SEAFARERS TRAINING CENTER INC

ADVANCED TRAINING FOR CHEMICAL TANKER CARGO OPERATIONS

In compliance with the 1978 International Agreement on Standards of Training, Certification and Watch keeping for Seafarers Code (STCW as amended)

SCOPE

This course provides training for masters, chief engineer officers, chief mates, second engineer and any person with immediate responsibility for loading, care in transit, handling of cargo, tank cleaning or other cargo-related operation on chemical tankers. It comprises an advanced training programme appropriate to their duties on chemical tankers for their ability to imbibe a safety culture to perform and monitor all cargo operations, familiarity with properties of chemical cargoes, take precautions to prevent hazards, apply health and safety precautions, respond to emergencies, fire safety measures, take precautions to prevent pollution of the environment, and monitor and control compliance with legislative requirements. The course takes full account of section A-V/1-1, paragraph 3 of the STCW Code.

This training may be given on board or ashore. It can be supplemented by practical training on board or wherever possible on simulators in training institutions or in a suitable shore-based installation.

OBJECTIVE

The successfully completing the Advanced training in chemical tanker cargo operation course should therefore meet the training requirements in accordance with regulation V/1-1 of the STCW Convention, paragraph 6.3.

ENTRY STANDARDS

This course is open to any person who intends to have immediate responsibility for loading, unloading, care in transit, handling cargo, tank cleaning or other cargo-related operations on chemical tankers. It comprises seafarers who have qualified in accordance with regulation V/1-1, paragraph 6.1 of the STCW Convention.

COURSE CERTIFICATE

Upon successful completion of the course, the trainee should be issued a course completion document for “Advanced training for chemical tanker cargo operations”.

COURSE INTAKE LIMITATIONS

The number of trainees should not exceed 20 and practical training should be undertaken in small groups no more than eight.

STAFF REQUIREMENTS

The instructor shall have appropriate training in instructional techniques and training methods (section A/1/6, STCW Code). It is recommended that all training and instruction is given by qualified personnel experienced in the handling and characteristics of chemical cargoes and the safety procedures involved. Staff may be recruited among deck officers and engineer officers of chemical tankers, and/or fleet superintendents as appropriate.

TEACHING FACILITIES AND EQUIPMENT

Ordinary classroom facilities and the ability to project visual aids are sufficient for most of the course content. However, dedicated computer-based training (CBT) modules to be run on an ordinary PC as well as exercises on an operational, hands-on liquid cargo handling simulator, will greatly enhance the quality and result of the audiovisual equipment will be required if using audiovisual aids in the teaching programme.

The following equipment should be available:

1. Resuscitator
2. Breathing apparatus
3. Portable oxygen meter
4. Portable combustible-gas detector
5. Portable tankscope/multi-point flammable gas (infra-red gas analyser)
6. Portable toxic-gas detector and chemical absorption tubes
7. Portable multigas-detector
8. Personal multigas-detector
9. Tank evacuation equipment

Due to the relatively high cost of obtaining and maintaining items3 to 8 respective Administrations may approve the use of simulator-based equipment to replace some or all of the gas measuring equipment, provided that the raining and competency assessments can be thoroughly and accurately completed.

TEACHING AIDS

Other equivalent teaching aids may be used as deemed fit by the instructor.

- Instructor Manual (Part D of this course)
- Resuscitator

- Breathing apparatus
- Portable oxygen meter
- Portable combustible-gas detector
- Portable tankscope/multi-point flammable gas (infra-red gas analyser)
- Portable toxic-gas detector and chemical absorption tubes
- Portable multigas detector
- Tank evacuation equipment
- Audiovisual equipment for power point presentations
- Chemical tanker cargo and ballast water handling simulator
- White board
- Videos

IMO REFERENCES

References should be latest versions.

- International Convention for the Safety of Life at Sea, 1974 (SOLAS 1974) (IF110E)
- International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended (STCW Convention) (IC938E)
- International Convention for the Prevention of Pollution from Ships, 1973 (MARPOL Convention) (ID520E)
- Inert Gas Systems (IG Systems) (I104E)
- Medical First Aid Guide for Use in Accidents involving Dangerous Goods (MFAG) (II210E: see IMDG Code Supplement)
- International Safety Management Code (ISM Code) (IC117E)
- International Code for Fire Safety Systems (FSS Code) (IB155E)
- International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code) (ID100E)
- Model Course 1.01, Basic Training in Oil Chemical Tanker Cargo Operations (TB101E)

TIMETABLE
COURSE OUTLINE

Couse Outline Competence and subject matter	Total hours for Lecture	Total Hours for Practical
COMPETENCE 1: Ability to safety perform and monitor all cargo operations		
1. Knowledge of chemical tanker designs, systems and equipment		0.5
1.1 General arrangement and construction		0.5
1.2 Pumping arrangement and equipment		0.5
1.3 Tank construction and arrangement		0.5
1.4 Pipeline and drainage systems		0.5
1.5 Tank and cargo pipeline pressure and temperature control system and alarms		0.5
1.6 Gauging control systems and alarms		0.5
1.7 Gas-detection systems		0.5
1.8 Cargo heating and cooling systems		0.5
1.9 Tank cleaning systems		0.5
1.10 Cargo tank environmental control systems		0.5
1.11 Ballast systems		0.5
1.12 Cargo area venting and accommodation ventilation		0.5
1.13 Vapour return/recovery systems		0.5
1.14 Firefighting systems		0.5
1.15 Tank, pipeline and fittings' material and coating		0.5
1.16 Slop management		0.5
2. Knowledge of pump theory and characteristics, including types of cargo pumps and their safe operation	1.5	
3. Proficiency in tanker safety culture and implementation of safety management system	1.5	

4. Knowledge and understanding of monitoring and safety systems, including the emergency shutdown system	**1.5**	
5. Ability to perform cargo measurements and calculations	**1.5**	**1.5**
6. Knowledge of the effect of bulk liquid cargoes on trim and stability and structural integrity		**1.5**
7. Knowledge and understanding of chemical cargo-related operations		
7.1 Loading and unloading plans		**3**
7.2 Ballasting and deballasting		**1.5**
7.3 Tank cleaning operations/prewash operations		**1.5**
7.4 Tank atmosphere control		**0.5**
7.5 Inerting		**0.5**
7.6 Gas freeing		**0.5**
7.7 Ship-to-ship transfers	**0.5**	
7.8 Inhibition and stabilizations requirements	**0.5**	
7.9 Heating and cooling requirements and consequences to adjacent cargoes	**0.5**	
7.10 Cargo compatibility and segregation	**0.5**	
7.11 High-viscosity cargoes	**0.5**	
7.12 Cargo residue operations	**0.5**	
7.13 Operational tank entry	**0.5**	
8. Development and application of cargo-related operation plans, procedures and checklists		**1.5**
9. Ability to calibrate and use monitoring and gas-detection systems, instruments and equipment	**0.5**	**1**
10. Ability to manage and supervise personnel with cargo-related responsibilities	**1.5**	
COMPETENCE 2: Familiarity with physical and chemical properties of chemical cargoes		
11. Knowledge and understanding of the chemical and physical and the physical properties of noxious liquid substances		
11.1 Chemical cargoes categories(corrosive, toxic, flammable, explosive)	**0.5**	

11.2 Chemical groups and industrial usage 11.3 Reactivity of cargoes	0.5 0.5	
12. Understanding the information contained in a Safety Data Sheet		**1.5**
COMPETENCE 3: Take precautions to prevent hazards		
13. Knowledge and understanding of the hazards and control measures associated with chemical tanker cargo operations 13.1 Flammability and explosion 13.2 Toxicity 13.3 Health hazards 13.4 Inert gas composition 13.5 Electrostatic hazards 13.6 Reactivity 13.7 Corrosivity 13.8 Low-bowling-point cargoes 13.9 High-density cargoes 13.10 Solidifying cargoes 13.11 Polymerizing cargoes	**1** **0.5** **0.25** **0.5** **0.25** **0.25** **0.25** **0.25** **0.25** **0.5** **0.5**	
14. Knowledge and understanding of dangers of non-compliance with relevant rules/regulations	**1**	
COMPETENCE 4: Apply occupational health and safety precautions		
15. Knowledge and understanding of safe working practices, including risk assessment and personal shipboard safety relevant to chemical tankers 15.1 Precautions to be taken when entering enclosed spaces, including correct use of different types of breathing apparatus 15.2 Precautions to be taken before and during repair and maintenance work 15.3 Precautions for hot and cold work	**1** **0.5** **0.5**	

15.4 Precautions for electrical safety 15.5 Use of appropriate Personal Protective Equipment (PPE)	**0.5** **0.5**	
COMPETENCE 5: Respond to emergencies		
16. Knowledge and understanding of chemical tanker emergency procedures 16.1 Ship emergency response plans 16.2 Cargo operations emergency shutdown 16.3 Actions to be taken in the event of failure of systems or services essential to cargo 16.4 Firefighting on chemical tankers 16.5 Enclosed space rescue 16.6 Cargo reactivity 16.7 Jettisoning cargo 16.8 Use of a Safety Data Sheet (SDS)	**0.25** **0.25** **0.25** **0.25** **0.25** **0.25** **0.5** **0.5**	
17. Actions to be taken following collision, grounding or spillage	**0.5**	
18. Knowledge of medical first aid procedures on board chemical tankers, with reference to the Medical First Aid Guide for Use in Accidents involving Dangerous Goods (MFAG)	**3**	
COMPETENCE 6: Take precautions to prevent pollution of the environment		
19. Understanding of procedures to prevent pollution of the atmosphere and the environment	**1.5**	
COMPETENCE 7: Monitor and control compliance with legislative requirements		
20. Knowledge and understanding of relevant provisions of the International Convention for the Prevention of Pollution from Ships (MARPL) and other relevant IMO instruments, industry guidelines and port regulations as commonly applied	**1.5**	

21. Proficiency in the use of the IBC Code and related documents	**3**	
22. Case studies	**3**	
23. Test and discussion	**1.5**	
Subtotals	**39.5**	**20.5**
Total	**60**	

COURSE TIMETABLE

Day 1	**1. Knowledge of chemical tanker designs, systems and equipment** 1.1 General arrangement and construction 1.2 Pumping arrangement and equipment 1.3 Tank construction and arrangement 1.4 Pipeline and drainage systems 1.5 Tank and cargo pipeline pressure and temperature control system and alarms 1.6 Gauging control systems and alarms 1.7 Gas-detection systems 1.8 Cargo heating and cooling systems 1.9 Tank cleaning systems 1.10 Cargo tank environmental control systems 1.11 Ballast systems 1.12 Cargo area venting and accommodation ventilation

Day 2	1.13 Vapour return/recovery systems 1.14 Firefighting systems 1.15 Tank, pipeline and fittings' material and coating 1.16 Slop management **13.Knowledge and understanding of the hazards and control measures associated with chemical tanker cargo operations** 13.1 Flammability and explosion 13.2 Toxicity 13.3 Health hazards 13.4 Inert gas composition 13.5 Electrostatic hazards 13.6 Reactivity 13.7 Corrosivity 13.8 Low-bowling-point cargoes 13.9 High-density cargoes 13.10Solidifying cargoes 13.11Polymerizing cargoes
Day 3	**11. Knowledge and understanding of the chemical and the physical properties of noxious liquid substances** 11.1 Chemical cargoes categories (corrosive, toxic, flammable, explosive) 11.2 Chemical groups and industrial usage **12. Understanding the information contained in a Safety Data Sheet (SDS)** **2. Knowledge of pump theory and characteristics, including types of cargo pumps and their safe operation** **3. Proficiency in tank safety culture and implementation of safety management system**
Day 4	**4. Knowledge and understanding of monitoring and safety systems, including the emergency shutdown system** **7. Knowledge and understanding of chemical cargo-related operations** 7.1 Loading and unloading plans 7.2 Ballasting and deballasting

Day 5	7.3 Tank cleaning operations/prewash operations 7.4 Tank atmosphere control 7.5 Inerting 7.6 Gas freeing 7.7 Ship-to-ship transfers 7.8 Inhibition and stabilization requirements 7.9 Heating and cooling requirements and consequences to adjacent cargoes 7.10 Cargo compatibility and segregation 7.11 High-viscosity cargoes 7.12 Cargo residue operations 7.13 Operational tank entry
Day 6	**14. Knowledge and understanding of dangers of non-compliance with relevant rules/regulations** **8. Development and application of cargo-related operation plans, procedures and checklists** **9. Ability to calibrate and use monitoring and gas-detection systems, instruments and equipment** **10. Ability to manage and supervise personnel with cargo-related responsibilities**
Day 7	**5. Ability to perform cargo measurements and calculations** **6. Knowledge of the effect of bulk liquid cargoes on trim and stability and structural integrity** **15. Knowledge and understanding of safe working practices, including risk assessment and personal shipboard safety relevant to chemical tankers** 15.1 Precautions to be taken when entering enclosed spaces including correct use of different types of breathing apparatus 15.2 Precautions to be taken before and during repair and maintenance work
Day 8	15.3 Precautions for hot and cold work 15.4 Precautions for electrical safety

	15.5 Use of appropriate Persona Protective Equipment (PPE) **16. Knowledge and understanding of chemical tankers emergency procedures** 16.1 Ship emergency response plans 16.2 Cargo operations emergency shutdown 16.3 Actions to be taken in the event of failure of systems or services essential to cargo 16.4 Firefighting on chemical tankers 16.5 Enclosed space rescue 16.6 Cargo reactivity 16.7 Jettisoning cargo 16.8 Use of a Safety Data Sheet (SDS) **17. Actions to be taken following collision, grounding or spillage** **18. Knowledge of medical first aid procedures on board chemical tankers, with reference to the Medical First Aid Guide for use in Accidents involving Dangerous Goods (MFAG)**
Day 9	**18. Knowledge of medical first aid procedures on board chemical tankers, with reference to the Medical First Aid Guide for use in Accidents involving Dangerous Goods (MFAG) (continuation)** **19. Understanding of procedures to prevent pollution of the atmosphere and the environment** **20. Knowledge and understanding of relevant provisions of the International Convention for the Prevention of Pollution from Ships (MARPOL) and other relevant IMO instruments, industry guidelines and port regulations as commonly applied** **21. Proficiency in the use of the IBC Code and related documents**
Day 10	**21. Proficiency in the use of the IBC Code and related documents (continuation)** **22. Case studies** **23. Test and discussion**

COMPETENCE 1: Ability to safety perform and monitor all cargo operations

1. Knowledge of chemical tanker designs, systems and equipment

1.1 General arrangement and construction

Tankers have been one of the oldest types of merchant ships; the need for these vessels arising due to heterogeneous distribution of natural oil reserves and liquid chemicals around the globe. The most common types of tankers operating at sea are oil tankers. While it may seem that oil tankers generally carry oil, the fact has quite more to it, if understood in detail. Which brings us to the need to understand that since there are different grades of oil (depending on the levels of purification), oil tankers have been designed separately and specifically to carry different oil types.

It is important to have a brief look into the history of oil tankers, especially to understand the dynamics of the oil market and relate its influence on the sizes of oil tankers used in different eras. The size of oil tankers had seen a rapid increase in the mid-seventies due to abundance in oil trade, and as a result, for the first time, tankers of deadweight in the ranges of 100000-200000 lakh metric tons were constructed in Japan to be able to carry more quantity of oil in a single voyage, and hence reduce the freight costs for more profits. But in the late nineties, due to the skyrocketing of oil prices, the quantity of oil being traded by sea had considerably reduced, hence almost putting an end to building of ULCC (Ultra Large Crude Carrier) and VLCC (Very Large Crude Carrier).

Machinery spaces shall be positioned aft of cargo tanks and slop tanks; they shall also be situated aft of cargo pump rooms and cofferdams, but not necessarily aft of the oil fuel bunker tanks. Any machinery space shall be isolated from cargo tanks and slop tanks by cofferdams, cargo pump rooms, oil fuel bunker tanks or ballast tanks. Pump-rooms containing pumps and their accessories for ballasting those spaces situated adjacent to cargo tanks and slop tanks and pumps for oil fuel transfer shall be considered as equivalent to a cargo pump-room within the context of this regulation, provided that such pump-rooms have the same safety standard as that required for cargo pump-rooms.

Accommodation spaces, main cargo control stations, control stations and service spaces (excluding isolated cargo handling gear lockers) shall be positioned aft of all cargo tanks, slop tanks, and spaces which isolate cargo or slop tanks from machinery spaces but not necessarily aft of the oil fuel bunker tanks and ballast tanks, but shall be arranged in such a way that a single failure of a deck or bulkhead shall not permit the entry of gas or fumes from the cargo tanks into an accommodation space, main cargo control stations, control station, or service spaces.

The slop tanks shall be surrounded by cofferdams except where the boundaries of the slop tanks, where slop may be carried on dry cargo voyages, are the hull, main cargo deck, cargo pump-room bulkhead or oil fuel bunker tank. These cofferdams shall not be open to a double bottom, pipe tunnel, pump room or other enclosed space. Means shall be provided for filling the cofferdams with water and for draining them. Where the boundary of a slop tank is the cargo pump-room bulkhead, the pump-room shall not be open to the double bottom, pipe tunnel or other enclosed space; however, openings provided with gastight bolted covers may be permitted.

Where the fitting of a **navigation position** above the cargo area is shown to be necessary, it shall be for navigation purposes only and it shall be separated from the cargo tank deck by means of an open space with a height of at least 2 m.

Deck spills shall be provided to keep away from the accommodation and service areas. This may be accomplished by provision of a permanent continuous coaming of a suitable height extending from side to side. Special consideration shall be given to the arrangements associated with stembow loading.

Exterior **boundaries of superstructures and deckhouses enclosing accommodation and including any overhanging decks**, which support such accommodation, shall be insulated to "A-60" standard for the whole of the portions which face the cargo area and on the outward sides for a distance of 3 m from the end boundary facing the cargo area. In the case of the sides of those superstructures and deckhouses, such insulation shall be carried as high as is deemed necessary.

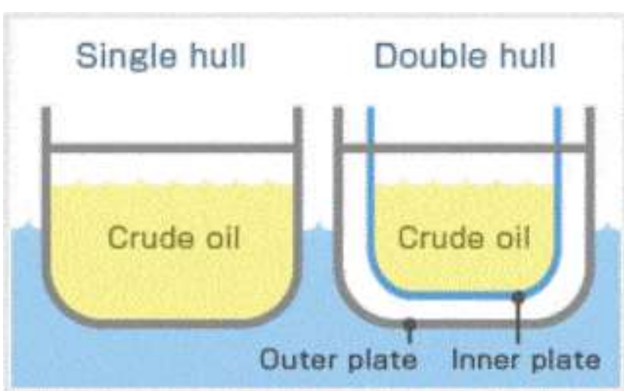
Access doors, air inlets and openings to accommodation spaces, service spaces, control stations and machinery spaces shall not face the cargo area. They shall be located on the transverse bulkhead not facing the cargo area or on the outboard side of the superstructure or deckhouse at a distance of at least 4% of the length of the ship but not less than 3 m from the end of the superstructure or deckhouse facing the cargo area. This distance need not exceed 5 m.

Windows and sidescuttles facing the cargo area and on the sides of the superstructures and deckhouses within the limits specified in paragraph above shall be of the fixed (non-opening) type. Such windows and sidescuttles in the first tier on the main deck shall be fitted with inside covers of steel or other equivalent material.

Single Hull Vs Double Hull Tankers

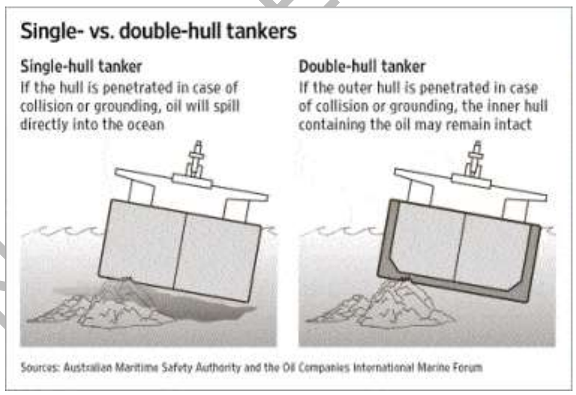
Double hull, as the name suggests, are tanker ship hulls with double layers of watertight hull surface. The inner and outer layers of the hull are on the bottom as well as the sides of the tanker ships. The double layer construction helps in reducing the risks of marine pollution during collision, grounding, and any other form of ship's hull damage.

Single hull have only one outer watertight layer which runs throughout the structure of the tanker ship. As a result of only one layer, single hull tankers pose a greater threat to marine environment during any kind of accidents.



The International Maritime Organisation (IMO) introduced the regulation 13 F of Annex 1 of MARPOL, which effectively mandated double hulls for new built oil tankers of 5000 dead weight tonnage and above. The Exxon Valdez oil spill disaster also led U.S. Government to make double hulls compulsory for all new tanker ships coming to the U.S. ports. After the sinking of Erika off the coast of France in December 1999, IMO proposed accelerating phase out of single hull ships. Single Hull Tankers Phase-out time table can be found here.

In double hull tankers, the space between the two layers is used as dedicated ballast tanks for ensuring ship's stability.



The ballast spaces extend for the full length of the cargo carrying area, providing an extensive safety measure. Single hull tankers do not have such ballast spaces.

In comparison to single hull design, double hull design is said to have less stability as it raises the centre of gravity and reduces the meta-centric height of the ship. Moreover, there is a risk of loss of stability because of free surface effects in cargo and ballast tanks. Single hull ships are considered more stable as compared to double hull tankers.

Corrosion is considered one of the main reasons for failure of hull structures in tankers. Improper maintenance of ballast tank structures and failure to maintain the integrity of protective coating and cathodic protection in ballast tanks have lead to structural failure in the past. In double hull tankers, the surface area of the tanks is more than double than that of single hull tanks. Thus they require more maintenance during the operating life.

As compared to the ballast tanks of single hull ships, those of the double bottom tanks are easily accessible because of their increased height and width. This makes the work during inspection much easier. However proper precautions must be taken into consideration while entering confined spaces of ballast tanks. Structures of ballast spaces in double hull tankers are more susceptible to hull fractures and minor failures as compared to single hull tankers. Double hull tanker operators have often complained about cargo leakage into ballast tanks as a result of stress concentration, fatigue, or construction defects.

Tanker ships with single hull design often faced problems of leakage of ballast water into cargo from ballast water pipes passing through cargo tanks. This problem also increased the risks of pollution during ballasting and de-ballasting from single hull tankers as leaking pipes passing through cargo tanks can contaminate the clean ballast water. The double hull design removed this problem with different piping systems passing through only the respective tanks.

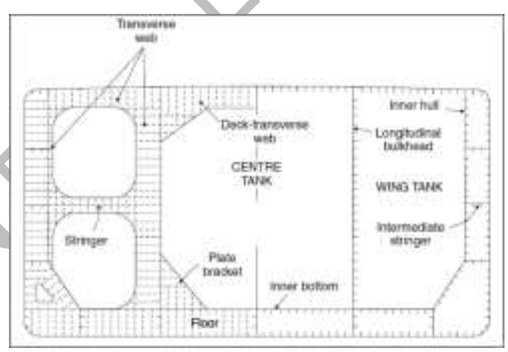
The surface area of ballast tanks is higher in double hull ships as compared to that of single hull. This is because of longer and narrower double bottom tanks which increases the surface area two to three times as compared to single hull tanks. However the design of the double hull ships makes the access to the confined spaces of the tanks more difficult as compared to the spacious ballast tanks of single hull ships.

According to a research, stresses in the structure of double hull ships are much higher than that in single hull ships.

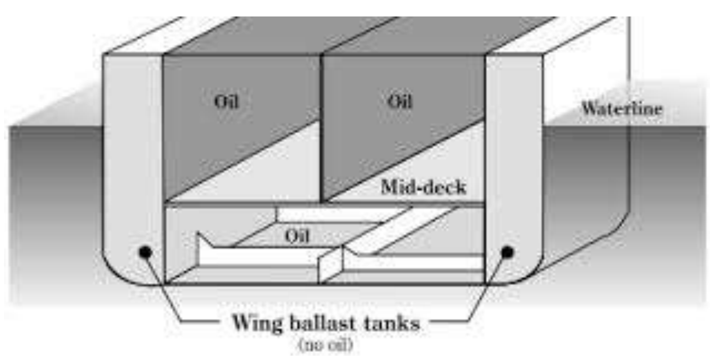
Thus double hull ships are more susceptible to minor structural failures as compared to the single hull tankers. This can also be a matter of concern during accidents which cause oil spill as a result of structural failure.

Ventilation is of utmost importance in double bottom tanks of double hull tankers as they need inspection from time to time. As double bottom tanks are free from any internal structure, it is easy to access them. However, they are not so friendly when it comes to close-up inspection, or accessing side tanks or deck head areas; whereas though tanks of single hull are difficulty to access, their confined areas much more inspection friendly.

Midship section of a double hull tanker



Midship section of a Mid-Deck Tanker



The major purposes of ballasting a vessel for a voyage are to increase its manageability (and safety), particularly under heavy weather conditions; control its draft and trim for maximum efficiency; and control its stability to ensure safe passage.

Ships must be deep enough in the water to ensure safe passage, particularly in heavy weather. If the bow of the ship is not deep enough, the ship's forefoot (the area under the bow) will emerge periodically from the water surface. This leads to slamming—or heavy impact—of the hull when the bow hits the water with a high velocity on re-entry. Excessive slamming can lead to hull structural damage or even to hull failure and ship loss in extreme conditions. In heavy weather conditions, the ship's master usually chooses to decrease speed, which reduces the rate of occurrence and severity of slamming. Deeper drafts forward will generally reduce the tendency for the ship to slam. Typically, ships ballast to a light-ballast draft in normal weather, then ballast to a deep-ballast draft in heavy weather.

Efficient propeller operation usually requires the propeller to be immersed, even in calm water conditions. Thus, if the stern is not deep enough, ballast may be needed to trim the vessel. Further, if the stern draft is not sufficient in rougher sea conditions, the ship's propeller will race (i.e., increase its revolutions per minute) when it emerges from the water and will slow down when it re-enters the water. This causes engine control problems and increased loading on the propeller shafting and machinery. Increasing stern drafts reduces the tendency for the propeller to emerge and, thus, reduces racing. Designs typically seek to achieve a stern draft in heavy ballast of about 80 percent of the load draft.

Segregated ballast tanks. These are tanks which must be provided on board crude oil tankers after the MARPOL 1973/1978 Convention entered into force in 1983.

Cargo oil and ballast must be segregated to prevent pollution. Segregated ballast is ballast water that is introduced into a tank which is completely separated from the cargo oil and oil fuel system and which is permanently allocated to the carriage of ballast or to the carriage of ballast or cargoes other than oil or noxious liquid substances.

The MARPOL convention, in 1983, introduced a number of radical new concepts, such as a requirement for new oil tankers to be fitted with segregated ballast tanks, so as to obviate the need to carry ballast water in cargo tanks. This was superseded by the requirement for oil tankers delivered from 1996 onwards to be fitted with a double hull. The protection of the marine environment was thus greatly enhanced.

Clean ballast Tank means the ballast in a tank which since oil was last carried therein, has been so cleaned that effluent there form if it were discharged from a ship which is stationary into clean calm water on a clear day would not produce visible farces of oil on the surface of the water or on the adjoining shore Line.

Both SBT and CBT have advantages and disadvantages. The principal advantage of this tanks is to contribute with the protection of the marine environment. And their principal disadvantage is that the tanker loses cargo capacity. The cost to retrofit CBT is less than the cost to retrofit SBT, however CBT require more port time than the SBT.

Crude oil washing COW is a system of cleaning cargo tanks using the dissolving action of crude oil to reduce clingage and sludge. Crude oil washing eliminates or reduces water washing, and thereby reduces operational oil pollution.

As per MARPOL annex 1, regulation 19, **Slop tanks** are the focal point of the Load-On-Top system used on crude oil tankers to prevent pollution of the sea. Design of these tanks and their operating procedures strongly affect the degree of oil-water separation achieved.

Every oil tankers shall be provided with slop tank arrangements in accordance with the requirements of this regulation. In oil tankers any cargo tank may be as a slop tank.

An ore-bulk-oil carrier, also known as **combination carrier or OBO**, is a ship designed to be capable of carrying wet or dry cargoes. The idea is to reduce the number of empty (ballast) voyages, in which large ships only carry a cargo one way and return empty for another. These are a feature of the larger bulk trades. OBO-carriers are today not as common as they were in the 1970-1980s.

Oil tankers aged 5 years and over are object to an enhanced survey programme. This enhance surveys are known as Intermediate Survey.

The Intermediate Survey is to be held at or between either the 2nd or 3rd Annual Survey. Those items which are additional to the requirements of the Annual Surveys may be surveyed either at or between the 2nd and 3rd Annual Survey. Concurrent crediting to both Intermediate Survey (IS) and Special

Survey (SS) for surveys and thickness measurements of spaces are not acceptable. The survey extent is dependent on the age of the vessel.

For weather decks, an examination as far as applicable of cargo, crude oil washing, bunker, ballast, steam and vent piping systems as well as vent masts and headers is to be carried out. If upon examination there is any doubt as to the condition of the piping, the piping may be required to be pressure tested, thickness measured or both.

Oil Tankers 5 – 10 Years of Age, the following is to apply:

- All Ballast Tanks are to be examined. When considered necessary by the surveyor, thickness measurement and testing are to be carried out to ensure that the structural integrity remains effective.
- Ballast Tank is to be examined at subsequent annual intervals where:
  - a hard protective coating has not been applied from the time of construction, or
  - a soft or semi-hard coating has been applied, or
  - substantial corrosion is found within the tank, or
  - the hard protective coating is found to be in less than GOOD condition and the hard protective coating is not repaired to the satisfaction of the Surveyor.

1.2 Pumping arrangement and equipment

Cargo pumps are provided in chemical tankers to load and discharge cargo, and also to ballast some of the tanks which becomes necessary when making voyages in the unloaded condition. Many modern chemical tankers have clean ballast capacity and these tanks are served by a separate pumping system. The particular cargo pumping system adopted depends very much on the range of cargo carried. A fairly straightforward system is available for the larger bulk oil carrier, carrying a single product. Where smaller tankers carry a number of oil products at one time, which must be kept separate, the pumping system is more complex.

Single Product – Crude Oil Carrier

Where a single oil product is carried, and where larger tankers are designed solely to carry crude oil, a single pump room is fitted aft, adjacent to the machinery spaces. The piping system is of the 'direct line' type, three or four lines being provided, each with suctions from a group of tanks. Each pump discharge is led up to the deck mains which run forward to the transverse loading and discharging connections.

A few large chemical tankers have a discharge system which relies on hydraulically controlled sluice valves in the tank bulkheads. These permit a flow of the oil to a common suction in the after tank space.

Many large tankers partially adopt this system, sluice valves being provided in the longitudinal bulk-heads, and the oil is allowed to find its way from the wing tanks to the center tanks. Suctions from the main cargo lines are located in the center tanks. Such an arrangement is shown in figure below, which also indicates the separate stripping system, and clean ballast lines.

Multi-Products Tankers

Where a number of oil products are carried, the more complex pumping arrangements require two and in some cases three pump rooms to be fitted. One may be fitted aft adjacent to the machinery space, a second amidships, and where a third pump room is pro- vided this is forward. On many older tankers the piping was often arranged on the 'ring main' system to provide flexibility of pumping conditions. To obtain the optimum number of different pumping combinations in modern multi-product carriers the tanks may be fitted with individual suction lines.

1.3 Tank construction and arrangement

A chemical tanker is a type of tanker ship designed to transport chemicals in bulk. As defined in MARPOL Annex II, 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.[1] 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 tones 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.

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.

Classification of Chemical Tankers

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

- **Type 1 -** is a chemical tanker intended to transport Chapter 17 of the IBC Code products with very severe environmental and safety hazards which require maximum preventive measures to preclude an escape of such cargo.
- **Type 2 -** is a chemical tanker intended to transport Chapter 17 of the IBC Code products with appreciably severe environmental and safety hazards which require significant preventive measures to preclude an escape of such cargo.
- **Type 3** - is a chemical tanker intended to transport Chapter 17 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. Most chemical tankers are IMO 2 and 3 rated, since the volume of IMO 1 cargoes is very limited.

1.4 Pipeline and drainage systems

There are three basic types of pipeline systems:

1. Direct Line System

This system permits 2 or 3 grades to be carried and is suitable for VLCCs as it facilitates quick loading and discharging. The arrangement is simple with lines leading directly to the tanks. Due to the straight lengths of the pipeline, there is better suction and less loss of pressure due to friction. Fewer bends and valves mean less erosion and leaks, reducing the maintenance required. The time spent in line washing is also reduced; however through washing of the line is not possible unless the washings are flushed into the tank and discharged from there. Due to their being fewer valves, leaks are difficult to control and may grades cannot be carried as the required line and valve segregation is not provided.

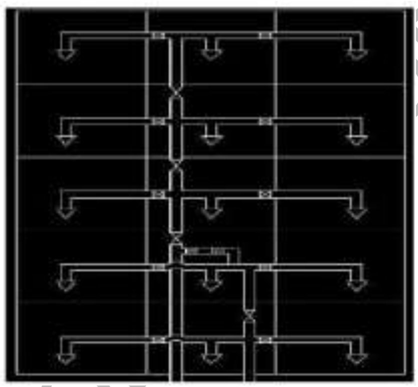
Advantages:

- Quick loading & discharging.
- Short pipe line.
- Less bend.
- Less loss of pressure due to pipe line friction.
- Direct line to provide better suction.
- Time of washing the line is short.
- System is cheaper than the other system.
- Leak is minimized.
- Easy to operate so less training is required.

- It is easy to separate each cargo.

Disadvantages:

- In case of leaking the control of leakage is difficult.
- This system is very inflexible.



2. Ring Main System

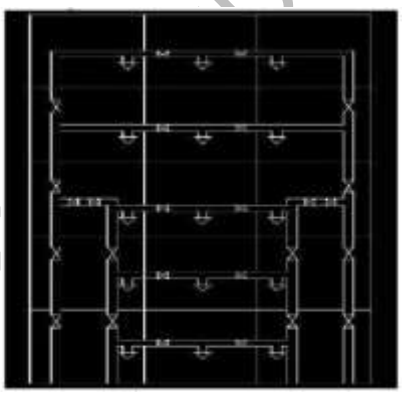
The system is ideal for product carriers where several different products are to be carried simultaneously in the different tanks. From the figure it will be noticed that any pump can be connected to discharge any tank, making it every versatile. Cargo may have to be pumped in a round about route but the required two valves segregation between products can always be met. Line washing can be carried out thoroughly without flushing into the tanks. But it takes a longer time due to the number of bends, joints and valves. Due to this the pumping rate is also affected and leaks due to erosion become common as the ship becomes older. The initial cost of fitting this system is higher.

Advantage:

- In this system any tank can be discharged by any pump. Thus different grade of the cargo can be loaded.

Disadvantages:

- It is expensive to build due to the extra length of the piping required.
- Extra bend is required. Thus decreasing in rate.
- Risk of leakage from radius of bend exists.



3. Free Flow System

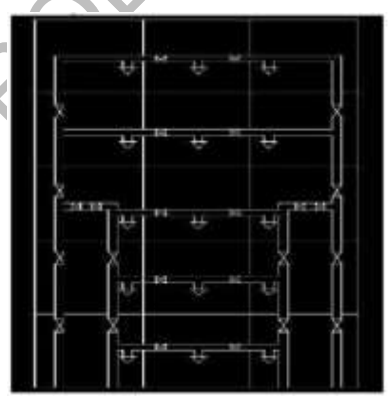
This system is mainly used on large crude carriers which carry only one grade of cargo which is required to be discharged quickly. Large gate valves built into the bulk heads of the tanks allow the oil to flow from the side tanks to the center tanks, from where the stern trim of the vessel causes the oil to flow to the aftermost tank, where the suctions of the main cargo pumps are situated. The large bulk heads sluice valves permit a good drainage of the cargo. Any residues are discharged by the stripping pumps.

Advantages:

- Main pipe line is not used for discharge.
- Less pipe line.
- Less bend.
- Less friction & more pressure cause very high discharge.

Disadvantages:

- Is not flexible.
- One grade is dischargeable if more risk of contamination exists.
- Risk of overflow exists if level of all tank doses not carefully monitoring.

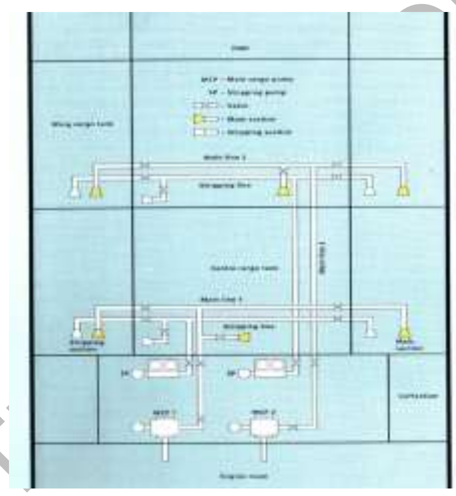


Stripping Cargo

The strategy employed in completing the discharge of cargo will determine, to a large degree, the impression the charterer and the facility will have of the ship's performance. A carefully planned and competently completed tank stripping (draining), operation will ensure a minimum discharge time and maximum cargo outturn. A full knowledge of the characteristics of the cargo and the capabilities of the ship's pumping systems are essential to achieve maximum outturn with minimum time in berth.

Types of stripping systems

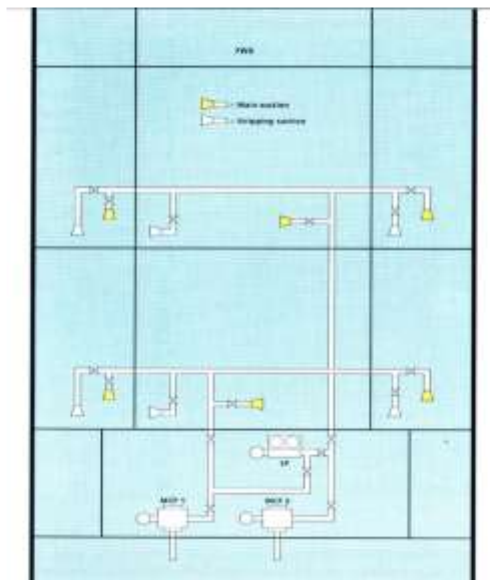
A tanker may have a stripping system made up of independent suction piping, or it may have alternative stripping suction outlets from the main cargo lines.



Simplified diagram of suction piping with an independent stripping system

The first alternative is the most versatile and permits the earliest stripping of tanks after they have been emptied as far as possible by the main cargo pumps. To use a stripping system off the main cargo lines, the main pumps must be either finished their work or stopped. This will tend to delay the discharge.

Stripping suction valves in tanks should be 'globe/check' valves, a special type of valve which acts as a non-return valve when opened only a few turns, but permits full flow when fully opened. These valves are opened fully when stripping begins, then closed to the check position as the tank becomes nearly empty.

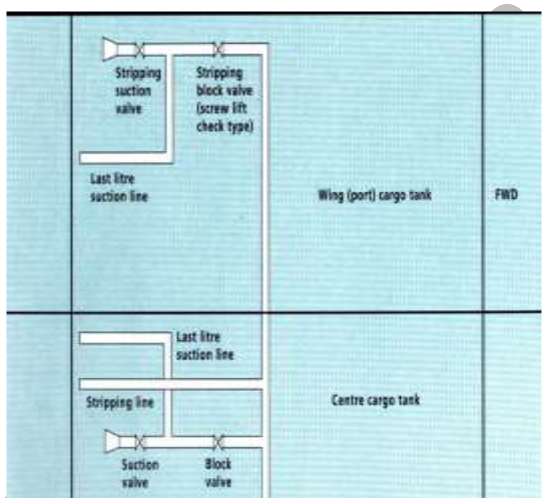


Simplified diagram of suction piping with main and stripping lines combined

Some stripping systems are fitted with 'last litre' (or 'last gallon') suctions, small diameter suction lines connected between the stripping suction valves and a stripping suction block valve. When the tank appears to be empty, the stripping suction valve is closed, leaving the block valve open. The pump then draws through the 'last litre' line suction located in the very corner of the tank a few millimetres above the tank bottom.

Either type of stripping system will normally have two stripping pumps in the pump room, arranged so that they can be used simultaneously and separately on different groups of tanks.

The stripping discharge piping will include lines to the midship manifold, to the slop tank(s) and possibly to an aft cargo tank which can be used for a stripping accumulation tank. There may also be a stripping overboard discharge line. The overboard valve(s) must be verified to be fully closed and sealed before the stripping pumps are started.

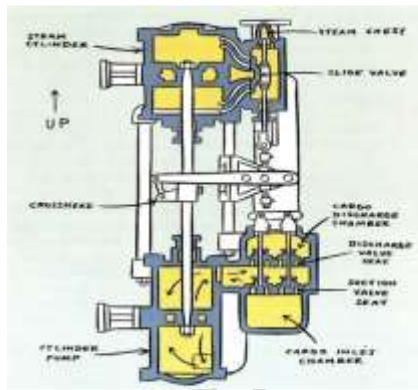


'Last-litre' stripping line used for maximum recovery on product tankers

Stripping pumps

Most stripping pumps are based on an operating principle called 'positive displacement'. The oil which enters the pump is mechanically moved from the suction side to the discharge side. This action creates a vacuum at the suction side of the pump, enabling the pump to 'lift' cargo from the tank into its pumping chambers.

The typical positive displacement pump is a reciprocating pump, normally of duplex (two pumping chambers), double-acting design. The internal mechanism is designed so that the cargo piston pumps on both the upstroke and the downstroke. The key components to the proper function of reciprocating pumps is the condition of the internal cargo valves. These should be examined regularly to ensure that their springs and seating arrangements are in good order.



Duplex reciprocating pump.

Reciprocating pumps are steam powered. To reduce the hazard from hot steam lines in the pump room, the lines must be completely and tightly insulated to prevent vaporization or ignition of any cargo leaks which could spray or flow onto them.

A second type of stripping pump is a rotary or gear pump. These usually consist of two meshing gears which move the cargo between the pump casing and the gear teeth as the gears are rotated. These pumps are usually powered by an electric motor. They are very efficient and particularly suited for pumping high viscosity oils, such as lubricating oils or molasses.

A third method of stripping tanks does not use a pump at all, but a device called an eductor. The eductor obtains its vacuum or 'lift' by use of a drive fluid, normally the stream of cargo from the main cargo pump discharge. The principal advantage of the eductor is that it cannot lose suction or be damaged by being run dry. The disadvantage is that once the main cargo pump is stopped, there is no drive fluid available and no further stripping is possible.

High-pour cargo

Effective stripping of high-pour-point cargo begins with achieving the correct cargo discharging temperature. The cargo must be heated to and maintained at the recommended discharge temperature until the cargo surface reaches the level of the heating coils. (Steam to the heating coils must be shut off just before they are exposed by the receding cargo.)

Tanks must be discharged systematically, so that a stripping pump is immediately available when the tank is at minimum main cargo pump level. It is usually desirable to line up and start the stripping pump before the main cargo pump is switched from the tank, so that the stripping pump is already working when the tank reaches the stripping level. Each tank should be stripped as dry as possible, then re-stripped two or three times at thirty minute intervals.

If the shore requests a discharge stop before stripping is complete, protest the delay, indicating that it will increase the vessel's ROB. If the stop is essential, the best course is to begin stripping to an accumulation tank. If sufficient strippings can be accumulated to cover the heating coils in the accumulation tank, cargo heating can be resumed. After all tanks have been stripped, recirculate cargo via the deck discharge line and loading drop to prevent line blockage until discharge ashore can be resumed.

It is particularly important to arrange for effective COWing of waxy crude oils so that the tank bottom wash occurs as soon as possible. If this is not done, the formation of wax in the cooling oil will block the limber holes, preventing the flow of cargo to the tank suction inlet.

If the best efforts of the stripping program do not prevent heavy clingage of un-pumpable ROB, then the only recourse is to back-load 500 to 1000 tonnes of light crude oil or light gas oil into the slop tank and closed cycle COW with this wash oil until the ROB/ clingage has been reduced to an acceptable level. After washing, the slop tank is measured to determine the gain from COWing and then discharged ashore.

After completion of high-pour cargo discharge, immediately circulate hot water (74 ºC), through all deck lines, pumps and risers, stripping all water and residue to the slop tank.

Stripping high vapour pressure cargoes

Stripping high vapour pressure cargo requires pumps that are in good mechanical condition and are carefully operated. Pumps should be operated at slow to moderate speed; else the rapid piston action of the reciprocating pumps will tend to 'flash' the cargo in the cylinder, forming vapour or gas. The vapour or gas reduces the effectiveness of the pump and may cause it to lose suction entirely be becoming vapour bound. It is particularly important to keep enough cargo in one tank for priming the pumps when stripping high vapour pressure cargo.

Keep stripping pumps separated; making their suction lines common increases the tendency to become vapour bound. The discharge valve of the pump may be closed slightly to provide additional back pressure to improve pump performance.

Increasing the inert gas pressure in the tanks being stripped will increase the effective positive suction head in the tank and reduce the tendency to cargo vaporization, however if COWing is being performed it will add additional pressure to the tank, which could cause the pressure relief valve to lift.

Accumulation tank

Cargo tanks can be stripped most efficiently when the ship is discharging a single cargo. As the tanks are emptied by the main cargo pumps, they can be stripped to an accumulation tank, which in turn can be discharged with the higher capacity (centrifugal) main cargo pump. When stripping to an accumulation tank, it is important that the tank be discharged to between 1/2 and 2/3 of total depth before stripping begins. This provides space to receive strippings.

The ullage of the accumulation tank must be carefully monitored to avoid an overflow. One method of avoiding this is to slightly open the accumulation tank main suction valve to an active cargo pump. This will keep the tank at about the same level while stripping and will help to keep the main cargo pump primed.

Shore back-pressure

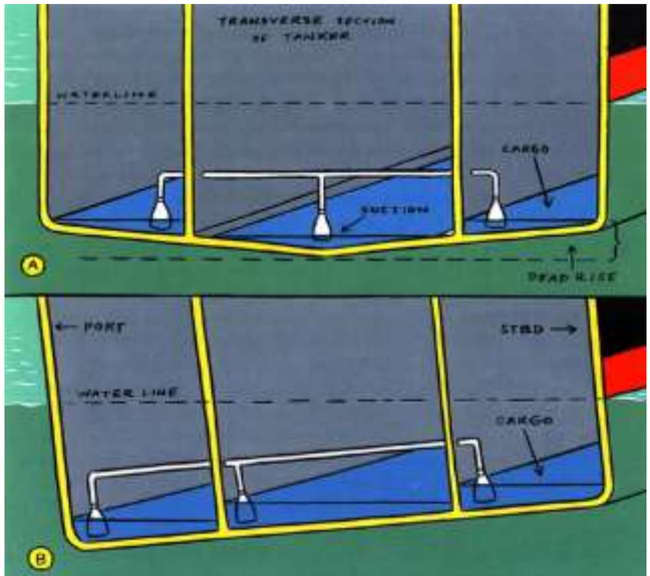
Shore back-pressure is occasionally so high that it is very difficult or impossible for the stripping pumps to move the final cargo residues ashore. Port Jefferson, New York is a good example of this. The 60 psi of shore back-pressure there can only be overcome by stripping pumps in top condition.

To overcome high shore back-pressure, the best recourse is to use a stripping accumulation tank on board to receive all of the tank strippings and all of the pipeline drainings except for one discharge line. The accumulation tank should be at least 14 filled when finished. If necessary, stop the discharge with the main cargo pump to retain that amount of cargo. (Remember that outturn is more important than turnaround time!)

When all strippings have been accumulated, start the main cargo pump on the last tank, discharging via a single cargo line to shore. Monitor the MCP performance carefully, reducing its speed and adjusting the pump discharge valve to maintain suction and discharge pressure as long as possible. When the MCP loses suction, the stripping pump can attempt to strip the remaining cargo in the accumulation tank ashore, followed by the remaining cargo pipeline(s) stripped ashore via the small-bore MARPOL discharge line.

Other stripping considerations

Stripping operations will be more successful if the ship is properly trimmed and listed. The largest trim aft, acceptable within the vessel's stress limitations, will provide the best draining of tanks. On a 240 meter vessel, four meters of trim aft represents *only one degree* of slope to aid the flow of cargo to the suctions. One degree is, not much! More trim provides better draining! The ship should be listed to port or starboard, or trimmed with no list depending on the location of the tank suctions.



A Tanker with deadrise - ranks are stripped with no list on the ship.

B Tanker without deadrise - port list required for effective stripping. Stripping suction location depends on hottom design and desired list (port and starboard) for best cargo recovery.

In some ships the tank suctions are located in the aft, port corner of each cargo tank. It is important that these ships be listed to port when stripping to achieve the best drainage. Other ships have the stripping suctions in the inboard corners of the wing tanks and at the center of the center cargo tanks. These ships must have zero list for best stripping. The cargo watch officer must know the suction locations in the tanks and the chief officer should include stripping trim instructions in the discharging orders. If a list is required for stripping, the aft wing tanks should be retained to provide it. At the same time, the tanks can perform additional service as pump priming tanks. Record the amount of stern trim in the logbook every two hours while stripping.

Automatic ullage tape floats will tend to stick to the bottom of the tank after discharging heavy or viscous cargo. Have the pump man roll up and secure the tapes immediately after stripping is completed.

The pulsating discharge pressure of reciprocating pump can occasionally set up a harmonic oscillation in cargo transfer arms. The deck watch should be instructed to watch for this and to advise the cargo watch officer if it begins. The oscillation can normally be stopped by reducing the speed of the stripping pump.

If stripping with an eductor system, use the smallest tank possible to provide drive fluid for the eductor during the final stripping. This final tank will have to be drained with the main cargo pump, making complete draining unlikely. A No.l wing tank makes a good choice. With the ship trimmed aft, it will have a good elevation above the pump and the small bottom section of the wedge-shaped wing tank will have the least volume/depth ratio of all tanks on the ship, leaving the least cargo on board when the MCP loses suction.
If a charterer or terminal representative is on board, he should be encouraged (or challenged), to witness and confirm that the stripping operation was thorough and successful. This will, at the least, put to the test his commitment and the authority of his position. It may avoid the difficulties of proving effective stripping efforts and results to the independent inspector at the final survey. Independent inspectors will rarely undertake any form of initial survey (inspection before completion of discharge), on behalf of their clients.

Stripping deepwell pumps

A well maintained and properly operated deepwell pump will drain a cargo tank almost as dry as a reciprocating stripping pump. At the end of the discharge there may remain a small amount of cargo in the tank and the pump well will be full, or partially full, of cargo. Some vessels, particularly chemical tankers, are fitted with small; air operated reciprocating pumps in the tank adjacent to the deepwell. Using reach-rods from the deck, the pumpman is able to first take suction from the tank bottom with this pump, completing the stripping of the tank. Then he can open a suction valve to the deep well and pump its contents (and in some cases the contents of the discharge line), to the discharge manifold via a small diameter line.

The small stripping discharge line is connected to the discharge manifold, outboard of the manifold valve.

Cargo tank venting arrangements in SOLAS Chapter II-2 (MSC.392(95)) have been revised for new oil tankers constructed on/after 1 January 2017 that will require secondary means of venting to allow full flow relief of cargo or inert gas vapors at all times including in the event of damage to, or inadvertent closing of, the primary means of venting.

The cargo tanks venting arrangements shall

- be so designed and constructed as to ensure that the pressure, above or below that of the atmosphere within the tanks does not exceed the design pressure;
- include pressure-vacuum (PV) valves capable of providing for the flow of vapour, air or inert gas mixtures caused by thermal variations within the cargo tank; and
- be capable of providing for the flow of vapour air or inert gas mixtures whilst the tank is being loaded, ballasted or discharged at the highest rate.

Every vent system outlet to atmosphere from a valve shall be located as high and at the furthest distance from a source of ignition as is practicable and in no case shall it be located less than 2 meters above the cargo tank deck or less than 5 meters from air intakes or openings to enclosed spaces containing a source of ignition or from machinery and equipment which may constitute an ignition hazard. Anchor windlass and chain locker openings constitute an ignition hazard.

By-pass arrangements for the pressure-vacuum valves may be fitted in the valves are located in a vent main or masthead riser. Indicators showing whether the by-pass is open or shut shall be provided.

Every vent system outlet to atmosphere shall

- Permit the free flow of vapour mixtures, or be so designed that the discharge velocity of the vapour mixtures is at least 30 meters per second;
- Be so arranged that the vapour mixture is discharged vertically upwards;
- Where the system permits the free flow of vapour mixtures, be such that the outlets to atmosphere are located at least 6 meters above the cargo tank deck and at least 10 meters measured horizontally, from the nearest air intake or opening to an enclosed space containing a source of ignition and from machinery and equipment which may constitute an ignition hazard; such deck machinery may include anchor windlass and chain locker openings. Any outlet less than 4 meters, measured horizontally, from a fore and aft gangway shall be located at least 6 meters above the gangway;
- Where the system is so designed that the discharge velocity of the vapour mixtures is at least 30 meters per second, be such that the outlets to

atmosphere are located at least 2 meters above the cargo tank deck and at least 10 meters, measured horizontally, from the nearest air intake or opening to an enclosed space containing a source of ignition and from machinery and equipment which may constitute an ignition hazard. Such outlets shall be provided with high velocity vents.

- Be so arranged as to prevent the design pressure of any cargo tank being exceeded. The system should be designed on the basis of the maximum designed cargo loading rate of any tank or group of tanks multiplied by a factor of at least 1.25
- On ships constructed on or after 1 July 2002 the arrangements of the venting of vapours displaced from the cargo tanks during loading and ballasting shall consist of either one or more mast risers, or a number of high velocity vents. The inert gas supply main may be used for such venting.

The venting arrangements of each cargo tank may be independent or combined with other cargo tanks and may be connected to the inert gas piping required by the Merchant Shipping (Fire Protection: Large Ships constructed before 1 July 2002) Rules 2003 or the Merchant Shipping (Fire Protection: Large Ships constructed on or after 1 July 2002) Rules 2003.

Where the arrangements are combined with other cargo tanks, stop valves or other effective means of isolating each cargo tank shall be provided.

Stop valves shall be provided with locking arrangements to permit control of their operation. Any cargo tank isolation arrangement shall not prevent the flow of vapour, air or inert gas caused by thermal variations within the tank. In addition, the following requirements shall apply to ships constructed on or after 1 July 2002

- The locking arrangements for the stop valves shall be under the control of the responsible ship´s officer
- There shall be a clear visual indication of an operational status of the valves or other acceptable means
- Where the tanks have been isolated, it shall be ensured that relevant isolating valves are opened before cargo loading or ballasting or discharging of those tanks is commenced.
- Where cargo loading and ballasting or discharging of a cargo tank group which is isolated from a common venting system is intended, that cargo tank or cargo tank group shall be fitted with a means of over-pressure or under-pressure protection.

The venting system shall be provided with devices to prevent the passage of flame into the cargo tanks. The devices of cargo tanks in which the atmosphere is flammable shall be flame arrestors or high velocity vents.
The vents shall be connected to the top of each cargo tank and be self-draining to the cargo tanks.

High level alarms or overflow control systems or other equivalent means together with cargo tank content gauges and filling procedures shall be provided to protect the tanks from excess pressure due to overfilling.

1.5 Tank and cargo pipeline pressure and temperature control system and alarms

Certain cargoes require the designated tank to be fitted with a separate high level alarm to give warning before the tank becomes full. The alarm may be activated by either a float operating a switch device, a capacitive pressure transmitter, or an ultrasonic or radioactive source. The activation point is usually pre-set at 95% of tank capacity.

The high level alarm must be independent of the normal gauging system. High level alarms must be maintained according to maker's instructions and tested as required before cargo operations begin.

Tank overflow control systems

A better name for this would be a tank overflow prevention system. It is required for particular cargoes designated in the IBC Code. The system should come into operation when the normal operational procedures fail to stop the tank liquid level exceeding the normal full condition. The activation point is usually set at 98% of tank capacity.

Operation of the system is required to be independent of the high level alarm described above. On activation, the system should give a visual and audible alarm, and a signal in sufficient time to permit sequential shutdown of onshore pumps and/or valves, and the ship's valves. The shutdown can be dependent or independent of the intervention of operators.

Particular care must be exercised with regard to automatic shutdown systems that are independent of operator intervention. Express approval for their use is required from both the flag administration and the port state authorities. Automatic shutdown systems are normally designed to shut the main cargo tank filling valve if the liquid level rises above the maximum level permitted.

Great care should be taken to ensure that the activation point is set accurately, and that the operation of the device is checked by simulation whenever the system is recommissioned. If the ship and shore shutdown circuits are to be linked their operation should be checked before cargo transfer begins; if not, the terminal should be informed of the closing rate of the ship's valves.

Pressure indicating devices

Pressure gauges are fitted at various points in the cargo system, on pumps, in pipelines and in tanks, some of which are specified in the IMO Codes. They may be used to indicate pressure in a liquid being pumped into or out of a tank, or static pressure such as inert gas overpressure. They can indicate negative as well as positive pressure, and can be linked to shutdown or alarm systems.

It is important that procedures exist for ensuring that pressure gauges are checked and calibrated in accordance with manufacturer's instructions.

Bourdon tubes

These instruments measure pressure by the movement of a coiled or helical tube, the amount being directly proportional to the applied pressure. The movement is used to drive a pointer for local readings, or to control a gas pressure valve or to alter a variable resistance that will serve indirect readings. Indirect readings may be necessary to avoid direct connection between safe and dangerous areas.

- The following precautions should be observed: the indicator should be periodically checked for zero calibration;
- the gauge should not be used to consistently indicate pressures beyond 75% of its maximum reading if the expected pressure is steady, or 60% if it is fluctuating;
- Bourdon tubes may be damaged by vibration or by excessive pressure pulsations; the latter can be eliminated by the use of a flow restrictor.

Capacitive pressure transmitters

Pressure in vapour spaces of cargo tanks (and elsewhere) can be monitored by measuring the effect of the existing pressure on sealed units that have a known internal pressure. By establishing the reference atmosphere in the sealed units at a low pressure, for example 0.8 bar absolute or 800 millibars, it is possibie to continue to measure modest underpressure within a tank as well as overpressure. Deflection of the sealed unit is measured by an internal capacitor, which sends an electronic signal to a remote display. An external measurement of atmospheric pressure is necessary for the display to show gauge pressure. Alarm levels can be set as desired.

The physical size of the sensors is quite small, and when used for inert gas monitors the devices are often incorporated into housings of other sensors, such as radar ullage gauges. Similar units can be used to indicate higher pressures in liquids.

General precautions

The following precautions apply to all pressure sensing equipment:

- Materials of construction should be compatible with the cargo. For example, brass must not be used for pressure gauge internals for amine cargoes such as ethylene diamine. The IBC Code gives guidance on cargoes where special attention must be paid to materials of construction;
- Before measurements are taken, all valves in the direct line should be opened and all cross-connections shut;
- No pressure gauge should be subjected to violent pressure change;
- In ships carrying cargoes which can solidify or form polymers (e.g. phenol or styrene respectively) it may be necessary to flush gauge lines and sensor chambers;
- If sensor lines are temporarily disconnected during maintenance they should be blanked.

Cargo temperature monitoring equipments for Chemical tankers

Temperature sensors are fitted so that the temperature of the cargo can be monitored, especially where required by the IBC Code. It is important to know the cargo temperature in order to be able to calculate the weight of cargo on board, and because tanks or their coatings often have a maximum temperature limit. Many cargoes are temperature sensitive, and can be damaged by overheating or if permitted to solidify. Sensors may also be fitted to monitor the temperatures of the structure around the cargo system.

Types of thermometers

- Liquid /vapour thermometers rely on the expansion or contraction of liquid in a very fine-bore calibrated tube or capillary. The liquids most commonly used are mercury, ethanol or xylene. it is important to ensure that the liquid column in the instrument is continuous, otherwise the reading will be inaccurate.
- Liquid filled thermometers have a metal bulb containing a fluid which changes volume with temperature change. The changes are transmitted via capillary tubing to an indicator or recorder. The system is sealed under considerable pressure to overcome the effects of vapour pressure from the liquid. Mercury filled thermometers should not be used with aluminum and certain other materials.
- Bi-metallic thermometers consist of two metals with different coefficients of expansion which are welded together to form a bi-metallic strip. When heated, the strip will bend because of the unequal expansion, and the flexing movement can be used to drive a pointer in a similar manner to the Bourdon tube. Bi-metallic thermometers are susceptible to vibration and should only be installed in positions free from this effect.

Thermocouples rely on heat applied to the junction of two dissimilar metals generating a very small voltage which can be measured. A change will indicate a change in temperature. Normally the voltage is sensed electronically and the read-out is remote.

Resistance thermometers use the fact that the electrical resistance of certain materials changes with temperature, and that if it is measured it will indicate temperature. The material normally used in resistance thermometers is fine platinum wire. Its resistance is measured by means of an electrical resistance bridge connected to an indicator or recorder, normally by electronic means, and the read-out is remote.

General precautions

The following precautions should be observed with all temperature indicating devices: the thermometers used should be suitable for the complete range of temperatures expected; the sensor should make good thermal contact with the material whose temperature is to be measured; if readings do not change when expected, the instrument should be checked; thermometers are easily damaged, especially those with capillary tubes.

They should be handled with care and protected from mechanical damage and extremes of temperature beyond their scales, otherwise they may become inaccurate; when a fixed thermometer is removed from its working location, care should be taken to avoid loosening or removing its pocket, especially if the system is pressurized; when a thermometer is replaced in a working location, care should be taken that it does not bottom in its pocket when screwed in as this could cause damage.

If the thermometer is slack in the pocket a material with high thermal conductivity (such as a suitable lubricating oil) can be used to ensure accurate readings; electrical connections should be clean, tight and correct. Care should be taken to see that intrinsically safe leads are not cross-connected with ordinary power sources.

Fixed cargo temperature indicating devices

Such equipment must be maintained in working order at all times and a calibration check utilizing the UTI (Portable Gauging / Temperature Equipment) should be carried out at frequent intervals (see PMS). Records and results of the checks are to be maintained. Calibration of the fixed equipment by Third Parties will be carried out as required after replacement of or repairs to any of the existing units.

Alarms and shutdown circuits

An important feature of many modern measurement and control instruments is the ability to signal a particular situation. This can be a main operational alarm that gives an indication of a pre-set situation such as liquid level in a tank, or a malfunction alarm indicating a failure within a sensor's own operating mechanism. The designs and purposes of alarm and shutdown circuits vary widely, and their operating system may be pneumatic, hydraulic, electrical or electronic. Safe operation of plant and systems depends on the correct operation of these circuits and a knowledgeable reaction to them.

The following precautions should be observed:

- where provided, test facilities should be used before cargo operations commence, to check that the circuits and their alarms are operating: any instrument fault should be rectified;
- wiring inside and outside cabinets should be checked for chafing, condensation, insulation deterioration, bad connections etc;
- watchkeepers should be instructed how to distinguish between each audible alarm and what action is necessary;

- the accuracy of all inputs to alarm circuits should be checked;
- if an alarm is activated, the cause must be investigated and necessary remedial action taken;
- if an alarm circuit becomes defective during cargo operations, it should be repaired as soon as possible. Defective circuits may be by-passed temporarily in case of an emergency, but this action should only be taken with the full agreement of the responsible officer and the decision should be recorded. Completion of the repair work should also be recorded.

It should be borne in mind that individual ship has got own characteristics and limitations may involve handling various chemical cargoes. The master and all personnel in all cases must be aware of cargo/ship information that has been given and comply with relevant safety procedures.

1.6 Gauging control systems and alarms

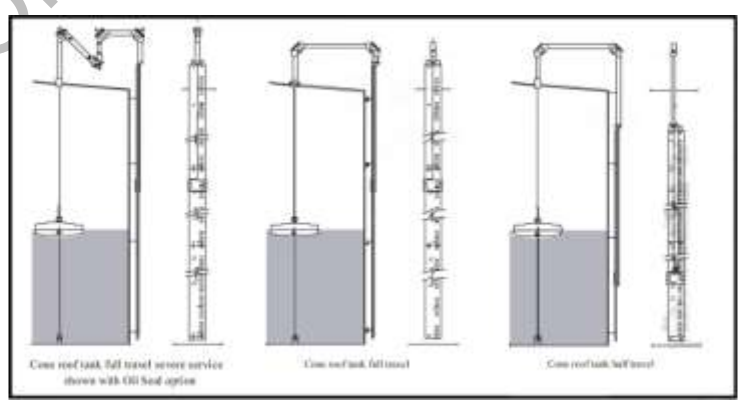
The need for accurate and reliable level measurement systems is increased by the demands of advanced automated processing systems, more stringent process control and strict regulatory requirements.

By improving the accuracy of level measurement, the variability in chemical-processes can be reduced, which, in turn, helps to improve product quality and reduce costs and wastes. The regulations laid down for electronic records are stricter in terms of electronic reporting, accuracy and reliability. These requirements are met using new level measurement technologies.

- **Mechanically Operated Float Gauges**

The principle behind the working of floats is placing a buoyant object, with specific gravity between that of the process fluid and the headspace vapor, into the tank and attaching a mechanical device to record its position. The float stays on top of the process fluid, but sinks to the bottom of the headspace. Even though a liquid's surface can be located by the float, reading the float still poses a problem.

Mechanical components like pulleys, tapes, cables and gears were used in early float systems to record the level. Currently, magnet-equipped floats are more popular. The level measurement provided by early float systems was in the analog or digital format through a network of multiple reed switches and resistor. This implies that the changes in the transmitter output were in the form of discrete steps. Hence, these devices cannot distinguish levels between steps, which continuous level measuring devices are capable of.



- **Glass Level Gauges**

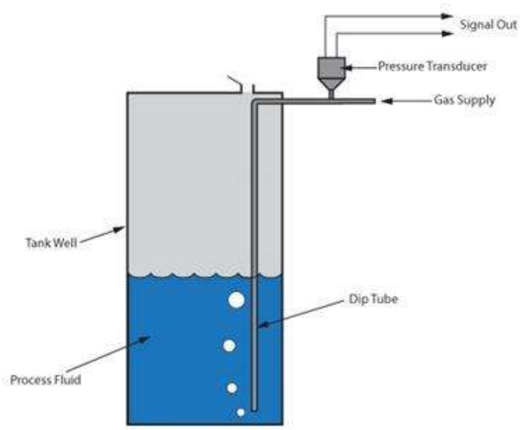
  Glass gauges, which have been being used for more than 2 centuries now are available in a number of designs, in both armored and unarmored forms. They are the simplest of methods available for liquid level measurement. The clear visibility provided by their design is their biggest advantage, while the fragility of the glass that may result in spills or compromise on the personnel safety is the disadvantage.

- **Bubbler Gauges**

  Bubblers, differential pressure transmitters and displacers are all different hydrostatic measurement devices. Changes in temperature cause a change in a liquid's the specific gravity of the liquid; similarly changes in pressure also affect the specific gravity of the vapor that is present over the liquid. As a result of these changes, the accuracy of the measurement is reduced.

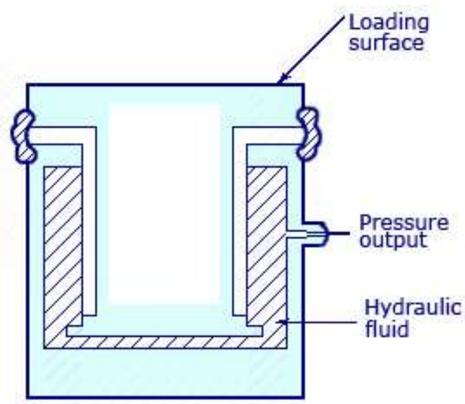
  The bubbler method is used in vessels that work under atmospheric pressure. A purge gas is carried in a dip tube with its open end near the opening of the vessel into the tank. The purge gas is usually air, but in some cases where there is danger of an oxidative reaction with the process fluid or contamination, dry nitrogen is used.

Due to the flow of gas through the dip tube outlet, the tube pressure rises till it is more than the hydrostatic pressure generated by the liquid level at the outlet. The product of the process fluid density and its depth from the end of the dip tube to the surface is equal to the pressure, which is monitored by a pressure transducer connected to the tube.



– **Hydraulic Load Cell**

As shown in the figure given below, the inside chamber of the device is filled with oil which has a pre-load pressure. The force is applied on the upper portion and this increases the pressure of the fluid inside the chamber. This pressure change is measured using a pressure transducer or is displayed on a pressure gauge dial using a Bourdon Tube.



Hydraulic Load Cell

www.InstrumentationToday.com

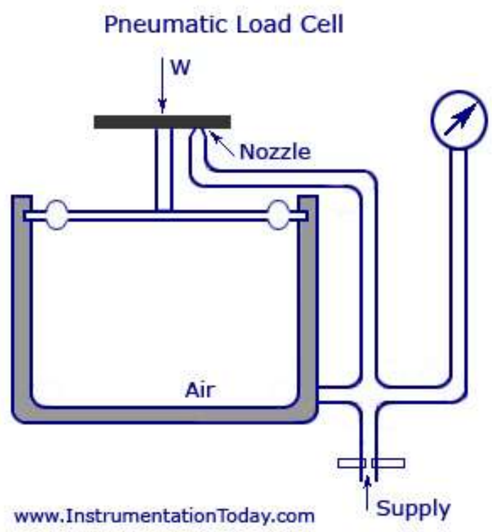
When a pressure transducer is used for measuring the value, the load cell is known to be very stiff. Even at a fully forced condition, it will only deflect up to 0.05mm. Thus, this device is usually used for calculating forces whose value lies between 500N and 200KiloN. The force monitoring device can be placed at a distance far away from the device with the help of a fluid-filled hose. Sometimes there will be need of multiple load cells. If so, a totaliser unit has to be designed for the purpose.

The biggest advantage of such a device is that it is completely mechanical. There is no need of any electrical assistance for the device. They can also be used for calculating both tensile and compressive forces. The error percentage does not exceed more than 0.25% if the device is designed correctly.

The device will have to be calibrated according to the temperature in which it is used as it is temperature sensitive.

– **Pneumatic Load Cell**

The working of a pneumatic load cell is almost same to that of a hydraulic load cell. The force, whose value is to be measured, is applied on one side of a piston and this is balanced by pneumatic pressure on the other side. The pressure thus obtained will be equal to the input force applied. The value is measured using a bourdon tube.

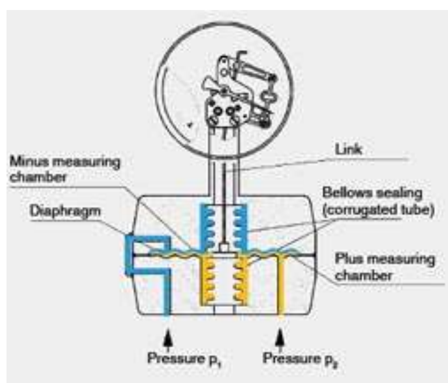


The pneumatic load cell has an inside chamber which is closed with a cap. An air pressure is built up inside the chamber until its value equals the force on the cap. If the pressure is increased further, the air inside the chamber will forcefully open the cap and the process will continue until both the pressures are equal. At this point, the reading of the pressure in the chamber is taken using a pressure transducer and it will be equal to the input force.

- **Differential-Pressure Type Gauges**

Differential pressure gauges measure the difference between two pressures. They are suitable for the monitoring of filter contamination, for level measurement in closed vessels, for overpressure measurement in clean rooms, for flow measurement of gaseous and liquid media and for the control of pumping plants.

In differential pressure gauges, different pressure elements and tube forms are used (diaphragm element, capsule element, Bourdon tube, etc.). This enables scale ranges of 0 ... 0.5 mbar up to 0 ... 1,000 bar to be covered, with a very high single and dual-sided and also bidirectional overpressure safety up to 400 bar.



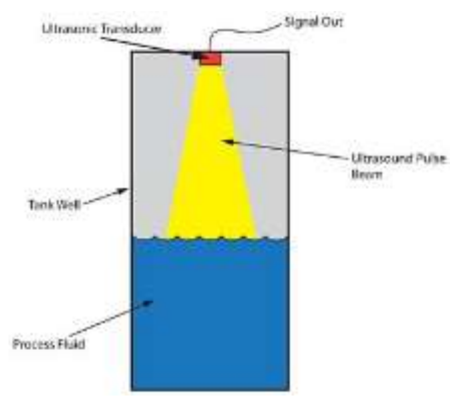
Function of a differential pressure gauge

The media chambers of a differential pressure gauge are separated from each other by the pressure element. If the two pressures being measured are the same, there is no movement through the pressure element and no pressure is indicated. As soon as the two measured values are different to each other, thus one of the pressures is higher or lower, then a differential pressure will be indicated. The transmission of the pressure element displacement and the indication of the pressure is achieved via a mechanical movement.

– **Ultrasonic or Sonic Gauges**

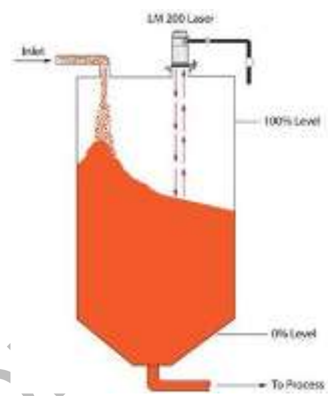
Ultrasonic level transmitters are capable of measuring the distance between the transducer and the surface based on the time taken by the ultrasound pulse to travel from the fluid surface to the transducer and back (TOF).

The operational frequency of these transmitters is tens of kilohertz and the transit times are approximately 6 ms/m. The composition of the gas mixture in the headspace and its temperature affect the speed of sound (340 m/s in air at 15°C). Even though the sensor compensates for temperature, it is limited to atmospheric measurements in nitrogen or air.



– **Laser Level Gauges**

Laser level transmitters have been designed for level measurements of slurries, opaque liquids and bulk solids. The operating principle is similar to ultrasonic level sensors but these sensors measure the speed of light for level measurement, instead of the speed of sound.



A laser transmitter uses a short burst of laser energy to measure level

A short pulse is transmitted by the laser sensor placed at the top of the vessel to the process liquid surface located below; this pulse is then reflected back to the detector.

The time of flight of the signal is measured by a timing circuit to calculate the distance. Since lasers are virtually beamless and devoid of false echoes, they can be directed through spaces as small as 2 inches. Another advantage is that lasers offer precise measurements even in vapor and foam.

Applications that use vessels with number of obstructions can use laser transmitters for accurate measurements up to distances of 1500 ft. Lasers must be combined with specialized sight windows to isolate the transmitter from the process in high temperature or high-pressure applications like reactor vessels. The glass windows must allow the laser to pass through with minimum attenuation and diffusion whilst also containing the process conditions.

– **Radar Level Gauges**

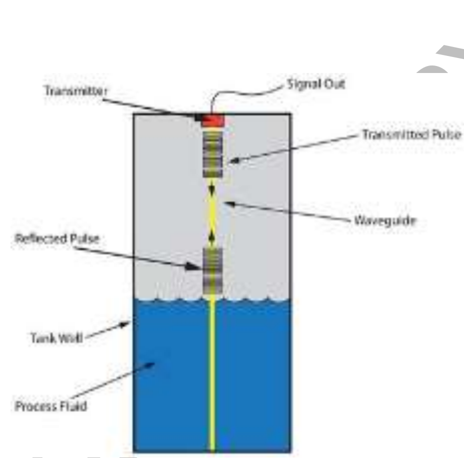
In air-radar systems, the microwave beam is directed downward from a horn or a rod antenna placed at the top of a vessel. The fluid surface reflects the signal back to the antenna, and the distance is calculated by the timing circuit which measures the round trip time (TOP).

In radar technology, the critical factor is the dielectric constant of the liquid because the amount of energy reflected at microwave frequencies varies with the dielectric constant of the fluid. If the Er is low, then the liquid will allow most of the radar energy to pass through. For high values of Er the reflection at the change in Er is high.

Another type of transmitters is guided wave radar (GWR) transmitters, which provide highly accurate and reliable measurements.

In these transmitters, a flexible cable antenna or a rigid probe channelizes the microwave from the top of the vessel down to the liquid level and then back to the transmitter. The change from a lower to higher Er causes the wave to be reflected.

The efficiency of this method is 20 times greater than that of air-radar since the guided transmission enables a focused path for the energy. Liquids with Er values of 1.4 and lower can be measured by this method. Furthermore, these systems allow both vertical and horizontal installation by bending the guide up to 90° angle.



Guided wave radar uses a waveguide to conduct microwave energy and from the fluid surface.

Most of the advantages of the aforementioned techniques, including ultrasound, laser and radar, and a few limitations are present in the GWR transmitters. The composition, pressure and temperature of the vapor space gas affects the speed of the radar.

It can even work in a vacuum without any calibration. Even foam layers can be measured using GWR. Issues like beam-spread or false echoes from tank walls and structures can be avoided by confining the wave so that it follows a probe or a cable.

- **High Level Alarms**

Certain cargoes require tanks to be fitted with high level alarms which are independent of any alarms fitted to the closed gauging system. The alarm may be activated by either a float operated switch, a capacitive pressure transmitter, or an ultrasonic device.

The activation point should be set to when the cargo is approaching the normal full condition. Typically this limit will be set at 95%.

Tank overtlow control systems should be set to alarm when the level in the tank reaches 98% of capacity.

All high level and overflow alarms should be tested in accordance with the manufacturers' instructions to ensure correct operation prior to cargo operations. This will ensure that the alarms are working correctly and can be relied upon.

1.7 Gas-detection systems

Ships carrying toxic or flammable products (or both) should be equipped with at least two instruments that are designed and calibrated for testing the gases of the products carried. If the instruments are not capable of testing for both toxic concentrations and flammable concentrations, then separate sets of instruments should be provided.

Vapour-detection instruments may be portable or fixed. If a fixed system is installed at least one additional portable instrument should be provided.

When toxic-vapour-detection equipment is not available for certain products that require such detection the Administration may exempt the ship from the requirement, provided an appropriate entry is made on the International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk. When granting such an exemption, the Administration should recognise the necessity for additional breathing-air supply and a further entry must be made on the International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk.

The provision and use of vapour detection equipment is required by the IBC Code for a number of functions, including:

- measuring concentrations of gas in or near the flammable range;
- detecting low concentraflons of cargo vapour in air and in inert gas, or in the vapour of another cargo;
- measuring concentrations of oxygen in inert gas or cargo vapour, or in enclosed spaces.

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

Combustible gas detectors

Combustible gas detectors are very common and are used to detect and measure combustible gases, usually within the concentration range of 0-100% LFL; that is, up to the point of flammability. Equipment can be fixed or portable.

A sensor containing a filament of a special metal is heated electrically and a sample of gas is passed over it. Any combustible gas in the sample is oxidized catalytically. The heat given out alters the electrical resistance of the filament in proportion to the gas concentration, and this effect is displayed on a suitably marked meter. The filament can easily be de-activated by materials such as silicones, halogenated gases, acids, water, oil and lead. Filters may therefore be required in the sample lines.

The equipment needs oxygen to operate, and can only be relied upon to detect combustible gas in air atmospheres, not in inerted atmospheres. If a mixture of inert gas and cargo vapour has to be tested, either an infrared or thermal conductivity meter must be used, or a sample must be mixed with air before a combustible gas detector can be used. A combustible gas detector will not indicate a safe atmosphere if a toxic vapour is involved: in such a case a different type of instrument should be used.

The instruments are calibrated against a known gas, called a span gas. Performance in use may be affected if the gas sampled is different from that used for calibration, and an appropriate conversion factor may to be applied to the readings.

Portable combustible gas detectors are frequently used to confirm the state of atmospheres believed to be free of cargo vapours, such as prior to tank entry or hot work. When used for this purpose, readings should be taken by or under the supervision of a responsible officer who should be satisfied that the instrument readings are correct, and are accurately interpreted, before allowing the safety of personnel to depend upon them. The calibration should be confirmed, and readings should be taken from the top or bottom of a space depending on the vapour density of the cargo. Readings will be inaccurate if inert gas is present in the sample.

When using the instrument every reaction of the meter is important, and not just the final resting position. The first movement indicates the presence of combustible vapour, while the final rest position indicates the concentration, as follows:

- a final rest position within the scale indicates a gas concentration below LFL, expressed as a percentage of LFL;
- a final rest position beyond 100% LFL indicates a concentration within the flammable range;
- a needle movement first above 100% LFL and then to a final rest position of zero indicates a concentration above UFL.

It is therefore strongly recommended that when a space is being checked the responsible officer should not be satisfied that an atmosphere is safe until consistent zero readings are obtained. Fixed gas detectors working on this principle have the same limitations as portable ones.

Personal combustible gas detectors, capable of continuously sampling an atmosphere to detect the presence of small amounts of combustible gas, are also available. They should automatically provide an audible and visual alarm when the level of combustible gas reaches a set level, to give the wearer adequate warning of unsafe conditions.

Thermal conductivity meters

These instruments work by measuring thermal conductivity of samples of gas. They are sometimes called catharometers. Electrical power is applied to a heater filament which is used as the sensing element: the filament temperature stabilizes at a value depending on the thermal conductivity of the gas around it. Any variation in the concentration of the gas affects the filament temperature, resulting in a change in electrical resistance which is in turn indicated by a meter.

The principle is similar to that of the combustible gas detector, but the filament temperatures are lower and the instruments can be used to detect concentrations of gas from 0-100% by volume (compared to 0-100% LFL).

The filament may be mounted so that the sampled gas flows directly over it or diffuses into it. The direct flow type responds more quickly to concentration changes but is dependent on flow rates. The diffusion type gives a slower response but is less flow sensitive. It is important to note that changes in operating conditions (e.g. filament voltage or gas flow rate) may alter the filament temperature. The maker's handbook for the instrument should be checked.

A thermal conductivity meter can be set to detect cargo vapour mixed with inert gas. The meter must be calibrated to suit the gas being tested, or manufacturer's correction curves used. Reference should be made to the manufacturer's instructions before every occasion of use.

Note: The roles of combustible gas detector and thermal conductivity meter can be combined into one instrument, although the two functions - measuring percentage of LFL and concentration of vapour by volume respectively - remain distinct. In some ships, fixed gas detection equipment uses this combination technique.

Infrared detectors

Organic gases such as butane, methane and petroleum absorb infrared radiation. This property is used in fixed or portable equipment to detect such gases in concentrations over the range 0-100% LFL or 0-100% volume. Infrared radiation is passed through two tubes, one containing a known concentration of gas, the other containing the sample to be measured.

The extent of absorption is in proportion to the gas concentration, and the output from the two tubes is compared electronically. The electronic signal can be used to drive an indicating meter or a pen recorder, or to trigger other equipment such as an alarm. Calibration of the instrument is set for each gas to be measured.

Infrared detectors will not reliably detect chemical gases, and are not commonly used on chemical tankers.

Chemical detector tubes

These instruments, often referred to as Draeger tubes, normally function by drawing a sample of the atmosphere to be tested through a proprietary chemical reagent in a glass tube.

The detecting reagent becomes progressively discolored if a contaminant vapour is present in the sample. The length of the discoloration stain gives a measure of the concentration of the chemical vapour which can be read from the graduated scale printed on the tube. Detector tubes give an accurate indication of chemical vapour concentration, whatever the oxygen content of the mixture.

It is important that the correct volume of atmosphere sample, according to the manufacturer's instructions, is passed through the tube, otherwise the measurement will not be accurate. Too small a sample volume will give a low value. With some instruments the length of hose is a critical factor in obtaining a correct reading. The presence of a second gas may affect readings and cause inaccuracies. Chemical detector tubes are specific for particular gases or vapours, which need not have flammable or combustible properties - for example, oxygen or water vapour (to establish dewpoint).

The tubes are designed to measure low vapour concentrations accurately, and are probably the most convenient and suitable equipment to use. They should always be used when the cargo vapour presents a serious inhalation hazard, e.g. acrylonitrile. The storage life of these tubes is usually limited, and it is necessary to ensure that out of date tubes do not remain available for use.

General precautions

Vapour detection is a means of measuring vapour concentrations, and great care is necessary to ensure that the readings are accurate, especially when the lives of personnel depend upon them. The following precautions should be observed:

- the maker's handbook should be studied before calibration or use;
- zero points should be checked regularly and reset if necessary before an instrument is calibrated. Great care should be taken when the zero is being set to ensure that the sample is free from any gas that would otherwise give a reading: pure nitrogen should be used if necessary;
- the instrument should be calibrated as often as recommended by the makers. The concentration and composition of the gas used for calibration (known as span gas) should be accurately known. Re-calibration should be recorded on or near the instrument;
- the same precautions must be observed when handling span gas which is toxic or flammable as would apply if the chemical was carried as cargo;
- tubes or liquids for equipment using the chemical absorption or reaction principles have a limited life with an expiry date. They should be replaced before expiry, otherwise readings may be inaccurate;
- all sample lines should be clean, unobstructed, leak-tight and connected to the correct point;
- all sample lines should be made of the correct material as specified by the maker. Incorrect tubing may absorb gas from the sample and cause misleading readings;

- if upper or lower sample points are provided (for lighter than air or heavier than air vapours respectively) the correct position should be used for the cargo;
- pumps, filters, flame screens and other components of the system should be well maintained to ensure accurate readings;
- for fixed instruments, remote and local read-outs should be compared to detect discrepancies;
- performance of most fixed instruments depends on flow rate, and fluctuations can cause inaccuracy. Flows should be kept steady, and flows from separate points should be balanced;
- the battery voltage of portable instruments should be checked frequently to ensure an instrument will provide accurate readings.

1.8 Cargo heating and cooling systems

In a modern chemical tanker in order to maintain product quality, to minimize the potential for discoloration, and to facilitate some liquid cargo transport in a safe manner cargo heating is required.

The voyage orders will contain heating information, if heating is required. As a rule the final heating instructions are given by the Shipper in writing to the Master / Chief Officer in the port of loading. If those written instructions are not given, the master should request them and issue a Letter of Protest if they are not received at departure. In the latter case the management office should be immediately informed.

The heating instructions may contain any, or all, of the following:

- Minimum and maximum temperature during the voyage

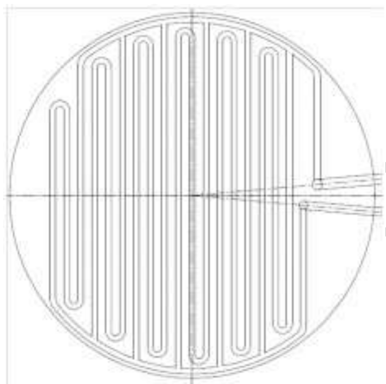
- Minimum and maximum temperature during discharge
- Maximum temperature of adjacent cargo
- Heating medium (when loading edible oils only steam and / or hot water should be utilized as the heating medium in coils / heat exchangers. Thermal oil should not be used as a heating medium for edible oils)
- Maximum temperature of the heating medium
- The maximum possible temperature increase per unit of time: delta T°C/hour

The heating of liquid cargo is a highly important matter as it regards the transport of high viscous fluids (crude oil, fuell oil, virgin naphta, molasses, etc.). For any type of crude oil there exists a minimal temperature that must be maintained during the transport, because under it there arise dangerous phenomena of settling. Moreover, normally a still higher temperature must be reached in order to obtain the necessary fluidity of the transported liquid needed during the pumping and discharging operations.

The heating system must assure adeguate mechanical resistance to the vibrations and to the stress transmitted by the hull to the heating coils. Moreover, it must guarantee resistance to the corrosion provoked by the cargo and the sea-water used for the washing and ballasting operations. Finally the system must be light and simple to be installed.

Normally the heating of the liquid cargo of the tanks can be realized with coils or with prefabricated elements.

The traditional concept of tank heating was to use a serpentine coil manufactured from pipes, laid at the bottom of the tank. The heating fluids such as steam / thermal fluids are passed through these pipes to achieve heating.



This traditional method did work fine and satisfactorily when the average tank sizes were relatively smaller. This concept itself was innovative once upon a time and gained popularity due to easy availability of raw material (in this case pipes), easy concept for design and fabrication.

In many instances of tank designs, the tank heating had been a matter of lesser importance due to several reasons such as:

- Heating coil design and fabrication is considered as part of tank design.
- Supply & installation of heating coil in the scope of tank fabrication and not routed through thermal or heat transfer designers.
- Thermal Performance subject to interpretation due to Changing temperatures over the day & year (due to changing seasons)
- Absence of uniformly accepted standard / code for measurement of thermal performance

- Traditionally the tank sizes had been relatively small. Due to changing dynamics and cost structure, the average storage tank sizes are increasing nowadays.
- The traditional method of heating with pipes worked fine for smaller tanks. Eventually an extension of the same traditional concept was being adopted for many larger tanks. On those projects, heating became more complicated.

Heating coils may be installed in Slop Tanks to heat and separate water in the emulsion layer.

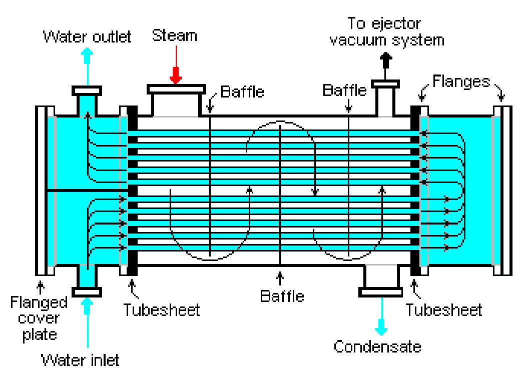
Bitumen is an oil based substance. It is a semi-solid hydrocarbon product produced by removing the lighter fractions (such as liquid petroleum gas, petrol and diesel) from heavy crude oil during the refining process. As such, it is correctly known as refined bitumen. In North America, bitumen is commonly known as “asphalt cement” or “asphalt”. While elsewhere, “asphalt” is the term used for a mixture of small stones, sand, filler and bitumen, which is used as a road paving material. The asphalt mixture contains approximately 5% bitumen. At ambient temperatures bitumen is a stable, semi-solid substance.

Bitumen must be transported at high temperatures up to 250°C in independent tanks supported by means of special methods.

High heat tankers are product carriers for the transportation of molten sulphur, bitumen, dirty petroleum products, coal tar, pitch and coal tar products. They maintain a cargo temperature between the ranges of 160°C and 240°C, which places very heavy demands on the heating, insulation of the tanks and pipework, as well as associated valves and pumps.

Heat exchanger is an equipment which reduces the temperature of a medium by transferring temperature of that medium to another, when both the mediums are separated by a solid membrane or wall like structure. For efficient operation, the surface area of the wall which separates the two mediums is maximized, simultaneously minimizing the flow resistance of the fluid.

Exchanging of heat in a heat exchanger can be in between- liquid and liquid, gas and liquid, liquid and gas etc.



For heat transfer basically three patterns of flow are used for construction of a heat exchanger:

- **Opposite flow**: Primary medium (to be cooled) and secondary medium (which is cooling the primary medium) enters in the heat exchanger in opposite direction to each other.
- **Cross flow**: Primary and secondary medium enters in an exchanger perpendicular to each other.
- **Parallel flow**: Primary and secondary medium both enter the heat exchanger parallel to each other.

1.9 Tank cleaning systems

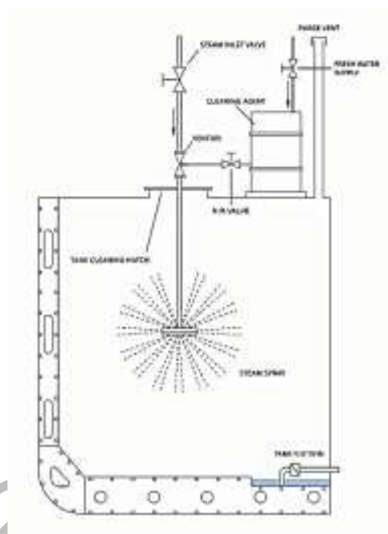
The tanks of Chemical Tankers may be constructed or coated with various different types of materials and it is important to check with the P&A manual and the Paint Manufacturers Coating Resistance list prior to commencing Tank Cleaning Operations in order to ascertain the tank coating materials and any 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 odorless tanks than does glycol intended for antifreezes;

caustic soda for making paper is more sensitive to iron contamination than caustic soda for the aluminum industry.

Modern Chemical tanker tank cleaning process



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. Manual work should preferably be reduced to inspection and possibly to a final drying up of washing water only.

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. This will now be even more important with the anti-pollution Convention of 1973

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

- Due regard to ship's trim and heel.
- Viscous cargoes may first be stripped from the various tanks to one tank near the pump room and from there be pumped ashore.
- Keep the cargo temperature sufficiently high so that the cargo drains also from remote corners of the tanks, especially in cold climates.
- Waxy deposits under the heating coils can sometimes be melted out by means of filling with water and then applying heat to the coils.
- Sometimes steaming is allowed during discharge of molasses, which facilitates draining of molasses from the bulkheads.
- 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.

- 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.
- 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:

- Water soluble? If the cargo is reasonably soluble in water then chemical cleaning agents are unnecessary in most cases.
- 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.
- Is it possible to emulate the cargo in water or in water with emulators added? Make a test on board.
- Will the product be affected by alkalies? Caustic soda is a relatively cheap and easily available alkaline chemical

- Will the product dissolve in other easily available products by which the tank walls can be treated? (Succesively "upgrading" or "floatation" methods).
- Will cargo residues vaporize without leaving any traces?
- 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.

Odor

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

Odors 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) degr.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 odors 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.

1.10 Cargo tank environmental control systems

Inerting: This is the process of reduction of the oxygen content in a tank by introducing an inert gas to prevent a flammable/explosive atmosphere developing within the cargo tank.

In the marine industry, a crude oil tanker with cargo tanks of an oxygen content of 8% or less is considered to be inerted. However, on chemical tankers, the general practice is to use large volumes of compressed nitrogen vapour, supplied from the shore, to reduce the oxygen content down to as low as 0.1% by volume. An onboard top-up generator maintains a positive pressure in the tanks.

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

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

Vent: This refers to forced or natural ventilation.

Some safety aspects of vents designs including:

- **Flame Arrestors**: permeable matrix of metal, ceramic or other heat resisting materials which can cool a deflagration flame, and any following combustion products, below the temperature required for the ignition of the flammable gas on the other side of the arrester.
- **Flame Screens**: a portable or fitted device incorporating one or more corrosion resistant wire woven fabrics of very small mesh which is used

for preventing sparks from entering a tank or vent opening or, for a short time, preventing the passage of flame.

- **High-velocity Vents:** a device to prevent the passage of flame, consisting of a mechanical valve which adjusts the flow opening in accordance with the pressure at the inlet of the valve in such a way that the efflux velocity cannot be less than 30 m/s.

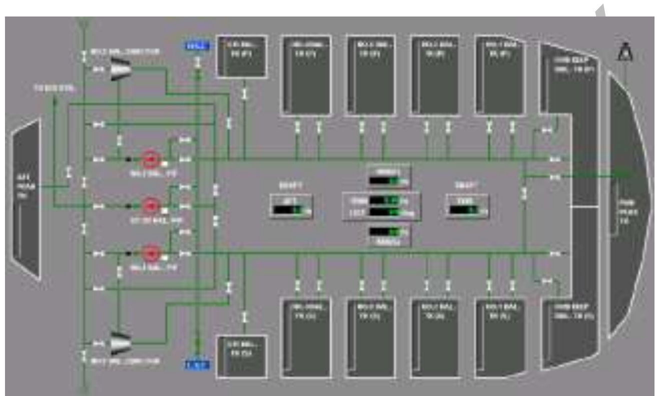
1.11 Ballast systems

Ballast system in ships are used to transfer sea water from one ballast tank to another tank, filling or discharge of water ballast tanks and anti-heeling system. Ballasting operation is required to maintain trim of vessel, to increase draft for better sea keeping, to fill double bottom tanks for better stability and transfer of water ballast from one side tank to another side to correct heel in ports. In Floating storage vessel ballast tanks are often designed in middle to reduce hull bending moments.

Ballast system requires manifold, main line, branch lines to tanks, mud box, strainers, valves and other fitting arrangements.

Often in small ships, ballast system is integrated with bilge system in which big ballast pumps are used for bilge system.

In container ships and RO-RO ships anti-heeling tanks and anti-heeling pumps are used to correct list during cargo transfer. These anti-heeling pumps are in range of 500-2500 m3/hr capacity. Many offshore vessels and heavy lifting vessels also use these system. These pump capacity depends on rate of cargo discharge or weight transfer. Heavy lift crane vessels lift heavy cargo and transfer that at certain rotating rate. So water ballast transfer rate shall be equal to weight transfer rate to maintain even keel. For example if 1000 t of cargo is being moved from port side to starboard side with some rate of crane rotation. So water ballast shall be moved from starboard side to port side with same rate.



There are ballast pumps installed in the engine room or pump rooms. These pumps take their suction from sea water main line, from the high sea chest being on the port side or starboard side and from the low sea chest being on opposite side. And also, they take their discharge line to the overboard or to the ballast tank through the ballast main line. When operating ballast, ballast pump takes suction from sea chest and discharges to ballast main line through the ballast pump discharge line. When operating deballast, ballast pump take suction from the ballast main line, and discharges to overboard through the overboard valve.

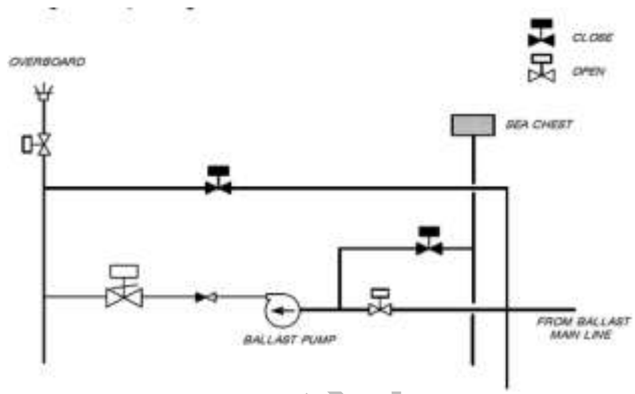
Each ballast tank has butterfly suction valve operated hydraulically and of the intermediate position controlled type except for the engine room, forward/aft peak tank fill/suction valves. The engine room, forward/aft peak tank fill/suction valves are of hydraulic on/off controlled type valves. Also ballast tank volume is calculated at the loading computer in accordance with the measured ballast tank level, which is transferred from the IAS to the loading computer by the serial link. The IAS monitors each ballast tank level and transfer to the loading computer by serial link. And the loading computer sends the calculated ballast volume to the IAS.

Sea inlet and overboard discharge valves are to be secured directly on the shell plating, or on sea chests built on the shell plating, or on extra-reinforced and short distance pieces attached to the shell/wing tank bulkhead. Sea inlet and overboard discharge valves are to be of a flanged type or equivalent.

Ballast water transfer valves shall be fitted directly at the penetration onto watertight bulkhead of the corresponding tank.

The collision bulkhead may be pierced below the bulkhead deck by not more than one pipe for dealing with fluid in the fore peak tank, provided that the pipe is fitted with a screw down valve capable of being operated from above the bulkhead deck, the valve chest being secured inside the fore peak to the collision bulkhead. The Society may, however, authorize the fitting of this valve on the after side of the collision bulkhead provided that the valve is readily accessible under all service conditions and the space in which it is located is not a cargo space.

If the fore peak is divided to hold two different kinds of liquids the Society may allow the collision bulkhead to be pierced below the bulkhead deck by two pipes, each of which is fitted as required by the above paragraph, provided the Society is satisfied that there is no practical alternative to the fitting of such a second pipe and that, having regard to the additional subdivision provided in the fore peak, the safety of the ship is maintained.



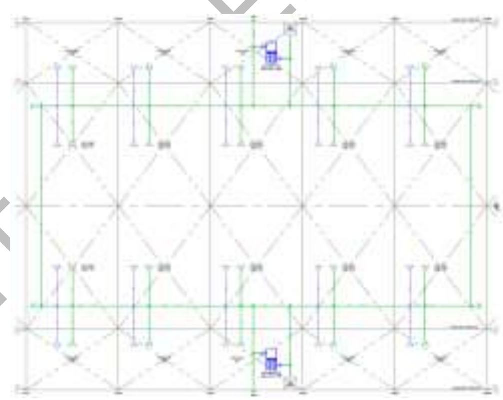
The segregated ballast pumping system shall be designed and arranged without a ballast pump room. The system shall be configured for both pumping and free flow (gravitation) of seawater to the ballast tanks.

The capacity of the ballast system shall be sufficient to maintain even keel during any loading / offloading sequence and condition.

Submerged hydraulic or electric driven pumps shall be installed in separate ballast tanks, each pump with a capacity of 100%. Pumps shall be able to effectively strip the ballast tanks.

Pipe work for the ballast tanks shall consist of two interconnected main headers with branches to each tank with remote actuated/controlled valves. The piping shall be designed to allow the running of both pumps simultaneously. Pumps suctions shall be taken from sea chests. Back flushing of sea chests shall be provided. Preventative measures must be incorporated into the design so that any single failure of the system or any operating failure will not permit ballast water to be inadvertently transferred from one tank to another causing unintentional flooding or emptying of tanks.

The ballast system shall be supplied with all necessary instrumentation for full control and monitoring of the system from the VMS in the Central Control Room (CCR). The Ballast Operator station is to have open /closed indication for all valves and start / stop, running indication for the ballast pumps. Remote control of the ballast system shall be incorporated in the cargo valve hydraulic system.



Ballast Tank Level Control

Sensor are provided in each water ballast tank. Ballasting and deballasting operation should be carried out based on those levels from relevant ballast tanks.

There are three (3) ballast pumps installed in the engine room. These pumps take their suction from sea water main line, from the high sea chest being on the port side and from the low sea chest being on the starboard side. And also, they take their discharge line to the overboard or to the ballast tank through the ballast main line.

When operating ballast, ballast pump takes suction from sea chest and discharges to ballast main line through the ballast pump discharge line. When operating deballast, ballast pump take suction from the ballast main line, and discharges to overboard through the overboard valve.

Also ballast tank volume is calculated at the loading computer in accordance with the measured ballast tank level, which is transferred from the IAS to the loading computer by the serial link. The IAS monitors each ballast tank level and transfer to the loading computer by serial link. And the loading computer sends the calculated ballast volume to the IAS. For the controlling of each tank level, the operator manipulates the ballast tank fill/suction valves on schematic display in the IAS.

Ballast Tank Volume and Flow Calculation

Ballast tank volume is calculated on the loading computer from the measured tank level that is transmitted from the IAS and the calculated volume is transmitted from the loading computer to the IAS through a serial link communication using RS485.

Because there is no measuring device on the ballast operation line, change of the ballast tank volume has to be calculated to calculate the ballast pump throughput or to calculate required time to finishing ballasting or deballasting.

During the deballasting, remained volume in the ballast tank is calculated per minute so that volume change between previous and current can be assumed as the current pump throughput. During the ballasting, remained void space is calculated per minute so that volume change is used to calculate the ballasting rate.

1.12 Cargo area venting and accommodation ventilation

The venting systems of cargo tanks are to be entirely distinct from the air pipes of the other compartments of the ship. The arrangements and position of openings in the cargo tank deck from which emission of flammable vapours can occur shall be such as to minimize the possibility of flammable vapours being admitted to enclosed spaces containing a source of ignition, or collecting in the vicinity of deck machinery and equipment which may constitute an ignition hazard.

The venting arrangements shall be so designed and operated as to ensure that neither pressure nor vacuum in cargo tanks shall exceed design parameters and be such as to provide for:

- The flow of the small volumes of vapour, air or inert gas mixtures caused by thermal variations in a cargo tank in all cases through pressure/vacuum valves;
- The passage of large volumes of vapour, air or inert gas mixtures during cargo loading and ballasting, or during discharging.

The venting arrangements in each cargo tank may be independent or combined with other cargo tanks and may be incorporated into the inert gas piping.

Where the arrangements are combined with other cargo tanks, either stop valves or other acceptable means shall be provided to isolate each cargo tank. Where stop valves are fitted, they shall be provided with locking arrangements, which shall be under the control of the responsible ship's officer. Any isolation must continue to permit the flow caused by thermal variations in a cargo tank.

The venting arrangements shall be connected to the top of each cargo tank and shall be self-draining to the cargo tanks under all normal conditions of trim and list of the ship. Where it may not be possible to provide self-draining lines, permanent arrangements shall be provided to drain the vent lines to a cargo tank.

The venting system shall be provided with devices to prevent the passage of flame into the cargo tanks. The design, testing and locating of these devices shall comply with the requirements stablished.

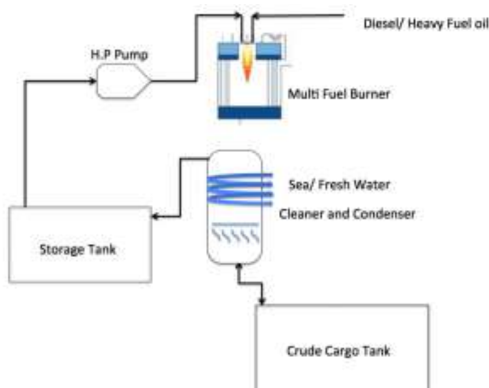
Provision shall be made to guard against liquid rising in the venting system to a height, which would exceed the design head of cargo tanks. This shall be accomplished by high-level alarms or overflow control systems or other equivalent means, together with gauging devices and cargo tank filling procedures.

1.13 Vapour return/recovery systems

In the late 1990s certain Administrations required offshore installations to reduce their emissions of VOC and this led to the development and installation of vapour recovery systems on board shuttle tankers in the North Sea. Different concepts were developed for the purpose of reducing the emissions of VOC (VOC). The initial efficiency requirement was set to 78% (i.e. 78% less VOC emissions when using vapour recovery systems).

The systems can recover VOC in all operational phases. For ships that have been provided with vapour recovery systems, the VOC emissions will be controlled when the recovery plant is in operation. The VOC recovery plant efficiency as well as any operational limitations related to, e.g., applicability for different cargo handling modes (loading, transit, COW), maximum allowable loading rates or crude vapour pressures, are to be specified in the VOC management plan.

The primary operation of an oil shuttle tanker is the loading and unloading of oil cargo at ports. During this process, a large quantity of lighter components evaporate from the oil. These oil vapours are technically called Volatile Organic Compounds (VOC), which are explosive in nature. VOC is also generated when the oil inside the tanks splashes while the ship is at sea. In order to prevent the gases reaching an explosive state, inert gas is used as a blanket over the cargo.



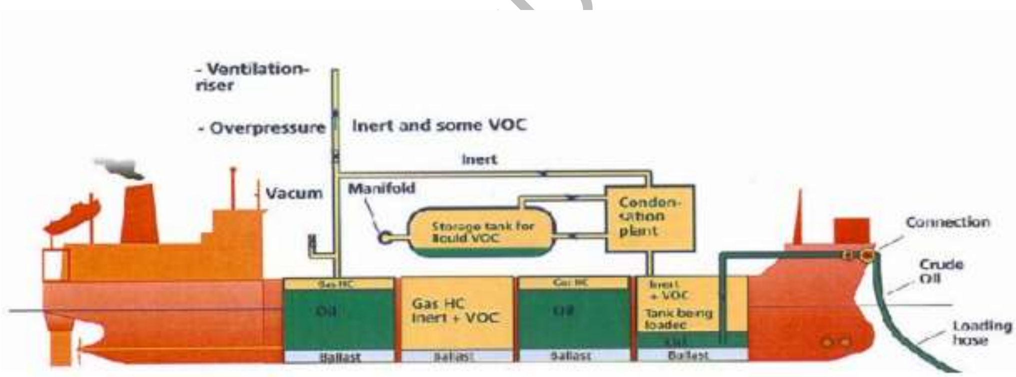
Since the generation of oil vapour will also lead to increase in the tank pressure, the cargo oil storage tanks are provided with vent pipes to discharge VOC to the atmosphere. The intention behind this is to maintain a constant safe pressure inside the tank; however, while doing so, a great amount of energy in the form of VOC is lost, which also leads to environmental problems related to air pollution.

Since VOC is a source of energy, same can be utilized as fuel for ship's engine in conjunction with heavy oil or diesel.

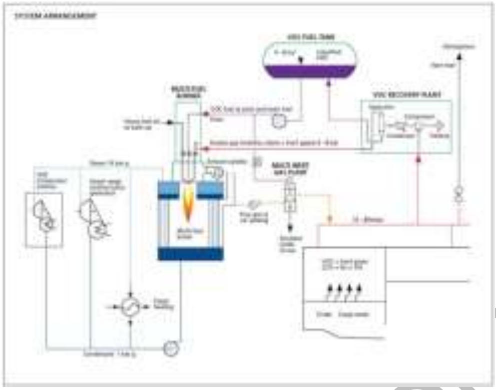
Vapour emission control systems which collect vapour of cargoes having characteristics which may pose hazards in addition to or other than flammability should be subject to special consideration by the Administration. These standards are not intended to require the use of vapour emission control systems but rather to recommend safety standards when such systems are utilized. The requirement to collect vapours will stem from a port Administration or terminal regulation. These standards are intended to promote the safety of terminals, tankers, and their personnel, recognizing the unique design features and characteristics of these systems.

Vapour Recovery Systems – Condensation Systems

The principle is similar to that of re-liquefaction plants on LPG carriers, i.e. condensation of VOC emitted from cargo tanks. In the process, the VOC passes through a knock out drum before it is pressurized and liquefied in a two stage process. The resulting liquefied gas is stored in a deck tank under pressure and could either be discharged to shore, or be used as fuel (possibly including methane and ethane) for boilers or engines subject to strict safety requirements. It is also conceivable that the stored gas could be used as an alternative to inert gas subject to the Administration's acceptance.

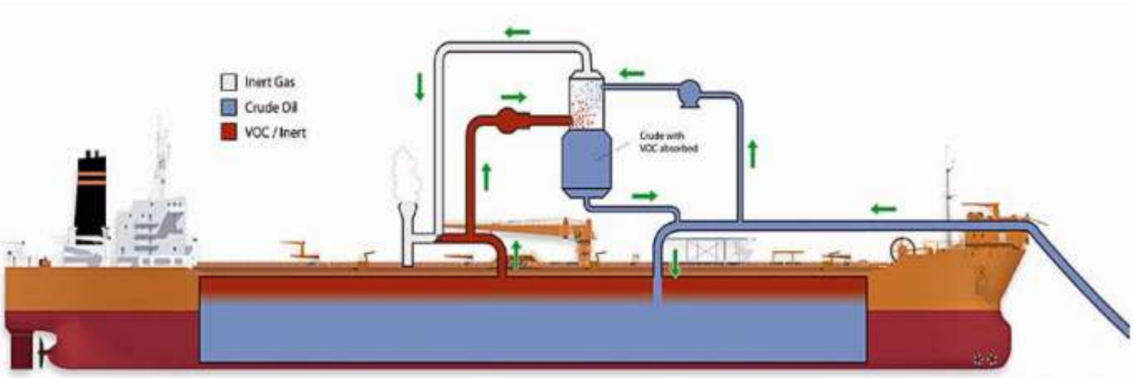


The advantage with compression-condensation technology is that VOC emissions can be avoided because condensed VOC is stored in a separate tank. The technology provides further opportunity to use associated gas in vapour boilers and vapour turbines for beneficial use such as running compressors. The vapour boiler may be designed with a multi-fuel burner capable of burning VOC gases that are not condensed (ca. 20%) in addition to associated gas (methane) and condensed liquids, so that the VOC emissions are reduced by nearly 100%.

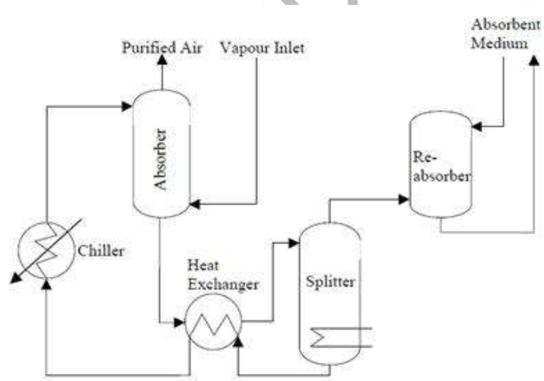


Vapour Recovery Systems – Absorption Systems

The technology is based on the absorption of VOCs in a counter-current flow of crude oil in an absorber column. The vapour is fed into the bottom of the column, with the side stream of crude oil acting as the absorption medium. The oil containing the absorbed VOC is then routed from the bottom of the column back to the loading line where it is mixed with the main crude oil loading stream. Oil pumps and compressors are used to pressurize the oil and gas. Unabsorbed gases are relieved to the riser to increase the recovery efficiency. Similar concepts have been developed using swirl absorbers instead of an absorption column.



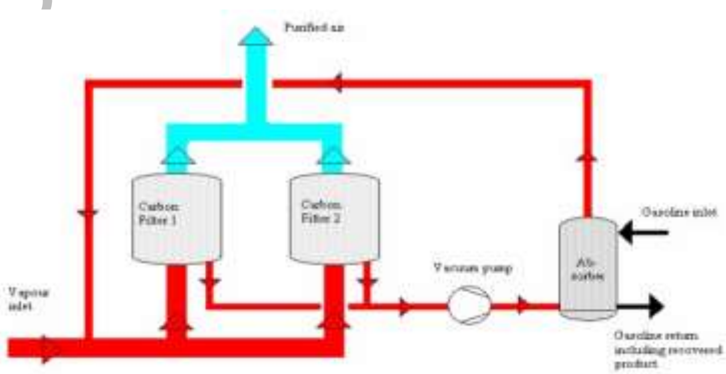
Emissions of VOCs can also be recovered by absorption in pressurized crude oil (8–11 bar) or chilled liquid. However, this system can lead to some increase in emissions of CO2 and NOX due to the energy demand for pressurizing the oil in addition to compression of the VOC and inert gas. The typical energy demand for a plant used for loading 8,000 m3/h is 2–3 MW. These types of plants can reduce VOC emissions by at least 80%. Some methane will also be absorbed. For chilled liquid absorption, methanol is injected to prevent water in the vapour from freezing at reduced temperatures. A typical process flow diagram for chilled liquid absorption is shown below.



Vapour Recovery Systems – Absorption Carbon Vacuum-Regenerated Adsorption

In the CVA process, the crude oil vapours are filtered through active carbon, which adsorbs the hydrocarbons. Then the carbon is regenerated in order to restore its adsorbing capacity and adsorb hydrocarbons in the next cycle. The pressure in the carbon bed is lowered by a vacuum pump until it reaches the level where the hydrocarbons are desorbed from the carbon. The extracted, very highly concentrated vapours then pass into the absorber, where the gas is absorbed in a stream of crude oil taken from and returned to the cargo tanks.

As carbon bed adsorption systems are normally sensitive to high concentrations of hydrocarbons in the VOC inlet stream, the VOC feed stream first passes through an inlet absorber where some hydrocarbons are removed by absorption. The recovered VOC stream may be reabsorbed in the originating crude oil in the same inlet absorber.



The main principle for an adsorption system is to separate fractions of hydrocarbons from inert gas. Several technologies are commercially available.

One type of adsorption system that is used on shuttle tankers transporting oil from the Heidrun field, and on floating storage and offloading units (FSOs), for example Åsgard C and Volve in the North Sea (Norway), uses an active coal filter to separate VOCs from inert gas.

Other technologies include carbon bed adsorption. Both use activated carbon beds, which require periodic desorption (vacuum regeneration) and have an expected service life of 7–10 years. The hydrocarbons (with the exception of methane) will then be recycled back to the oil with help from the adsorption plant. The reduction of the emissions of VOC is ca. 90%. The system is of special interest for gases with low fractions of hydrocarbons or low loading rates, where the oil produced is passed directly over to combined storage/shuttle tankers or FSOs. The system is not suitable for ordinary shuttle tankers due to the large size of the tanker.

1.14 Firefighting systems

The characteristics of fires and the effectiveness of extinguishing agents differ with the fuels involved. While particular extinguishing agents are very effective on fires involving certain fuels, they may be much less effective or even hazardous for use on other types of fires. Take for example, the use of a portable water extinguisher. Water is a good extinguishing medium and is very effective on deep-seated fires, such as burning wood or rubbish. However, a firefighter would not want to use a portable water extinguisher on a fire involving a “live” electrical panel or switchboard due to the conductivity of the water and the possible shock that could result. Considering the different types of fuels that may be involved in a fire, the different types of extinguishing agents available and the different mechanisms which the various agents use to extinguish a fire, it is important to be able to identify the type of fire on which a particular medium will be effective. The job of selecting the proper extinguishing agent has been made easier by the classification of fires into four types, or classes, lettered “A” through “D”, based upon the fuels involved. Within each class are fires involving those materials with similar burning properties and requiring similar extinguishing agents. Thus, knowledge of these classes is essential to efficient firefighting operations, as well as familiarity with the burning characteristics of materials that may be found aboard a vessel.

CLASSES OF FIRES	TYPES OF FIRES	PICTURE SYMBOL
A	Wood, paper, cloth, trash & other ordinary materials.	
B	Gasoline, oil, paint and other flammable liquids.	
C	May be used on fires involving live electrical equipment without danger to the operator.	
D	Combustible metals and combustible metal alloys.	
K	Cooking media (Vegetable or Animal Oils and Fats)	

The IMO under UN is the major Organisation taking care of regulations applicable for ships and floating units in international trade or operation. Taking into account the Montreal Protocol and concern for environmental protection, IMO discussed the measures that may be considered practical for international trade at sea. New installations of fixed fire extinguishing systems and portable fire extinguishers using Halon were prohibited from 1.1.1994 on board all ships and floating units. IMO considers that the shore-based regulations on Halons will govern the phasing out of existing installations, as the availability of Halons decreases. IMO has thus not defined any target date for the phasing out of Halons.

Alternative Extinguishing Systems

Commercial ships are in general to comply with SOLAS Ch. II-2 and Flag State requirements. The Flag State requirements are often identical to SOLAS with minor additions and interpretations. Some alternative chemical gases have been proposed banned under national legislation.

SOLAS Ch. II-2, Reg.7 requires all machinery spaces with power output exceeding 375 kW (510 hp), all oil-fired boiler rooms and purifier rooms to be provided with a fixed extinguishing system. Some of the existing Halon installations have been installed as an additional safety measure in spaces not required to be protected and may normally be decommissioned without replacement.

SOLAS Ch. II-2, Reg.7 basically identifies three options for extinguishing systems for the spaces to be protected:

Water spray systems (SOLAS Ch.II-2, Reg.10)

The system is to be designed according to SOLAS Ch.II-2, Reg.10 and IMO MSC/Circ. 847, 10. Increased water flow rates is to be applied on hazard objects. Use of low expansion foam premix is advised. Great care should be put into design, as water spray systems (at these low flow rates and pressures) will not effectively extinguish all concealed or spraying fires. Use of tested and type approved systems should be considered.

Reliability is considered to be fair. Emergency power required, whereas close down of ventilation may be done after the release of the system. A moderate or inexpensive system (may be combined with any sprinkler system/deluge system). Using water only, the system represents no hazard to humans or the environment. With the use of foam agent, no specific hazard to humans or the environment has been presently identified.

CO2 extinguishing systems (SOLAS Ch.II-2, Reg.5)

The system is to be designed according to SOLAS Ch.II-2, Reg.5 and IMO MSC/Circ. 847, 5. All oil fires will be extinguished at a net concentration between 30-35%. SOLAS regulations require at least 35% of gross volume. Extinguishment of smouldering fires cannot be guaranteed (as for other gas systems). The safety factor will vary with difference between gross/net volume, consequently, use of 40% design concentration is advised.

Reliability is considered to be fair. Emergency power is not required, whereas close down of ventilation and closing appliances is vital. CO2 in the required concentration is lethal to humans. The protected space is to be evacuated before release. Two release controls, alarm and time delay device are required. Release of the system will be delayed due to safety procedures. Late response will increase the fire damage and corresponding repair costs and may, in some cases, impair the effectiveness of the extinguishing agent, thus reducing the probability of extinguishing the fire. The CO2 system is considered to be an inexpensive system (often best with respect to cost). No specific hazard to the global environment (limited amount of CO2).

High expansion foam systems (SOLAS Ch.II-2, Reg.9)

The system is to be designed according to SOLAS Ch.II-2, Reg.9 and IMO MSC/Circ. 847, 9. Distribution of foam is critical and dedicated ducts and overpressure ventilation openings are required.

Reliability is considered to be fair. Emergency power is required, whereas close down of ventilation is not important and closing appliances should be in open position. Drainage of foam will delay re-operation of engines. Moderate or expensive system (probably one of the most expensive systems considering the relatively small machinery spaces in question). The large duct may be difficult to fit into existing machinery spaces. May be dangerous and impair evacuation for personnel although not toxic. The protected space is to be evacuated before release. No specific hazard to the global environment.

In addition to the above systems, alternative and equivalent systems have later been developed and acceptance criteria established in IMO Circulars referred to in Amendments to SOLAS 1974. The equivalent systems are subject to fullscale prototype testing, including fire extinguishing tests and mechanical testing of components. The systems can be categorized as follows:

Water mist systems equivalent to SOLAS Ch.II-2, Reg.10 (equivalent standard: IMO MSC/Circ. 668/728)

The system is to be designed according to IMO MSC/Circ. 668/728 (which is based on full-scale fire testing). Tested systems are effective on oil spray and pool fires and to some extent able to extinguish concealed fires. Volume is critical and the two type approved systems are limited to 2000 m3 /7.5 m deckhead height and 1000 m3 /5.0 m deckhead height, respectively.

Reliability is considered to be fair. Emergency power is normally required and close down of ventilation and closing appliances should be carried out, although this may be done after release of system. Moderate or expensive system (probably one of the most expensive, but may be combined with for instance any sprinkler system). No hazard for global environment.

Alternative gas extinguishing systems (equivalent standard: IMO Circ. 776)
System to be designed according to IMO Circ. 776 (which is based on full-scale fire testing). Effective on oil spray and pool fires and also concealed fires if correct concentration is obtained.

Reliability is considered to be fair. Emergency power is not required, whereas close down of ventilation and closing appliances is vital. Moderate or expensive system. Inert gas systems (Inergen and Argonite) will normally require more storage space than CO2 systems. Not lethal to humans (those type approved so far). Protected space is normally to be evacuated before release. This may delay use of system. Some chemical agents have a relatively high ODS or Global Warning Potential, though within international regulations.

Inside air high expansion foam systems (equivalent standard: IMO MSC/Circ. 668/728)
System to be designed according to IMO MSC/Circ. 668/728 and requirements in type approval certificates. Foam generation is made inside the protected the

space by using generators and foam liquid designed to produce foam at high temperatures. Dedicated ducts (as for system III) are not required. Considered being an effective system.

Reliability is considered to be fair. Emergency power is required, whereas close down of ventilation and closing appliances is not very important. In fact, close down of ventilation may reduce effectiveness of the system. Drainage of foam will delay re-operation of engines. Moderate or expensive system. Release of foam may impair evacuation of personnel, hence space is to be evacuated before release. No specific hazard to the environment.

1.15 Tank, pipeline and fittings' material and coating

Cargo tank coating has two main roles, first to create a separation barrier to avoid direct contact between the mild steel (tank construction) and the corrosive cargo substance. Secondly, it must have smooth/slippery surface to provide easy tank cleaning operation.

Cargo tank coatings can be categorized into two main groups:

1. **Inorganic coatings- zinc silicates and ethyl silicate types.**

Generally, the life of this coating is proportional to the thickness of the coat. This coating is one-layer coating, comprising of inorganic silicates pigmented with high percentage of zinc powder.

2. **Organic coatings – epoxy and modified epoxy systems.**

This type of coating consists an organic resin system, which form strong chemical bonds between the resin molecules. Those types of coating have the ability to resist in more strong acids or alkalis than inorganic coatings. And they tend to absorb significant quantities of cargo and contamination problems can occurs

Coating Systems and Types

Numerous types of coating have been used for cargo tank service in sea trades. Some of these coating have stopped to being used. And more reliable and flexible coating has been developed. Typical coating system can be categorized as Zinc and Epoxy coating

Zinc silicates are formulation of zinc powder plus organic or inorganic binder, and designed to be porous films, which can create problem in the tank cleaning process especially when vessel carry non-volatile cargoes.

Main Characteristics:

- Not resistant to strong acid or bases, including sea water which has a slow weakening effect
- High resistance and tolerance to aromatic hydrocarbon solvent, alcohols and ketones
- Volatile cargoes are desorbed very fast, and retain non-volatile oil like cargoes
- Residues can result in contamination of next or after next cargo

Epoxy coating, generally suitable for the carriage of alkalis, animals fats and vegetable oils but they have limited resistance to aromatics such as benzene and toluene, alcohols such as ethanol and methanol

Main Characteristics:

- Resistant to most strong acids and bases
- Do not retain oil like cargoes. Solvent cargoes are absorbed
- Water wash before thorough ventilation and desorption of residues could result in serious damage of the coating
- Residues can result in contamination of next or after next cargo

- Suitable for carriage of animal fats and vegetable oils provided the free fatty acid content of 5%

Coatings are required for any cargo tank which constructed from mild steel. Most of BLT Chembulk Group modern chemical fleet is SUS cargo tank. SUS are good materials for chemical tanks, because of their ability to create a passive layer on their surface. This passive layer is mainly consisted by chromium oxide, which is very resistant to corrosive environment.

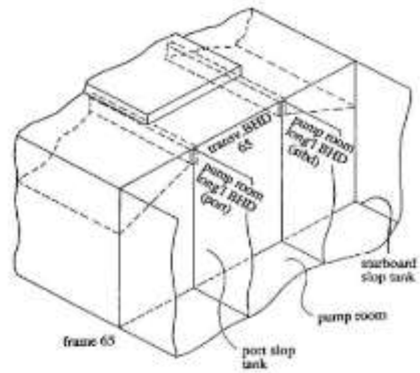
However, in some environments like strong hot acids, chloride solutions and generally solutions which contain halogens, the passive film can break down locally and new film formulation can be disrupted. Generally, SUS is considered to be the ideal material of construction because it's non-corrosive and easy to clean.

1.16 Slop management

As per MARPOL annex 1, regulation 19. Slop tanks are the focal point of the Load-On-Top system used on crude oil tankers to prevent pollution of the sea. Design of these tanks and their operating procedures strongly affect the degree of oil-water separation achieved.

Adequate means shall be provided for cleaning the cargo tanks and transferring the dirty ballast residue and tank washings from the cargo tanks into a slop tank approved by the Administration.

In this system arrangements shall be provided to transfer the oily waste into a slop tank or combination of slop tanks in such a way that any effluent discharged into the sea will be such as to comply with the provisions of regulation 34 of this Annex.



The arrangements of the slop tank or combination of slop tanks shall have a capacity necessary to retain the slop generated by tank washings, oil residues and dirty ballast residues. The total capacity of the slop tank or tanks shall not be less than 3 per cent of the oil-carrying capacity of the ship, except that the Administration may accept:

- 2% for such oil tankers where the tank washing arrangements are such that once the slop tank or tanks are charged with washing water, this water is sufficient for tank washing and, where applicable, for providing the driving fluid for eductors, without the introduction of additional water into the system;
- 2% where segregated ballast tanks or dedicated clean ballast tanks are provided in accordance with regulation 18 of this Annex, or where a cargo tank cleaning system using crude oil washing is fitted in accordance with regulation 33 of this Annex. This capacity may be further reduced to 1.5% for such oil tankers where the tank washing arrangements are such that once the slop tank or tanks are charged with washing water, this water is sufficient for tank washing and, where applicable, for providing the driving

fluid for eductors, without the introduction of additional water into the system; and

– 1% for combination carriers where oil cargo is only carried in tanks with smooth walls. This capacity may be further reduced to 0.8% where the tank washing arrangements are such that once the slop tank or tanks are charged with washing water, this water is sufficient for tank washing and, where applicable, for providing the driving fluid for eductors, without the introduction of additional water into the system.

2. Knowledge of pump theory and characteristics, including types of cargo pumps and their safe operation

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. In essence all pumps are similar in that there is an input and output and a means of motive power. Pumps that are part of machinery with a rotating element such as the main engine may be driven from it by gears but otherwise the motor can be an internal combustion engine, a hydraulic or electric motor.

Pumps on ships are rarely developed solely for use on board ships but are variants of pumps used in industrial processes and shore-based power production. Even the pumps used on oil and chemical tankers have applications in other industries

A look at the technology of pumps on ships

– **Centrifugal Pumps**

One of the simplest types of pumps but found in a variety of situations on board vessels including ballast, bilge, fire, general service, cooling and deepwell cargo pumps among other applications. Strictly speaking, centrifugal pumps add energy to an already moving fluid. They are therefore not self-priming so either require a feed to the inlet or as is common rely on a gravity feed with the inlet immersed.

The pump typically comprises a motor, a drive shaft connected to the impeller, a volute or housing, seals and bearings. Fluid is drawn into the suction eye of the rotating impeller when the pump is operating and forced by centrifugal pressure to the outlet via the volute. As the fluid leaves the impeller under pressure, a pressure drop is produced at the eye of the impeller creating suction and drawing the fluid into the pump.

Sealing is provided by a mechanical seal or by packed gland. For the former cooling water is supplied from the discharge side of the pump. For the latter cooling is provided by the allowance of slight leakage, lubrication is by a grease filled manual lubricator. Depending upon the length of the drive shaft, one or more bearings will be fitted. The efficiency of the pump is affected by both the shape of the housing and impeller designs.

Although the working of centrifugal pumps is basic, there is great variety in their design depending upon application and pumps for different purposes can look very different despite the operating principle being the same. The choice of materials for impeller, housing, shaft and bearings will depend upon the intended use of the pump.

– **Positive Displacement**

Most other types of pump found on ships fall into the positive displacement category. These are generally self-priming and require a safety valve to limit maximum pressure and cannot be started against a closed discharge valve.

Although they are self-priming, most makers recommend that where possible to reduce wear or the risk of seizure pumps should be flooded with liquid before starting.

It is considered that this family of pumps on ships are more suited to low to medium flow rates and can handle higher viscosity fluids than centrifugal pumps. Positive displacement pumps fall into two types – reciprocating or rotary. Reciprocating pumps are also referred to as piston pumps while the rotating category includes types such a gear, screw and lobe pumps.

Positive displacement pumps are usually fitted with an air vessel. An air vessel usually fitted in the discharge pipe work to dampen out the pressure variations during discharge. As the discharge pressure rises the air is compressed in the vessel, and as the pressure falls the air expands. The peak pressure energy is thus stored in the air and returned to the system when pressure falls. Air vessels are not fitted on the reciprocating boiler feed pumps since they may introduce air into the de-aerated water.

Types of pumps on ships

A piston pump can be single or double acting meaning it operates either on one or both directions of the piston travel in the cylinder. In a single acting pump there are an inlet and outlet valves at one end of the cylinder. With the outlet valve closed and the inlet valve open the travel of the piston away from the valves creates suction which draws the liquid into the cylinder. At the end of the piston travel the inlet valve closes and the discharge valve opens so that as the piston returns the liquid in the cylinder is forced into the discharge line. Piston pumps are frequently used for bilge pumping and tank stripping.

In a double acting piston pump, there are inlet and outlet valves at each end of the cylinder operating in opposite action. So that liquid is constantly drawn into the cylinder and discharged regardless of the direction of travel of the piston. A radial piston pump will have several pistons contained in a circular housing and actuated by a central eccentric drive cam. In an axial pump the cylinders are operated by a swash plate the angle of which can be varied to control flow.

In a gear pump the inlet and outlet sides are separated by a pair of meshing toothed wheels or gears housed within the pump casing, one of the gears is attached to a shaft driven by the pump motor and the other is driven by this drive gear. The wheels are a close fit within the casing.

When the pump is started, any air or gas is trapped between each pair of consecutive teeth and dragged along the casing from suction to discharge side till no more air is left on the suction side. Liquid is then drawn into suction line under atmospheric pressure, subsequently this liquid is trapped and moved around the casing into the discharge side and pumping of liquid will commence.

Gear pumps are motor driven through a chain or wheel drive. Control of flow rate is achieved by a bypass valve or controlling the speed of the motor. Gear pumps are commonly used for fuel and lube oil transfer. In order to meet high pressure requirements it is quite common for one or more booster pumps to be installed along the transfer line.

Lobe pumps are a variation of gear pumps in which the meshing toothed wheels are replaced by wheels with a small number of lobes – usually two three or four.

The lobes interlock as they rotate moving fluid around the casing similar to gear pumps.

Screw pumps are one of the oldest means of moving fluids and liquids using the principle developed by Archimedes. In an Achimedean screw, a helicoid rotating inside a cylinder transports the fluid along the cylinder. Modern screw pumps employ the same basic concept but tend to use two or three screws instead of a single screw. They are mainly used on board ship to pump high pressure viscous fluids such as fuels and lubes and hydraulic fluids.

Because the fluid is moved axially along the pump, there is much less turbulence than in a centrifugal pump. This is desirable as it reduces foaming in the fluid.

Pump or Pumping system is a major equipment in any process or power plants. So the equipment should operate properly to give best output in terms of performance. However, there are many factors which influence the pump performance. Out of those, the main (major) factors which affect the performance of pump are:

– **IMPELLER DESIGN:**

- Backward curved blades, $\beta 2<90°$
- Forward curved blades, $\beta 2>90°$
- Radial blades, $\beta 2=90°$

– **IMPROPER PRIMING:**

All the air in the pipe line should be expelled completely. Precautions to eliminate trouble:

- The pump should be primed completely before starting
- Suction pipe should be 1m below the lowest water level
- It should be completely air tight

- Eccentric reducers should be used if necessary to avoid air pockets in pipe line

– **INSUFFICIENT NPSH (Net Positive Suction Head)**

- NPSH depends on the temperature of the operating liquid
- Variation in water level is considerable – Lowest level should be taken in to account for NPSH determination
- Frictional losses should be kept minimum by selecting suitable diameter.
- It is commonly accepted the static head in the pump will be maintained as 6.7m for water with a temperature of 10-20°c
- NPSH avaiable > NPSH required

– **REDUCED CAPACITY:**

- One of the main reason for the reduced capacity is increased head
- Total head > designed head
- Pump or the impeller should be changed to obtain the rated capacity

– **WRONG DIRECTION OF ROTATION:**

- This cause the rated capacity and head will not be obtained
- Pump fails often to operate
- Remedy :
  - arrow cast is indicated in pump casing
  - care should be taken while mounting the impeller

– **CLOGGING OF SUCTION PIPELINE AND IMPELLER:**

- Suction pipe is clogged by some bricks, woods often
- Strainer is clogged by paper, leaves
- To rectify this pipeline should be inspected periodically

– **IMPROPER SHAFT ALIGNMENT:**

- It is due to misalignment of motor and pump shaft
- It results in the vibration and noisy operation

- To avoid this two shafts should be aligned properly

– **NOISY OPERATION:**

- Air leakage in the pump
- Shaft misalignment resulting in the vibration
- Cavitations
- They can be reduced by proper dynamic balance of the shaft and impeller
- The cavitations is reduced by properly designing the pump with suitable NPSH

Cavitation is a problem condition which may develop while a centrifugal pump is operating. This occurs when a liquid boils inside the pump due to insufficient suction head pressure. Low suction head causes a pressure below that of vaporization of the liquid, at the eye of the impeller.

The resultant gas which forms causes the formation and collapse of 'bubbles' within the liquid. This, because gases cannot be pumped together with the liquid, causes violent fluctuations of pressure within the pump casing and is seen on the discharge gauge. These sudden changes in pressure cause vibrations which can result in serious damage to the pump and, of course, cause pumping inefficiency.

PRIME MOVERS

The prime movers for pumps are the devices used to drive them - whether they are rotating machines or otherwise.

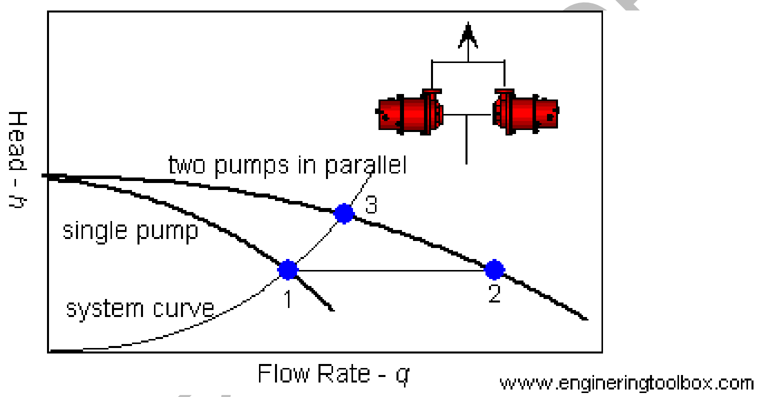
The types of prime mover used for modern pumps are:

1. Electric Motor.
2. Diesel (or petrol) engine.
3. Gas Turbine.

4. Steam Turbine.

Pumps in Parallel - Flow Rate Added

When two or more pumps are arranged in parallel their resulting performance curve is obtained by **adding the pumps flowrates** at the same head as indicated in the figure below.



Centrifugal pumps in parallel are used to overcome larger volume flows than one pump can handle alone.

– for two identical pumps in parallel and the head kept constant - the flowrate doubles compared to a single pump as indicated with **point 2**

Note! In practice the combined head and volume flow moves along the system curve as indicated from 1 to 3.

– **point 3** is where the system operates with **both pumps** running

– **point 1** is where the system operates with **one pump** running

In practice, if one of the pumps in parallel or series stops, the operation point moves along the system resistance curve from point 3 to point 1 - the head and flow rate are decreased.

Note that for two pumps with equal performance curves running in parallel

- the head for each pump equals the head at point 3
- the flow for each pump equals half the flow at point 3

3. Proficiency in tanker safety culture and implementation of safety management system

The ISM International Safety Management Code was adopted by the International Maritime Organization (IMO) by resolution A.741 (18). The objectives of the ISM Code are to ensure safety at sea, prevention of human injury or loss of life, and avoidance of damage to the environment, in particular, to the marine environment, and to property. The Code requires companies to establish safety objectives as described in section 1.2 of the ISM Code. In addition companies must develop, implement and maintain a Safety Management System (SMS) which includes functional requirements as listed in section 1.4 of the ISM Code.

Compliance with the ISM Code became mandatory with the adoption of SOLAS, Chapter IX, "Management for the Safe Operation of Ships." The IMO provided amplifying guidance on implementation of the requirements of SOLAS, Chapter IX, and the ISM Code in resolution A.788 (19), "Guidelines on the Implementation of the International Safety management (ISM) Code by Administrations."

In a Final Rule, published on December 24, 1997, the U.S. Coast Guard implemented the requirements of the ISM Code into its regulations. These regulations apply to both foreign and domestic commercial ships operating in U.S. waters. To maintain consistency with existing U.S. shipping regulations, some of the terms used in the Final Rule differ from those used in SOLAS and the ISM

Code. The following table provides a list of some of those terms and the equivalent SOLAS term.

The Code's origins can be traced back to the late 1980s, when concern was growing about poor management standards in the shipping industry. In 1989, IMO adopted Guidelines on management for the safe operation of ships and for pollution prevention "to provide those responsible for the operation of ships with a framework for the proper development, implementation and assessment of safety and pollution prevention management in accordance with good practice."

These guidelines were revised in November 1991 and the ISM Code itself was adopted as a recommendation in 1993. However, after several years of practical experience, it was felt that the Code was so important that it should be mandatory.

It was decided that the best way of achieving this would be through the International Convention for the Safety of Life at Sea, 1974 (SOLAS). This was done by means of amendments adopted on 24 May 1994, which added a new Chapter IX to the Convention entitled Management for the safe operation of ships. The Code itself is not actually included in the Convention, but is made mandatory by means of a reference in Chapter IX.

The Tanker Management and Self-Assessment (TMSA) programme provides companies with a means to improve and measure their own safety management systems.

The programme encourages companies to assess their safety management systems (SMS) against key performance indicators (KPIs) and provides a minimum expectation (level 1) plus three levels of increasing best practice guidance. Self-assessment results can be used to develop phased improvement plans that support continuous improvement of their ship management systems. Companies are encouraged to regularly review their self-assessment results against the TMSA KPIs and to create achievable plans for improvement.

Aligning their own policies and procedures with industry best practice helps companies to improve their performance and attain high standards of safety and pollution prevention.

4. Knowledge and understanding of monitoring and safety systems, including the emergency shutdown system

Oil tankers operations at sea and while at port requires some basic safety procedure to be observed. Prior entering a space which contained or has a risk of the presence of any Toxic gases such as benzene, H2S, etc., the MSDS (Marine Safety Data Sheets) and other relevant information and precautions for Toxic gases as listed in ISGOTT should be referred to. Thorough gas checks using suitable Toxic gas detector tubes need to be carried out.

– **Hydrocarbon Vapors**

- Hydrocarbon gases are heavier than sir (1.5 to 3 times), and tend to accumulate in the vicinity of the area where they are generated. A large amount of gas might exist sometimes in unpredictable locations. The bottom of the pump room is a typical example.
- Gases flow to the leeward side, and are dangerous in that they may cause explosion at spaces other than where they are generated.

- The explosion limits or flammable limits (LEL / UEL or LFL / UFL) varies according to the type of Hydrocarbon gas in question.

Their proportionate mixtures present in the petroleum vapor in question. This is generally around 1.8% Vol. in Air (Min.) to 9.5% Vol. in Air (Max); whereas International Chamber of Shipping recommends a range of 1.0% to 10.0 Vol.%, to assume safer standards.

- The danger for explosion is far greater in a lightly laden ship, while loading / unloading cargo, during ballasting operations or during tank cleaning, rather than when fully laden. This is because on a loaded vessel, the tank atmosphere contains hydrocarbons concentrations of well over above UEL
- The Company permits limit of Hydrocarbon (petroleum) gas mixture in air conducting man-entry as 1.0 % LFL as measured with suitable approved type gas detector.

– **Hydrogen Sulfide (H2S)**

- H2S is a Highly toxic, corrosive and flammable gas that in low levels will smell like rotten eggs.
- It may be present in bunkers in dissolved state or as a gas. In may also be found in certain Natural gases, Crude oils and certain Refined products such as Naphtha.
- It is Colorless and Heavier than Air, having relative vapor density of 1.189
- Exposure to high levels of H2S can be fatal after a very short period of time.
- H2S is a liquid soluble gas and produces vapor when the liquid is agitated or heated. It is not possible to predict the likely H2S vapor concentration present above a liquid in a tank, from any given liquid concentration but, as

an example, an oil containing 70 “ppm by weight”? as concentration of H2S in liquid has been shown to produce 7000 “ppm by volume

Precautions for Hydrogen Sulfide (H2S)

- In cases where H2S concentrations are known to be greater than 100 ppm in the vapor space and likely to be present in the atmosphere, Emergency escape Breathing Apparatus shall be made available to personnel working in the hazardous area, who, should already have a Personal (pocket-able) H2S gas monitoring alarm / instrument.
- The presence of H2S in bunkers should not be ruled out. Empty bunkers tanks shall be tested for the presence of H2S prior to bunkering.

If new to be supplied bunkers contains H2S the DPA shall be informed immediately.

Gas Detection Equipment

Under the following circumstances the cargo tank or any enclosed space on-board the ship has to be evaluated to ensure that the particular space is gas-free and has ample amount of oxygen for personnel to work there if required. The circumstances may be:

- Prior to entry,
- Prior to any repair work (which may be at dry-dock or even at the shipyard)
- As quality control before loading (A person called the vetting inspector usually inspects the cargo tank.)

Tank evaluation is done to ensure that the atmosphere inside the tank is safe enough for personnel to make an entry. There are different equipments available on-board for the evaluation of tank atmosphere. Some of them are:

- Combustible gas indicators or explosimeters

- Tankscope or non-combustible gas indicators
- Multi-gas analyzers
- Oxygen analyzers

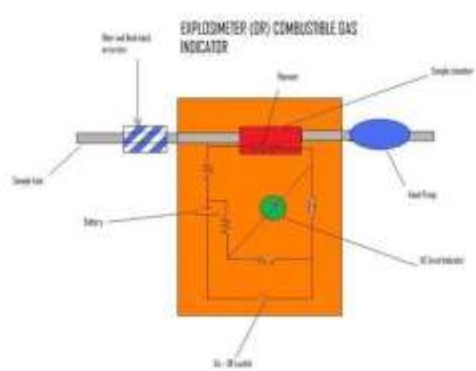
These are some of the widely used equipment onboard tankers. In this article we will discuss in detail the working principle of the above equipment.

Combustible Gas Indicators or Explosimeters

An explosimeter is a device used to detect the amount of combustible gases present in a sample of the given atmosphere. This gives the reading in terms of percentage of the LFL (lower flammable limit).

“Resistance proportional to heat" is the working principle.

The equipment consists of a Wheatstone bridge in which one of the resistances is variable. The circuit is shown below:



It consists of four resistances in which one varies according to the amount of the gas present. A hand pump is used to draw the gas or the atmosphere containing the gas inside the device. A filter and flash back arrestor is used to filter the gas and also acts as a flame arrestor.

The device is switched on. As the hand pump is operated to suck a sample of gas from the cargo tank, simultaneously the filament gets heated. Any combustibles in the sample will land on the filament in the sample chamber. The combustibles will burn as the filament is already hot causing an increase in resistance which disturbs the Wheatstone bridge. The reading can be read from the indicator. The instrument gives the reading in percentage of the Lower Flammable Limit or Lower Explosive Limit which is 1%.

This type of gas meter can only be used if the gas content is very low (i.e.) this instrument should not be used if the atmosphere contains:

- H/C + inert gas – then the gas will not burn as there is no oxygen
- H/C + oxy-acetylene – then the burning will be too violent
- H/C + oxy-hydrogen – Same as above
- Lead petroleum vapors – Lead oxide deposits on the filament cause a reduction in sensitivity

All meters require calibration. This meter requires the following before using:

- Zero check
- Span check
- Battery check

Proper working of the equipment can be achieved by regular maintenance. Clean the filters regularly and it is advisable to have it serviced by the manufacturer once every six months.

Tankscope or Non-combustible Gas Indicator

A Tankscope is a device used for measurement of hydrocarbon gas content in a sample of given atmosphere. This instrument is meant for measuring the hydrocarbon vapor in inerted atmospheres. This instrument is not as sensitive as the explosimeter. The reading is only in percentage of the volume of the hydrocarbon vapor and hence used only during the gassing up operations and during inerting. This is purely meant for measuring the volume of the hydrocarbon vapors present inside any enclosed space, and hence it is not meant for measuring during a man-entry.

It works on the same principle as that of an explosimeter except that the gas does not burn inside the sample chamber; there is an alteration in the temperature of the heated filament which enhances the change in resistance.

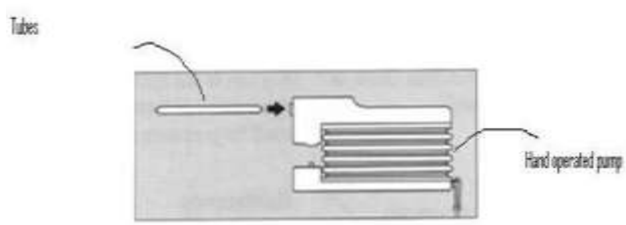
It is always advisable to flush the sample tube with fresh air after every use. The following checks are done to ensure the proper working of the instrument:

- Zero check
- Span check
- Voltages check (battery check)

Multi-Gas Analyzers

Multi-gas analyzers are used to detect only targeted gases and vapors. It is very specific to that type of gas only, so care has to be taken to ensure that correct tubes are used for the particular type of gas.

The multi-gas analyzer consists of a portable bellows pump and detector tubes. The detector tube is like a vial filled with reagent that will react with the specific chemical. Both the ends of the tube are closed. In order to use it we have to break the two ends of the tube and insert it into the pump according to the directions mentioned on the tube. Now start pumping 3-4 times (or as specified by the manufacturer) to suck in the particular gas from the atmosphere. If the atmosphere contains that particular gas or vapor, then the color of the tube changes. The length of the color change can be read from the tube and compared to obtain the level of that particular gas or vapor. Some of the gases include carbon monoxide, chlorine, hydrogen sulphide, organic arsenic compounds, arsine, and phosphoric acid esters. An extension hose is provided to measure the concentration of vapor present at a different height. In a situation like this, we have to insert the hose with the pump and the tube connected to the other end of the hose.



Oxygen Analyzers

The oxygen analyzer is a device used to measure the concentration of oxygen in a given atmosphere. This device plays a vital role since with the reading provided, only man-entry is done. The important checks that are done on the oxygen analyzers are:

- Calibration with fresh air (which contains 21% of oxygen)
- Battery check

Never change the batteries in a gas dangerous zone.

Further references can be found in the Bright Hub article "Oxygen Analyzer used On-board Ships."

5. Ability to perform cargo measurements and calculations

Transportation of chemicals by tankers is usually accompanied by considerable documentation. Documentation can be even greater when trading to and from less developed countries. The vessel's management is presented with a great deal of documentation from parties to the cargo, authorities, etc. Furthermore vessel's management must also issues papers serving to record evidence, claims etc.

Cargo is bought and sold in various units of measurement. These may be Barrels (Bbls) at 60F, Cubic metres (M3) @ 15C, Metric Tonnes in Vacuum, Metric Tonnes in Air and Long tons in Air.

Different methods of calculation for various substances can be applied, but they must be similar for loading and discharging. The method must be agreed with the surveyor. The range of substance temperatures (port of loading and port of discharging) must also be taken in to consideration. Necessary data for the expected temperature of a substance should be requested from the surveyor at the loading port.

Calculation with Specific Gravity

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

The following may be received in loading port:

S.G. at 25/20 = 0.8250

ASTM Tables

In 1980, the American Society for Testing and Materials (ASTM) together with the London Institute of Petroleum (IP) and the American Petroleum Institute (API), introduced the new API/ASTM-IP Petroleum Measurement Tables (further ASTM tables).

Presently the set of ASTM tables consists of 14 volumes however only a few tables are required for onboard cargo calculations. The following is the list of ASTM volumes (with description of required tables) each vessel should carry on board:

For tankers carrying Petroleum Products:

- Volume II (Tables 5B and 6B).
- Table 6B to be used for petroleum Products correction of volume to 60ºF against API Gravity at 60ºF. (American Measurement System).
- Volume VIII (Tables 53B and 54B)
- Table 54B to be used for Petroleum Products correction of volume to 15ºC against Density at 15ºC. (Metric Measurement System).
- Volume XI/XII (Tables 1-4, 8-14 and 21, 22, 26-31, 33, 34, 51, 52, 56-58).

– Tables for conversion between various Volume and Density Measures.

These sets of books together with ship's Ullage Tables or Sounding tables provide everything required for calculating the quantities of oil cargoes on board the vessel

Density, Relative density and API

Density is by definition measured in vacuum at 15C Density x volume (M^3) gives metric tons in vacuum. Density in vacuum subtracted by 0.0011 is known as density in air".

For example:

1000M^3 at 15C of density 0.8560 is 856 metric tons (MT) in vacuum or 854.9 MT in air. Use tables 54A or B in volumes VII and VIII.

For chemical cargoes the vessel to check with surveyors if density in air is supplied by cargo surveyors for the cargo to be loaded.

Relative density 15/4 is the density of oil at 15C/density of fresh water at 4C.

Relative density 15/4 can be treated exactly the same way as density at 15C as it is almost the same. Use table 54A or B in volumes VII or VIII or convert to API using table 3 in volume XI/XII.

Relative Density 60/60 (SG): Relative density 60/60 is the density of cargo at 60F/density of fresh water at 60F. Convert this to density at 15C, or API using table 3 in volume XI/XII

Volume reduction to standard temperature

There are several standard temperatures in use throughout the industry. It is the Company policy that, except where tank calibrations are only in barrels, calculations of cargo quantity will be done using density at 15C and cubic metres as a volume measure. If the density is given at 20C, as in Brazil or Rumania, it should be converted to 15C in the following way.

Product density @ 20C = 0.8764

Table 53B, Volume VIII, page 209. Call 20C “observed temperature”. Corresponding density @ 15C is 0.8798. Proceed with calculation using density @ 15C.

Reduce the volume to 15C with table 54B, or 60F with table 6B as appropriate.

Ullage Reports

On completion of loading and prior to commencement of discharge operations the Chief Officer together with the surveyor will check the ullage and the temperature of the relevant tanks. These two parameters are the basis for the cargo calculation and they are to be recorded in the “Ullage Report Form”.

With heated cargoes, great care must be taken to establish the correct average temperature in each tank. This can only be done with electronic probe thermometers. Some cargoes however, will block the sensor of the thermometer. If this occurs, glass thermometers are to be used in preference to blocking up all the ship’s electronic thermometers.

If glass thermometers have been used, a note is to be made on the Ullage Report Form. Water dips can successfully be taken in almost any heated cargo, if the sounding rod is left on the bottom for a minute, and gently worked up and down. Kolor Kut water finding paste should be used if possible, in preference to Vecom water finding paste as the Vecom paste tends to change colour in contact with suspended traces of waterin the cargo, and may cause great errors in the recorded free water quantity.

Good practice

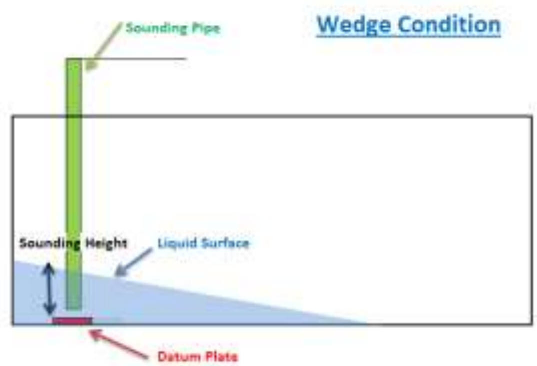
Careful assessment to be done for applicable load lines during cargo calculations , it is also important that a structured message containing all the applicable deductibles sent to the charterers immediately on receipt of cargo query.

Wedge Formula is calculation to determine the small quantity of liquid or non-liquid cargo (On Board Quantity – OBQ or Remaining On Board – ROB) on cargo tanks, where it should fulfill the following conditions:

- The vessel has huge trim, but there is no trim correction value available on the tank table,
- The liquid or cargo on tank is not touch one or more of the tank bulkheads,
- Observed sounding tanks at several points to ensure the cargo is not touch one of the tank bulkheads,

In order to standardize the OBQ/ROB calculations on board the Crude Oil carrying tanker vessels, the following geometric form of the Wedge Formula shall be used and this form of the formula assumes that the cargo tank is 'box shaped' with no internal 'deadwood' or pipeline systems, heating coils etc. that would impact the accuracy of the volume calculated from the sounding. Furthermore this wedge formula calculation makes the enormous assumption that any 'liquid' found in a cargo tank is in the form of a regular wedge shape with its base at the aft bulkhead of the cargo tank.

It is obvious that such a series of assumptions normally can invalidate the absolute accuracy of the calculation immediately given, amongst other issues, the shape of the wing tanks (the turn of the bilge) and in particular those wing tanks at the fore and aft parts of the vessel.



The calculation method for the Geometric edition of the Wedge Formula

Assumption: Given the small angle involved with the trim of the vessel, then the 'Sine' of an angle can be considered as the same as the 'Tangent' (Tan) of an angle and consequently:

Step 1:

Correct the position of the sounding position with respect to the aft bulkhead of the cargo tank due to the trim of the vessel, distance = **A**

A = Tank Reference Height (Observed Height) x Tan X; where **X** = the Trim angle of the vessel and;

Tan X = (Aft draft – Forward draft) / Length Between Perpendiculars (L.B.P.) of the vessel.

Step 2:

Determine the distance of the apex of the wedge from the aft bulkhead for obtaining information whether:

- Should a Wedge Formula be used at all (kindly note that a wedge formula is not applicable if:
  - the liquid surface covers the total cargo tank bottom or the calculated apex of the wedge is at or beyond the forward bulkhead of the cargo tank or:
  - it is sludge ROB volumes only); And
- Whether the wedge is a regular wedge (which can be checked by comparison with alternative soundings being taken).

S = Observed Sounding;

F (Distance of the apex of the wedge from the sounding position) = **S x Tan X;**

E (Distance of the apex of the wedge to the aft bulkhead) = (**F** – **A**) + **B**; where **B** is the distance on deck from the point of sounding to the aft bulkhead.

Step 3:

Determine the depth of the wedge at the aft bulkhead of the cargo tank, depth = **D;**

D = E x Tan X

Step 4:

Knowing **D** (sounding depth at the aft bulkhead) and **E** (the distance from the aft bulkhead to the apex of the wedge), then the area of the longitudinal cross section of the wedge may be calculated, thus as the area of a triangle = (Base x Height) / 2 then; **(D x E) / 2 = cross sectional area of wedge.**

Step 5:

Having obtained the cross sectional area of the wedge, the volume of the wedge is calculated by multiplication by the breadth of the cargo tank (please note that the breadth of the cargo tank should be measured at the bottom of the tank at the aft bulkhead position and not at deck level or elsewhere within the cargo tank)

Volume of the Wedge = Cross sectional Area x Breadth of Tank

Throughout this calculation it is very important that all distances are in metres. Do not use centimetres for the observed sounding.

6. **Knowledge of the effect of bulk liquid cargoes on trim and stability and structural integrity**

Factors affecting stability calculations

Loading computers are a mandatory part of tanker cargo control systems, providing information on the correct loading conditions. The computer calculates the correct cargo and ballast loading for tankers prior to berth departure, ensuring that the load does not exceed the vessel's damage stability, and longitudinal and local strength requirements.

Damage stability is calculated based on the hullform and inner structure of the ship, using the lost buoyancy method. Whenever the levels of cargo or ballast and bunker tanks have been changed, the required stability conditions, as laid down by the classification society, also change. The calculation results are checked against the appropriate damage stability criteria, such as Solas or the IBC Code.

The rules relating to requirements are changing. IMO is acting to tighten the requirements for verifying that tankers do not exceed the damage stability requirements in response to recent issues identified by the Paris Memorandum of Understanding (MoU) on port state control. A concentrated inspection campaign in 2010 targeting tankers found that 77 oil tankers and 84 chemical carriers could not demonstrate that they were loaded in accordance with the Stability Information Booklet (SIB). Paris MoU members were concerned that in some cases tankers were not being loaded in compliance with IMO damage stability rules, which means that in the case of a collision or grounding the ship may not survive, resulting in possible pollution or even loss of life.

At the February 2013 meeting of IMO's sub-committee on vessel stability (SLF) there was agreement over the mandatory carriage requirements for stability instruments on board tankers. The sub-committee agreed to draft amendments to Marpol Annex 1 regulation 28 (concerning damage stability), with a new paragraph to require oil tankers to be fitted with a stability instrument capable of verifying compliance with intact and damage stability requirements. These amendments will be forwarded to IMO's Marine Environment Protection Committee (MEPC 65) and the Maritime Safety Committee (MSC 92) for approval with a view to subsequent adoption. There will also be changes to the IBC Code.

Classification societies provide a lengthy list of requirements for type-approved loading computers, which are regarded as supplementary to the loading manual and stability booklet. According to Det Norske Veritas, the results from a loading computer are only applicable to specific ships. They should be capable of producing print-outs of these results in both graphical and numerical form, also showing percentage of allowable values. Class should approve both the hardware and the software, which should present relevant parameters of each loading condition, such as:

- deadweight definition
- light ship data
- displacement and centre of gravity
- draughts at the forward and aft perpendiculars and at Midship
- draughts at the ship's forward, midship and aft draught marks
- ship trim
- free surface moments listed for each tank and for the vessel
- free surface corrections
- external heeling moments

The software should also show the stability limitations, listing and descriptions of all relevant stability criteria, the limit values, and the obtained values compared with the limit values – including the shear forces and bending moments for seagoing and harbour conditions. As DNV says, calculation of damage stability should be done either with control against approved limit curves, or with direct calculation and control against a predefined group of all relevant damage cases.

API Marine has developed the TSS/Cargo control system for remote monitoring and controlling of cargo and ballast systems. This monitors cargo levels, temperatures and pressures, as well as inert gas and pressures at manifolds. TSS/Cargo includes remote valve control and draught, heel and trim monitoring. The measurement accuracy is based on the use of high-precision level temperature and pressure measurement instruments combined with a digital output. Information from the sensors is transmitted to the cargo computer, such as API's MasterLoad, where loading, strength, and stability are calculated. It is also where safety of operation parameters in the current loading condition is controlled, enabling officers to prepare the cargo plan for the tanker. TSS/Control is connected to the ship's automation through a ring main network. It is an open system, so it can integrate other manufacturers' equipment.

API Marine also manufactures sets of sensors and switches. Its latest development, the TSS/ BMS4 sensors, received DNV type approval certification at the end of 2012. TSS/BMS4 is the next-generation electro-pneumatic system for cargo tank levels and cargo density, as well as vessel draught measurements. The sensors and gauges are linked to API's TSS/Alarm system for level control in cargo and slop tanks. When a critical filling level is reached, an alarm is cargo control systems Operators can monitor tank levels during loading and discharging operations arrows symbolise state of operation alarm limit indications 48 I Tanker Shipping & Trade | April/May 2013 www.tankershipping.com actuated, sending signals to the alarm devices and display panel. This can be switched off, but if the emergency level is reached again, the process is repeated. The level switches are located in explosion hazard zones, so sparkproof circuits and spark protection barriers are included. API also has an alarm system for cargo temperature measurements. This consists of the UTT temperature sensors, local stations and an alarm panel.

7. Knowledge and understanding of chemical cargo-related operations

7.1 Loading and unloading plans

The loading plan for a tanker must address a multitude of requirements including carrying capacity, hull stresses, loading and discharge instructions, parcel separation, sequence of loading and discharge, vapour pressure, expansion and contraction. A properly prepared cargo loading plan begins with the most basic requirements and proceeds through a review of all other essential considerations. The objective is to adequately ensure the safety of the cargo at a minimum preparation expense in time, fuel and effort.

By the time the tank washing and tank cleaning operations have been completed, the tanker should have received the final loading orders and any necessary clarifications.

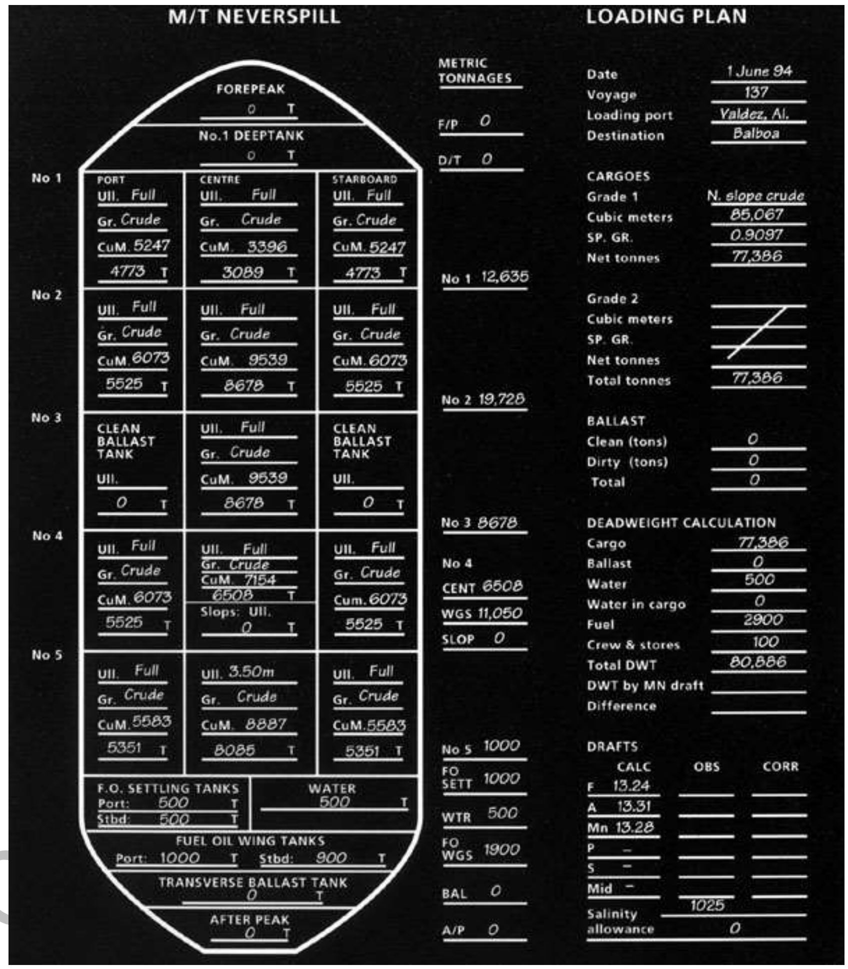
Loading orders may have been prepared in some detail by the owner's or charterer's shore staff and may already represent the optimum loading for the ship. Even detailed loading instructions must never be implemented without careful review by the chief officer and master. The responsibility for safe loading of the ship always rests with the master

Written loading plan

When the chief officer has completed his review of all necessary factors and checked his calculations, he prepares a written loading plan which must include the following details:

- Names of each grade of product or crude oil to be loaded and the quantity of each.
- Anticipated specific gravity and loading temperature of each grade of cargo.

– The cargo tank(s) each grade will be loaded into.



– The pipeline system and loading path for each grade, including setting of valves (identified by their unique identification numbers).

– The sequence of loading of cargo grades.

– The final ullage for each cargo tank.

– The stand-by time required by the terminal for reducing loading rate or stopping the cargo loading.

- The anticipated departure draft.
- Bunkers and ballast to be on board at departure.
- Identification of all valves to be sealed closed before, during, or after loading.
- The maximum loading rates to be allowed and loading rate(s) expected with the terminal.
- Loading rate to be used for topping off tanks.
- Special cargo procedures to be followed.
- Special precautions with respect to moorings.
- Equipment required (radios, ullage tapes, etc.).
- Points in the loading when the chief officer is to be called or extra manning is required.
- Reference to standing orders for cargo operations.
- Requirement that shore terminal regulations be read and signed by each cargo watch officer.

7.2 Ballasting and deballasting

Ballasting or de-ballasting is a process by which sea water is taken in and out of the ship when the ship is at the port or at the sea. The sea water carried by the ship is known as ballast water.

Ballast or ballast water is sea water carried by a vessel in its ballast tanks to ensure its trim, stability and structural integrity. Ballast tanks are constructed in ships with piping system and high capacity ballast pumps to carry out the operation.

In ancient times, ships used to carry solid ballast for stability as the cargo was minimal or there was no cargo to be carried. However, as time passed difficulties were faced during loading and discharging of solid cargo. The process of transferring of solid cargo was also time-consuming and for this reason solid ballast was replaced by water ballast. As sea water was readily available and in huge amount, it was used for the ballasting and de-ballasting process.

Ballasting or de-ballasting is required when the ship is to enter a channel, cross any canal like Panama canal and Suez Canal, during loading or unloading of cargo, and when ship is going for berthing.

Ballasting and De ballasting Simplified

When no cargo is carried by the ship, the later becomes light in weight, which can affect its stability. For this reason, ballast water is taken in dedicated tanks in the ship to stabilize it. Tanks are filled with ballast water with the help of high capacity ballast pumps and this process is known as Ballasting**.**

However, when the ship is filled with cargo, the stability of the ship is maintained by the weight of the cargo itself and thus there is no requirement of ballast water. The process of taking out ballast water from the ballast tanks to make them empty is known as de-ballasting.

7.3 Tank cleaning operations/prewash operations

All tank cleaning procedures are essentially a logical sequence of events that will ultimately allow any vessel to change from one grade of cargo to another. The precise nature of the cleaning process is specifically determined by the chemical and physical properties of the cargo being cleaned from, the type of lining inside the cargo tanks, the size and dimension of the cargo tanks and the pre-loading specifications of the next nominated cargo.

Tank cleaning is a common procedure performed on board ships. Those associated with the process are very well aware of the hazards involved and fatal accidents that have occurred in the past. In spite of all the necessary safety precautions and enclosed space entry procedures, accidents still occur while cleaning tanks on board ships.

Few months ago, a chief officer died on board a chemical tanker after he entered a cargo tank which contained hydrocarbon vapours and was deficient in oxygen. When the ship sailed at night after the cargo had been discharged, the two tanks that had carried hexene-1 were still inerted with nitrogen gas. As the tanks were to be loaded at the next port within two days, the crew began day/night tank cleaning operations soon after sailing. The chief mate was a non-watch keeper, so was able to direct the tank cleaning crew continuously. Early the next morning, during post-cleaning ventilation, the chief mate, who was preparing to conduct pre-loading inspection of the empty tanks, was informed that a 'petrol-like' odour was still coming from 5P tank. He had filled out the enclosed space entry checklists for the tanks he intended to enter that morning, but significantly, no enclosed space entry checklist was filled out for 5P tank.

Very simply, the key to any successful cleaning operation is knowing how far to clean and determining whether each step of the cleaning process has been effective.

7.4 Tank atmosphere control

During Gas purging / Gas freeing operation, the tank and pipelines atmosphere should be controlled and not allowed to enter the flammable range (of the flammability diagram) at any time.

In all operations, where gas is being vented (purged or gas freed), great vigilance should be exercised, as the highest concentrations of gases (hydrocarbon or inert gas) is emanated at the start of such operations. Hence, where portable gas free fans are used, where the venting velocity is minimum, great care needs to be exercised.

The venting of flammable gas during Gas freeing should be by the vessels approved method. Where gas freeing involves the escape of gas at deck level or through tank 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.

Once an oil cargo tank has been confirmed free of explosive hydrocarbon vapors (less than 1% HC LEL), toxic gases, contaminants and the oxygen content is measured at 21.0% the tank should be isolated from the IG (Inert Gas) main line by inserting blind flange at the IG tank supply valve.

IG in adjacent tanks to be reduced to minimum (200mmAq) to prevent the ingress of hydrocarbon gas / IG through any leaking valves, pipelines or (damaged/cracked) bulkheads. All other valves to the tank (including Machine valves) should be in closed position.

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.

7.5 Inerting

An inerting system decreases the probability of combustion of flammable materials stored in a confined space, especially a fuel tank, by maintaining a chemically non-reactive or "inert" gas, such as nitrogen, in such a space. "Inerted" fuel tanks may be used on land, or aboard ships.

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.

Two other methods in current use to inert fuel tanks are a foam suppressant system and an ullage system. The FAA has decided that the added weight of an ullage system makes it impractical for implementation in the aviation field.[11] Some US Military aircraft still use nitrogen based foam inerting systems, and some companies will ship containers of fuel with an ullage system across train routes.

7.6 Gas freeing

The procedure of removing dangerous and explosive gases from the interior of tanks (usually vapours originating in the cargo of oil tankers and chemical carriers). Gas freeing consists of a series of operations in which cargo vapour is replaced with inert gas which, in turn is purged with air to prevent explosion hazard.

It is generally recognized that Tank cleaning and Gas freeing is the most hazardous period of tanker operations. This is true whether washing for clean ballast tanks, Gas freeing for entry, or Gas freeing for hot work.

The additional risk from the Toxic effect of petroleum gas 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 tank cleaning and gas freeing.

Refer to ISGOTT regarding the various hazards involved. Also, follow the check items as described in Tank Cleaning, Purging and Gas Freeing Checklist

Precautions below mentioned shall be considered to Hazard identification and Risk control In due course of a Risk management.

Prevent human injury

The chief officer is the responsible person for such operation and shall brief all crew regarding the safety measures to be followed on deck.

During gas freeing operations only personnel directly involved in the Gas freeing operations should be allowed on the main deck. Tank openings shall be guarded.

The proposed duration and Job / Watch schedule

All crew involved in the Gas freeing operations must wear appropriate clothing. Antistatic precautions must be observed on deck.

The covers of all tank openings should be kept closed until actual ventilation of the individual tank is about to commence.

If small crafts are alongside the tanker, their personnel should also be notified. The atmosphere in the operations area should be monitored for explosive hydrocarbon vapors during such conditions.

Prevent for Gas enter into accommodation area

To prevent hydrocarbon vapors to accumulate in the accommodation areas, it may be necessary to change course during Gas freeing operations.

The presence of Sparks / Hot soot emanating from the funnel stacks should be considered.

If gas freeing is taking place while the vessel is at anchor, it may be necessary to suspend operation during periods with calm or no winds (local regulations regarding port permissions / emissions shall be complied with).

Intakes of central air conditioning or mechanical ventilating systems should be adjusted to prevent the entry of petroleum gas, if possible by Partial recirculation of air within the spaces, but should be maintained Positive pressure in accommodation.

If at any time it is suspected that gas is being drawn into the accommodation, central air conditioning and mechanical ventilating systems should be stopped and the intakes covered or closed.

7.7 Ship-to-ship transfers

Ships like oil tankers and gas carriers carry huge amount of cargo in bulk which does not have to be unloaded in just one port but at different ports. Even some carriers like VLCC and ULCC which are massive in size does not berth in port or jetty for discharge operation due to draught restrictions. In such condition ship to ship transfer is utilized.

A ship to ship transfer becomes very economical as ship does not have to berth at the jetty, especially for huge oil tankers, which removes the port berthing charges and also cut short the time for berthing and mooring. But all these comes at a cost of high environmental pollution and fire risk as chances of leakage in operation is always there in open sea when ship is not moored or it is moving.

A STS or ship to ship transfer refers to the transfer of ship's cargo, which can be oil or gas cargo, between two merchant tanker vessels positioned alongside each other.

Cargoes typically transferred via STS methods include crude oil, liquefied gas (LPG or LNG), bulk cargo, and petroleum products

Either the ships can be stand still or the STS operation can also be performed while ships are underway. But it requires proper coordination, equipment and approval to perform such operation. Both the masters of the ships are responsible for the entire STS operation

Following are the requirements for conducting Ship to Ship transfer operation:

- Adequate training of oil tanker's staff carrying out the operation.
- Proper STS equipment to be present on both the vessels and they should be in good condition.
- Pre planning of the operation with notifying the amount and type of cargo involved.
- Proper attention to the difference in freeboard and listing of both the vessel while transferring oil.
- Taking permission from the relevant port state authority.
- Properties of Cargo involved to be known with available MSDS and UN number.
- A proper communication and communication channel to be set up between the ships.
- Dangers associated with the cargo like VOC emission, chemical reaction etc to be briefed to the entire crew involved in transfer.
- Fire-fighting and oil spill equipment to be present and crew to be well trained to use them in emergency.

- All guidelines to be followed as per MEPC 59, MARPOL Annex 1 chapter 8, SOPEP, SMPEP, STS transfer guide and operational plan.

Regulations

As Per Resolution of MEPC (59) a new chapter 8 is added to MARPOL Annex I for prevention of pollution during STS operation between two ships.

This new regulation is applicable for oil tankers of 150 GT but bunkering operation and oil transfer operations for fixed or floating platform has been excluded.

Following are the important features:

- The STS operation plan should be approved by administration.
- The STS operation plan is to be in the working language and to be approved not later than the date of first annual survey (intermediate or renewal under MARPOL annex I) carried out on or after 1st, Jan 2011.
- The guidelines of the STS plan should be in accordance with the requirements of IMO "Manual on oil pollution prevention, amended section 1" , ICS and OCIMF " ship to ship transfer guide".
- The plan may be incorporated in SMS required by the Chapter IX of SOLAS 74, but in any case plan is to be approved as required by the resolution.
- After an approval of administration on STS plan, Operation before 1st April 2012 shall be in accordance to the plan as far as possible.
- The complete operation is to be recorded in Oil Record Book (ORB) and STS operation record book.
- The above record to be retained in the ship for 3 years.

- Any oil tanker under STS plan operate under the territorial waters or exclusive economic zone of MARPOL, must notify the following information to relevant coastal authority prior to 48 hours of the commencement of the STS operation:
  - Ship's name, call sign and IMO number.
  - Details of Owner, operator or shipping company.
  - Type and quantity of oil for STS operation
  - Preparation done in brief for carrying out the operation.
  - Estimated time duration of the complete operation.
  - The operation to be performed underway or in anchorage.
  - Identification of STS operations service provider or person in charge for overall advisory
- If there is a delay in the ETA, same must be informed to the coastal authority.
- After Delay in ETA, all the information listed above to be re-confirm to coastal authority prior to 6 hrs carrying out the operation

Ship-to-ship transfer while underway or at anchor

The following guidance has been prepared by reference to the IMO Manual and the Guide. It is not applicable to transfers associated with fixed or floating platforms, nor does it apply to STS operations necessary for securing the safety of a ship, life at sea or the environment. The reporting requirements may not apply to bunkering operations.

STS transfer area

The STS transfer area should be carefully chosen for a safe operation, in co-ordination with the appropriate authorities. In selecting the area, the following considerations should be taken into account, such as sea room, traffic density, water depth and the availability of a safe anchorage.

Ship to Ships Operation Equipment

Prior to the commencement of the STS operation, the masters of the two tankers should exchange information regarding the availability, readiness and compatibility of the equipment to be used in the operation.

The oil tankers should be provided with fenders, both primary and secondary, which should ideally comply with ISO 173575. The fenders can be secured to either vessel although landing on an unprotected section of the hull is less likely if they are secured to the maneuvering ship.

The master of the tanker to which the fenders are to be secured should request copies of the certificates demonstrating that the primary fenders have been tested in accordance with industry best practice, which is at intervals not exceeding two years. Secondary fenders do not require testing because they are not fitted with safety valves.

The hoses employed in the STS operation for the transfer of crude oils or petroleum should be specially designed and constructed for the product being handled and the purpose for which they are being used. They should comply with EN1765 (or latest equivalent). A visual inspection of the hoses should be carried out before they are connected to the manifolds.

The hoses should carry the appropriate markings and the commensurate certification be made available.

A visible inspection of the hoses should be carried out before connection to the manifolds to determine that they are free of any damage and in good order. Mooring equipment, which includes lines, winches, fairleads and bitts, should be in good order and free of defects.

A prime consideration in mooring during STS operations is to provide bitts and fairleads for all mooring lines without the possibility of the ropes chaffing against each other, the ships involved or fendering arrangements.

STS Mooring equipment

It is important that ships involved in STS operations are equipped with good quality mooring lines, efficient winches, well placed and sufficiently strong closed fairleads, bollards and other associated mooring equipment.

Only fairleads of the enclosed type should be used to ensure effective control of the mooring lines as the freeboards of the two ships changes during cargo transfer.

Ships equipped with steel wire or high modulus synthetic fiber mooring lines should fit rope tails of at least 11 meters long and have a dry breaking strength of at least 25% greater (or 37% greater if polyamide (nylon), than that of the lines to which they are attached.

STS Communications between vessels

Good communications between the ships are an essential requirement for successful STS transfer operations. The Client may supply approved, UHF radios.

To avoid any misunderstanding, a common language shall be agreed before operations commence.

No maneuvering or cargo transfer is to take place unless good communications between vessels is established.

During cargo transfer, key personnel on both ships must maintain a common means of communication. This is normally via hand-held UHF radios.

The ships main radio transmitting aerials on both ships shall be earthed and neither ship shall use this equipment whilst alongside one another.

Mobile telephones and non-intrinsically safe electrical items must not be used, or carried when switched on, on the open cargo deck.

Satellite communications present no safety hazard, but must not be used if flammable gas accumulates near the antenna. AIS equipment is considered safe and should be kept operational for the purposes of port VTMS.

In the event of a communication breakdown during an approach maneuver, and if appropriate and safe to do so, then the maneuver should be aborted. During cargo operations, in the event of a complete breakdown in communications on either ship, the emergency signal (7 or more short blasts on the ships whistle) should be sounded and transfer suspended in a safe and controlled manner. Transfer should not resume until satisfactory communications have been re-established.

7.8 Inhibition and stabilization requirements

Certificate of inhibition

Care must be taken to ensure that the cargoes are sufficiently inhibited to prevent polymerization during the entire voyage.

When the ship carries such cargoes, a Certificate of Inhibition in which the following items are shown must be given by the shipper, or manufacturer of the cargoes:

- Name and amount of inhibitor added
- Date inhibitor was added and the length of its effectiveness
- Any temperature limitations qualifying the inhibitor's effective lifetime
- The action to be taken should the length of the voyage exceed the effective lifetime of the inhibitor

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

7.9 Heating and cooling requirements and consequences to adjacent cargoes

Cargoes carried by a chemical tanker differ widely in characteristics and mode of handling, and thus in the care they require during transit. During the voyage, attention must be paid to these special needs of cargoes.

Inert gas capacity should be sufficient for the entire voyage. If stored nitrogen is relied upon, it must be confirmed prior to sailing that the ship has sufficient nitrogen on board to be able to comply with the inerting requirements.

Regular checks on tank contents should be made to detect an unexpected change in liquid level. Cargoes that need cooling or heating must be monitored daily and a temperature log kept. Temperature log for the voyage to be maintained as per the instructions provided by the shippers. Some cargoes are liable to self-react under certain conditions. Cargoes that may self-react should be monitored daily in order to detect any abnormal behaviour at an early stage.

Unexpected changes of temperature are an important early indicator of a possible self-reaction, and attention should be given to ensuring that any required heating does not cause part of the cargo to become overheated. Crystallisation. of inhibited liquid cargoes can lead to depletion of inhibitor in parts of the tank's contents (because the inhibitor does not crystallise as well), and subsequent remelting of the crystals can thus yield pockets of uninhibited liquid, with the risk of starting dangerous self-polymerisation.

With inhibited cargoes, the precautions and limitations described in the inhibitor certificate should be carefully observed. If control of the tank atmosphere is being used, ullage spaces should be monitored regularly to ensure that the correct atmosphere and overpressure are being maintained. Most inhibitors are not themselves volatile, so they do not vaporise with the cargo and are unlikely to be prese~t in cargo vapours. Therefore, polymerisation may occur where cargo vapours condense. Such places as inside vent valves and flame arresters should be regularly inspected, and any blockage by solid polymers promptly cleared.

Precaution/attention & record sheets are necessary for cargoes that need:

Cargo heating: Cargoes that require heating must be monitored at least once daily and a temperature log must be kept. Ensure that correct heating medium is used, and that heating coils in tanks that do not require heating are blown dry and blanked. Prior to loading heated cargo, heating coils should be pressure tested and results recorded in the log book.

Cargo cooling: In specialized cases, is required to prevent products from giving-off toxic and flammable vapours. Special care requirements are generally documented in the condition of carriage details contained in the ships Certificate of Fitness and also in the IBC/BCH Codes. The Company and Charterers are to be consulted if additional information is required.

Tank Atmosphere: monitoring and recording of the ullage space of pressure and/or oxygen should be carried out at regular intervals (daily) to ensure that the correct environment is being maintained.

Temperature Control: Cargoes that may self-react must be monitored on a daily basis for any increase temperature that deviates from the ambient climatic conditions.

Nitrogen cover: Prior sailing the vessel must have sufficient Nitrogen of the correct quality on board to comply with the padding requirements. No of bottle = Total Ullage Space (m3) x 0.2 / 180` x 50, for 4 changes maintaining 50mb, N2 bottle = 50l x 180bar

Tank atmosphere: O2 content strictly controlled :Some cargoes like Hexane-HMD-Octene do have a maximum requirement with respect to oxygen in the vapour space. The vapour space has to be checked with the appropriate oxygen meter. The Shipper determines the frequency of the routine checks. The results are to be recorded in 'Voyage Log?

Agitation/ Circulation: Some chemicals, e.g. Phosphoric Acid, require agitation to prevent sediment separation and different temperature/density layers from forming. Re-circulating through a diffuser is one method of agitating the cargo

Avoiding claims

On many occasions cargo losses may occur during voyage and resulting in claims to the owners. Shipboard losses can be attributed to

1. Evaporation via PV vents.
2. Excessive ROB due to high pour-point of cargo or pumping problems.

While in some trades the discharge port out turn figures alone determine the amount of cargo delivered, in others they are still compared to the bill of lading figures provided by the load port.

Virtual losses (On paper only): In many shortage claims no actual loss has taken place but the amount of cargo has been overstated when loading and/or understated when discharging.

Stowing volatile cargo next to heated cargo causes evaporation losses. Charterers should specify maximum adjacent temperatures. Adjacent heat is an important spec on chemical tankers.

Chief Officer must find out that number of shore tanks to be loaded from, the quantity, temperature and SG of cargo in each. Whether there are any planned loading stops for shore tank changes. Whether density is being expressed ‘in air or ‘in vacuum. Whether shore pipelines are full or empty, and details of any pipeline displacements planned. Whether loading by gravity or shore pumps.

Good Practices

The inspector must be accompanied at all times and his ullage measurements actively verified. Frequently maintaining and checking ship’s equipment - and arranging for yearly calibration of electronic measuring devices by an agent approved by the manufacturer.

Never permit the use of the terminal’s measuring equipment on board. If measurements taken with the inspector’s equipment differ from those taken with the ships, propose that all measurements be taken with each, and both be sent for verification ashore afterwards.

If the ship is pitching or rolling, five measurements should be taken, withdrawing the tape as soon as it penetrates the surface of the cargo. The highest and lowest should be ignored and the middle three averaged. Weather and sea conditions should be logged.

Cargo temperature may vary by 5 °C at different levels in the tank, so must be averaged from at least three readings -top, middle and bottom. Some digital probes can measure at more frequent intervals .Measurement error of 1°C can distort the volume calculation substantially , however this will depend on cargo density also.

7.10 Cargo compatibility and segregation

Cargo compatibility

Transporting of dangerous and noxious liquid chemicals in bulk involved various risk factors. Chemical cargoes can be very dangerous, most of them being flammable and/or toxic, some of them extremely so. Between some chemicals violent reactions may occur if the chemicals are mixed in certain proportions. The result may possibly be an eruption and tank rupture. Such an occurrence must be prevented. Water may also have to be considered in this respect.

Leakages through bulkheads occur at times in any tanker. Normally, however, such leakages are only minor seep ages. They will not cause any violent reaction due to the great disproportion in mixture from dangerous proportions. But legislation as expressed in the IMO Chemicals Bulk Code ref (25), and in the US Coast Guard Rules ref (18) and Appendix 3 expressly prohibits the placement of inter-reactive cargoes on both sides of a bulkhead. There must be an empty tank, a cofferdam or a tank with a cargo neutral to both products in between. This requirement causes some headaches in cargo planning. "Diagonal contact" between tanks is normally considered as sufficient separation between reactive cargoes.

More important, however, is the complete separation of piping systems so that one product cannot inadvertently be pumped into another. To this effect strategic pipe bends may have to be removed and blind flanges fitted on each pipe end. Modern chemical tankers will have blind flange valves fitted . Such a blind flange valve must have a double separation between the products with a drain in the interspace. A single blind flange is not acceptable. Remember also to separate drain lines or slop connections to avoid the possibility of cargo mixing.

The cargo inter- reactions may be of type:

Chemical reaction: Strong (inorganic) acid plus alikali (or water) causes heat, e g sulphuric acid plus caustic soda or water. Therefore sulphuric acid may not be carried in tanks bordering the side shell or filled ballast tanks. Similarly sulphuric acid may react with a number of hydrocarbons except parraffines (petroleum oils). Amines (aniline, diethylamine) may react with esters (butyl, acetate, ethyl acetate). Caustic soda will react violently with acrolein, acrylonitrile and allyl alcohol.

Oxidation: An Oxygen-rich compound like propylene oxide may react with an amine (e g diethylamine) or an aldehyde (e g acetaldehyde). An ether (e g ethyl ether) may react with oxygen and from a peroxide which is an explosive hazard. The ether should be inhibited and carried in an inerted (N 2) tank.

Auto-reaction: Certain hydrocarbons compounds have a tendency to polymerize with time, accelerated by heat, light, sometimes air or other matter such as rust. Polymerization means that several molecules of the same kind binding together to bigger molecules. The compound tends to become more viscous or eventually solidify. Heat is liberated, which accelerates further polymerization.

Chemically most cargoes are monomers, which means that they, before any polymerization, consist of single molecules.

Toxic vs edible products

Toxic products must never get mixed into edible products for human or cattle feed! In this case minor seepages between tanks might prove disastrous.

IMPORTANT: Edible products should never be loaded with bulkhead to bulkhead contact with toxic cargoes! The piping systems should be entirely segregated or provided with double blind flanges.

Chemical cargoes segregation and compatibility

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 stabilizing 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.

For details, refer to FOSFA International (Federation of Oils, Seeds and Fats Association) published lists and procedures.

The FOSFA 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.

7.11 High-viscosity cargoes

In a modern chemical tanker in order to maintain product quality, to minimise the potential for discoloration, and to facilitate some liquid cargo transport in a safe manner cargo heating is required.

The voyage orders will contain heating information, if heating is required. As a rule the final heating instructions are given by the Shipper in writing to the Master / Chief Officer in the port of loading. If those written instructions are not given, the master should request them and issue a Letter of Protest if they are not received at departure. In the latter case the management office should be immediately informed.

The heating instructions may contain any, or all, of the following:

- Minimum and maximum temperature during the voyage
- Minimum and maximum temperature during discharge
- Maximum temperature of adjacent cargo
- Heating medium (when loading edible oils only steam and / or hot water should be utilised as the heating medium in coils / heat exchangers. Thermal oil should not be used as a heating medium for edible oils)
- Maximum temperature of the heating medium
- The maximum possible temperature increase per unit of time: delta T°C/hour

Unintended heating

The risk of heating a cargo, which should not be heated, must be eliminated. An ‘unintended heating’ of a cargo can not only influence the quality of the cargo, but can endanger the crew, the vessel and the environment, e.g. lifetime of an inhibitor can be shortened drastically by unintended heating and a monomeric cargo such as styrene monomer can polymerise.

In order to prevent unintended heating of cargoes that do not require heating the following preventive measures should be taken:

- Blank the supply and return of the heating coils
- When heat is supplied to other tanks, check manually the supply and return of the tanks that do not require heating. Maintain a log of

temperatures of tanks being heated along with surrounding tanks on TNK08.

- Do not stow heated cargo adjacent to cargoes that do not require heating Beware of hot wash of adjacent besides cargo not requiring heating

Heating required by Marpol Annex II

Category Y, high Viscosity and solidifying cargoes may require prewash, if not heated. These cargoes do not require a prewash if the following is complied with:

Category Y Cargoes with a melting point less than 15°C.

Discharge temperature should be at least 5°C. above melting point of the product. Example: Benzene with a melting point of 4.5°C. should be discharged with a temperature of at least 9.5°C. to avoid the prewash requirements.

Category Y Cargoes with a melting point above 15°C.

Discharge temperature must be at least 10°C. Above melting point of the cargo. Example: Phenol, with a melting point of 40.9°C. Should be discharged with a temperature of at least 51°C. In order to be considered not solidifying.

Category Y Cargoes with Viscosity < 50mpa at discharge temperature

The Master has to obtain the shipping document with above information from shipper when transporting such cargoes so that the products will be heated accordingly so as to avoid the prewash obligation if at all possible.

Temperature checks

When carrying heated cargoes the following parameters are to be checked regularly:

1. Temperature of the cargo at 3 levels
2. Inflow temperature of the heating medium (or steam pressure)
3. Outflow temperature of the heating medium (or steam pressure)

7.12 Cargo residue operations

Effect on marine environment after discharge from ships

The growing importance of environmental care demands that the crews of chemical tankers have a clear understanding of the pollution regulations. Many additional tasks undertaken during cargo handling in a chemical tanker are dictated by a need to protect against any chance of discharge of cargo into the sea. These additional tasks must be performed safely, and an understanding of their purpose is a necessary part of chemical tanker operations today.

Even after careful unloading, final disposal of residues may only be carried out in accordance with approved procedures and arrangements. It is necessary for tanks that have contained some specified cargoes to have a first rinse at the unloading port, called a pre-wash, and the initial washings discharged to shore reception facilities (usually the cargo receiver). Pre-wash sets a minimum required level of dilution of cargo residue for environmental protection. It has no direct relevance to preparing a tank for its next cargo. The commercial justification for any further tank cleaning is not addressed by authorities, although handling and disposal of washings must continue to take account of MARPOL.

When a tank is washed with a washing medium other than water which would itself require control if carried as a cargo, discharge or disposal of the strippings will be governed by the provisions of MARPOL applying either to the washing medium or to the original cargo, whichever are the more severe.

Discharge into the sea of cargo residues and tank cleaning products is strictly controlled. It is recommended that any discharge should be as far from land as practicable. Any discharge of effluent containing controlled substances (except in an emergency situation) is subject to a maximum concentration of the substance in the ship's wake or the dilution of substances prior to discharge, and must take account of the following:

- A maximum quantity of such substance per tank.
- The speed of the ship during the discharge.
- The minimum distance from the nearest land during discharge.
- The minimum depth of water during discharge.
- The need to carry out the discharge below the water line.

Some areas of the sea are designated as special areas in which even more stringent discharge criteria apply.

Discharge overboard in port is always prohibited by local, national or regional standards that are usually supplementary to MARPOL, rather than in conflict with it.

Tank Cleaning IMO regulation///MARPOL 73/78 Annex II MEPC 2/ Circ. 15 Annex /10

The International Maritime Organisation (IMO) MARPOL 73/78 ANNEX II regulates the discharge of Noxious Liquid Substances and the use of chemicals that are used for tank cleaning purposes.

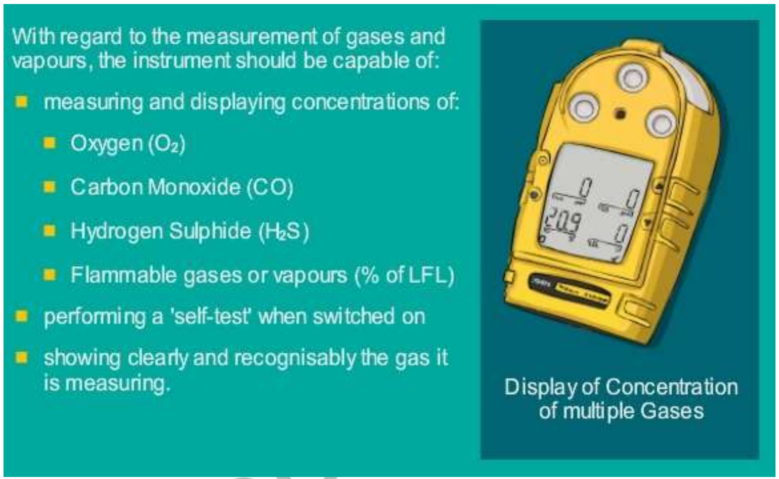
The IMO is changing current regulation MEPC./Circ.363 in order to cut down on the number of chemicals used for tank-cleaning purposes. For future products no perfume or colouring agents will be allowed in tank-cleaning chemicals that will be discharged to sea inside the shore limits as listed in the MARPOL 73/78 ANNEX II.

All tank-cleaning products approved to MEPC./Circ.363 prior to 1 January 2007 need to be re-evaluated based on criteria outlined in MEPC1/Circ 590. All IMO approved products evaluated through MEPC./Circ.363 before 1 January 2007 will cease to be valid on 1 August 2010.

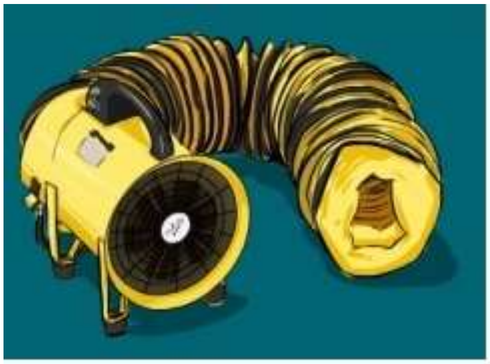
The new and revised regulation MEPC 2 /Circ.15 came into force on 1 August 2010. All cleaning additives evaluated and found to meet the requirements of paragraph 13.5.2 of Annex II of MARPOL 73/78 are consolidated into annex 10 of the MEPC.2/Circular 15.

7.13 Operational tank entry

On chemical tankers the entry of personnel into cargo tanks is a more common practice than on oil tankers as a result of the requirement for inspections between grades etc; despite this, it is essential that the necessary checks are conscientiously made and recorded prior to entry in order to ensure the safety of personnel, enclosed space rescue equipment must be made ready for immediate use.



On Chemical Tankers, entry into enclosed spaces should be treated with the same extreme caution .Entry into Enclosed Spaces, must be adhered to. The SCAFFTAG Enclosed Space Tag system must be in place to indicate which cargo tanks are safe for entry; these should be placed at the tank accesses or hatches. In the absence of a suitable "Safe Condition" tag, entry is prohibited.



Tank fan

Tank fans: Tank fans are most commonly used for ventilating cargo tanks. They are normally supplied with flexible ducting that may be lowered or pushed into the tank. The further that the ducting can be placed into the tank (without its operator entering into the tank), the more effective it is.

Each member of the team entering the enclosed space must utilize the "Man in Tank" tags by clipping them onto the Entry Tag.

Entry into non gas free space / contaminated cargo tanks is prohibited, unless a risk assessment has been carried out and approved by the management office responsible for the vessel.

If this is agreed to, then in such cases, spaces should only be entered by personnel wearing breathing apparatus and appropriate protection against exposure to flammable, toxic or corrosive cargo vapours and, if practicable, a lifeline. Prior to such entry, reference must be made to ISGOTT, Chapter 11, Section 11.4.4, ICS Chemical Tanker Safety Guide, Chapter 3.5 and IBC code concerning entry with Breathing Apparatus.

The following minimum conditions must be met with respect to such entries and included in the risk assessment:

- A permit must be issued by the Master stating that there is no practicable alternative to the proposed method of entry.
- Ventilation is provided where possible, provided this does not create a flammable atmosphere,
- Personnel use PPE and positive pressure breathing apparatus and are connected, where practicable, to a lifeline

- Means of communication are provided and a system of signals is agreed and understood by the personnel involved.
- Spare sets of breathing apparatus, a resuscitator and rescue equipment are available outside the space and a standby party with breathing apparatus donned is in attendance in case of an emergency.
- Work carried out in such circumstances will be limited to absolutely essential maintenance and or inspection only.

It may be necessary, especially during the carriage of Vegetable Oils etc., for personnel (shipboard or shore contractors) to enter the cargo tanks to carry out “squeezing” operations in order to maximize the cargo outturn. It is essential on such occasions that all Enclosed Space Entry precautions and procedures are in place both prior to and during the entry operations. Familiarity with the practice should not obscure the potential dangers of cargo generated vapours or an oxygen deficient atmosphere.

Cargoes such as of Coconut Oil may give off dangerous concentrations of CO (Carbon Monoxide) and when entry into tanks is required for “squeezing,” readings for CO in ppm (in addition to LEL, 02, H2S) must be checked and monitored prior to and during entry of personnel. Tank must be gas free 0% LEL, less than TLV for CO, H2S etc. and personal gas meters with alarms should be used by persons entering the space.

If personnel are required to enter cargo tanks for hand cleaning with all Enclosed Space Entry precautions and procedures must be observed prior to and during entry, in such cases, full protective clothing and self-contained breathing apparatus must be worn.

8. Development and application of cargo-related operation plans, procedures and checklists

Telephone and portable VHF/UHF and radiotelephone systems should comply with the appropriate safety requirements.

The provision of adequate means of communication, including a backup system between tanker and shore, is the responsibility of the terminal.

Communication between the Responsible Crew Member and the Terminal Representative should be maintained in the most efficient way.

When telephones are used, they should be continuously manned by persons, on board and ashore, who can immediately contact their superior. Additionally, it should be possible for that superior to override all calls. When VHF/UHF systems are used, units should preferably be portable and carried by the Responsible Crew Member on duty and the Terminal Representative, or by persons who can contact their respective superior immediately. Where fixed systems are used, they should be continuously manned.

The selected system of communication, together with the necessary information on telephone numbers and/or channels to be used, should be recorded on an appropriate form. This form should be signed by both tanker and shore representatives.

To ensure the safe control of operations at all times, it should be the responsibility of both parties to establish, agree in writing and maintain a reliable communications system.

Before loading or discharging commences, the system should be tested. A secondary standby system should also be established and agreed. Allowance should be made for the time required for action in response to signals.

Signals should be agreed for:

- Identification of tanker, berth and cargo.
- Stand by.
- Start loading or start discharging.
- Slow down.
- Stop loading or stop discharging.
- Emergency stop.

Any other necessary signals should be agreed and understood. When different products or grades are to be handled, their names and descriptions should be clearly understood by the tanker and shore personnel on duty during cargo handling operations.

The use of one VHF/UHF channel by more than one tanker/shore combination should be avoided. Where there are difficulties in verbal communication, these can be overcome by appointing a person with adequate technical and operational knowledge and a sufficient command of a language understood by both tanker and shore personnel.

Completion of safe and efficient cargo, ballast and bunkering operations is dependent upon effective co-operation and co-ordination between all parties involved. This Section covers information that should be exchanged before those operations begin.

The following information should be made available to the Responsible Crew Member:

- Cargo specifications and preferred order of loading.
- Whether or not the cargo includes toxic components, for example H2S, benzene, lead additives or mercaptans.
- Tank venting requirements.
- Any other characteristics of the cargo requiring attention, for example high True Vapour Pressure.
- Flashpoints (where applicable) of products and their estimated loading temperatures, particularly when the cargo is non-volatile.
- Bunker specifications including H2S content.
- Proposed bunker loading rate.
- Nominated quantities of cargo to be loaded.
- Maximum shore loading rates.
- Standby time for normal pump stopping.
- Maximum pressure available at the tanker/shore cargo connection.
- Number and sizes of hoses or arms available and manifold connections required for each product or grade of the cargo and Vapour Emission Control (VEC) systems, if appropriate.
- Limitations on the movement of hoses or arms.
- Communication system for loading control, including the signal for emergency stop.

- Material Safety Data Sheets or similar for each product to be handled.
- Testing overfill and emergency equipment.

Cargo Sampling

There is no doubt that bill of lading is the most important aspect of commercial shipping. In my view the close second is the sampling of the cargo.

Just as we need to be watchful for bill of ladings, we need to be equally concerned about sampling procedures we adopt.

As per Swedish club, cargo contamination is the current major issue for chemical and product tankers. It would not be wrong to say that it is most costly type of claim too.

The cost of cargo carried on board chemical tankers is sometimes more than the value of ship itself. And as such if the cargo is off spec at discharge port, it could be a disastrous situation.

If the cargo is off spec during loading, there are two main sources for it. Contamination before the manifold valve and contamination after the manifold valves.
Our job is to ensure is that there is no chance of contamination after the manifold.

There can be many reason for cargo contamination after the manifold. This may include but not limited to:

- remains of previous cargo in the cargo lines
- not properly washed tanks

- Cargo temperatures or nitrogen padding not maintained as instructed

But even when the contamination is on the shore side, the onus to prove same is always on the ship. Valid samples is the only way to prove that the contamination was not because of ship.

Valid sample is a cargo sample which

- Has been taken from the correct location
- represent the actual condition of the cargo on board and
- Records are available for these samples

Sample Locations

- **Manifold sample**

  Shippers never allow ship staff to do shore tank sampling. As such manifold samples are the nearest possible proof to show the condition of the shore cargo.

As manifold is the first point for cargo to enter into the ship system, any contamination after this is considered to be because of ship. This makes the manifold sampling the most important one.

We take manifold sample with the manifold valve closed. The sampling need to be witnessed by the shipper surveyor. What we need to check in this sample depends upon the cleaning requirements of the tank for this cargo.

For cargo requiring visual inspection, we check this sample for any visual impurities, water content and color of the cargo. If the cargo requires wall wash sampling of tanks, apart from checking the sample visually, we need to do the wall wash test of sample.

As a minimum we need to check the manifold sample for HC and Chloride tests.

If the visual or wall wash test of the manifold sample fails, vessel must not open the manifold valve. The cargo surveyor will most likely drain some cargo into the drums. After draining, we need to take the manifold sample again. We can only open the manifold valve when the sample looks OK.

The final manifold sample then need to be sealed in presence of cargo surveyor. We need to put appropriate sticker on the manifold sample. The sticker need to have all the information and must be signed by cargo surveyor.

If cargo surveyor refuses to witness or sign manifold samples, we must issue a letter of protest.

Some terminal may not allow the sampling with the closed manifold valve. This may be because of terminal regulations or because of type of pump they have. For example we cannot close the manifold valve if the shore pump is of positive displacement type.

In this case we can take a running sample of manifold and then lodge a protest to the terminal for not allowing manifold sample.

– **Final tank Sample**

After completion of loading, a final sample from each tank will be taken by the surveyor. If the cargo is loaded in more than one tank, shipper might also require a composite sample. Composite sample is one combined sample with cargo sample from multiple tanks.

9. Ability to calibrate and use monitoring and gas-detection systems, instruments and equipment

Gas detection equipment is required for ensuring spaces are safe for entry, work or other operations.

Their uses include the detection of:

- Cargo vapour in air, inert gas or the vapour of another cargo.
- Concentrations of gas in or near the flammable range.
- Concentrations of oxygen in inert gas, cargo vapour or enclosed spaces.
- Toxic gases

All vessels are supplied with portable gas measuring equipment, according to the specific requirements of the vessel owners. Personnel must fully understand the purpose and limitations of vapour detection equipment, whether fixed or portable.

The importance of careful calibration cannot be over emphasized as the gas detection or analyzing 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. Instruments must always be checked, zeroed and spanned where applicable before every use as per the manufacturer's instructions.

Calibration may be required to be carried out ashore for some instruments. The Chief Officer is responsible for the condition monitoring and maintenance of all portable and fixed gas measuring instruments on board and ensuring sufficient span gas of the correct grade is on board. The Chief Officer is responsible for identifying, calibrating, and adjusting all portable gas measuring instruments available onboard.

Notes:

- For all Meters on board the Manufacturer's Operating Manual and a suitable Calibration Kit must be on board.
- The performance of these meters is to be scrupulously monitored and repairs arranged in the case of malfunction.
- These meters are a high cost item and must be looked after carefully. If supplied with carrying cases and or covers they should be used at all times.
- Meters may be combined in one instrument i.e. combined 02 meter and explosimeter.
- Toxic gas tubes have a limited shelf life

10. Ability to manage and supervise personnel with cargo-related responsibilities

The Chief Officer shall prepare a detailed Watch Keeping Schedule and Person in Charge List for all personnel directly involved in Cargo Oil Transfer operations, and the schedule shall be posted in the CCR and on the Navigation Bridge. The Chief

Officer shall ensure that sufficient personnel is available to safely conduct all activities required for Cargo Oil transfer operations.

The Chief Officer shall attend cargo & ballast operations to direct as to the operations at the beginning and end of work, before and after the beginning of deballasting operations, under rough weather and sea conditions, during tank cleaning and at all other major steps of the operations.

The watchkeeping officer's principal duties include:

- Implementing and managing the cargo handling plan and maintaining a log;
- Being the principal point of contact with the shore terminal;
- Controlling and verifying the performance of the following:
- The correct functioning of tank level gauges and tank level alarms;
- The operation of cargo pumps and valves;
- Controlling the distribution of ballast;
- Operation of the inert gas system;
- Ensuring that safety and fire-fighting equipment is ready for immediate use;
- Ensuring that all watchkeepers are using appropriate PPE; and
- Ensuring that there are no unplanned activities being carried out.

The Chief Officer shall arrange deck crew as follows:

- At the beginning and end of cargo work, all officers and deck ratings should be available and positioned at the site in principle.
- As far as possible at the beginning of operations the number of officers present in the Cargo Control Room and monitoring the operations should be more than one.

- During cargo work, at least one officer and two deck ratings (including the watch keeper in port) must be on duty as to the cargo work, and one of them must be placed near the manifold. Sufficient crew should be available to man the manifold at all times, as well as to attend the moorings.

The Second and Third Officers should be on duty as cargo watch officer in two shifts, and the Chief Officer must give adequate instructions to the officer on duty. Such instructions, so as to effectively be passed on and monitored for completion, should, as far as possible, be noted down for confirmation.

The duty officer should make use of the white board provided to verify and confirm such instructions execution.

Deck ratings should be on duty as to cargo operations in two or three shifts depending on the case. The watch keeping in port in two or three shifts must be maintained all the times, but the assigned watch keeper in port should also participate and attend to cargo operations, provided his duties are being attended to.

The Chief Officer shall ensure that sufficient personnel is available to safely conduct all activities required for Cargo Oil transfer operations.
The Chief Officer & Chief Engineer shall affix the duty schedule both for deck and engine departments to the cargo operations plan, and put it up in the Cargo Control Room and Engine Control Room.

COMPETENCE 2: Familiarity with physical and chemical properties of chemical cargoes

11. Knowledge and understanding of the chemical and physical and the physical properties of noxious liquid substances

11.1 Chemical cargoes categories (corrosive, toxic, flammable, explosive)

Corrosive Chemicals

Standard operating procedures (SOP) are intended to provide you with general guidance on how to safely work with a specific class of chemical or hazard. This SOP is generic in nature. It addresses the use and handling of substances by hazard class only. In some instances multiple SOPs may be applicable for a specific chemical (i.e., both the SOPs for flammable liquids and carcinogens would apply to benzene). If you have questions concerning the applicability of any item listed in this procedure contact the EHRS 215-898-4453 or the Principal Investigator of your laboratory. Specific written procedures are the responsibility of the Principal Investigator.

If compliance with all the requirements of this standard operating procedure is not possible, the Principal Investigator must develop a written procedure that will be used in its place. This alternate procedure must provide the same level of protection as the SOP it replaces. The Office of Environmental Health and Radiation Safety is available to provide guidance during the development of alternate procedures.

Corrosive chemicals are substances that cause visible destruction or permanent changes in human skin tissue at the site of contact, or are highly corrosive to steel. Corrosive chemicals can be liquids, solids, or gases and can affect the eyes, skin, and respiratory tract. The major classes of corrosives include strong acids, bases, and dehydrating agents. Liquid corrosive chemicals are those with a pH of 4.0 or lower or a pH of 9 or higher. Solid chemicals are considered corrosive when in solution; they fall in the above pH range. A highly corrosive chemical has a pH of 2 or lower or a pH of 12.5 or higher. Injurious chemicals cause tissue destruction at the site of contact.

Some examples of corrosive materials:

- **Strong Acids:** hydrochloric, sulfuric, phosphoric
- **Strong Bases:** hydroxides of sodium, potassium, ammonia
- **Strong Dehydrating Corrosives:** sulfuric, phosphophrous pentoxide, calcium oxide
- **Strong Oxidizing Corrosives:** concentrated hydrogen peroxide, sodium hypochlorite
- **Corrosive Gases:** chlorine, ammonia
- **Corrosive Solids:** phosphorous, phenol

Toxic Chemicals

The toxicity of a chemical refers to its ability to damage an organ system (kidneys, liver), disrupt a biochemical process (e.g., the blood-forming process) or disturb an enzyme system at some site remote from the site of contact. Toxicity is a property of each chemical that is determined by molecular structure. Any substance can be harmful to living things. But, just as there are degrees of being harmful, there are also degrees of being safe. The biological effects (beneficial, indifferent or toxic) of all chemicals are dependent on a number of factors.

For every chemical, there are conditions in which it can cause harm and, conversely, for every chemical, there are conditions in which it does not. A complex relationship exists between a biologically active chemical and the effect it produces that involves consideration of dose (the amount of a substance to which one is exposed), time (how often, and for how long during a specific time, the exposure occurs), the route of exposure (inhalation, ingestion, absorption through skin or eyes), and many other factors such as gender, reproductive status, age, general health and nutrition, lifestyle factors, previous sensitization, genetic disposition, and exposure to other chemicals.

The most important factor is the dose-time relationship. The dose-time relationship forms the basis for distinguishing between two types of toxicity: acute toxicity and chronic toxicity. The acute toxicity of a chemical refers to its ability to inflict systemic damage as a result (in most cases) of a one-time exposure to relative large amounts of the chemical. In most cases, the exposure is sudden and results in an emergency situation.

Chronic toxicity refers to a chemical's ability to inflict systemic damage as a result of repeated exposures, over a prolonged time period, to relatively low levels of the chemical. Some chemicals are extremely toxic and are known primarily as acute toxins (hydrogen cyanide); some are known primarily as chronic toxins (lead). Other chemicals, such as some of the chlorinated solvents, can cause either acute or chronic effects.

The toxic effects of chemicals can range from mild and reversible (e.g. a headache from a single episode of inhaling the vapors of petroleum naphtha that disappears when the victim gets fresh air) to serious and irreversible (liver or kidney damage from excessive exposures to chlorinated solvents). The toxic effects from chemical exposure depend on the severity of the exposures. Greater exposure and repeated exposure generally lead to more severe effects.

Exposure to toxic chemicals can occur by:

- Inhalation
- Dermal absorption
- Ingestion
- Injection

Flammable Chemicals

Generally, a flammable liquid is a combustible liquid that can easily catch fire. However, it is not the liquid itself that burns, but the vapor cloud above the liquid that will burn if the vapor's concentration in air is between the lower flammable limit (LFL) and upper flammable limit (UFL) of the liquid.

A number of attempts have been made to standardize the definition of 'flammable' based on the need to classify such fluids as presenting a higher risk of ignition and therefore needing additional precautions.

In the US, a flammable liquid is defined as one with a flash point below 100 degrees Fahrenheit (38 degrees Celsius). This definition is part of a categorization of *combustible liquids* used by the National Fire Protection Association, The US Department of Transportation, the US Environmental Protection Agency, the US Occupational Safety and Health Administration and others.

These categories are further subdivided, depending on the liquid's flash point and boiling point.

- Class IA flammable liquids have a flash point below 73 °F (22.8 °C) (the upper end of the common range of room temperature) and a boiling point below 100 °F
- Class IB flammable liquids have a flash point below 73 °F (22.8 °C) and a boiling point greater than or equal to 100 °F (37.8 °C)
- Class IC flammable liquids have a flash point greater than or equal to 73 °F (22.8 °C) and below 100 °F (37.8 °C)
- Class II combustible liquids have a flash point greater than or equal to 100 °F (37.8 °C) and below 140 °F (60 °C)
- Class IIIA combustible liquids have a flash point greater than or equal to 140 °F (60 °C) and below 200 °F (93.3 °C)
- Class IIIB combustible liquids have a flash point greater than or equal to 200 °F (93.3 °C)

Explosive Chemical

An explosive chemical is a substance or mixture that experiences violent combustion as a reaction to an ignition source. This reaction is an exothermic process that involves the rapid release of large amounts of energy and is characterized by a rapid, violent release of pressure, gas, and heat. Ignition sources include heat, shock, and other substances that react with a chemical substance to cause it to explode.

11.2 Chemical groups and industrial usage

Organic Chemical Compounds

An organic compound is virtually any chemical compound that contains carbon, although a consensus definition remains elusive and likely arbitrary. However, the traditional definition used by most chemists is limited to compounds containing a carbon-hydrogen bond. Organic compounds are rare terrestrially, but of central importance because all known life is based on organic compounds. The most basic petrochemicals are considered the building blocks of organic chemistry.

Organic compounds may be classified in a variety of ways. One major distinction is between natural and synthetic compounds. Organic compounds can also be classified or subdivided by the presence of heteroatoms, e.g., organometallic compounds, which feature bonds between carbon and a metal, and organophosphorus compounds, which feature bonds between carbon and a phosphorus.

Another distinction, based on the size of organic compounds, distinguishes between small molecules and polymers.

Inorganic Chemical Compounds

Inorganic compound, any substance in which two or more chemical elements (usually other than carbon) are combined, nearly always in definite proportions. Compounds of carbon are classified as organic when carbon is bound to hydrogen. Carbon compounds such as carbides (e.g., silicon carbide [SiC_2]), some carbonates (e.g., calcium carbonate [$CaCO_3$]), some cyanides (e.g., sodium cyanide [NaCN]), graphite, carbon dioxide, and carbon monoxide are classified as inorganic. See chemical compound: Inorganic compounds.

Chemical tanker cargoes

Chemical tanker cargoes may be divided into four main groups:

Petrochemicals

This is the collective name for organic chemicals derived from crude oil, natural gas and coal. Organic chemicals are those produced from living or once-living organisms, petroleum and natural gas (marine animals and plants) and coal (plants). It is now possible to synthesize organic chemicals from inorganic chemicals to the extent that 'organic chemicals' really means those compounds based upon the element carbon. But the term does not include the simplest carbon compounds such as carbon dioxide, carbon monoxide and the carbonates.

Alcohols and carbohydrates

Alcohols may be derived from hydrocarbons or produced by fermentation.

Vegetable and animal oils and fats

Derived from the seeds of plants and from the fat of animals and fish.

Acids and inorganic chemicals

Inorganic chemicals are those that are not produced from living or once-living organisms. However, a number of inorganic chemicals such as sulphur and ammonia can be manufactured using petroleum as the raw material. Acids may be organic or inorganic.

Hydrochloric Acid Storage Guidelines

Hydrochloric acid should be stored in a cool, dry, well-ventilated area in tightly sealed containers protected from exposure to weather, extreme temperature changes, and physical damage.

Hydrochloric acid is considered a strong oxidizer and steps should be taken to separate hydrochloric acid and hydrochloric acid products from incompatible materials such as copper, brass, bronze, galvanized steel, tin, zinc, oxidizers, combustible materials, plastics, rubber and some coatings. Contact with metals causes erosion and the formation of flammable hydrogen gas. The heat generated from the exothermic reaction of metal and hydrogen chloride or hydrochloric acid could cause ignition of combustible materials

DANGER – Explosion Risk

- Hydrochloric Acid in contact with metals results in the formation of Hydrogen Gas
- Hydrogen is highly flammable and ignites easily
- All acid leaks and spills must be cleaned up immediately
- Stow acid away from incompatible chemicals and substances
- Do not store near Sodium Hypochlorite
- Ventilation must be in place at all times

11.3 Reactivity of cargoes

Transporting of dangerous and noxious liquid chemicals in bulk involved various risk factors. Chemical cargoes can be very dangerous, most of them being flammable and/or toxic, some of them extremely so. Between some chemicals violent reactions may occur if the chemicals are mixed in certain proportions. The result may possibly be an eruption and tank rupture. Such an occurrence must be prevented. Water may also have to be considered in this respect.

Chemical carrying at sea

Leakages through bulkheads occur at times in any tanker. Normally, however, such leakages are only minor seep ages. They will not cause any violent reaction due to the great disproportion in mixture from dangerous proportions. But legislation as expressed in the IMO Chemicals Bulk Code ref (25), and in the US Coast Guard Rules ref (18) and Appendix 3 expressly prohibits the placement of inter-reactive cargoes on both sides of a bulkhead. There must be an empty tank, a cofferdam or a tank with a cargo neutral to both products in between. This requirement causes some headaches in cargo planning. "Diagonal contact" between tanks is normally considered as sufficient separation between reactive cargoes.

More important, however, is the complete separation of piping systems so that one product cannot inadvertently be pumped into another. To this effect strategic pipe bends may have to be removed and blind flanges fitted on each pipe end. Modern chemical tankers will have blind flange valves fitted. Such a blind flange valve must have a double separation between the products with a drain in the interspace. A single blind flange is not acceptable. Remember also to separate drain lines or slop connections to avoid the possibility of cargo mixing.

The cargo inter- reactions may be of type:

Chemical reaction: Strong (inorganic) acid plus alikali (or water) causes heat, e g sulphuric acid plus caustic soda or water. Therefore sulphuric acid may not be carried in tanks bordering the side shell or filled ballast tanks. Similarly sulphuric acid may react with a number of hydrocarbons except parraffines (petroleum oils). Amines (aniline, diethylamine) may react with esters (butyl, acetate, ethyl acetate). Caustic soda will react violently with acrolein, acrylonitrile and allyl alcohol.

Oxidation: An Oxygen-rich compound like propylene oxide may react with an amine (e g diethylamine) or an aldehyde (e g acetaldehyde). An ether (e g ethyl ether) may react with oxygen and from a peroxide which is an explosive hazard. The ether should be inhibited and carried in an inerted (N 2) tank.

Auto-reaction: Certain hydrocarbons compounds have a tendency to polymerize with time, accelerated by heat, light, sometimes air or other matter such as rust. Polymerization means that several molecules of the same kind binding together to bigger molecules. The compound tends to become more viscous or eventually solidify. Heat is liberated, which accelerates further polymerization.

Chemically most cargoes are monomers, which means that they, before any polymerization, consist of single molecules.

12. Understanding the information contained in a Safety Data Sheet (SDS)

A safety data sheet (SDS), material safety data sheet (MSDS), or product safety data sheet (PSDS) is an important component of product stewardship, occupational safety and health, and spill-handling procedures. MSDS formats can vary from source to source within a country depending on national requirements.

MSDSs are a widely used system for cataloging information on chemicals, chemical compounds, and chemical mixtures. MSDS information may include instructions for the safe use and potential hazards associated with a particular material or product. The MSDS should be available for reference in the area where the chemicals are being stored or in use.

There is also a duty to properly label substances on the basis of physico-chemical, health or environmental risk. Labels can include hazard symbols such as the European Union standard symbols.

A MSDS for a substance is not primarily intended for use by the general consumer, focusing instead on the hazards of working with the material in an occupational setting.

It is important to use an MSDS specific to both country and supplier, as the same product (e.g. paints sold under identical brand names by the same company) can have different formulations in different countries. The formulation and hazard of a product using a generic name may vary between manufacturers in the same country.

COMPETENCE 3: Take precautions to prevent hazards

13. Knowledge and understanding of the hazards and control measures associated with chemical tanker cargo operations

13.1 Flammability and explosion

Explosive conditions in tanks that store crude oil and light petroleum distillates have been assessed in order to promote safe product storage.

Safe storage can be achieved by knowing the explosion limits for light distillates and crude oil, and understanding how those limits can be exceeded.

Light petroleum distillates include: LPG, gasoline, light and heavy naphtha, kerosine, and light gas oil (LGO).

Usually, LPG is stored under pressure in cylindrical or spherical tanks where the whole volume of the tank is full of LPG. There is no space above the product surface in the tank, and therefore, explosion and fire hazards caused by vapor space flammability are minimized.

Other light distillates, however, are stored in atmospheric floating-roof and domed tanks. It is not practical to fill these tanks completely, therefore, a space is left above the surface of the stored product. This space provides the potential for flammable mixtures and the possibility of explosion or fire.1

Very light petroleum distillates are a mixture of light and heavy hydrocarbon compounds. Part of the light compounds may vaporize under ambient storage conditions.

The vapor will gather in the vapor space above the product surface and form a vapor cloud where it is mixed with air that infiltrates into the tank. If the composition of the vapor cloud contains the proper proportions of air and light hydrocarbons, an ignitable or explosive mixture exists.

The explosion or fire danger becomes critical when the storage temperature is near the flash point of the fraction or fractions being stored. Therefore, knowledge of the flash points and explosion limits of the petroleum fractions, the size of the vapor space in the tank, and the ambient temperature range that the stored product can be exposed to is important to assess the explosive potential and assure safe product storage.

13.2 Toxicity

We call something toxic if it harms living things. The amount of harm caused depends on how an organism is exposed and to how much oil. For example, crude oil is considered toxic and causes two main kinds of injury: physical and biochemical.

The physical effects of freshly spilled crude oil are all too obvious. You've likely seen the disturbing images of birds and other animals coated in crude oil, struggling to survive. When oil washes ashore, it can completely cover and smother the plants and animals living there.

Crude oil not only destroys the insulating properties of animal fur and bird feathers, which can lead to hypothermia, but it also impairs animals' abilities to fly and swim, sometimes causing oiled animals to drown.

During the months after the 1989 Exxon Valdez oil spill, researchers collected about 30,000 dead birds—ranging over 90 different species—from the oiled areas, and they estimated that perhaps ten times as many birds died.

Spilled oil also can harm life because its chemical constituents are poisonous. As we previously learned (link is external), petroleum-derived oil is a complex mixture of thousands of chemical compounds. Given oil's chemical complexity, we need to consider how these different components—and their very different effects on living things—cause harm.

13.3 Health hazards

Human exposure to crude oil spills is associated with multiple adverse health effects including hematopoietic, hepatic, renal, and pulmonary abnormalities. The purpose of this study was to assess the hematological and liver function indices among the subjects participating in the Gulf oil spill cleanup operations in comparison with the standardized normal range reference values.

Breathing the fumes from crude oil are known to cause chemical pneumonia, irritation of the nose, throat, and lungs, headache, dizziness, drowsiness, loss of coordination, fatigue, nausea, and labored breathing. Chronic exposure can result in irregular heartbeats, convulsions, and coma.

Acute contact, via inhalation and skin, with small amounts of light crude oil and dispersants cause transitory respiratory, vomiting, diarrhea, and skin reactions. However, long-term exposure, which can be a matter of days or weeks, can cause central nervous system problems, or do damage to blood and organs such as kidneys or livers, according to the Centers for Disease Control and Prevention. There is also a significant increase in the risk of cancer.

Crude oil is not readily biodegradable and the effects of exposure to this toxin will be felt from generation to generation. Children and pregnant mothers are at significant risk. As a Toxicologist, I utilize the Bradford Hill Criteria of Causation, the methodology accepted by the scientific and medical community, in the correlation of all incidences of exposure and resultant health issues.

Crude Oil is not readily biodegradable, and the effects of exposure to this toxin will be felt not only acutely, but from generation to generation. Children and pregnant mothers are at significant risk. All exposures, no matter how seemingly insignificant, may prove to be consequential. What may seem to be a relatively trivial exposure in a healthy individual may potentially prove catastrophic, and the consequences of both acute and chronic exposures to crude oil may take years, even decades, to fully reveal the array of disease and morbidity than will result from exposure to this substance. Not only will a good working knowledge of both the acute and chronic effects of exposure be required by healthcare workers, but timely diagnosis and treatment of crude oil-related illnesses will be needed to limit or avoid serious adverse outcomes and potential medical-legal issues.

13.4 Inert gas composition

Inert gas means a gas or a mixture of gases, such as flue gas, containing insufficient oxygen to support the combustion of hydrocarbons.

The oxygen content of the Inert Gas supplied to cargo tanks should be 5% or less. However, it is to be noted that too less content of oxygen in the IG would introduce other impurities into the cargo tanks.

After efficient scrubbing of the inert gas, the typical constituents of a flue gas are:

- Nitrogen (N)- 83%
- Carbon Dioxide (CO_2)- 12-14%
- Oxygen (O_2) 2-4%
- Sulphur Dioxide (SO_2) 50 ppm
- Carbon Monoxide (CO) Trace
- Nitrogen Oxides (NO_x) 300 ppm
- Water Vapour (H_2O) Trace (hIGh, if not effectively dried)
- Ash and Soot C Traces
- Density 1.044 (heavier than air)

Inert condition means a condition in which the oxygen content throughout the atmosphere of a tank has been reduced to 8% or less by volume by addition of inert gas.

Points to pounder for inert gas:

- Inert gas systems on ships Inert gas is produced on board of mainly crude of oil carriers, gas carriers and Chemical carriers, and in Bulk carriers when carrying fish flower, and in refrigerating ships when carrying fruit products, by using either a flue gas system or by burning Marine Diesel Oil (MDO or MGO) in a dedicated inert gas generator, or produced clean Nitrogen by an dedicated Nitrogen Generator.
- IG keeps the oxygen content of the tank/cargo hold atmosphere below 8%, thus making any air/hydrocarbon gas mixture in the tank too lean to

IGnite. IG is most important during discharging of cargo on tankers and during the ballast voyage when more cargo and/or hydrocarbon vapour is likely to be present in the tank atmosphere.

Inert gas can also be used to purge the tank of the volatile atmosphere in preparation for gas freeing – replacing the atmosphere with breathable air – or vice versa. Inert Gas can also be used for emptying cargo lines or Cargo pumps.

Sources of inert gas on tankers including combination carriers are:

- The uptake from the ships main or auxiliary boilers
- An independent inert gas generator, or
- A gas turbine plant when equipped with an afterburner.
- Different types of Inert Gas:

Inert Gas for ship's can be one of the following gas and the choice of this gasses is depending on the product being carried and the capacity required.

Inert Gas is generated by burning MDO (marine diesel oil) in a furnace and the exhaust gas is blown by ordinary blowers via a scrubber/filter unit for cleaning out the Sulphur, towards the Cargo tanks; (This unit making the Inert gas is often called Inert Gas Generator)

Flue Gas: This Gas is exhaust gas from the steam generating boilers or occasionally from the main engine and blown by a blower via a scrubber/filter unit for cleaning and cleaning out the Sulphur towards the cargo tanks.

Nitrogen, which is made by blowing compressed air from the booster compressor through a small fiber tube, like a Filter material, or via an absorption filtering system, by which the air and its gasses will be separated and finally N2 will be forwarded to the Cargo tank by means of the overpressure caused by the booster compressor.

13.5 Electrostatic hazards

Static electricity presents fire and explosion hazards during the handling of flammable liquids and during other tanker operations such as tank cleaning, dipping, ullaging and sampling. Certain operations can give rise to accumulations of electric charge that may be released suddenly in electrostatic discharges with sufficient energy to ignite flammable product gas/air mixtures. There is, of course, no risk of ignition unless a flammable mixture is present. There are three basic stages leading up to a potential electrostatic hazard:

- Charge separation.
- Charge accumulation.
- Electrostatic discharge.

All three of these stages are necessary for an electrostatic ignition of a flammable atmosphere. Electrostatic discharges can occur as a result of accumulations of charge on:

- Liquid or solid non-conductors, for example a static accumulator oil (such as kerosene) pumped into a tank, or a polypropylene rope.
- Electrically insulated liquid or solid conductors, for example mists, sprays or particulate suspensions in air, or an unbonded metal rod hanging on the end of a rope.

The principles of electrostatic hazards and the precautions to be taken to manage the risks are described fully below.

Charge Accumulation

Charges that have been separated attempt to recombine and to neutralize each other. This process is known as ‘charge relaxation’. If one or both of the separated materials carrying charge is a very poor electrical conductor, recombination is impeded and the material retains or accumulates the charge upon it. The period of time for which the charge is retained is characterized by the relaxation time of the material, which is related to its conductivity; the lower the conductivity, the greater the relaxation time.

If a material has a comparatively high conductivity, the recombination of charges is very rapid and can counteract the separation process, and consequently little or no static electricity accumulates on the material. Such a highly conductive material can only retain or accumulate charge if it is insulated by means of a poor conductor, and the rate of loss of charge is then dependent upon the relaxation time of this lesser conducting material.

The important factors governing relaxation are therefore the electrical conductivities of the separated materials, of other conductors nearby, such as tanker’s structure, and of any additional materials that may be interposed between them after their separation.

Electrostatic Discharge

Electrostatic discharge occurs when the electrostatic field becomes too strong and the electrical resistance of an insulating material suddenly breaks down.

When breakdown occurs, the gradual flow and charge recombination associated with relaxation is replaced by sudden flow recombination that generates intense local heating (e.g. a spark) that can be a source of ignition if it occurs in a flammable atmosphere. Although all insulating media can be affected by breakdowns and electrostatic discharges, the main concern for tanker operations is the prevention of discharges in air or vapour, so as to avoid sources of ignition.

Electrostatic fields in tanks or compartments are not uniform because of tank shape and the presence of conductive internal protrusions, such as probes and structure. The field strength is enhanced around these protrusions and, consequently, that is where discharges generally occur. A discharge may occur between a protrusion and an insulated conductor or solely between a conductive protrusion and the space in its vicinity, without reaching another object.

Conductivity

Materials and liquid products that are handled by tankers and terminals are classified as being non-conductive, semi-conductive (in most electrostatic standards the term ‘dissipative’ is now preferred to ‘semi-conductive’) or conductive.

Non-Conductive Materials (or Non-Conductors)

These materials have such low conductivities that once they have received a charge they retain it for a very long period. Non-conductors can prevent the loss of charge from conductors by acting as insulators. Charged non-conductors are of concern because they can generate incendive brush discharges to nearby earthed conductors and because they can transfer a charge to, or induce a charge on, neighbouring insulated conductors that may then give rise to sparks.

Liquids are considered to be non-conductors when they have conductivities less than 50 pS/m (pico Siemens/metre). Such liquids are often referred to as static accumulators. Reference should be made to a product's MSDS to ascertain its conductivity.

The solid non-conductors include plastics, such as polypropylene, PVC, nylon and many types of rubber. They can become more conductive if their surfaces are contaminated with dirt or moisture.

Semi-Conductive Materials (or Dissipative Materials or Intermediate Conductors)

The liquids in this intermediate category have conductivities exceeding 50pS/m and, along with conductive liquids, are often known as static non-accumulators. The solids in this intermediate category generally include such materials as wood, cork, sisal and naturally occurring organic substances. They owe their conductivity to their ready absorption of water and they become more conductive as their surfaces are contaminated by moisture and dirt. However, when new or thoroughly cleaned and dried, their conductivities can be sufficiently low to bring them into the non-conductive range.

If materials in the intermediate conductivity group are not insulated from earth, their conductivities are high enough to prevent accumulation of an electrostatic charge. However, their conductivities are normally low enough to inhibit production of energetic sparks.

For materials with intermediate conductivities, the risk of electrostatic discharge is small, particularly if practices in this Guide are adhered to, and the chance of their being incendive is even smaller. However, caution should still be exercised when dealing with intermediate conductors because their conductivities are dependent upon many factors and their actual conductivity is not known.

Conductive Materials

In the case of solids, these are metals and, in the case of liquids, the whole range of aqueous solutions, including sea water. The human body, consisting of about 60% water, is effectively a liquid conductor. Many alcohols are conductive liquids.

The important property of conductors is that they are incapable of holding a charge unless insulated, but also that, if they are insulated, charged and an opportunity for an electrical discharge occurs, all the charge available is almost instantaneously released into the potentially incentive discharge.

13.6 Reactivity

Reactivity is the tendency of a substance to undergo chemical reaction, either by itself or with other materials, and to release energy.

Elements with the Highest Reactivity

Fluorine is the most reactive element - a stream of fluorine gas will spontaneously ignite a concrete block at room temperature.

The most chemically reactive metal is francium. Francium is radioactive, with no stable isotopes.

The most chemically reactive metal with a stable isotope is cesium. Cesium reacts explosively with water.

Elements with the Lowest Reactivity

The least reactive element is helium, which forms no compounds.

The least reactive metal is platinum. Platinum cannot be oxidized in air, even at high temperatures. It is unaffected by common acids, although it can be dissolved in aqua regia (a mixture of nitric acid and hydrochloric acid in the ratio 1:3) to yield chloroplatinic acid (H_2PtCl_6).

13.7 Corrosivity

A substance that is corrosive is one that has the ability to damage or destroy other substances when they come into contact. A corrosive substance can severely attack a number of materials, including organic compounds and metals. In addition to that, living tissues can also be greatly affected by the corrosivity of a substance.

There are different levels of corrosivity. If a corrosive substance is of low concentration, then it is referred to as an irritant. Corrosion of surfaces that are non-living, such as metals, take place in a process that is distinct. A good example is where air or water electrochemical cells eat up or corrode iron, thus resulting in a condition known as rust.

Alkalis, oxidizers, acids, non-alkalis and bases are all known to be corrosive. Poisons are different from corrosives in that the corrosive affects the tissue it comes into contact with immediately. The use of personal protective equipment such as safety shoes, face shields, safety goggles, acid suits, protective gloves and protective aprons, among other personal protective clothing, is recommended when handling chemicals with corrosivity. Most of the protective equipment is made of rubber.

Household cleaning agents are one of the economic advantages of corrosive elements. For instance, in various drain cleaners used for domestic purposes, alkalis or acids are used for the purpose of dissolving proteins and greases that are contained inside the pipes. To increase corrosivity, a catalyst which normally speeds the rate of reaction is used. Once the corrosive has been used, the corrosive elements can either be neutralized or recycled instead of disposing. Untreated corrosives can lead to environmental problems, and thus one should be careful while handling them.

13.8 Low-bowling-point cargoes

Pressures above or below the design range can damage a system, and operating personnel should be fully aware of any pressure limitation for each part of the cargo system; pressures should always be kept between the specified maximum and minimum.

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.

13.9 High-density cargoes

Structural Damage due to High Density Cargoes

High density cargoes have a greater weight than their volume may imply. Lighter cargoes occupy more space. For example, the stowage factor for corn is 1.42 m3/ton while for iron ore, the stowage factor can be as small as 0.24 m3/ton. Tank top strength is provided in the ship's stability booklet. However, as a ship ages, this strength reduces and a greater safety margin is recommended for older ships.

According to the IMSBC Code, any cargo with a Stowage Factor less than 0.56 m3/ton is considered a high density cargo. There are three recommended ways by which maximum tonnage allowed in any cargo hold (not just bulk carriers) can be calculated if no other information is provided in the ship's documentation. These are:

- Maximum cargo loaded (in tones) in a hold = 0.9 × L × B × D
  Where L = Length (in meters) of cargo hold
  B = Breadth (in meters) of cargo hold
  D = Summer load draught (in meters).
- If the cargo is untrimmed or partially trimmed, then:
  Maximum height of cargo pile = 1.1 × D × Stowage Factor
  Where Stowage Factor is given in m3/ton. If the cargo is trimmed level, then 20% more cargo may be loaded (as calculated in [i] above) in the lower hold.
- The cargo officer should calculate the maximum permissible tonnage for each cargo hold. This is found in the ship's stability book, but can be calculated by the formula:
  Permissible Tonnage = Total Area of Tank top (m2) × Allowed Load (Tank top Strength in Tones per m2).

  (Note: the above formula may only be used for homogeneous bulk cargoes and not cargoes such as steel coils.)

Another peculiar characteristic of high density cargoes is that they do not provide much support to the internal structure of the cargo hold, which may increase the risk of damage from panting stresses. This is particularly true with ships where the maximum safe load for cargo holds is either not given or is not considered when loading such cargoes.

Panting is a term used to describe the movement of the ship caused by the shock of contact with a succession of waves at the bow or the stern. It can be thought of as breathing-like movement in the fore and aft plane of the vessel.

Typical bulk carrier manoeuvering with tug

The International Association of Classification Societies (IACS) estimates that an extra 10% load on a vessel's structure increases the still water bending moments by 40% and shearing forces by 20%. These small variations in loads can easily be caused by inappropriate and/or careless loading/discharging. For example, in the loading port, if the rate of discharge of ballast water is not similar to the rate of cargo being loaded then stresses are likely to cause severe damage to the ship's structure.

It is the job of the ship's officers to ensure that this does not happen and the procedure should be established in the cargo plans. If it is suspected that a vessel has been overloaded, tank top and deck structures (particularly deck plates between hatchways and at hatch corners) should be carefully inspected for any signs of cracking or buckling.

13.10 Solidifying cargoes

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. Annex II, Chapter 1, Regulation 1.

Solidification in the cargo tanks can occur when solidifying cargoes are stowed adjacent to "cold cargoes" or cold ballast water in adjacent spaces. Tank bottoms must therefore always be checked for hard factions especially when carrying vegetable and animal oils, at regular intervals throughout the voyage and always prior to arrival in the discharge port.

To avoid solidification of cargo in adjacent tanks, do not ballast the ballast tanks in contact with the surrounding the cargo tanks. Keep the ballast water in these ballast tanks about 30 cm below the tank top, allowing for trim.

Special care must be exercised when the vessel is advised that the shore tanks have been "squeezed" (swept) into the vessel, in such cases the "squeezed" (swept) cargo from the shore tank should as far as possible be confined to one tank onboard. The particular tank onboard which received this cargo can then be re-circulated onboard if soundings indicate a “hard bottom” problem. Solidification can also occur when inhibited cargoes or their condensates are exposed to excessive heat. If excessive heat is caused by the sun, spraying the deck area with seawater may prevent this type of solidification (polymerisation).

Because of the risk of solidifying cargo being hard and blocking the venting pipe due to evaporation through the vent pipe, the following precautions are recommended:

1. During voyage, regular checking of proper functioning of PV valves.
2. During voyage, regular checking of the vent lines by N2 / air depending on the type of cargo.
3. During tank cleaning, PV valves, vent lines to be thoroughly washed with hot water and same to be drained to the tank.
4. After the loading, all cargo lines to be flushed with high pressure N2 / air depending on the type of cargo.

13.11 Polymerizing cargoes

Chemicals which polymerize form complex aggregates called polymers by the combination of two or more identical molecules from the original chemical which is a monomer. Monomers are among the purest organic chemicals produced. Inhibitors converted to free radicals halt a second reaction chain. Inhibitors react with reactive intermediates thus removing them from the reaction.

When a single molecule reacts with another molecule of the same substance. A long chain molecule is formed having thousands of individual molecules.

Can be with rapid evolution of heat to form sticky, resinous materials. Cargo then becomes viscous and unpumpable.

Some unsaturated compounds with one or more double bondings are able to polymerise, like-- Vinyl compounds, Vinyliden compounds, Acryl compounds, Carbonyl compounds (eg:aldehyde), Styrene, Ethylene / propylene oxide, Ethylene, Propylene, Isobutylene, Butadiene, Isoprene.

Polymers are usually distinguished by a high molar mass (formula weight), often ranging into thousands or millions of grams per formula unit. Polymerization is a poly-reaction of a monomer compound whose molecule contains double bondings or rings. Ethylene is a highly flammable gaseous molecule with a formula weight (molar mass) of 32 grams per mol. When polymerized using a catalyst, it forms an insoluble solid called polyethylene. Polyethylene is a widely used commodity plastic.

Unstable chemicals decompose or polymerize. A decomposing chemical is stabilized and a polymerizing chemical is inhibited.

Chemicals like Acetone Cyanohydrin and Lacto Nitrile which decompose are stabilized by inorganic acid to prevent decomposition or poisonous gas will evolve.

Heat shortens life of the inhibitor. Inhibitors have a shelf life. Heat, light and radiation catalyzes polymerization. Opposite of inhibitor is initiator. Add Sodium Naphtalene to Styrene and the tank gets polymerized. Hydrocarbons weaken inhibitors.

Inhibitors are not volatile. They are very difficult to remove by tank cleaning. PTT will be affected. An inhibitor killer can be used if next cargo is WWT.

A test for inhibitor content of Styrene consists of mixing one part of Styrene is 3 parts of Methanol. If the mixture remains clear or slightly bluish the product is intact. A slightly white turbidity indicates polymerization or that the inhibitor is slightly consumed. If there is an unexplained temperature rise consult shippers and operators immediately. The action might be as drastic as jettisoning the parcel.

Polymerization reactions are exothermic reactions. Reaction speed is strongly influenced by catalysts (usually metals). Many polymerization reactions are started by heating and by liquids after the formation of Peroxides.

Inhibitors are added in very low concentrations—10 to 40 ppm. Unlike monomers inhibitors prefer to react with Oxygen, and this way the formation of Peroxides is prevented. Inhibitors have a shelf life and they have to be replenished.

If the inhibitor is oxygen dependant NEVER nitrogen pad the tanks.

The list of chemicals required to be inhibited is attached to this manual. Generally all monomers, Acrylates, and chemicals like Acetone Cyanohydrin, Benzyl Chloride, Butadiene, Iso Propyl Ether, Isoprene, Pentadiene, and Vinyl chemicals require to be inhibited. Ethylene oxide , Propelene oxide and Iso Butylene can also polymerise.

No polymerising cargo can be loaded without a signed inhibitor certificate, a copy of which is attached to this manual.

14. Knowledge and understanding of dangers of non-compliance with relevant rules/regulations

International regulations are followed in the design and construction of tankers and when working on them. The regulations are issued by the administration of the country under which flag the ship in question sails and they are based on the decisions of the International Maritime Organisation (IMO), which is a UN body, and on international standards.

The authorities of the country under which the ship sails and the representatives of the ship's classification society monitor the technical condition of the ship by inspections which are carried out regularly. In addition, the ship and the competence of its crew are audited in inspections which are carried out without informing in beforehand. The inspections are based on the Paris Memorandum of Understanding signed between maritime countries. Furthermore, Port State Control inspections are carried out based on the Memorandum when a ship visits foreign ports. The authorities performing the inspections keep a database on the inspections which is available to everyone. This procedure aims at monitoring efficiently that deficiencies are corrected and at informing everyone openly

In addition to the inspections carried out by authorities on tankers, an inspector of the customer (an oil company) or of a possible customer (charterer) carries out numerous so called vetting inspections. They are based on a standard of the OCIMF (Oil Companies International Marine Forum) industry. With the inspections, the oil companies' aim at ensuring that the ship complies with the safety requirements stated in international standards, which may deviate from the requirements set by authorities. Oil companies keep a joint SIRE database on the results of vetting inspections, which is available to members for internal use. Oil companies monitor the technical and operative condition of a ship by using the SIRE reports.

COMPETENCE 4: Apply occupational health and safety precautions

15. **Knowledge and understanding of safe working practices, including risk assessment and personal shipboard safety relevant to chemical tankers**

15.1 Precautions to be taken when entering enclosed spaces, including correct use of different types of breathing apparatus

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 equipment. 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.

Self-Contained Breathing Apparatus (called SCBA for short)

Is respiratory protective device apparatus to prevent a user from inhaling the oxygen deficient air, contaminated particulate, toxic gas and vapors or potentially harmful gases in the plant, mine, the fire site, the vessel, the tunnel, and etc.

The apparatus has been widely used in such fields as firefighting, rescue operation, escape guidance at fire station, for prevention of disaster, at steel works, chemical plant, nuclear facilities, hotels, and vessels, etc. throughout Japan.

The apparatus can be used even if in the oxygen deficiency or unknown the contaminants and toxic gases.

Self-Contained Breathing Apparatus has the air breathing apparatus and oxygen breathing apparatus.

There are two types of Self-Contained Breathing Apparatus:

–**Open-Circuit Air Breathing Apparatus**

The SCBA supplies the compressed air from the air cylinder to the wearer through cylinder valve, pressure reducer, pressure demand valve or demand valve. Exhaled air goes to the atmosphere through exhalation valve.

–**Closed-Circuit Oxygen Breathing Apparatus**

The SCBA supplies the compressed oxygen from the oxygen cylinder to the wearer through cylinder valve, pressure reducer, demand valve, etc.

Carbon dioxide in exhales air is absorbed by the absorbing canister, and oxygen is re-supplied through breathing bag. This mechanism enables for long time use.

15.2 Precautions to be taken before and during repair and maintenance work

Safe maintenance work requires proper planning, a safe work area, appropriate equipment, careful work execution and diligent final checks.

The onboard work in an oil tanker involved many hazards. Following are the basic check items that crew should take in to account for ensuring safe working area

Before work, the conditions of working area, such as the density of inflammable gas and fire, shall be positively managed, and the work shall be started after necessary safety of the work is confirmed.

Unnecessary tools shall not be carried on clothing when moving on cargo tanks / decks. Special care should be taken when bending over, while peeping into tanks. While carrying necessary tools into tanks, preventive measures against dropping of tools, such as use of a canvas bag or lowering using rope, shall be taken.

Anti-Electrostatic Clothes and Shoes for Ship's crew:

Only anti-electrostatic clothing and shoes should be worn during work outside of the accommodation. Although, as per the guidelines laid out in ISGOTT, experience over a long period indicates electrostatic discharges caused by clothing and foot wear do not, however, resent a significant hazard in the oil industry and those encountered on tankers.

The tendency for synthetic material to melt and fuse together when exposed to high temperatures leads to a concentrated heat source which causes severe damage to body tissue. Clothing made of such synthetic material is therefore not considered suitable for persons who may in the course of their duties be exposed to flame or hot surfaces.

Permission of Hot Work

Work using fire and other mechanically powered tools shall be carried out as per procedures for Hot Work

Use of Explosion-proof Type Electric Torch equipment:

Only Torches (flash lights) that have been approved by a competent authority for use in flammable atmospheres shall be used onboard Tankers.

Use of Hand Tools

For guidance on the efficient use of Hand tools, refer to the relevant section of the latest ISGOTT publication.

Prior to use of “Non-sparking hand tools”, although they are not recommended to use with the latest ISGOTT, they should be inspected and proved free from any hard substances embedded in the softer non-ferrous material. Non-spark tools shall be marked with yellow paint.

Maintenance of Fixed Lighting Units

- All fixed electrical equipment must be of an approved type in the dangerous area as well as locations where a flammable atmosphere is infrequently expected.
- Check the illumination test of all fixed lighting systems, prior to arrival port. Check the "Earth" function test.
- The equipment should be properly maintained, so as to ensure, that neither the equipment nor the wiring should become a source of ignition.
- Any observed defect light bulbs, light covers or defect/damaged cables must be repaired / replaced prior to port entry. Do not replace light bulbs outside of the accommodation during cargo oil transfer operations (including Gas freeing).
- The integrity of the protection afforded by the design of explosion proof or intrinsically safe equipment may be compromised by even the simplest of maintenance procedures, especially in case of "Explosion Proof Lights", where incorrect closing, after changing of light bulb could cause dangerous situation.

15.3 Precautions for hot and cold work

Hot work means any work requiring the use of electric arc or gas welding equipment, cutting burner equipment or other forms of naked flame, as well as spark generating tools. It covers all such work, regardless of where it is carried out on board a ship, including open decks, machinery rooms and the engine room.

Performing hot works onboard modern tankers involved numerous hazards .It is anticipated that owners and operators of chemical tankers will issue clear guidance to masters and crews on the control of hot work on board while the ship is in service. The following is intended to assist safety by indicating principal areas that should receive attention.

Hot work requirement

Repair work outside the main engine room which necessitates hot work should only be undertaken when it is essential for the safety or immediate operation of the ship, and when no alternative repair procedure is possible.

Hot work outside the engine room (and in the engine room when associated with fuel or lubrication systems) must be prohibited until the requirements of national legislation and other applicable regulations have been met, safety considerations taken into account, and a hot work permit has been issued. This may involve the master, owner's superintendent, shore contractor, terminal representative and port authority as appropriate.

Hot work in port at a chemical terminal is normally prohibited. If such work becomes essential for safety or urgent operational needs, then port and terminal regulations must be complied with. Full liaison should be established with port and terminal authorities before any work is started.

Assessment of hot work

The master is responsible for deciding whether the hot work is justified, and whether it can be conducted safely. Hot work in areas outside the engine room should not be started until a procedure has been discussed and agreed, and the master has informed the ship's owners or operators of details of the work intended.

Before hot work is started a safety meeting under the chairmanship of the master must be held, at which the planned work and the safety precautions are carefully reviewed. The meeting should be attended at least by all those who will have responsibilities in connection with the work. An agreed written plan for the work and the related safety precautions should be made. The plan must clearly and unambiguously designate one officer who is responsible for the supervision of the work, and another officer who is responsible for safety precautions and communications between all parties involved.

All personnel involved in the preparations and in the hot work operation must be briefed and instructed on their own role. They must clearly understand which officer is responsible for work supervision and which for safety precautions. A written hot work permit should be issued for each intended task. The permit should specify the duration of validity, which should not exceed a working day.

Preparations for 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 meters 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 utilizing 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.

Cold working refers to the process of strengthening a metal by plastic deformation. Also referred to as work hardening, the metal working technique involves subjecting metal to mechanical stress so as to cause a permanent change to the metal’s crystalline structure.

The following properties are affected by cold work significantly:

- Tensile Strength
- Hardness
- Yield Strength
- Ductility

Advantages of cold work:

- Good dimensional control
- Good surface finish of the component.
- Strength and hardness of the metal are increased.
- An ideal method for increasing hardness of those metals which do not respond to the heat treatment.

Cold work refers to work with tools that may expose the user to hazardous situations such as:

- Working on electrical equipment within a hazardous environment. This should only be done when electrical power has been cut off and tagged;
- Opening up of pipelines and cargo equipment which may expose personnel to trapped toxic or flammable products; and
- Chipping and scaling of the ship's structure which may cause contact sparking.
- Whenever cold work is planned within the cargo area or other hazardous areas, a permit to work should be issued for each intended task. The permit should specify the duration of validity, which should not exceed one working day.

The atmosphere within any enclosed space in which hot or cold work is to take place should be tested for hydrocarbons and a reading of less than 1 % LFL obtained on suitable monitoring equipment.

15.4 Precautions for electrical safety

It's vitally important to take safety precautions when working with electricity. Safety must not be compromised and some ground rules need to be followed first. The basic guidelines regarding safe handling of electricity documented below will help you while working with electricity.

1. Avoid water at all times when working with electricity. Never touch or try repairing any electrical equipment or circuits with wet hands. It increases the conductivity of electric current.
2. Never use equipment with frayed cords, damaged insulation or broken plugs.
3. If you are working on any receptacle at your home then always turn off the mains. It is also a good idea to put up a sign on the service panel so that nobody turns the main switch ON by accident.
4. Always use insulated tools while working.
5. Electrical hazards include exposed energized parts and unguarded electrical equipment which may become energized unexpectedly. Such equipment always carries warning signs like "Shock Risk". Always be observant of such signs and follow the safety rules established by the electrical code followed by the country you're in.
6. Always use appropriate insulated rubber gloves and goggles while working on any branch circuit or any other electrical circuit.
7. Never try repairing energized equipment. Always check that it is de-energized first by using a tester. When an electric tester touches a live

or hot wire, the bulb inside the tester lights up showing that an electrical current is flowing through the respective wire. Check all the wires, the outer metallic covering of the service panel and any other hanging wires with an electrical tester before proceeding with your work.

8. Never use an aluminium or steel ladder if you are working on any receptacle at height in your home. An electrical surge will ground you and the whole electric current will pass through your body. Use a bamboo, wooden or a fiberglass ladder instead.
9. Know the wire code of your country.
10. Always check all your GFCI's once a month. A GFCI (Ground Fault Circuit Interrupter) is a RCD (Residual Current Device). They have become very common in modern homes, especially damp areas like the bathroom and kitchen, as they help avoid electrical shock hazards. It is designed to disconnect quickly enough to avoid any injury caused by over current or short circuit faults.
11. Always use a circuit breaker or fuse with the appropriate current rating. Circuit breakers and fuses are protection devices that automatically disconnect the live wire when a condition of short circuit or over current occurs. The selection of the appropriate fuse or circuit breaker is essential. Normally for protection against short circuits a fuse rated of 150% of the normal circuit current is selected. In the case of a circuit with 10 amperes of current, a 15 ampere fuse will protect against direct short circuits whereas a 9.5 amperes fuse will blow out.
12. Working outside with underground cabling can be dangerous. The damp soil around the cable is a good conductor of electricity and ground faults are quite common in the case of underground cabling.

Using a spade to dig at the cable can damage the wiring easily so it is better to dig at the cable by hand while wearing insulated gloves.

13. Always put a cap on the hot/live wire while working on an electric board or service panel as you could end up short circuiting the bare ends of the live wire with the neutral. The cap insulates the copper ends of the cable thus preventing any kind of shock even if touched mistakenly.
14. Take care while removing a capacitor from a circuit. A capacitor stores energy and if it's not properly discharged when removed it can easily cause an electric shock. An easy way to discharge low voltage capacitor is that after removal from the circuit is to put the tip of two insulated screw drivers on the capacitor terminals. This will discharge it. For high voltage ones a 12 Volts light bulb can be used. Connecting the bulb with the capacitor will light up the bulb using up the last of the stored energy.
15. Always take care while soldering your circuit boards. Wear goggles and keep yourself away from the fumes. Keep the solder iron in its stand when not in use; it can get extremely hot and can easily cause burns.

15.5 Use of appropriate Personal Protective Equipment (PPE)

Employers have duties concerning the provision and use of personal protective equipment (PPE) at work.

PPE is equipment that will protect the user against health or safety risks at work. It can include items such as safety helmets, gloves, eye protection, high-visibility clothing, safety footwear and safety harnesses. It also includes respiratory protective equipment (RPE).

Making the workplace safe includes providing instructions, procedures, training and supervision to encourage people to work safely and responsibly.

Even where engineering controls and safe systems of work have been applied, some hazards might remain.

These include injuries to:

- the lungs, eg from breathing in contaminated air
- the head and feet, eg from falling materials
- the eyes, eg from flying particles or splashes of corrosive liquids
- the skin, eg from contact with corrosive materials
- the body, eg from extremes of heat or cold

PPE is needed in these cases to reduce the risk.

COMPETENCE 5: Respond to emergencies

16. Knowledge and understanding of chemical tanker emergency procedures

16.1 Ship emergency response plans

It is Company's policy to ensure that the Company's organisation can respond at any time to hazards, accidents and emergency situations involving the ships.

The Company, in order to identify potential emergency situations and prepare itself for promptly and efficiently responding to such situations:

- Ensures that each ship is equipped with all necessary Life-Saving and Fire-Fighting appliances, security equipment and arrangements required by SOLAS / MARPOL/ Flag State.
- Has developed and implements a Safety Drills Programme.
- Has developed:
  - A "Shore Emergency Response Plan" and a “Ship-Board Contingency Plan” providing instructions, guidelines and

communication details for Emergency response purposes to both Shore Based personnel and Sea Going personnel.

- "Shipboard Oil Pollution Emergency Plans (SOPEP)" for each vessel, regarding onboard mobilization in case of emergency outside U.S.A. waters.
- Vessel Response Plans for each vessel regarding vessel response in case of oil pollution, in U.S.A. waters.

– Ensures that the above Emergency Plans developed are drilled and exercised.

The Master has the final and overriding authority and responsibility to make decisions in respect to safety and security of the ship, her crew and the environmental protection, regardless of any commercial considerations and to request the company's assistance as may be necessary.

In case of an emergency, the Master must decide as a matter of urgency whether assistance, including salvage assistance, is needed or if the situation can be handled using the ship's own resources.

The Master should take whatever action is possible to remedy the situation. Once the Master has decided that assistance is necessary, he should act promptly to request it from any available source using the most expeditious means at his disposal and keep the officials advised of his actions.
Prior to commencing any salvage operation, the Master should seek to agree to a contract for assistance. Lloyd's standard form of Salvage Agreement, known as Lloyd's Open Form (LOF 2000), is the form most usually offered and should be agreed upon to avoid any delays.

16.2 Cargo operations emergency shutdown

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

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

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

Tankers can be equipped with following emergency shut down systems:

- **During loading**

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

  The signal should be transmitted to the shore facility via a watertight two-pin plug of a connector device in accordance with standard identification colour white, position of the nose 10 h. The plug should be permanently fitted to the tanker close to the manifold position. The high level sensor should also have the capability of shutting down the tanker's pumps when discharging.

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

- **During discharging**

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

  It should be possible for the binary signal of the shore facility to be transmitted via a watertight two-pole socket or a connector device in accordance with standard identification colour white, position of the nose 10 h.

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

16.3 Actions to be taken in the event of failure of systems or services essential to cargo

In the event of total failure of the inert gas system to deliver the required quality and quantity of inert gas and maintain a positive pressure in the cargo and slop tanks, action must be taken immediately to prevent any air being drawn into the tank; all cargo tank operations should be stopped, the deck isolating valve closed, and the vent valve between it and the gas pressure regulating valve opened and immediate action taken to repair the inert gas system.

16.4 Firefighting on chemical tankers

Without doubt, one of the main causes of accidents onboard ships is fire. This is because of the presence of high temperature, excess quantity of flammable oil and other combustible materials. A ship is approved to sail in international waters only if it is constructed as per Fire Safety System code and carries required Fire Fighting Appliances approved by the concerned authority.

A ship is fitted with various types of fire retardant and firefighting equipments so as to fight any kind of fire and extinguish it as soon as possible before it turns into a major catastrophic situation. In this article we bring to you a list of important firefighting equipments and measures present on board.

Following are the Firefighting equipments which are used onboard ships:

- **Fire Retardant Bulkhead:** Different Class of bulkhead such Class-A, Class-B and Class-C are used on board ship for construction of bulkhead in areas like accommodation, machinery space, pump room etc. The main applications of such bulkhead are to contain or restrict the spread of fire in sensitive areas.
- **Fire doors:** Fire doors are fitted in fire retardant bulkhead to provide access from the same. They are self-closing type doors with no hold back arrangement.
- **Fire Dampers:** Dampers are provided in the ventilation system of cargo holds, engine room, accommodation etc. in order to block out excessive oxygen supply to the fire. For this, it is necessary that open and shut position clearly marked for fire dampers.
- **Fire Pumps:** As per regulation, a ship must have main fire pump and an emergency power pump of approved type and capacity. The location of

the emergency fire pump must be outside the space where main fire pump is located.

- **Fire Main Piping and Valves:** The Fire Main piping which is connected to the main and emergency fire pump must be of approve type and capacity. Isolation and relief valves must be provided in the line to avoid over pressure of the same.
- **Fire Hose and Nozzles:** Fire hoses with length of at least 10 meters are used in ships. Number and diameter of the hoses are determined by the classification society. Nozzle of diameters 12 m, 16 m and 19 m used on ship are of dual purpose types- Jet and spray mode.
- **Fire Hydrants:** Fire hoses are connected to fire hydrants from which the water supply is controlled. They are made up of heat retardant material to get least affected from the sub zero temperatures and also to ensure that hoses can be easily coupled with them.
- **Portable Fire Extinguishers:** Portable fire extinguishers of CO2, Foam and Dry Chemical Powder are provided in accommodation, deck and machinery spaces carried along with number of spares as given by the regulation.
- **Fixed Fire extinguishing system:** CO2, Foam and water are used in this type of system, which is installed at different locations on the ship and is remotely controlled from outside the space to be protected.
- **Inert Gas System:** The inert gas system is provided in the oil tankers of 20000 dwt and above and those which are fitted with Crude oil washing. The IG system is to protect Cargo space from any fire hazards.
- **Fire Detectors and Alarms:** Fire detection and alarm systems are installed in Cargo area, accommodation, deck areas, and machinery

spaces along with alarm system to notify any outbreak of fire or smoke at the earliest.

- **Remote Shut and Stop System:** The remote station shutdown is provided to all fuel lines from fuel oil and diesel oil tanks in the machinery space and which is done by quick closing valves. Remote stop system is also provided to stop the machineries like fuel pumps, purifier, ventilation fans, boiler etc. in the event of fire in the engine room or before discharging fixed fire fighting system in the E/R.
- **EEBD:** EEBD (Emergency Escape Breathing Device) is used to escape from a room on fire or filled with smoke. The location and spares of the same must be as per the requirements given in FSS code.
- **Fire Fighter's Outfit:** Fire fighter's outfit is used to fight a fire on the ship made up of fire retardant material of approved type. For a cargo ship at least 2 outfits and for passenger ship at least 4 outfits must be present onboard.
- **International Shore Connection (ISC):** ISC is used to connect shore water to the ship system to fight fire when the ship fire pump system is not operational and is on port, lay off or dry dock. The size and dimensions are standard for all the ship and at least one coupling with gasket must be present onboard.
- **Means of Escape:** Escape routes and passages must be provided at different location of the ship along with ladders and supports leading to a safe location. The size and location are designed as per the regulation.

16.5 Enclosed space rescue

An enclosed space is a space with poor or no natural ventilation which is not designed for continuous occupancy, where access is limited and which may contain a dangerous atmosphere. Enclosed spaces include but are not limited to cargo tanks, double bottoms, cargo pump rooms, duct keels, ballast tanks, void spaces, peak tanks, cofferdams, chain lockers, bunker tanks, freshwater tanks, machinery internals and any other spaces that are normally kept closed. An enclosed space may include a deck area that due to its construction and location has poor or limited access and where a dangerous atmosphere may accumulate. The hazards identified below may be present around such a deck area.

Rescue from Cargo Tanks and Other Enclosed Spaces

It is essential that regular drills and exercises to practice rescue from enclosed spaces are carried out, and that all members of a rescue team know what is expected of them.

When personnel are in need of rescue from an enclosed space, the first action from the person assigned as the attendant should be to raise the alarm. Although speed is often vital in the interest of saving life, rescue operations should not be attempted until assistance has arrived and a planned approach can be made. Over the years, there are many examples of lives having been lost through hasty, ill prepared rescue attempts.

Enclosed space rescue procedures should be well planned and regular drills held to improve effectiveness. There are a number of issues that rescue procedures should address.

The rescue team should comprise a dedicated team of personnel drilled and trained as appropriate in all aspects of enclosed space rescue including in the use of resuscitation equipment. All team members should be familiar with the ship's SMS, and its operating and emergency procedures. Although a dedicated team offers major advantages it is essential that back up personnel are also identified in case a member(s) of the dedicated team is unavailable.

The Rescue team should consist of the following personnel:

- **Team leader** - this should be a senior officer. The role will be to direct the rescue effort, therefore the leader should not form part of the team that enters the enclosed space; Entry into an enclosed space where the atmosphere is known or suspected to be unsafe should only be conducted in an emergency.
- **Entry team** - the number of entry team personnel should be kept to a minimum. However, at least two persons should enter the space to carry out the rescue; and
- **Back up personnel** - these should be employed to rig the rescue equipment, ensuring that the entry team have the equipment and support necessary to carry out their task and to monitor the enclosed space atmosphere. One crew member should be assigned to assist the rescue team leader with communications and to maintain a record of events.

Depending on the overall crew composition and assessment of the incident some roles can be executed by a single person who may carry out more than one function.

The rescue operation

The person on watch at the entrance to the enclosed space (attendant) should, as soon as they are aware that a person in the space is in difficulty, immediately raise the alarm. It is therefore essential that a method of raising the alarm is agreed and tested in advance together with a means of communicating the details of the emergency. It is also essential that the rescue team is advised regarding the nature of the accident and how many persons are affected.

Rescue team personnel should proceed immediately to the entrance to the enclosed space together with any additional equipment. No one should enter the space without the team leader's permission.

Unless it has been positively assessed that the atmosphere in the enclosed space is safe to breathe, the entry team should in addition to wearing appropriate protective equipment use breathing apparatus. Only after a full test has confirmed that the enclosed space atmosphere is safe to enter should the entry team proceed without breathing apparatus.

On reaching the casualty the entry team should ascertain if the casualty is still breathing. If the casualty is not breathing the entry team should remove the casualty from the space as soon as possible for resuscitation.

If the casualty is breathing, any injuries should be assessed before the casualty is removed from the space. If the condition of the atmosphere in the enclosed space is not verified as safe, the casualty should be provided with a safe independent air supply in the enclosed space. Regular training of the emergency rescue team is essential to ensure a successful enclosed space rescue.

Emergency rescue team members should be:

- Prepared for the physical and technical demands of enclosed space rescue;
- Well trained in all rescue team duties;
- Familiar with the use and deployment of rescue equipment that should be of a size and weight to allow its ready deployment into the enclosed space and placement in any location where work may take place; and
- Capable of fulfilling any role within the rescue team. In an emergency rescue, the atmosphere of an enclosed space should always be considered to be unsafe unless confirmed otherwise.

During the incident the team leader and back up personnel should:

- Monitor the rescue team and ensure the provision of spare air supplies;
- Rig rescue equipment such as hoists;
- Monitor the atmosphere of the space;
- Communicate with the vessel's command team; and
- Arrange additional lighting, ventilation and improve access to the space, as appropriate.

Removal of the casualty should be carried out utilizing the most appropriate equipment such as stretchers, lifting harnesses and hoisting apparatus.

16.6 Cargo reactivity

A chemical may react in a number of ways; with itself, with water, with air, with other chemicals or with other materials.

Self-reaction

The most common form of self-reaction is polymerisation. Polymerisation generally results in the conversion of gases or liquids into viscous liquids or solids. It may be a slow, natural process which only degrades the product without posing any safety hazards to the ship or the crew, or it may be a rapid, exothermic reaction evolving large amounts of heat and gases.

Heat produced by the process can accelerate it. Such a reaction is called a run-off polymerisation that poses a serious danger to both the ship and its personnel. Products that are susceptible to polymerisation are normally transported with added inhibitors to prevent the onset of the reaction.

An inhibited cargo certificate should be provided to the ship before a cargo is carried. The action to be taken in case of a polymerisation situation occurring while the cargo is on board should be covered by the ship's emergency contingency plan.

Reaction with water

Certain cargoes react with water in a way that could pose a danger to both the ship and its personnel. Toxic gases may be evolved. The most noticeable examples are the isocyanates; such cargoes are carried under dry and inert condition. Other cargoes react with water in a slow way that poses no safety hazard, but the reaction may produce small amounts of chemicals that can damage equipment or tank materials, or can cause oxygen depletion.

Certain chemical cargoes, mostly ethers and aldehydes, may react with oxygen in air or in the chemical to form unstable oxygen compounds (peroxides) which, if allowed to build up, could cause an explosion. Such cargoes can be either inhibited by an anti-oxidant or carried under inert conditions.

Reaction with other cargoes

Some cargoes react dangerously with one another. Such cargoes should be stowed away from each other (not in adjacent tanks) and prevented from mixing by using separate loading, discharging and venting systems. When planning the cargo stowage, the master must use a recognised compatibility guide to ensure that cargoes stowed adjacent to each other are compatible.

Reaction with other materials

The materials used in construction of the cargo systems must be compatible with the cargo to be carried, and care must be taken to ensure that no incompatible materials are used or introduced during maintenance (e.g. by the material used for replacing gaskets). Some materials may trigger a self-reaction within the product. In other cases, reaction with certain alloys will be non-hazardous to ship or crew, but can impair the commercial quality of the cargo or render it unusable.

Heat adjacent

The maximum temperature of adjacent cargo permitted for each cargo to be loaded shall be obtained from shippers when handling heated cargo. In addition, care shall be taken to avoid indirect heating of adjacent cargoes and bulkheads during hot water washing of adjacent tanks.

16.7 Jettisoning cargo

Act of throwing **cargo** or equipment (jetsam) overboard in order to lighten the vessel or improve its stability in case of emergency.

Cargo jettisoning is always a emergency situation and we normally won't do such a thing, Pls be assured. This only done to protect the stability of the ship so that the remaining cargo and the ship can be saved. It can be defined as strategic throwing of goods so that the ship becomes stable again. This situation might arise if the ship had a collision/grounding/flooding etc or any other cause which is causing it to flounder.

The cost of the cargo which is so jettisoned is covered by what is known as general average law. This is basically, that the guys who's cargo was saved and the ship owner who's ship was saved due to this act of throwing some guys cargo overboard, compensate that guy the cost of his goods by sharing the loss. Insurance pays it but that's how the chain of money goes.

16.8 Use of a Safety Data Sheet (SDS)

A safety data sheet (SDS), material safety data sheet (MSDS), or product safety data sheet (PSDS) is an important component of product stewardship, occupational safety and health, and spill-handling procedures. MSDS formats can vary from source to source within a country depending on national requirements.

MSDSs are a widely used system for cataloging information on chemicals, chemical compounds, and chemical mixtures. MSDS information may include instructions for the safe use and potential hazards associated with a particular material or product. The MSDS should be available for reference in the area where the chemicals are being stored or in use.

There is also a duty to properly label substances on the basis of physico-chemical, health or environmental risk. Labels can include hazard symbols such as the European Union standard symbols.

A MSDS for a substance is not primarily intended for use by the general consumer, focusing instead on the hazards of working with the material in an occupational setting.

It is important to use an MSDS specific to both country and supplier, as the same product (e.g. paints sold under identical brand names by the same company) can have different formulations in different countries. The formulation and hazard of a product using a generic name may vary between manufacturers in the same country.

17. Actions to be taken following collision, grounding or spillage

- **Collision**
  1. Inform the Master and Engine Room
  2. Immediately send distress signal
  3. Record important data
  4. Sound the alarms
  5. Assess the damages
  6. Take the soundings
  7. Take immediate action in case of damage
  8. Check for oil spill

9. Reach the nearest port if is possible
10. Abandon the ship only if everything else fails

– **Grounding**
  1. Stop Engines
  2. Sound General Alarm
  3. Close water tight doors
  4. Send distress signal
  5. Check position on the chart
  6. Take note of any valuable information
  7. Take soundings
  8. Evaluate risk of pollution

- **Oil Spills**

1. If any body sees oil on deck immediately close the ship side scuppers and alarm the ship staff by shouting and contacting duty officer on bridge and engine room.
2. Stop all the transfer immediately and locate the effected tank and its sounding pipe and vent position.
3. Emergency muster to be called up by the master and everybody must carry out their duty as listed in the muster list for oil spill.
4. Use of SOPEP equipment and other means to be done to contain the spill within the ship.
5. Lower the quantity of spilled tank to a safer level in any other permissible tank.
6. Putting saw dust over the scupper plug will give an additional barrier for oil to go overboard.
7. Collect the spread oil in a 200 liter SOPEP drum and clear the affected area.
8. Master to enter the whole scenario in the ship's incident report form and call up for meeting to discuss the accident so such accidents can be avoided in near future.

18. Knowledge of medical first aid procedures on board chemical tankers, with reference to the Medical First Aid Guide for Use in Accidents involving Dangerous Goods (MFAG)

When ships are far from land, the crew must independently manage most problems that arise. In case dangerous goods are involved in an accident or incident of any kind, it is recommended that two "instruction books”"be kept available onboard for reference: EmS (Emergency Procedures for Ships Carrying Dangerous Goods) and MFAG (Medical First Aid Guide).

EmS contains procedures for the actions that can be taken if there is a fire or spill of dangerous goods. It contains general procedures applicable to an entire substance class as well as procedures specific to certain products. Examples of the information found in the specific "emergency schedules" are necessary protective equipment and the types of extinguishing agents that can be used to put out fires involving dangerous goods.

A new EmS has been drafted and was published with the 31st version of the IMDG Code. The new EmS is divided into EmS for fires and EmS for spills. As before, there will be EmS numbers for every UN number in column 15 of the Dangerous Goods List. EmS number does not have to be specified in the Dangerous Goods Declaration.

The consignor may also judge that the EmS procedures should be supplemented for a specific substance, but the basic rule (according to Swedish regulations) is that the EmS number is adequate as emergency procedures.

MFAG was revised in conjunction with publication of the 30th version of the IMDG Code. As a result, MFAG table numbers do not have to be stated on the Dangerous Goods Declaration. MFAG consists of a flow chart which shows what actions should be taken, based on the situation and symptoms, when a person has been exposed to dangerous goods of some kind. However, it is important that the crew has been trained to use MFAG in advance so that it will work in an emergency.

The crew can also get in touch with a doctor via Radio Medical to get assistance treating an injured person onboard.

The Swedish Transport Agency's regulations on transport of dangerous goods in packaged form also state what medicines and medical devices must be found onboard when dangerous goods are being transported.

In emergencies, it is important to utilise all information available in the IMDG Code, EmS and MFAG (as well as the IMSBC, IBC or IGC Codes with regard to bulk cargoes).

COMPETENCE 6: Take precautions to prevent pollution of the environment

19. Understanding of procedures to prevent pollution of the atmosphere and the environment

1.1 Pollution prevention requirements of ship`s construction and equipment

The expanded use of fuel cells in transportation and power generation is an exciting proposition for public health officials because of the potential of this technology to help reduce air pollution levels around the globe. Such work is about prevention of air emissions of hazardous substances. Prevention is a key concept in public health. An example is quarantine, which aims to prevent the spread of a disease-causing organism. In the environmental arena, prevention includes cessation of pollution. Air pollution prevention policies also have a practical impact.

Oil discharge monitoring equipment (ODME) is based on a measurement of oil content in the ballast and slop water, to measure conformance with regulations. The apparatus is equipped with a GPS, data recording functionality, an oil content meter and a flow meter. By use of data interpretation, a computing unit will be able to allow the discharge to continue or it will stop it using a valve outside the deck.

All records of Oil Detection Monitoring Equipment must be stored on board ships for no less than 3 years.

Controlled operational pollution at sea

A sample point on the discharge line allows for the analyzer to determine the oil content of the ballast and slop water in PPM. The analyzer is self-maintaining by periodical cleansings with fresh water, and therefore requires a minimum of active maintenance from the crew. The results of the analyzer are sent to a computer, which determines whether the oil content values are to result in overboard discharge or not. The valves that direct the ballast water either over board or to slop tank are controlled by the integrated computer, and a GPS signal further automates the process by including special areas and completes the required input for the Oil Record Book.

All oil tankers with a gross tonnage of larger than 150 must have efficient Oil Discharge Monitoring Equipment on board.

The oily discharge is sent out to sea through a pump. The oily mixture has to pass through a series of sensors to determine whether it is acceptable to be sent to the discharge pipe.

Based on regulations, the following values must be recorded by the system:

- Date and time of the discharge
- Location of the ship

- Oil content of the discharge in ppm
- Total quantity discharged
- Discharge rate

Oil Discharge Monitoring systems today consist of a computing unit that is installed in the cargo control room. The computer unit control and receives data from other ODME components.

ODME systems also have an analyzing unit that contains the Oil content meter, a fresh water valve for cleaning purposes, and a pressure transmitter that monitors the sample flow through the measuring cell.

COMPETENCE 7: Monitor and control compliance with legislative requirements

20. Knowledge and understanding of relevant provisions of the International Convention for the Prevention of Pollution from Ships (MARPL) and other relevant IMO instruments, industry guidelines and port regulations as commonly applied

MARPOL 73/78 is the International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978. ("MARPOL" is short for marine pollution and 73/78 short for the years 1973 and 1978.)

MARPOL 73/78 is one of the most important international marine environmental conventions. It was developed by the International Maritime Organization in an effort to minimize pollution of the oceans and seas, including dumping, oil and air pollution. The objective of this convention is to preserve the marine environment in an attempt to completely eliminate pollution by oil and other harmful substances and to minimize accidental spillage of such substances.

The original MARPOL was signed on 17 February 1973, but did not come into force at the signing date. The current convention is a combination of 1973 Convention and the 1978 Protocol. It entered into force on 2 October 1983. As of April 2016, 154 states, representing 98.7 per cent of the world's shipping tonnage, are state parties to the convention.

All ships flagged under countries that are signatories to MARPOL are subject to its requirements, regardless of where they sail and member nations are responsible for vessels registered under their respective nationalities.

Annex I

MARPOL Annex I came into force on 2 October 1983 and deals with discharge of oil into the ocean environment. It incorporates the oil discharge criteria prescribed in the 1969 amendments to the 1954 International Convention for the Prevention of Pollution of the Sea by Oil (OILPOL). It specifies tanker design features that are intended to minimize oil discharge into the ocean during ship operations and in case of accidents. It provides regulations with regard to treatment of engine room bilge water (OWS) for all large commercial vessels and ballast and tank cleaning waste (ODME). It also introduces the concept of "special sea areas (PPSE)" which are considered to be at risk to pollution by oil. Discharge of oil within them has been completely outlawed, with a few minimal exceptions.

The first half of MARPOL Annex I deals with engine room waste. There are various generations of technologies and equipment that have been developed to prevent waste such as: Oily water separators (OWS), Oil Content meters (OCM), and Port Reception Facilities.

The second part of the MARPOL Annex I has more to do with cleaning the cargo areas and tanks. Oil Discharge Monitoring Equipment (ODME) is a very important technology mentioned in MARPOL Annex I that has greatly helped improve sanitation in these areas.

The Oil Record Book is another integral part of MARPOL Annex I. The Oil Record Book helps crew members log and keep track of oily waste water discharges among other things.

Annex II

MARPOL Annex II came into force on 6 April 1987. It details the discharge criteria for the elimination of pollution by noxious liquid substances carried in large quantities. It divides substances into and introduces detailed operational standards and measures. The discharge of pollutants is allowed only to reception facilities with certain concentrations and conditions. No matter what, no discharge of residues containing pollutants is permitted within 12 miles of the nearest land. Stricter restrictions apply to "special areas".

Annex II covers the International Bulk Chemical Code (IBC Code) in conjunction with Chapter 7 of the SOLAS Convention. Previously, chemical tankers constructed before 1 July 1986 must comply with the requirements of the Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (BCH Code).

Annex III

MARPOL Annex III came into force on 1 July 1992. It contains general requirements for the standards on packing, marking, labeling, documentation, stowage, quantity subtraction, division and notifications for preventing pollution by bulbol substances. The Annex is in line with the procedures detailed in the International Maritime Dangerous Goods (IMDG) Code, which has been expanded to include marine pollutants. The amendments entered into force on 1 January 1991.

Annex IV

Marpol Annex IV came into force on 22 September 2003. It introduces requirements to control pollution of the sea by sewage from ships.

Annex V

MARPOL Annex V (Regulations for the Prevention of Pollution by Garbage from Ships) came into force on 31 December 1988. It specifies the distances from land in which materials may be disposed of and subdivides different types of garbage and marine debris. The requirements are much stricter in a number of "special areas" but perhaps the most prominent part of the Annex is the complete ban of dumping plastic into the ocean.

Annex VI

MARPOL Annex VI came into force on 19 May 2005. It introduces requirements to regulate the air pollution being emitted by ships, including the emission of ozone-depleting substances, Nitrogen Oxides (NOx), Sulphur Oxides (SOx), Volatile Organic Compounds (VOCs) and shipboard incineration. It also establishes requirements for reception facilities for wastes from exhaust gas cleaning systems, incinerators, fuel oil quality, for off-shore platforms and drilling rigs and for the establishment of SOx Emission Control Areas (SECAs).

In order for IMO standards to be binding, they must first be ratified by a total number of member countries whose combined gross tonnage represents at least 50% of the world's gross tonnage, a process that can be lengthy. A system of tacit acceptance has therefore been put into place, whereby if no objections are heard from a member state after a certain period has elapsed, it is assumed they have assented to the treaty.

All six Annexes have been ratified by the requisite number of nations; the most recent is Annex VI, which took effect in May 2005. The country where a ship is registered (Flag State) is responsible for certifying the ship's compliance with MARPOL's pollution prevention standards. Each signatory nation is responsible for enacting domestic laws to implement the convention and effectively pledges to comply with the convention, annexes, and related laws of other nations. In the United States, for example, the relevant implementation legislation is the Act to Prevent Pollution from Ships.

One of the difficulties in implementing MARPOL arises from the very international nature of maritime shipping. The country that the ship visits can conduct its own examination to verify a ship's compliance with international standards and can detain the ship if it finds significant noncompliance. When incidents occur outside such country's jurisdiction or jurisdiction cannot be determined, the country refers cases to flag states, in accordance with MARPOL. A 2000 US GAO report documented that even when referrals have been made, the response rate from flag states has been poor.

On January 1, 2015, maritime shipping levels became legally subject to new MARPOL directives because the SECA (Sulphur Emission Controlled Areas) zone increased in size. This larger SECA zone will include the North Sea, Scandinavia, and parts of the English Channel. This area is set to include all of the Republic of Ireland's international waters in 2020 culminating in all of Western Europe's subjection to the MARPOL directive. This has proven controversial for shipping and ferry operators across Europe.

Concerns have been raised about the environmental damage moving back to the roads by some of the larger ferry operators that ship substantial amounts of freight and passenger traffic via these routes affected by IMO standards. They claim that MARPOL will drive up ferry costs for the consumer and freight forwarding companies pushing them back onto the European roadways as a financially more cost effective measure compared to increased ferry costs, thereby defeating the object of reducing water pollution.

21. Proficiency in the use of the IBC Code and related documents

The International Building Code (IBC) is a model building code developed by the International Code Council (ICC). It has been adopted for use as a base code standard by most jurisdictions in the United States. It may also be used in Abu Dhabi, the Caribbean Community, Colombia, Georgia, Honduras, Afghanistan and Saudi Arabia.[citation needed] The IBC addresses both health and safety concerns for buildings based upon prescriptive and performance related requirements. The IBC is fully compatible with all other published ICC codes. The code provisions are intended to protect public health and safety while avoiding both unnecessary costs and preferential treatment of specific materials or methods of construction.

History

Since the early twentieth century, the system of building regulations in the United States has been based on model building codes developed by three *regional* model code groups. The codes developed by the Building Officials Code Administrators International (BOCA) were used on the East Coast and throughout the Midwest of the United States. The codes from the Southern Building Code Congress International (SBCCI) were used in the Southeast. The codes published by the International Conference of Building Officials (ICBO) were used primarily throughout the West Coast and across a large swath of the middle of the country to most of the Midwest.

Although regional code development had been effective and responsive to the regulatory needs of local U.S. jurisdictions, by the early 1990s it had become obvious that the country needed a single coordinated set of national model building codes. Therefore, the nation's three model code groups decided to combine their efforts, and in 1994 formed the International Code Council (ICC) to develop codes that would have no regional limitations.

After three years of extensive research and development, the first edition of the International Building Code was published in 1997. A new code edition has since been released every three years thereafter. The code was patterned on three legacy codes previously developed by the organizations that constitute ICC. By the year 2000, ICC had completed the International Codes series and ceased development of the legacy codes in favor of their national successor. The word "International" in the names of the ICC and all three of its predecessors, as well as the IBC and other ICC products, despite all 18 of the company's board members being residents of The U.S. reflects the fact that a number of other countries in the

Caribbean and Latin America had already begun to rely on model building codes developed in the United States rather than developing their own from scratch. Thus, ICC from its inception was well aware that it was writing model codes for an international audience.

Legacy codes

- BOCA National Building Code (BOCA/NBC) by the Building Officials Code Administrators International (BOCA)
- Uniform Building Code (UBC) by the International Conference of Building Officials (ICBO)
- Standard Building Code (SBC) by the Southern Building Code Congress International (SBCCI)

Competing codes and final adoption

The National Fire Protection Association, initially joined ICC in a collective effort to develop the International Fire Code (IFC). This effort however fell apart at the completion of the first draft of the document. Subsequent efforts by ICC and NFPA to reach agreement on this and other documents were unsuccessful, resulting in a series of disputes between the two organizations. After several failed attempts to find common ground with the ICC, NFPA withdrew from participation in development of the International Codes and joined with the International Association of Plumbing and Mechanical Officials (IAPMO), the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the Western Fire Chiefs Association to create an alternative set of codes. First published in 2002, the code set named the Comprehensive Consensus Codes, or C3, includes the NFPA 5000 building code as its centerpiece and several companion codes such as the National Electrical Code, NFPA 101 Life Safety Code, UPC, UMC, and NFPA 1. Unlike the IBC, the NFPA 5000 conformed to ANSI-established policies and procedures for the development of voluntary consensus standards.

The NFPA's move to introduce a competing building standard received strong opposition from powerful trade groups such as the American Institute of Architects (AIA), BOMA International and the National Association of Home Builders (NAHB). After several unsuccessful attempts to encourage peaceful cooperation between NFPA and ICC and resolution of their disputes over code development, a number of organizations, including AIA, BOMA and two dozen commercial real estate associations, founded the *Get It Together* coalition, which repeatedly urged NFPA to abandon code development related to NFPA 5000 and to work with ICC to integrate the other NFPA codes and standards into the ICC family of codes.

Initially, under Governor Gray Davis, California had adopted the NFPA 5000 codes as a baseline for the future California Building Code, but in 2003, Davis was recalled from office and Arnold Schwarzenegger was elected to replace him. Upon taking office, Schwarzenegger rescinded Davis's directive, and the state adopted the IBC instead. Adopting NFPA 5000 would have caused a disparity between California and the majority of other states which had adopted the IBC. Furthermore, the legacy ICBO had started in California and was headquartered in Whittier, California.

22. Case Studies

- **Chemical Tanker ECE**

On 31st January 2006, the Marshall Islands-registered chemical tanker, ECE (8,003 GT, built 1988) was on a laden voyage from Safi, Morocco to Ghent, Belgium with a cargo of 10,361 tones of Phosphoric Acid when she collided with the bulk carrier GENERAL GROT-ROWECKI (38,498 DWT) off Alderney, Channel Islands, UK. The tanker was seriously damaged and took on a heavy list. Despite attempts by the French Authorities to tow the vessel to a port of refuge, she sank the following day in International waters. At the time, there were 69 tones of Intermediate Fuel Oil (IFO 180), 15 tones of marine diesel oil and 22.3 tones of lubricating oils on board.

The Manche Plan, cooperation agreement between France and the United Kingdom in case of shipping incident, was implemented on 1st February. Following meetings between the French and British authorities and the ship-owner a response plan was agreed and implemented. An underwater survey of the wreck was carried out and it was found that the vessel had suffered massive damage on sinking. Despite strong currents that made the overall operation very challenging, all pump able oils were removed from accessible tanks and three options were considered to deal with the phosphoric acid cargo: leave in the shipwreck, controlled release or cargo removal. Following a risk assessment of the three options it was agreed to release the phosphoric acid in a controlled manner based on its high solubility and low toxicity of the phosphates resulting from the acid dissociation in the seawater.

Throughout the operation, the level of phosphates and pH was monitored in the vicinity of the wreck. Although phosphate levels were found to be several times above background, they were not sufficiently high to raise concerns that damage to the environment would result, recognizing the short life of the phosphoric acid under this form once released and the fact that the cargo was destined to be used as fertilizer.

- **Chemical Tanker Tibil**

On January 20, 2014 the Turkish chemical tanker TIBIL suffered an explosion, which caused a fire onboard the vessel. Accident took place while the ship was at anchor near the Tuzla Shipyard in Istanbul. As reported, one person had died, four people were injured and 19 crewmen were evacuated.

According to the Turkish Directorate General of Coastal Safety, in the starboard side of the tanker occurred the blast. The explosion caused a two meter hole in the vessel's hull and the TIBIL had a heavy list to starboard. This was stabilized by ballasting. The tanker was not transporting any cargo when the blast occurred.

- Chemical Tanker Maritime Maisie

A laden chemical tanker has suffered what looks like a catastrophic fire following a collision with a car carrier on sea trials near Busan, South Korea.

South Korea's Yonhap news reports that the car carrier Gravity Highway was on sea trials from Hyundai Mipo Dockyard when it collided with the Hong Kong-flagged chemical tanker, Maritime Maisie, early Sunday morning about 9 nautical miles from the port of Busan, causing the tanker to catch fire.

The report said that all 91 personnel -27 from the tanker and 64 from the car carrier- were safely rescued by coast guard and navy crews, although some sustained minor burns and abrasions.

The fire was brought under control within a matter of hours, but photos of the Maritime Maisie show extensive damage around amidships. The ship was laden with 29,337 tons of inflammable chemicals when the collision occurred and 4,000 tons of paraxylene and acrylonitrile burned in the fire, according to the Yonhap.

The Gravity Highway is believed to be one of two Pure Car and Truck Carriers under construction at the Hyundai Mipo shipyard for Ray Car Carriers Ltd. The vessel reportedly sustained minor fire damage and has been brought to the nearby shipyard in Ulsan.

The 44,404 DWT Maritime Maisie was built in 2003 and is managed by MSI Ship Management Private Ltd, of Singapore.