure under all load conditions. The electrically driven foam liquid pump is provided for this purpose. Foam solution is supplied to the deck monitors and hand lines by the deck main fitted with isolating valves. Each monitor is isolated from the main supply pipe by means of butterfly valves, which are normally closed. Four portable foam-making branch pipes are provided. Each branch pipe has a solution rate of 400 l/min.



6.6 Portable firefighting foam operations

Applicator Foam

Medium expansion foam is used for Applicator foam. It has an expansion ratio from about 15:1 up to 150:1. It is made from the same concentrates as high expansion foam, but its aeration does not require a fan. Portable applicators can be used to deliver considerable quantities of foam on to spill fires, but their throw is limited and the foam is liable to be dispersed in moderate winds. Foam applicators are a supplement to the foam monitors. Sheltered areas not reachable by the foam monitors can be covered by a foam applicator. This gives increased flexibility. Different applicators are available, covering varying needs for proportioning ratio, Typically, an applicator needs to be supplied with a fire hose and a foam concentrate container and is stored in a foam station.

Applicator Foam Systems

Medium expansion foam is used for applicator foam. It has an expansion ratio from about 15:1 up to 150:1. It is made from the same concentrates as high expansion foam, but its aeration does not require a fan. Portable applicators can be used to deliver considerable quantities of foam on to spill fires, but their throw is limited and the foam is liable to be dispersed in moderate winds. Foam applicators are a supplement to the foam monitors .Sheltered areas not reachable by the foam monitors can be covered by a foam applicator. This gives increased flexibility. Different applicators are available, covering varying needs for proportioning ratio, Typically, an applicator needs to be supplied with a fire hose and a foam concentrate container and is stored in a foam station.

6.7 Fixed dry chemical system operations

Dry Chemical is a powder composed of very small particles usually of sodium bicarbonate, potassium bicarbonate, urea-based potassium bicarbonate, or monoammonium phosphate with added particulate material supplemented by special treatment to provide resistance to packing, resistance to moisture absorption (caking) and the proper flow capabilities

[FIRE EXTINGUISHING MECHANISMS]

- Interruption of the chain reaction sequence.
- Heat absorption effects

Multipurpose Dry Chemical is usually monoammonium phosphate-based and is effective on fires in ordinary combustibles, such as wood or paper, as well as on fires in flammable liquids, etc.

Characteristics

1. Best applicable to fire extinguishing systems for protection of dangerous and associate articles which involve serious hazard and the danger of quick spread of fire.

2. Easy to clean after application of Dry chemicals Economical as they are less contaminative.

3. Excellent insulation permits application of Dry chemicals to high-tension electric installation such as a transformer.

Handling of Control Valve is simple and plain ensuring easy cleaning of piping after use

Total Flooding System

A total flooding system means a supply of dry chemical permanently connected to fixed piping, with fixed nozzles arranged to discharge dry chemical into an enclosed space or enclosure about the hazard.

This type of system shall be used only where there is a permanent enclosure about the hazard that is adequate to enable the required concentration to be built up.

The leakage of dry chemical from the protected space shall be minimized since the effectiveness of the flooding system depends upon obtaining an extinguishing concentration of dry chemical.

In total flooding system, the rate of application shall be such that the design concentration in all parts of the enclosure shall be obtained within 30 seconds.

Local Application System

Local application system shall be used for the extinguishment of fires in flammable or combustible liquids, gases, and shallow solids such as paint deposits, where the hazard is not enclosed or where the enclosure does not conform to the requirements for total flooding. Application of dry chemical shall be from nozzles mounted on the tank side or overhead.

(1)Area Method

Applicable to superficial fire, and the amount of extinguishing agent depends upon the hazardous area.

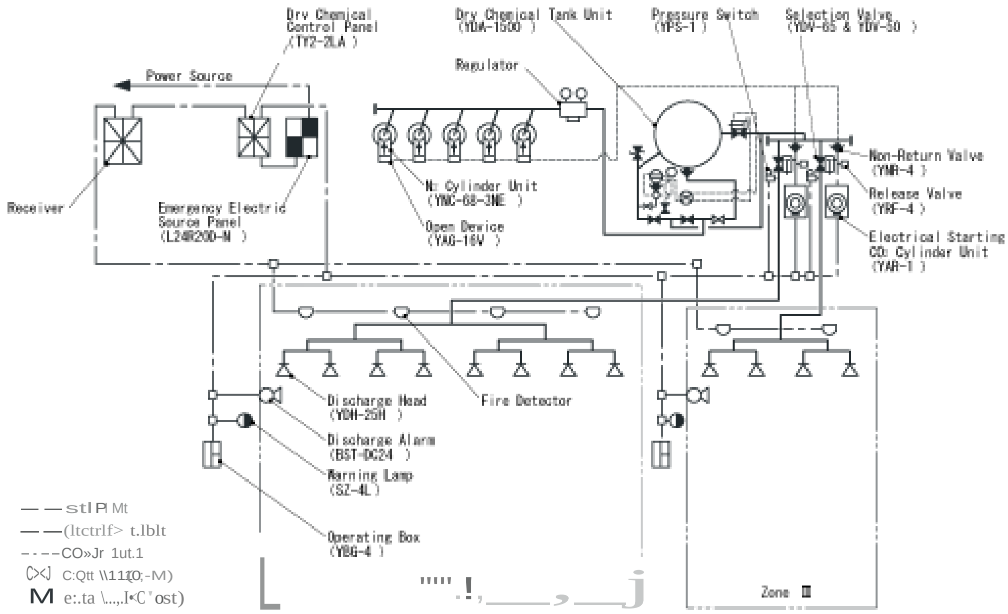
(2)Volume Method

Applicable to cubical fire, and the amount of extinguishing agent depends upon the volume of the object in danger.

The hazard shall include all areas that are or may become coated by combustible or flammable liquids or shallow solid coatings, such as areas subject to spillage, leakage, dripping, splashing, or condensation, and all associated materials or equipment such as freshly coated stock, drainboards, hoods, ducts, etc., that might extend fire outside or lead fire into the protected area.

eSy$temic Diagram

•Startint System of Electtic Operation (Wanual or Auto)



estarting System of Gas Pressure

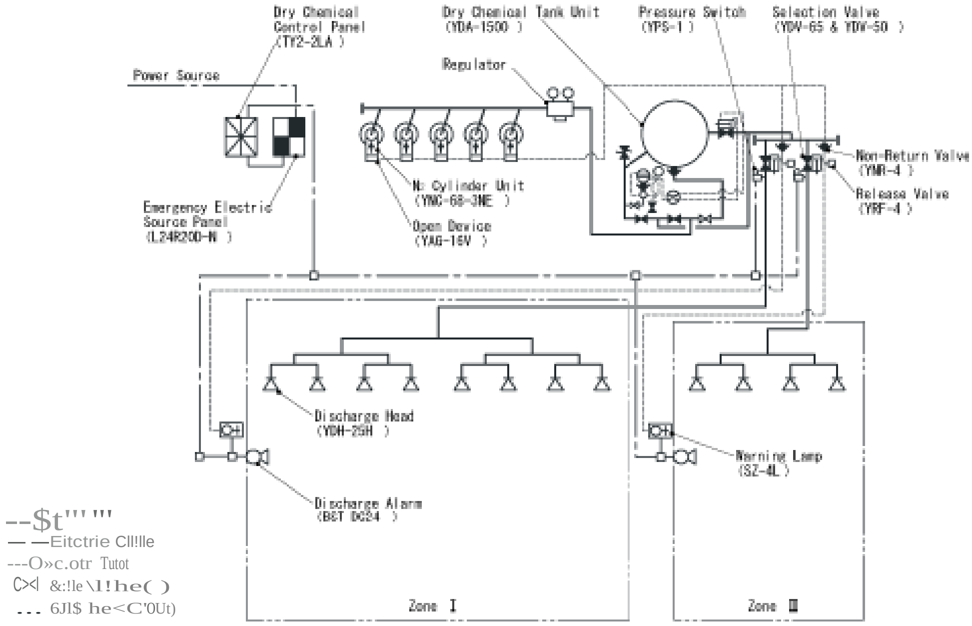


Fig.6.7.A: System Diagram

Fig. 6.7.B: Dry Chemical Agent

1.Sodium Bicarbonate Based Dry Chemical.

This agent consists primarily of sodium bicarbonate($NaHCO_3$) and is suitable for use on all types of flammable liquid and gas fires (Class B) and also for fires involving energized electrical equipment (Class C).

Sodium bicarbonate base dry chemical is not generally recommended for the extinguishment of fires in ordinary combustibles (Class A), although it may have a transitory effect in extinguishing surface flaming of such materials.

[Principle]

$2NaHCO_3 \text{ ---> } Na_2CO_3+CO_2+H_2O$

$Na_2CO_3 \text{ ---> } Na_2O+CO_2$

2.Potassium Bicarbonate Based Dry Chemical.

This agent consists primarily of potassium bicarbonate($KHCO_3$) and is suitable for use on all types of flammable liquid and gas fires (Class B) and also for fires involving energized electrical equipment (Class C).

Dry chemicals based on the salts of potassium are not generally recommended for the extinguishment of fires in ordinary combustible (Class A), although they may have a transitory effect in extinguishing surface flaming of such materials.

[Principle]

$2KHCO_3 \rightarrow K_2CO_3+CO_2+H_2O$

$K_2CO_3 \rightarrow K_2O+CO_2$

6.8 Spill containment in relation to firefighting operations

The actions to be taken in case of a oil/chemical spillage and pool fire are: - Prompt implementation of the ESD(Emergency Shut Down) will do much to limit the amount of liquid spilled and because of the fish plate, restrict the overflow of cargo overboard.

- restrict sources of ignition to ignite the vapour

- Foam gently spread over the pool fire will smother and restrict it from spreading.

- Jets of water should never be directed onto burning liquid, as this will cause a violent increase in flame and shall spread the fire.

- When contained in drip trays, the liquid may also be spilled onto the deck and water - jet should therefore be avoided.

- Wear full protective clothing and take advantage of water spray protection.

7. CARGO OPERATIONS

7.1 Oil and chemical tanker cargo operations

Cargo operations on board oil and chemical tankers require extra and special care as the nature of hazards are different and are in addition to the hazards on board other type of vessels.

Hazards;

1. Fire and explosions,
2. Spillage,
3. Toxicity and corrosiveness to men.
4. Reactivity of cargo with;
    a) Air,
    b) Water,
    c) Other cargo
    d) Metals
    e) With itself
    f) Coating.

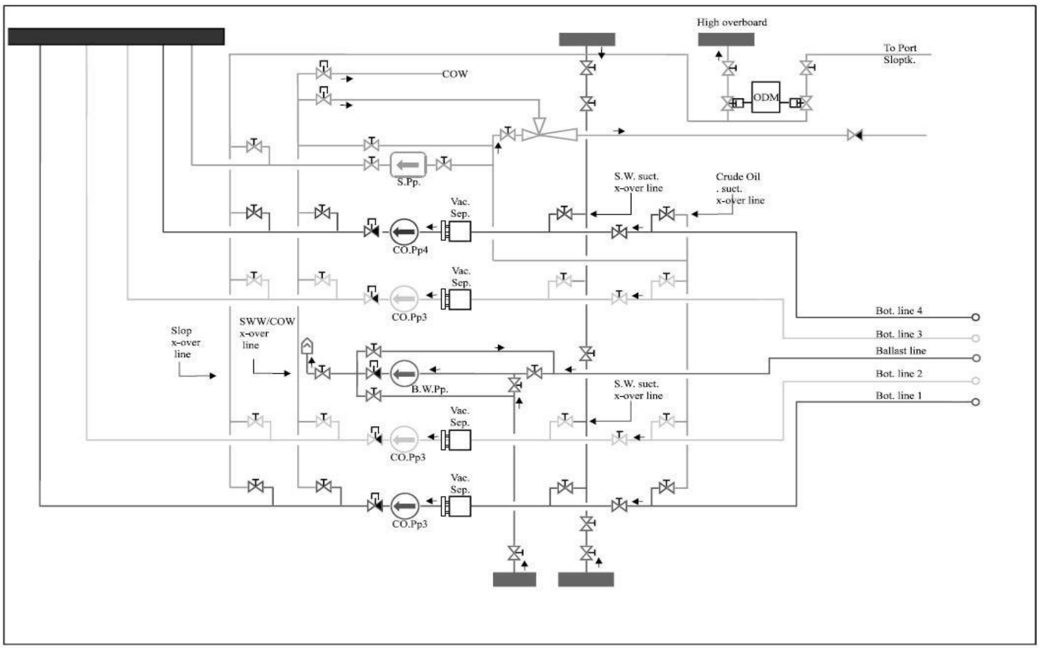


Fig. 7.1.A: Cargo system Piping diagram of Oil Tanker

Safety notices must be placed at conspicuous places with warning signs as applicable.

SAFETY FIRST must always be kept in mind at all the times. Before berthing a vessel complete information must be obtained on the rules and regulations applicable at that terminal, and any extra procedures are to be followed.

Before a cargo is loaded on board, complete specification of the cargo, and MSDS must be obtained, Cargo loading plan must be well prepared. Ship shore check lists must be completed. Only the competent men are to be employed for the operations. All tanks must be inerted as required and oxygen level maintained. Cargo must be loaded in accordance with the loading plan to ensure segregation, coating compatibility etc. Loading rates must be controlled for safe loading. During voyage correct cargo temperature must be maintained. Discharge operations require similar precautions with special care to avoid spillage due to the improper coordination with the shore terminal e.g. sudden closing of shore line valves.

7.2 FOR OIL TANKERS

7.2.1 Cargo information

Loading oil cargo in a tanker ship require utmost diligence in planning and most careful consideration will need to be made for safe operation. Following are the basic procedures at various stages of loading oil cargo.

Line up of the Vent lines

Prior loading operation commence, cargo tanks IG inlet lines to the designated tanks shall be re-checked and confirmed in desired position.

The control of the key to the locking arrangements for cargo tank IG inlet valves shall be with the Chief Officer.

For tanks which are required to be isolated by vapor (as per the Charterer's instructions), the individual I.G. pressure shall be monitored Every 4 hrs.

Safety Confirmations and Clearance:

• Once the Chief Officer is satisfied that all preparations have been made in accordance with the cargo oil loading plan and the shore facility representative has confirmed that the facility is ready to load cargo, he may order the opening of the designated manifold valves and loading operation to commence in accordance with the loading plan.

• Commence loading at reduced rate (to avoid static generation), watching the manifold back pressure at all times.

• The first loading tank shall be documented in the 'Tanker Cargo Log Book' and the number should be restricted to a minimum.

• Ullage confirmation shall be carried out to confirm cargo oil flowing as planned into the designated cargo tank.

• In case of heated cargo, confirmation of temperature of cargo is as per agreed value and within the Charterer's instruction. Also, the loaded cargo temperature shall be within the vessel's design criteria (of valve / tank coating limitations)

• Only after receiving reports of all safety checks confirmed from all stations of deck / pump room watch and the chief officer may open other loading tanks and carefully increase the loading rate. Close watch of the manifold back pressure shall be maintained, until completion of settling down of final maximum agreed loading rate.

• Close communication to be kept with shore side, until all parameters have stabilized.

• Loading cargo tanks IG back pressure shall be adjusted to maintain slight positive, at all times. The same shall be monitored, for any change.

Deck Watch and Personnel Arrangement

• The deck watch shall check for oil leaks in the cargo area throughout the cargo oil loading operation.

• At the beginning of the operations, confirm that no oil leaks from piping joints and that no oil in flowing into tanks other than the tank being loaded.

Keep continuous monitoring of the Oil Level of the loading tanks, until settling down of shore flow rate. Also, monitor other tanks (unused) for any change in the level.

• After reaching the desired full loading rate and confirmation reports have been received from all stations at deck / pump room watch, (including the cargo piping and sea surface around the vessel) the Chief Officer may dismiss the off duty crew and revert to the routine Watch Schedule

• During loading operations, monitor the manifold back pressure, especially when changing over the valves / tanks.

Leakage Monitoring System

Cargo leakage, however small shall be paid attention to- at an early stage of operations. Leakages from piping system, joints and valves shall be monitored. Tanks not being loaded shall be monitored to ensure that no oil is flowing into tanks other than the loading tanks.

During loading operations, watch oil loading pressure all the time, and monitor portions where oil is likely to leak. Excessive vibrations on piping systems must be attended to immediately.

Cargo Loading Rates:

a) General

The vessel's maximum loading rate and maximum venting capacity must be posted in the cargo control room giving details of the rates for homogenous(entire the vessel), Group-by-group and Tank-wise loadings.

Such information, based on calculations, shall assist the Master to determine how fast the ship can safely load a particular cargo at a particular facility, taking into account the vessel's design parameters and the cargo involved.

The Chief Officer should indicate, in the loading plan, rates required at stages throughout the operation.

b) Theoretical Rates

The maximum flow rate into any single tanks shall be less than the maximum venting capacity (SOLAS). To allow for generation of gas when loading, the venting rate shall be taken as 125% of the oil loading rate.

Maximum loading rates are affected by a number of factors:

- Diameter of Manifold valve / line.

- A cross section of the Pipe [m2] x Instant Flow Rate 7[m/sec] x 3,600[sec] = Reference Max. Loading Rate

- Number of tanks being loaded at any one time.

- Gas venting capacity – main system.

- Secondary gas venting capacity.

c) Setting Loading Rates

The initial and maximum loading rates, topping off rates and normal stopping times should be considered, having regard to: -

The nature of the cargo to be handled;

The arrangement and capacity of the ship's cargo lines and gas venting systems: the vent line pressure should not exceed that indicated by the builder and must be closely monitored at terminals where loading rates are known to be high.

Builder's maximum vent pressure may be based on a rate for loading all tanks simultaneously; rates must be reduced accordingly for a smaller number of tanks tank being loaded.

The ability and competence of the vessel's staff.

The loading rate should also be governed by the age, condition and reliability of the vessel's pipeline system and the gauging system.

Precautions to avoid accumulation of static electricity.

Any other flow control limitations.

De-Ballasting of Segregated Ballast:

• Obtain the Berth (Loading) Master's permission before starting to de-ballast the segregated ballast tanks. In principle, de-ballasting operations should commence, after starting of cargo operations.

• De-ballast, as per the cargo plan to achieve ample trim, especially towards the completion of de-ballasting operations.

Such period should be planned well before the level in cargo tanks are near Topping-off ullages.

Recording during operations in Tanker Log Book:

Following items shall be recorded in Tanker Cargo Log Book hourly.

• Loading Quantity (Rate) to compare it with that of the terminal side

Regular ship/shore comparisons of loaded cargo figures shall be carried out and changes in difference to be investigated / reported.

If the Duty Deck Officer cannot account for the variation of rate then he must call the Chief Officer immediately.

• Manifold Pressure / Temperature,

• Draft & Trim

• Monitor of levels in tanks not being discharged

• The Stress and Stability of the vessel

• Tank pressure

SBM / FSO position monitoring shall be carried throughout the operations. The crew on watch shall be briefed as to the danger limits for the bearing and distance of the SBM / Hawser to be reported.

7.2.2 Inerting

Oil tankers fill the empty space above the oil cargo with inert gas to prevent fire or explosion of hydrocarbon vapors. Oil vapors cannot burn in air with less than 11% oxygen content. The inert gas may be supplied by cooling and scrubbing the flue gas produced by the ship's boilers. Where diesel engines are used, the exhaust gas may not have a low enough oxygen content so fuel-burning inert gas generators may be installed.

One-way valves are installed in process piping to the tanker spaces to prevent volatile hydrocarbon vapors or mist from entering other equipment. Inert gas systems have been required on oil tankers since the SOLAS regulations of 1974.

The International Maritime Organization (IMO) publishes technical standard IMO-860 describing the requirements for inert gas systems. Other types of cargo such as bulk chemicals may also be carried in inerted tanks, but the inerting gas must be compatible with the chemicals used.

7.2.3 Loading

Commence loading at reduced rate (to avoid static generation), watching the manifold

- Back pressure at all times. Ullage confirmation shall be carried out to confirm cargo oil flowing as planned into the designated cargo tank.
- Only after receiving reports of all safety checks confirmed from all stations of deck / pump room watch and the chief officer may instruct the opening of other loading tanks and carefully increase the loading rate.

- Close watch of the manifold back pressure shall be maintained, until completion of settling down of final maximum agreed loading rate. Close communication to be kept with shore side, until all parameters have stabilized.
- Loading cargo tanks IG back pressure shall be adjusted to maintain slight positive, at all times.
- The same shall be monitored, for any change.

7.2.4 Unloading

When starting to ballast, cargo pumps should be operated so that no oil is allowed to escape overboard when the sea suction valve is opened. See the ICS/OCIMF publication "Prevention of Oil Spillages through Cargo Pump room Sea Valves". Sequence of Valve Operations

The following procedures should be adopted when loading ballast into non-inerted tanks which contain hydrocarbon vapour:

The tank valves should be the first valves opened.

- The initial flow of ballast should be restricted so that the entrance velocity is less than
- Meter/second until the longitudinal are covered or, if there are no longitudinal, until the depth of the ballast in the tank is at least 1.5 meters. These precautions are required to avoid a geyser effect which may lead to the buildup of an electrostatic charge in a mist or spray cloud near the point where the ballast enters the tank. When a sufficient charge exists the possibility of a discharge and ignition cannot be excluded. The Chief Officer shall also prepare a watch schedule and Person in-Charge list for oil.
- Transfer operations for the discharge operation. Prior to commencement of discharge operation the Chief Officer shall conduct a “Pre transfer cargo safety meeting” with all the concerned crew.

7.2.5 Tank cleaning

Fig. 7.2.5.A: Tank cleaning machines

The nozzle of an automated tank cleaning machine

Tanks must be cleaned from time to time for various reasons. One reason is to change the type of product carried inside a tank Also, when tanks are to be inspected or maintenance must be performed within a tank, it must be not only cleaned, but made *gas-free*.

On most crude-oil tankers, a special crude oil washing (COW) system is part of the cleaning process. The COW system circulates part of the cargo through the fixed tank-cleaning system to remove wax and asphaltic deposits. Tanks that carry less viscous cargoes are washed with water. Fixed and portable automated tank cleaning machines, which clean tanks with high-pressure water jets, are widely used. Some systems use rotating high-pressure water jets to spray hot water on all the internal surfaces of the tank. As the spraying takes place, the liquid is pumped out of the tank.

After a tank is cleaned, provided that it is going to be prepared for entry, it will be *purged*. Purging is accomplished by pumping inert gas into the tank until hydrocarbons have been sufficiently expelled. Next the tank is *gas freed* which is usually accomplished by blowing fresh air into the space with portable air powered or water powered air blowers. "Gas freeing" brings the oxygen content of the tank up to 20.8% O2. The inert gas buffer between fuel and oxygen atmospheres ensures they are never capable of ignition. Specially trained personnel monitor the tank's atmosphere, often using hand-held gas indicators which measure the percentage of hydrocarbons present. After a tank is gas-free, it may be further hand-cleaned in a manual process known as mucking. Mucking requires protocols for entry into confined spaces, protective clothing, designated safety observers, and possibly the use of airline respirators.

7.2.6 Purging and gas freeing

Gas-Freeing for Cargo Tank entry

Cargo Tank entry shall not be permitted unless the Oxygen Content is 21% and the hydrocarbon vapor content is less than 1% of the Lower Flammable Level (LFL). Follow company's "Procedure for Entry into Enclosed Spaces" with related permits.

If the previous cargo contains Hydrogen Sulfide (H2S) or other toxic contaminants which could evolve toxic gases (e.g. benzene, toluene, Mercaptans, etc), the tank should be checked for such gases. Refer to "Guidelines for Toxic Gases Hazards".

Carrying out "Hot Work" inside Tanks within the 'Dangerous Area' need special caution as per "Procedures for Hot Work" and carry out preparation accordingly.

Gas-Freeing or Purging for the Reception of Cargo

If the intention of Gas-Freeing or Purging operations is to prevent the next cargo to be loaded from contamination due to the previous cargo oil hydrocarbon gas, use the gas content indicated by the Charterer as standard.

PURGING AND GAS FREEING ONBOARD OIL TANKER SHIPS

Inert Gas Purging

If inert gas purging is being carried out by the displacement method any dense concentrated hydrocarbon layer at the bottom of the tank is expelled in the early stages, followed by the remainder of the tank atmosphere as it is pressed downwards by the inert gas. If there is a uniformly high concentration throughout the tank, For example after product washing, the product concentration of the vented gas remains high throughout the purging process until the inert gas reaches the bottom of the tank. If inert gas purging is being carried out by the dilution method the gas concentration at the outlet is highest at the beginning of the operation and falls continuously as it proceeds.

Gas Freeing

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

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

Gas Free for Entry Without Breathing Apparatus

In order to be gas free for entry without breathing apparatus, a tank or space must be Ventilated until tests confirm that the cargo vapour concentration throughout the compartment is less than 1% of the LEL, that the oxygen content is 21% by volume, and that there are no hydrogen sulphide, benzene or other toxic gases present, as appropriate. Before entering a tank without breathing apparatus, the atmosphere in the tank should be checked by a competent person.

Procedures and Precautions

The following recommendations apply to gas freeing generally: A Responsible Person must supervise all gas freeing operations.

- All personnel on board should be notified that gas freeing is about to begin.
- Appropriate "No Smoking" regulations should be enforced.
- Instruments to be used for gas measurement should be calibrated and tested in accordance with the manufacturer's instructions before starting operations.
- Sampling lines should, in all respects, be suitable for use with, and impervious to, the gases present.
- All tank openings should be kept closed until actual ventilation of the individual compartment is about to commence.
- Venting of flammable gas should be by the tanker's approved method. Where gas freeing involves the escape of gas at deck level or through

hatch openings, the degree of ventilation and number of openings should be controlled to produce an exit velocity sufficient to carry the gas clear of the deck.

- Intakes of central air conditioning or mechanical ventilation systems should be adjusted, if possible, to prevent the entry of petroleum gas, by recirculating air within the spaces.
- If at any time it is suspected that gas is being drawn into the accommodation, central air conditioning and mechanical ventilation systems should be stopped and the intakes covered or closed.
- Window type air conditioning units which are not certified as safe for use in the presence of flammable gas, or which draw in air from outside the superstructure, must be electrically disconnected and any external vents or intakes closed.
- Gas vent riser drains should be cleared of water, rust and sediment, and any steam smothering connections tested and proved satisfactory.
- If several tanks are connected by a common venting system, each tank should be isolated to prevent the transfer of gas to or from other tanks.
- If cargo vapours persist on deck in high concentrations, gas freeing should be stopped.
- If wind conditions cause funnel sparks to fall on deck, gas freeing should be stopped.
- Tank openings within enclosed or partially enclosed spaces, such as under forecastles, should not be opened until the compartment has been sufficiently ventilated by means of openings in the tank that are outside these spaces. When the gas level within the tank has fallen to 25% of the LEL or less, openings in enclosed or partially enclosed spaces may be opened to complete the ventilation. Such enclosed or partially enclosed spaces should also be tested for gas during this subsequent ventilation.

7.3 FOR CHEMICAL TANKERS

7.3.1 Cargo information

Information about cargoes to be handled is essential to the safety of the vessel and her crew

- Such information may be found on ICS or other Cargo Data Sheets for each product,

• Which also include all necessary data for the safe handling and carriage of the cargo information for most tanker cargoes is kept on board and available for all concerned

• The cargo will not be loaded unless sufficient information necessary for its safe handling and transportation is available

• The cargo will not be loaded unless sufficient information necessary for its safe handling and transportation is available

• The responsible officer will see to it that the necessary cargo information is posted on the notice board prior to cargo operations

• All personnel engaged in cargo operations should familiarize themselves with the cargoes

• By studying the ICS or other Cargo Data Sheets cargo operations on chemical tankers may involve simultaneous loading, unloading and tank cleaning.

7.3.2 Loading

All personnel must follow standing instructions at all times whether or not the cargo to be loaded is dangerous personnel on watch or involved in the loading operation should wear appropriate protective clothing, as indicated in the ICS or other Cargo Data Sheets, when handling dangerous cargoes are stowed according to a stowage plan that was prepared before loading began.

• Prior to loading, cargo tank are inspected for cleanliness and suitability for cargo according to the stowage plan.

• Prior to the loading of cargoes which present a major fire hazard, tanks are purged with nitrogen.

• To remove air so that the atmosphere above the cargo will be non-flammable such cargoes are kept under nitrogen "padding" during the voyage.

• Cargo is routed from the manifold to tanks on a chemical tanker with separate lines for each tank.

• Cargoes giving off vapours which present a major health hazard are loaded in a "closed circuit",

• Requiring a vapour- return line in order to check for impurities, cargo samples are taken from lines and tanks during loading

- A vessel’s trim, list and stability may be adjusted, if necessary, during loading by filling or emptying ballast tanks

- All events during cargo operations are recorded.

7.3.3 Unloading

All personnel must follow standing instructions at all times during unloading, whether or not the cargo is considered dangerous personnel on watch or involved in the unloading operation should wear appropriate Protective clothing, as indicated in the CS or other Cargo Data Sheets, when handling dangerous cargoes. Cargoes are unloaded according to a planned sequence of emptying tanks.

Prior to unloading, cargo samples from each tank and from cargo lines are analyzed to Check if a product has been contaminated on board during passage.

Cargo unloading safety procedure for chemical tankers

Just prior to commencing discharge the responsible officer should check that the cargo pipeline system is set correctly, that correct valves are open, that valves not being used are closed, and that the cargo venting system is appropriate for the cargo operation. Particular attention should be paid to ship's cargo discharge equipment, such as pumps and pump room ventilation.

When a vapour balance is to be used by returning inert gas displaced from the shore receiving tank to the ship, the pressure in the ship's cargo tank must be carefully monitored, and necessary action taken to avoid excessive over or under pressure. At the start of any unloading, and at regular intervals throughout the operation, checks should be made to ensure that cargo is not leaking.

Adding nitrogen to maintain overpressure

When unloading cargoes that have to be carried under a blanket of nitrogen, it may be necessary to ensure that no air is drawn into the tank. Therefore an overpressure of nitrogen should be maintained as the liquid level falls. The nitrogen can be supplied from stored compressed gas or from a nitrogen generator on board, and be introduced into the tank ullage space. But if it is necessary to obtain nitrogen from the shore, it is essential that the pre-transfer discussion includes agreement on the nitrogen flow rate and pressure to be used.

Although the overpressure required is no more than about 0.2 bar, it is usual for the shore nitrogen supply system to be well above this figure, perhaps as high as 7 bar. Particularly in the early stages when the ullage space is still small, it is possible for the flow rate to exceed the tank venting capacity, and for an overpressure to develop. A safe procedure is to use a pressure reducing device on the nitrogen supply line, and to have a calibrated gauge showing the pressure in the pipeline. There should be direct communication with the terminal, and the ship should monitor cargo tank ullage space pressure throughout.

Sweeping of cargo residues

After the carriage of animal and vegetable oils and fats, manual sweeping of the cargo tanks is usually necessary to push the semi-liquid residues towards the pump suction to complete the discharge, and before commencing tank cleaning. (The process is sometimes called, squeegeeing' or 'puddling'.) Despite the natural origins of the cargo, it is essential that safety precautions are observed on every occasion that personnel are sent into an enclosed space.

The tank should be mechanically ventilated for at least 1 hour, concurrently with discharge, to ensure its atmosphere is safe for entry without breathing apparatus before sweeping begins. An enclosed space entry permit issued before personnel enter the tank. Ventilation should continue during the sweeping operation. A responsible person should remain in attendance at the tank entry hatch throughout the sweeping operation, keeping the personnel within under observation.

If at any time the oxygen level falls below 21%, the tank must be vacated until the oxygen level has been restored by ventilation.

Completion of discharge

It is essential to reduce the cargo residue in a tank to the minimum attainable. Tanks should be stripped according to the requirements of the ship's P&A Manual.

When discharge of a product is completed, the relevant manifold valve on the ship and the shore should be closed. This will provide separation of the ship and the shore system from a failure or unexpected action in the other. All openings on cargo tanks used for that product must be finally closed and secured.

After completion of discharge, lines and hoses should be cleared to shore. Cargo hoses or arms must only be disconnected from the manifold after they have been drained of cargo residues, and relieved of any pressure.

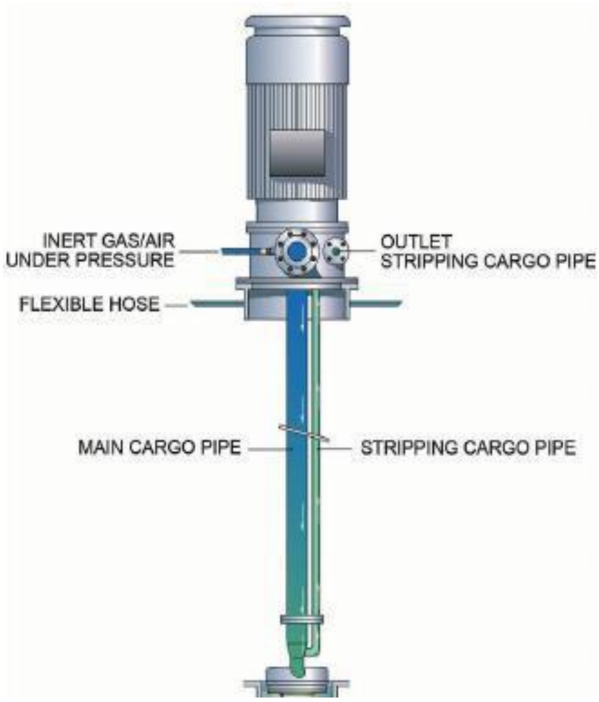


Fig. 7.3.3.A: Stripping Pump

7.3.4 Tank cleaning and gas freeing

Tank cleaning methods onboard chemical tankers

The tanks of Chemical Tankers may be constructed or coated with various different types of materials and it is important to check with the P&A manual and the Paint Manufacturers Coating Resistance list prior to commencing Tank Cleaning Operations in order to ascertain the tank coating materials and any limitations with regards to temperature, use of cleaning chemicals etc. which may be applicable to the vessel.

Cleaning of tanks is usually the responsibility of the ship. Tank cleaning and the cleanliness involved have different standards depending upon the previous cargo and the cargo to be loaded. But the matter can be still more complicated, as cleanliness for one and the same product may vary, depending on who the receiver is and for what purpose the cargo is finally intended.

Examples: glycol intended for cosmetics or pharmaceutical purposes requires cleaner and completely odourless tanks than does glycol intended for antifreezes; caustic soda for making paper is more sensitive to iron contamination than caustic soda for the aluminium industry.

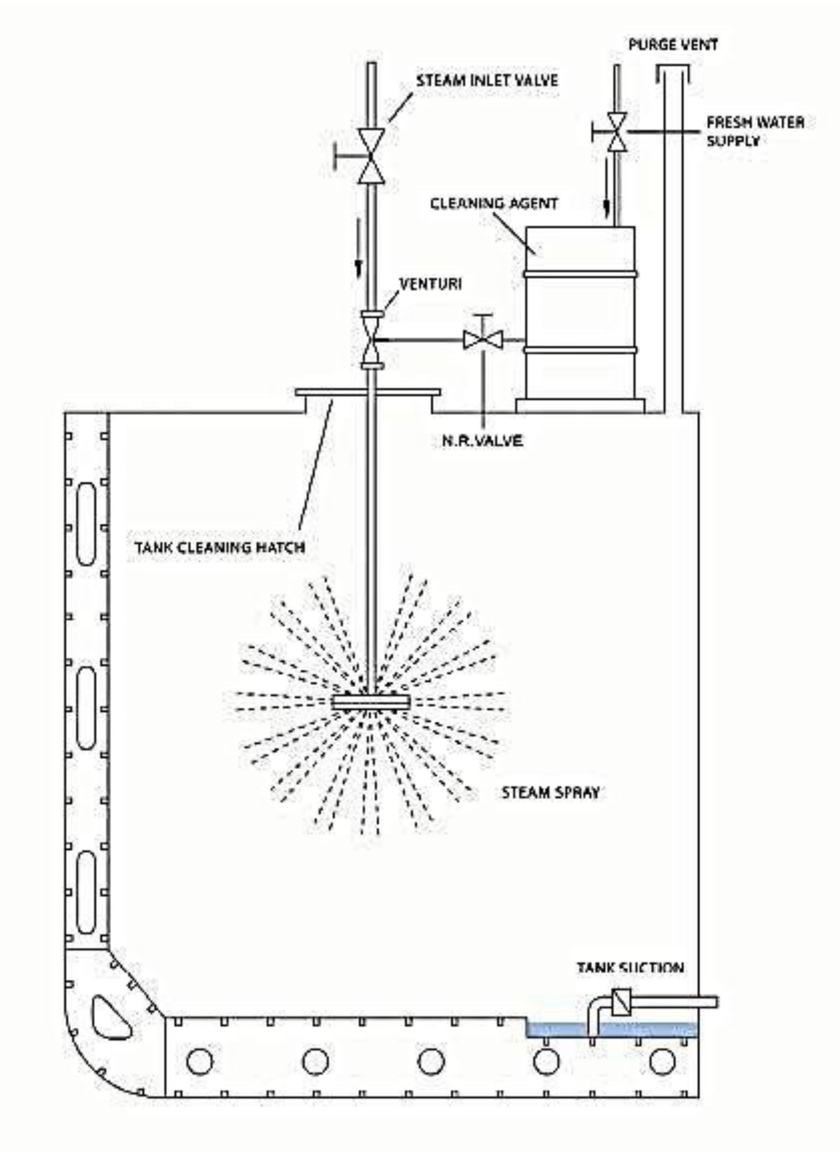


Fig. 7.3.4.A: Modern Chemical tanker tank cleaning process using steam spray

It must be mentioned first that the majority of cleaning operations on board chemical tankers are being carried out by means of water washing only. Further chemical cleaning is required for only a limited number of cargoes, but these cases may be very important.

One must take into consideration the nature of the previous cargo and the cargo to be loaded, time factor, available equipment and cleaning chemicals etc. It is stated the necessary degree of cleanliness for a number of products, in line with what cargo surveyors normally require.

Generally speaking one should use mechanical tank cleaning methods, that is usually washing with water, before applying more expensive methods involving chemical cleaning agents. The most expensive, and least safe, method is manual cleaning, which should be kept to a minimum.

It is important to drain the tanks as much as possible in order to deliver all cargo and to reduce pollution of the seas to an absolute minimum.

Examples on measures on how to obtain the best possible cargo stripping:

i) Due regard to ship's trim and heel.

ii) Viscous cargoes may first be stripped from the various tanks to one tank near the pump room and from there be pumped ashore.

iii) Keep the cargo temperature sufficiently high so that the cargo drains also from remote corners of the tanks, especially in cold climates.

iv) Waxy deposits under the heating coils can sometimes be melted out be means of filling with water and then applying heat to the coils.

v) Sometimes steaming is allowed during discharge of molasses, which facilitates draining of molasses from the bulkheads.

vi) Vegetable oil tanks may in the last phase of discharge be recirculated and hosed down with vegetable oil taken from the cargo pump delivery side . Similarly phosphoric acid can be recirculated to loosen sediments on the tank bottom.

vii) Drain cargo piping to shore. It is useful to have a small stripping pump with 50 mm delivery line to the hose connection for delivery of contents in the cargo piping to shore.

viii) Before loading sensitive cargoes: mudboxes, valve bodies and pump housings must be drained by opening the drain plugs (with due regard to personal safety).

Practical examples on solving problems

The following text is intended as a general guide and will give some practical examples on problems and methods. The information given should not substitute your own or others' good and proven methods! Also consult shippers and tank inspectors coming on board.

Analyze the properties of the previous cargo and take advantage of its "weak points", e.g as follows:

i) Water soluble? If the cargo is reasonably soluble in water then chemical cleaning agents are unnecessary in most cases.

ii) Will an increased cleaning temperature cause a beneficial reduction of cargo viscosity and lower surface tension or could it cause the opposite: that cargo residues polymerize or oxidize ("dry"). Polymerization and drying must be avoided, therefore the first cleaning operation must be carried out cold.

iii) Is it possible to emulgate the cargo in water or in water with emulgators added? Make a test on board.

iv) Will the product be affected by alkalies? Caustic soda is a relatively cheap and easily available alkaline chemical.

v) Will the product dissolve in other easily available products by which the tank walls can be treated? (Successively "upgrading" or "floatation" methods).

vi) Will cargo residues vaporize without leaving any traces?

vii) Can cargo remains be safely mixed with the cargo to be loaded? In many cases it is not known what the next cargo will be but sometimes this method can be applied.

Odour

Some products are very sensitive to foreign odours, usually stemming from previous cargoes in the same tank. Examples of sensitive cargoes are: glycols, glycerin, vegetable and animal oils, molasses.

Odours remaining after a thorough tank cleaning are usually best removed by steaming and/or ventilation of the tank. Steaming "sweats out" cargo from pores etc. Cargo piping may also have to be steamed out. Epoxy coatings should not be heated above 60 - (80) ^{o}C, zinc silicates tolerate somewhat higher temperatures. So called deodorant fresh air sprays have an effect only on the atmosphere in the tank. Usually the odours stem from cargo residues on the actual tank walls and will therefore soon come back. The spray method is more of a symbolic value with regard to the care of the cargo.

Safe method of gas freeing after a tank cleaning onboard chemical tankers

Gas freeing onboard chemical tankers is required for entry into cargo tanks, for hot works or washing for clean ballast tanks. Gas Freeing is one of the most hazardous operations routinely undertaken onboard a Chemical

Tanker and the additional risk created by cargo gases expelled from the tanks, which may be toxic, flammable and corrosive, cannot be over-emphasised.

Fig. 7.3.4.B: Tank Cleaning heater

It is therefore extremely important that all care is exercised during gas freeing operations as the consequences of an inadvertent error can be serious and have far reaching consequences for personnel and the environment.

A space is considered as "gas free" when the concentration of flammable gases in its atmosphere is less than 0% LEL, the concentration of toxic gases (including IG components) is less than the TLV and the Oxygen concentration is not less than 20.8%.

Hazards may encounter at various stages. The following recommendations apply to cargo tank gas freeing in general. The IBC Code contains advice about cargo tank gas freeing.

It is essential to know what type of vapours can be expected: they may be flammable and/or toxic and/or corrosive:

a) Venting of toxic and flammable gas during gas freeing should be through the vessel's approved gas freeing outlets, and therefore the exit velocity should be sufficient to carry the vapours clear of the deck. No escape of cargo vapours should occur at deck level before the concentration within the tank has fallen below 30% LFL and the relevant TLV. Thereafter, final clearance of the vapour mixture may continue at tank deck level through other larger deck openings.

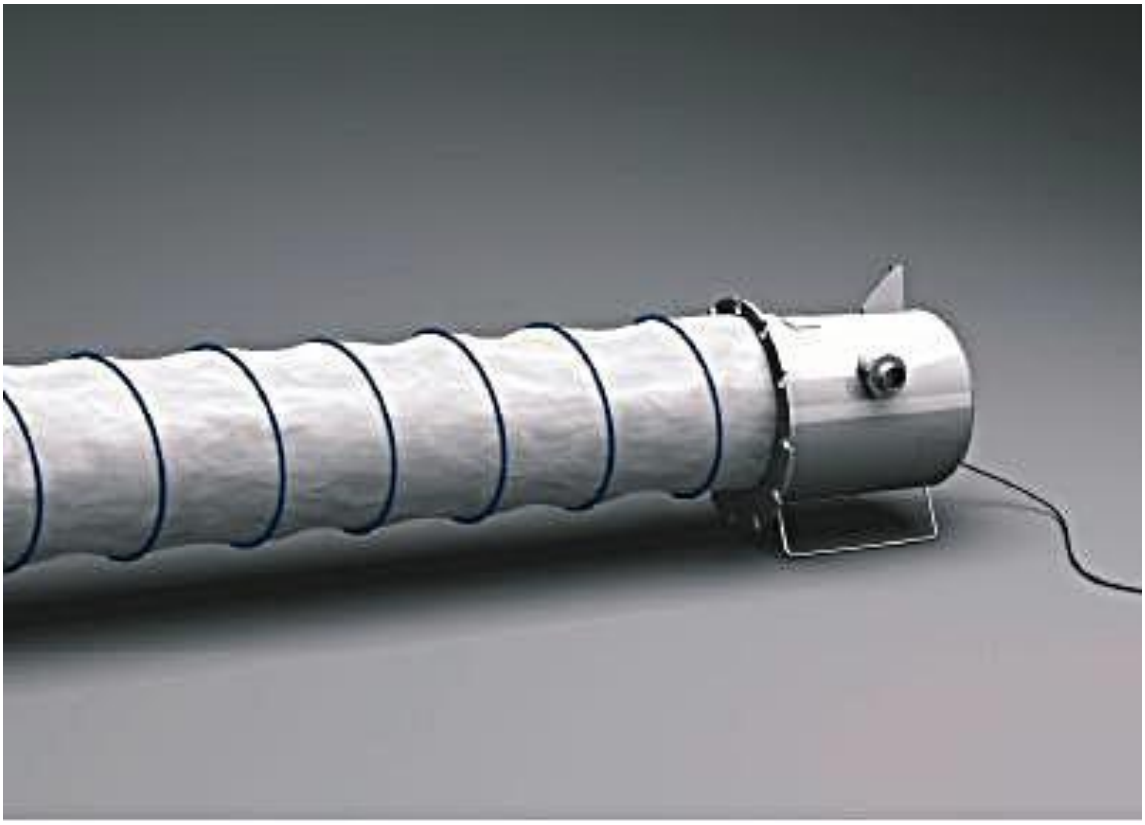


Fig. 7.3.4.C: Chemical tanker tank ventilation hose

b) If portable ventilation equipment is to be used to blow air into a tank, tank openings should be kept closed until work on that tank is about to commence.

c) Where cargo tanks are gas freed by means of permanently installed fans, air is introduced into the cargo tank through the cargo lines. The entire line system should be thoroughly drained before venting to avoid any obstruction of the air flow or tendency for water or cargo residues to be blown into a cargo tank. Valves on the systems, other than those required for ventilation, should be closed and secured. The fans should normally be blanked or disconnected from the cargo tank system when not in use.

d) Fixed gas freeing equipment should not be used for gas freeing of a tank while simultaneously being used to ventilate another tank in which washing is in progress, regardless of the capacity of the equipment.

e) Portable fans should only be used if they are water driven, or hydraulically or pneumatically driven. Their construction materials should be such that no hazard of incendiary sparking arises if, for any reason, the impeller touches the inside of the casing. The manufacturer's recommendations for maintenance should be followed. Guards should be in place to prevent accidental contact with fan blades.

f) Portable fans, where used, should be placed in such positions and the ventilation openings so arranged that all parts of the tank being ventilated are effectively and equally gas freed. Fans should generally be as remote as possible from the ventilation outlets.

g) Portable fans should be so connected to the deck that an effective electrical bond exists between the fan and the deck.

h) The wind direction may cause cargo vapours to pass near to air intakes for accommodation spaces or engine room ventilation, and necessitate additional precautions. Central air conditioning or mechanical ventilation system intakes should be adjusted to prevent the entry of gas, if possible by using recirculation of air within the spaces.

i) If at any time it is suspected that gas is being drawn into the accommodation block, the central air conditioning and any mechanical ventilating systems should be stopped and the intakes covered or closed. It is unlikely that any ship now uses window-type air conditioning units which draw in air from outside the superstructure, but any which are still in use, or other plants which are not certified as safe for use in the presence of flammable gas, should be electrically disconnected and any external vents or intakes closed.

j) If the tanks are connected by a common venting system, each tank should be isolated to prevent the transfer of gas to or from other tanks.

k) When a tank appears to have been gas freed and all mechanical ventilation has been stopped, a period of about ten minutes should elapse before taking final gas measurements. This allows relatively stable conditions to develop within the tank space. Tests should then be made at several levels and, where the tank is sub-divided by a wash bulkhead, in each compartment of the tank. In large compartments such tests should be made at widely separate positions. If satisfactory gas readings are not obtained, the tank should be checked for cargo residues and then ventilation resumed.

l) On completion of all gas freeing and tank washing, the gas venting system should be carefully checked, particular attention being paid to the efficient working of the P/V valves and any high velocity vent valves. If the valves or vent risers are fitted with devices designed to prevent the passage of flame, these should also be checked, and cleaned if found necessary. Gas vent risers and their drains should be checked to ensure that they are free of any blockage.

m) On completion of gas freeing, attention should be given to all equipment that has been used, and to enclosed or partially enclosed spaces that can retain or contain cargo residues or vapours, so that no unsuspected dangerous pockets can remain. Places where such cargo traces may exist include cargo lines, cargo valves, cargo pumps, stripping lines and valves, venting lines and P/V valves, vapour return lines, ullaging or sounding arrangements, heating coils, cargo handling equipment store rooms, protective clothing store rooms and cargo sample store rooms.

8. EMERGENCIES FOR OIL AND CHEMICAL TANKERS

8.1 Basic knowledge of emergency procedures, including emergency shutdown

This section covers the aspects of emergency operations on board. It includes emergency measures, organizational structure, alarms, emergency procedures and first-aid treatment. The syllabus provides the necessary guidelines for this topic. The main purpose for first-aid treatment is to emphasize the importance of familiarizing with the „emergency procedures" in the Cargo Data Sheet of the cargo carried. In the event of an accident involving cargo, the trainee should be able to take proper action as recommended in the Cargo Data Sheet. For planning and preparation are essential for dealing successfully with emergencies, the information which should be readily available:

type of cargo and its disposition

- Location of other hazardous substances
- General arrangement plan of the ship
- Stability information
- Location of firefighting equipment and instructions for its use in an emergency, important
- Actions to take would include: giving audible and visual warnings that an emergency exists by means of:
- Bells, whistles, klaxons or other audible devices
- Flashing lights advising the command centre of the location and nature of the emergency
- Promptly activating the ESD and stopping any cargo-related operations, closing valves
- And openings in tanks as initiated by the ESD system. removing any craft alongside
- Location of all safety equipment, such as; breathing apparatus
- Protective clothing
- Approved portable electric lights

- Instruments for measuring oxygen and other gases
- First-aid kits
- Tank evacuation equipment
- Firefighting equipment with instructions for its use
- All equipment which may be needed in an emergency must be maintained in good order and always be ready for use, and lists important items as: firefighting equipment
- Breathing apparatus
- Protective clothing
- Alarm systems
- Communication systems
- Arrangement plans

8.2 Organizational structure

Emergency Organization An emergency organization should be set up which will come into operation in the event of an emergency. The purpose of this organization will be in each situation to:

a. Raise the alarm and muster at designated station.

b. Locate and assess the incident and possible dangers.

c. Organize manpower and safety equipment.

The following suggestions are for guidance in planning an emergency organization, which should cover the following four elements:

Command Centre There should be one group in control of the response to the emergency with the master or the senior officer on board in charge.

The command centre should have means of internal and external communication.

Communication is of the utmost importance and the possibility of communication failing should always be taken into account as such back up for communication means should always be provisioned for – such as spare batteries for W/T sets, spare W/T sets, loudhailers, PA system and messengers. Emergency Party.

This group should be under the command of a senior officer and should assess the emergency and report to the command centre on the situation, advising what action should be taken and what assistance should be provided, either from on board or, if the ship is in port, from ashore.

Back up Emergency Party

The backup emergency party under the command of an officer should stand by to assist the emergency party as instructed by the command centre and to provide backup services, e.g. equipment, stores, medical services including cardio-pulmonary resuscitation etc. Technical Party This group should be under the command of the chief engineer or the senior engineering officer on board and should provide emergency assistance as instructed by the command centre.

The prime responsibility for dealing with any emergency in the main machinery spaces will probably rest with this group. It may be called on to provide additional manpower elsewhere. The plan should ensure that all arrangements apply equally well in port and at sea.

Duties assigned for the operation of remote controls such as:

a. main engine stop

b. ventilation stops

c. lubricating and fuel oil transfer pump stops

d. dump valves

e. CO_2 discharge

f. watertight doors

Operation of essential services such as:

a. emergency generator and switchboard

b. emergency fire and bilge pumps

Balance crew

The rest of the crew if not allotted any of the duties under the different groups as mentioned above would act as back up for the emergency parties. As backup they may be utilized in various other duties such as accumulating passengers and herding them away from danger to the evacuation decks. Escorting feeble passengers or crew including any injured crew to the safe places as designated.

Rendering first aid and trauma counseling. Filling extinguishers as required, mustering fire hoses from elsewhere, recharging and supplying W/T batteries. In case of abandoning ship possibility then taking in additional provisions and clothing/ water.

Preparation of the survival crafts such that it does not lead to any panic. Making rounds of areas adjacent of the fire area. Preliminary Action The person who discovers the emergency must raise the alarm and pass on information about the situation to the officer on duty who, in turn, must alert the emergency organization. While this is being done, those on the scene should attempt immediate measures to control the emergency until the emergency organization takes effect.

A fire in the galley is dangerous since it can spread very easily into the rest of the accommodation. The fire is dangerous as well as the fumes from burning plastics and any cooking oil. The person in charge of the galley or the person first locating the fire should try and extinguish the fire himself after alerting the officer of the watch.

Generally the fire as it is detected and begins is a small fire and later develops into a major one. Thus the fire may be put off by a single person with the equipment available in the galley and nearby areas Fire dampers should be engaged and DCP extinguishers used to put out he galley fire if anywhere on the stove area since these are electric circuits.

In case of cooking oil fire in the provision locker (rare) this may be put out using foam extinguishers and also with DCP extinguishers. An accommodation fire may be caused by a short circuit or due to smoking or flammable material catching fire inadvertently.

The items to be available would be:

a. DCP extinguishers

b. Fire hoses – low to moderate pressure on the fire mains

c. Insulated fire axe

d. Fire mans out fit

e. Safety lamps – many

f. Fire blanket

8.3 Alarms

Alarms onboard are the audio visual warnings that, an unsafe situation may develop if prompt action is not taken, e.g., high level alarms and over fill alarms also state the following:

- a fire alarm signal or general alarm signals are given in case of:

- fire
- collision
- grounding
- cargo hose burst
- major cargo spillage or escape vapour
- every other emergency situation which calls for emergency actions

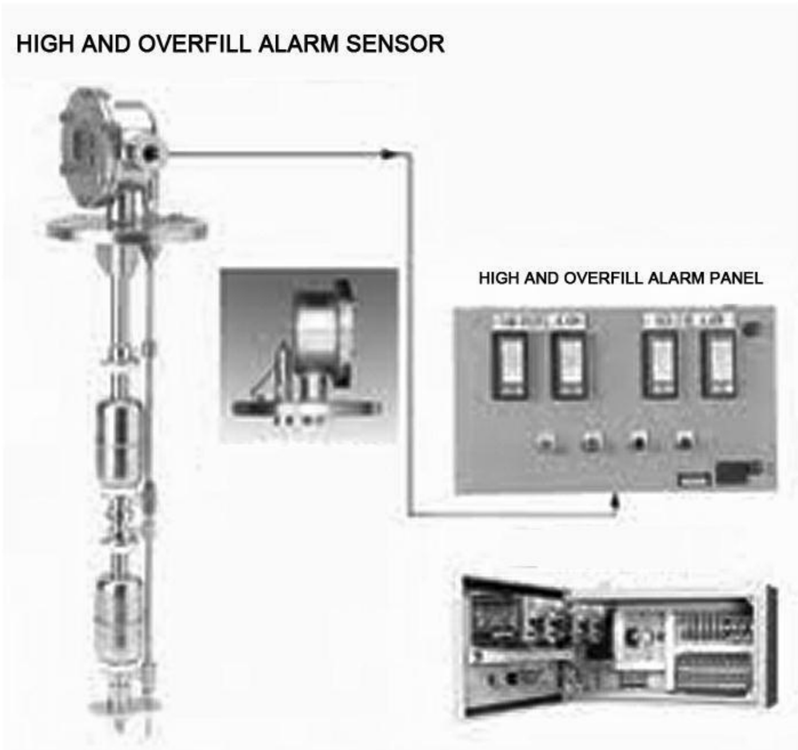


Fig. 8.3.A: High level and overfill alarms

Other alarm signals are given in case of

- high concentration of toxic or flammable vapours
- unacceptable condition in cargo tanks or cargo systems

- unacceptable conditions in auxiliary cargo systems
- system failure in cargo plant and auxiliary systems
- system failure in engine-room or machinery spaces
- a CO2 discharge in engine-room or pump-rooms
- a high level of oxygen in inert gas
- high level of oil residues in overboard discharge

If your ship's alarms are ringing, it does not necessarily mean that the situation is out of control. Alarms are warnings, which are sounded so that people onboard take the emergency measures like wearing their life jackets, or gathering at a common point, depending upon the type of emergency and instructions given to them.

8.4 Emergency procedures

Emergency situations on a ship tend to be more critical because ships are isolated, solitary floating objects moving in the vast and deep oceans. Since there are so many possible types of emergencies, it is necessary to know about both common and emergency essentials.

On hearing the emergency alarm crew must proceed promptly to the muster station. They must carry along life jackets, to the muster station as some of the emergencies may not allow them to return to the accommodation to fetch their life jackets for abandoned ships. Person responsible for the custody of master key to the accommodation doors must also carry it along to the muster stations. On muster stations the team leaders shall report to the bridge on the headcount of the crew, and a lot the duties and responsibilities to his team members to deal with emergency as required.

The "General Emergency Alarm" consists of seven or more short blasts followed by one long blast of the ship's horn or whistle (some lines don't sound the signal on the horn or whistle) and by the ship's internal alarm (such as fire alarm bells) accompanied with flashing strobe lights in corridors and public areas for hearing impaired) and PA systems with a tone.

Emergency Essentials - Types of Emergencies

For effective usage of the limited emergency equipment available on board, all personnel must be aware of the location of firefighting gear and lifesaving appliances and be trained in their use. They must also be aware of the alarm signals, recognize them, and muster at the muster point in case of any type of emergency.

The general alarm will be sounded in the event of:

- Fire
- Collision
- Grounding
- Cargo hose burst
- Major leakage or spillage of oil cargo
- Any other event which calls for emergency action

Other alarms could include:

- Engineer alarm for unmanned machinery spaces
- Carbon dioxide alarm
- Fire detector alarms
- Cargo tank level alarms
- Refrigerated store alarm

If your ship's alarms are ringing, it does not necessarily mean that the situation is out of control. Alarms are warnings, which are sounded so that people onboard take the emergency measures like wearing their life jackets, or gathering at a common point, depending upon the type of emergency and instructions given to them.

9. POLLUTION PREVENTION FOR OIL AND CHEMICAL TANKERS

Causes of marine (air and water) pollution Oil in the oceans is one of the ugliest forms of marine pollution. Just thinking about oil pollution in the oceans conjures up images of massive tanker spills, oiled seabirds and shorelines covered with gooey black oil. However, oil spills are not the major cause of oceanic oil pollution. Instead the majority of marine oil pollution comes from other sources. This page will examine the causes of marine oil pollution and methods for pollution prevention and spill cleanup.

Types of Marine Oil Pollution Oil spills are actually just a small percent of the total world oil pollution problem. According to Ocean Planet there are 706 million gallons of oil pollution in a given year. That is a massive amount of oil! The following chart will indicate the different methods of oil pollution and their respective percentage of total pollution.

The definitions of the different forms of oil pollution are as follows. Offshore drilling pollution comes from operation discharges and drilling accidents during oceanic oil exploration. Large oil spills typically result from and oil tanker accidents such as collisions and groundings. Natural oil pollution (seeps) comes from seepage off the ocean floor and eroding sedimentary rocks. Natural oil pollution into the marine environment has occurred for thousands if not millions of years.

Up in Smoke: This type of oil pollution comes from oil consumption in automobiles and industry. Typically the oil hydrocarbons find their way into the ocean through atmospheric fallout. Oil pollution from routine maintenance occurs from ship bilge cleaning and so forth. Lastly, oil pollution occurs from people dumping oils and oil products down storm drains after oil changes, urban street runoff and so forth. The worst oil pollution comes from oil dumped into the drains and road runoff. The following images illustrate some oil spills and accidents that have occurred.

9.1 Basic knowledge of the effects of oil and chemical pollution on human and marine life

Marine pollution is a diversified term. Several factors have created the present dilapidated condition of the sea. Sources are many but the solutions are few. Because oceans are part of the food chain, marine pollution affects a wide spectra of species, including humans. Ocean and human life is so inextricably interwoven that the effects of marine pollution are drastically visible on human life.

The main effects of oil spills on humans may be due to direct and indirect contact with the spill. The main oil spill effects on humans include a variety of possible health effects, economic impact, as well as recreational and aesthetic.

The main oil spill effects on humans are synthesized below:

- **A variety of health effects** (from minor illnesses to serious conditions possibly including cancers) from:
  - **Direct exposure to oil spill** – a variety of health effects may develop when the oil spill occurs close to where people live or work and may come in contact with humans through breathing gaseous oil compounds and/or oil compounds adsorbed on particulate matter (dispersed through air). Another exposure pathway may relate to activities in contaminated ground (e.g., soil) or through skin adsorption when touching spilled material.
  - **Indirect exposure** through consumption of contaminated food or water – especially relevant in the case of consumption of fish that was in contact or in an oil spill polluted environment. This is because some oil components have ability to "bio accumulate" in living organisms. This means that if a fish lives in a polluted environment, it will keep adsorbing in its body some oil components (without excretion) which may reach concentrations several orders of magnitude higher than those of the surrounding waters. Through consumption of such polluted fish meat, humans may become seriously exposed to higher concentrations of oil components than in the surrounding environment or as compared to ingestion of the polluted water or bathing in the polluted water.
- **Economical impact by**:
  - **Long-term ceasing of activities** such as fishing in polluted waters – for example the BP oil spill in the Gulf of Mexico had already impacted many local fisherman and fisheries normal activity and this looks like a long-term effect due to the very large amount of spilled oil
  - **Reduction of property value** – depending on the magnitude of the oil spill, this negative effect (on property value) apply not only to those properties directly affected by the oil spill, but to all the properties in a certain area exposed to oil spill pollution or of risk to become polluted at some point in time;
  - **Reduction of tourism** in affected areas;

- **Disturbance of traffic** (e.g., marine traffic) – affecting import-export activities

- **Recreational and aesthetic impact** – obviously relates to the visible effects of oil spill (e.g., oil slick, sheens) on coast waters, shorelines and beaches, wetlands, etc. When more serious, the complete closure of such recreational areas to general public enjoyment may also occur, at least temporary, until the spill is removed or cleanup.

9.2 Basic knowledge of shipboard procedures to prevent pollution

A fleet of double-hull tankers

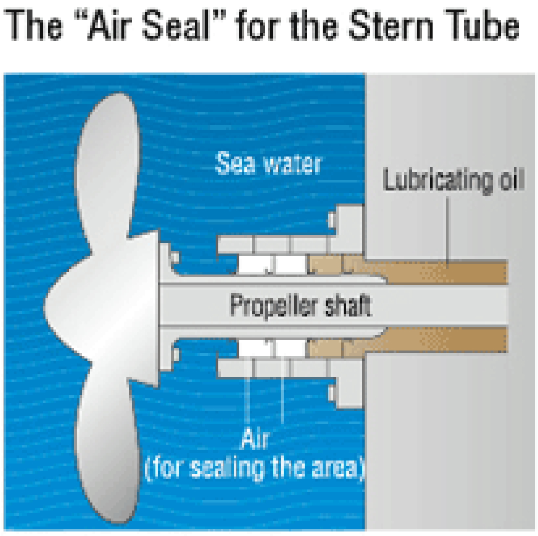
Our tankers feature a double-hull structure, which prevents the leakage of cargo oil into the sea if the ship is damaged in a collision, for example. Transportation by single-hull tankers will be prohibited in 2015 under the MARPOL Convention .

MARPOL Convention : The MARPOL Convention is an international convention that sets out rules for preventing marine and air pollution caused by ship operations, etc.

Fig. 9.2.A: Large double-hull tanker (VLCC) YAMATOGAWA

Using the Air Seal for the Stern Tube

We apply an air seal for the stern tube of our ships. An air seal is a device that continuously sends compressed air into the space in the stern tube where the propeller shaft penetrates out of the ship. This creates a sealed area inside the stern tube, which prevents leakage of lubricating oil and stops seawater from getting into the ship.



Air Seal for the Stern Tube

Use of electric powered deck equipment

We are introducing to our new ships electrically driven deck equipment, such as mooring winch and ramp ways, instead of hydraulic powered equipment. This has eliminated the risk of hydraulic oil leaks.

Fig. 9.2.B: Electric mooring winch and mooring lines (forward deck)

Central Cooling System (Indirect Cooling System)

The Central Cooling System cools the engine coolant and lubricating oil indirectly by exchanging heat with seawater via dedicated freshwater. Use of this system prevents leakages or spills of lubricating oil into the sea, because seawater does not become contaminated with lubricating oil in this system. In the event of the cooling system failure, leaked lubricating oil remains in the freshwater circuit only and never contaminates seawater and is never discharged into the sea.

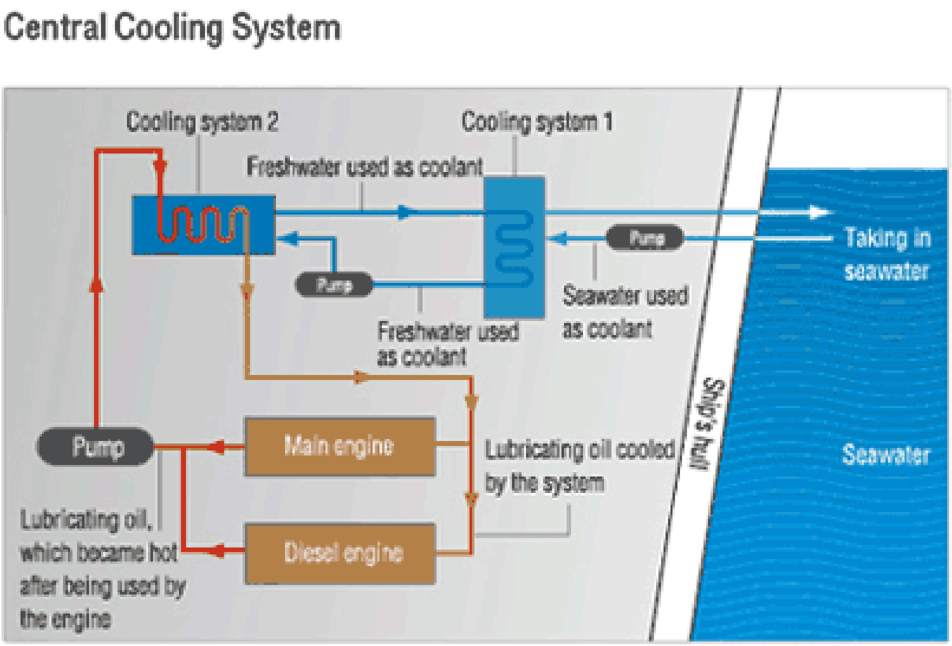


Fig. 9.2.C: Central Cooling System

9.3 SOPEP and SMPEP

SOPEP

A ship's SOPEP must be in the approved form, and include the following particulars –

(a) the procedure to be followed by the ship's master, or someone else having charge of the ship, in notifying a reportable incident that is a discharge or probable discharge of oil involving the ship (see below);

(b) a list of the entities to be notified by persons on board if the reportable incident happens;

(c) the procedure to be followed for coordinating with entities notified about the reportable incident;

(d) the name of the person on board through whom all communications about the reportable incident are to be made;

(e) a detailed description of the action to be taken, immediately after the reportable incident, by persons on board to minimize or control any discharge of oil from the ship resulting from the reportable incident.'

For chemical tankers at sea and in port: SMPEP

A shipboard marine pollution emergency plan for noxious liquid substances must be in accordance with the prescribed form and set out the following particulars:

a) the procedures to be followed by the master of the ship, or any other person having charge of the ship, in notifying a prescribed incident in relation to the ship;

b) a list of the authorities or persons that are to be notified by persons on the ship if a prescribed incident occurs in relation to the ship;

c) a detailed description of the action to be taken, immediately after a prescribed incident, by persons on board the ship to reduce or control any discharge from the ship resulting from the incident.

10. CASE STUDIES ON OIL AND NLS SHIP EMERGENCIES

10.1 Fire and Explosion on an oil tanker

(i) STOLT VALOR, off the Kingdom of Saudi Arabia

Incident

On 15th March 2012, STOLT VALOR (15,732 GT; built 2004) carrying 13,000 tonnes of methyl tertiary-butyl ether (MTBE) and 1,300 tonnes of isobutylaldehyde (IBAL) as well as 430 tonnes of Intermediate Fuel Oil (IFO 380) as bunkers, suffered an explosion in international waters off Ras Tanura, Kingdom of Saudi Arabia. The crew were evacuated by the US Navy and salvors appointed by the shipowner to respond to the incident. In the following days, attempts to tow the vessel further away from the coast were made, until the towline broke in bad weather and STOLT VALOR drifted off the Kingdom of Bahrain towards the State of Qatar with the fire still raging. A towline was successfully re-established on 19th March a few nautical miles from the coast of the State of Qatar and the casualty was eventually towed offshore.

Response

The fire was controlled on 20th March and an assessment of the vessel was undertaken by salvors. At that time, mid ship tanks had suffered extensive damage. Boundary cooling of the hotspots and the closing of ventilation and outlets of fuel oil tanks was carried out. Simultaneously, investigations for potential places of refuge, in order to carry out safe removal and lightering of the fuel oil and remaining cargo, were being made with requests sent to the State of Qatar, the Kingdom of Bahrain, the Kingdom of Saudi Arabia and the Islamic Republic of Iran. None of these countries granted refuge to the casualty and bunker oil removal started at sea on 24th March once the risk of further fire and explosion risk were reduced.

A salvage tug was deployed with oil spill response equipment onboard to address any oil spillage during the bunker oil removal operation and daily oil trajectories were simulated as part of the contingency arrangements. Other response capacities were deployed by the neighbouring Gulf States at various stages of the incident. The oil removal operation was completed on 2nd April and the cargo removal was completed on 29th April. No leakage of oil or cargo was reported throughout the operation and the casualty was eventually towed to a shipyard in the Kingdom of Bahrain to be recycled.

ITOPF Involvement

Owners and the vessel's P&I Club were in contact with ITOPF from the early stages of the incident and after monitoring remotely it was agreed that ITOPF would travel to the State of Qatar on 19th March in relation to the risk of grounding. ITOPF relocated to the Kingdom of Bahrain on 23rd March to assist the salvors and oil spill response contractor. ITOPF liaised extensively with MEMAC (Marine Emergency Mutual Aid Centre), which played a central coordination role in the incident, as well as with Qatar Petroleum while in the State of Qatar, and the Bahraini authorities while in the Kingdom of Bahrain, to discuss the development of the operations, explain the contingency arrangements and to promote a reasonable response from the neighbouring States. A contingency plan, as well as risk assessments in relation to the cargo remaining onboard were produced with ITOPF's input at various stages of the response, and were presented to the Bahraini authorities and MEMAC. ITOPF also provided comments on a study proposal submitted by the Kingdom of Saudi Arabia and MEMAC to assess the damage caused to the environment as a result of the incident.

(ii) Tank explosion case onboard a chemical tanker

Prior to loading cargo the vessel was required to gasfree and clean her cargo tanks. To accomplish this, the de-humidifier system was used to gas-free the tanks. The system consisted of a blower within the forward store, a main line along the deck and branch lines to each cargo tank.

Recognising the risk of cargo vapours passing along the line to the forward store, the system was fitted with individual tank valves, a main line isolation valve, a non return valve and a spool piece, which the Company required to be removed when the system was not in operation to isolate the forward store from the cargo side of the system.

The day after loading her cargo of Naptha, and three days prior to the incident, five crew members entered the forward store as part of a familiarisation tour conducted by a junior deck officer. They were met by a strong smell of cargo, however this was not reported to a senior officer.

Fig.10.1.B: Exploded ford store

Two days later and with the vessel now at sea, the ventilation flaps, hatch and door of the forward store were secured. The following day the Bosun opened the door of the forward store and turned on the ventilation fan. An explosion occurred and the Bosun was killed.

What Went Wrong (Critical Factors):

Several valves in the de-humidifier system were passing and the spool piece was not removed after the tank cleaning operation. It was therefore possible for cargo vapours to enter the forward store and with the store room secured for sea, an explosive atmosphere was created. The ventilation fan provided the ignition source.

Five crew members smelt cargo vapour in the forward store but did not report this to a senior officer. Some of them were new to the vessel and junior in rank. The spool piece was not removed as required by the Company. Designed as the last line of defence, it was found that the position and design of the spool piece made it difficult to handle. The spool piece is 2 metres above deck height and 50kg in weight.

Lessons learned & Recommendations:

* Use your senses! Any irregularities must be reported to a senior officer.

* On completion of operations spool pieces must be removed and the blanks properly fitted. In order to make them conspicuous, all portable bends, and spool pieces are to be conspicuously marked and labelled with intended purpose.

* Vessels with awkward and heavy spool pieces on the dehumidifier system, as in this case, should consider alternative arrangements with their Superintendent. In this case, the Managers replaced the spool pieces on the dehumidifier system with a flexible hose.

10.2 Fatality during Tank Cleaning operations

Case Study:

SECTION – 1 SYNOPSIS

On the morning of 15 April 2012, the chemical tanker STOLT SKUA was on passage from Rotterdam to Antwerp. The ship had finished discharging a cargo of PYGAS in Rotterdam and was completing tank washing and preparation operations prior to loading a new cargo in Antwerp. During the tank cleaning operations one of the Ordinary Seafarers (OS) was discovered inside one of the tanks being prepared for cargo. When discovered, the on board emergency team quickly arrived on the scene and affected a tank rescue. When recovered from the tank, the OS was unresponsive and arrangements were made for him to be evacuated from the ship.

The OS was evacuated by helicopter to the James Paget Hospital in Great Yarmouth. The OS did not regain consciousness and was pronounced dead at 09:20 hours on 15 April 2012 on arrival at the James Paget Hospital. The cause of death was recorded as "Asphyxia in association with inhalation of benzene fumes".

The investigation found that the direct cause of the accident was the OS making an unauthorised entry into the cargo tank when a toxic and oxygen deficient atmosphere was present. Contributing to the accident was a failure to follow the company's procedures for tank cleaning.

SECTION : 2 – ANALYSIS

2. Supervision of Tank Cleaning Operations by the Chief Officer

In addition to a general safety policy and procedure controlling entry into cargo tanks and other enclosed spaces, Stolt Tankers BV also operate to a Tank Cleaning Manual to supplement the other policies and procedures. This Tank Cleaning Manual requires that:

"Whenever a tank cleaning or gas freeing operation is being carried out the either the Chief Officer or Master must be in attendance throughout the operation."

On this occasion, the deck crew were all briefed as to the tank cleaning operation, including the safety precautions to be put in place, and had signed the prepared Tank Cleaning Plan. When the OS joined the tank cleaning team at 06:00 LT, he was also briefed by the Chief Officer as to the operations underway and also signed the Tank Cleaning Plan. The briefing by the Chief Officer included a reminder of the absolute prohibition on the entry of any cargo tank until the atmosphere inside the tanks had been tested and an "Entry Permit" issued.

The decision by the Chief Officer to issue the filter masks required for tank venting and then retire to his cabin to rest until he would be needed to test the atmosphere of the tanks after venting would appear not to be in accordance with the Tank Cleaning Manual in use on board.

3. Adequacy of procedures controlling tank cleaning and enclosed space entry on board STOLT SKUA

As the airborne concentration of Benzene during stages of the tank cleaning process could be expected to exceed 1 ppm, but were not expected to reach 50 ppm, crew were routinely issued with filter masks for protection when performing cargo operations on deck when carrying cargoes containing benzene.

Amongst other requirements, these procedures required that a tag be permanently attached to the entrance to each tank.

These tags were either:

RED: Unsafe for entry

GREEN: Tested and safe for entry, all conditions of entry permit met

YELLOW: Tank inerted and unsafe for entry. (Normally only used when required by shore terminals)

Permits were required for each operation requiring tank entry, and these permits would only be issued after thorough testing of the tanks atmosphere for sufficient oxygen present, the absence of any toxins and the absence of any fire/explosion risk. At the time of the accident a *RED (Unsafe for Entry)* tag was prominently displayed at the entrance to 10S tank.

Previous records of tank entry were examined and found to be in compliance with the requirements of Stolt Tankers BV's procedures.

4. Adherence by the deck crew to relevant procedures during the tank cleaning operations

4.1. Sea Water Washing

Sea water was to be introduced into each tank, circulated and then discharged to the sea for a period of 1.5 hours.

4.2 Fresh water Washing

After the sea water washing was complete, fresh water was to be circulated in the tank for a period of ten minutes and the discharged to the sea.

4.3. Venting

Although the water washing would have diluted and removed any cargo residue remaining in the tank, the atmosphere in the tank would have remained largely unchanged from when the cargo was discharged from the tank. This atmosphere would consist of vapour from the PYGAS cargo carried and nitrogen introduced into the tank to provide an inert atmosphere. The purpose of venting the tank was to displace this atmosphere with fresh air so that any PYGAS vapour remaining was removed and sufficient oxygen was introduced into the tank to restore a breathable6 atmosphere. The tanks were to be initially vented through the ship's vent risers, with the tanks only opened to complete ventilation when the atmosphere in the tanks was expected to be below 30% LEL and the concentration of benzene below the TLV/TWA for benzene of 10ppm. It is then necessary for the tank lid to be opened by the crew to complete the venting. Crew members perform this task wearing filter masks designed to protect against any remaining toxic vapour that may be present in the tank atmosphere.

4.4. Atmospheric Testing and Permit Issue

After venting, the atmosphere in each tank was to be tested for the absence of toxic vapour and to confirm the presence of sufficient oxygen. Once the atmosphere in the tank has been confirmed as safe, an “Entry Permit” would be issued allowing crew members to enter the tank.

4.5. Ejection

An air driven Wilden Pump was to be lowered into the tank and used to remove any diluted washings remaining after the sea and fresh water washing. This pump was to be lowered from deck on ropes and it was not required for any crew to enter the tank to perform this operation.

4.6. Mopping and Drying

The last stage of the tank cleaning process involved crew members entering the tank to manually mop up any moisture that may remain either in the bottom of the tank or clinging to the inside surfaces of the tank. Once the tank was clean and dry, the next cargo could be loaded without contamination from any previous cargo.

Each step in the process was designed to provide the maximum level of safety for those conducting the tank cleaning operations. In particular, although it was not required for a crew member to enter the tank to deploy the Wilden Pump, it would be necessary for them to lean over the open tank hatch and lower the pump to the bottom of the tank. In addition to the crew member wearing a filter mask to protect against toxic vapours, the process was designed to minimise the exposure to any such vapours that may be present. This stage of the process was only to be performed after the atmosphere in the tank had been confirmed as safe.

Rather than waiting for the atmosphere in the tank to be confirmed as safe, the “Optimising Violation” was to lower the Wilden Pump into the tank before the atmosphere had been checked, with the seafarer remaining on deck and not entering the tank. It was not possible to determine if this practice had become the norm on board STOLT SKUA or if it was employed only in certain circumstances. It was also not possible to determine if it the practice was undertaken with the knowledge and approval of the Chief Officer. However, it is clear that this deviation from the standard tank cleaning procedure was being employed on the day of the accident.

5. Actions of the Ordinary Seafarer

The Post Mortem conducted on the OS showed no evidence of him falling into the tank from the deck onto the first platform on which he was found (a height of 3.31m). It is therefore concluded that he climbed into the tank and down the ladder onto the first platform. The most likely reason for him to take such a course of action is that he was attempting move the Wilden

Pump to a new location in the tank after it had become caught in the tank's internal structure.

A number of factors acting in combination may have led the OS to act in contravention of his training and accepted safe working practice, these factors may have included8:

Risk Taking – Taking an action where the outcome is uncertain, often in

contravention of norms, regulations or procedures. "I'll take a chance."

Impulsiveness – Inclined to act on impulse rather than thought. "I know what I am doing."

Invulnerability – Impervious to danger or risk. "It won't happen to me."

The tank cleaning operation was already in violation of standard procedures and the OS may have considered his actions in entering the tank as merely a "stretching" of the "accepted violation" already in progress. Routine violations do not necessarily result in accident themselves. Generally accidents occur when a routine violation occurs in conjunction with an "error". In this case the "error" was the OS's decision to enter the tank.

1. Conclusions

A) The primary cause of this accident was the OS's decision to enter cargo tank 10S which contained a toxic and oxygen deficient atmosphere incapable of sustaining life.

B) Contributing to this accident was the practice on board of not following the established tank cleaning procedures in the belief that in doing so would improve tank cleaning performance. A so called "Optimising Violation".

C) The level of supervision and control by the chief officer on board was insufficient to prevent this Optimising Violation occurring.

D) Stolt Tankers BV had robust and adequate procedures in place to prevent such an accident occurring. These procedures met all international requirements and represented "best practice"; however they were not always followed by the crew of STOLT SKUA.

E) The members of the on board rescue team acted on knowledge and training, not on emotion and instinct which has led to many failed rescue attempts in the past. The prompt actions of the crew gave the OS every chance of survival.

2. Actions Taken

Following this accident, Stolt Tankers BV have taken the following actions:

Filter masks

Stolt Tankers BV have introduced an immediate and comprehensive ban on the use of filter masks on all company vessels .

Replacement equipment

The company has provided each ship with light weight breathing apparatus sets specifically designed for respiratory protection of the crew while handling toxic cargo on deck.

Where possible, the use of Wilden Pumps has been supplemented by the fitting of an eductor on deck.

Awareness Raising

Additional safety committee meetings have been held on all ships highlighting the circumstances of this accident and the lessons to be learned.

Training

Stolt Tankers BV use their investigation into this accident as a case study for training purposes at their "Officers and Crew Safety Excellence" conferences and in other company training courses.
