TANK BARGE
DANGEROUS LIQUIDS

Student Manual

Maritime & Industrial

Training Center

MANUAL

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Section 1

Regulatory Compliance

Introduction: Tank vessels operate under a variety of laws, rules and regulations. These interlocking regulations form a web linking rules for operation and vessel construction on the:

- International level
- National level
- Local levels

Organizations: In this module we will introduce you to the main organizations that implement and enforce the regulations we live with. The organizations are as follows:

- IMO
- Marpol 73/78
- Other international conventions
- The U.S. Coast Guard

IMO: The International Maritime Organization is an international organization operating under the auspices of the United Nations. The IMO has no direct regulatory authority. The IMO regulations are agreed to:

- By the member countries of the organization, or flag states
- As set forth in conventions
- By IMO regulatory compliance for International waters

Ratification: The flag state members and other countries ratify these conventions through their own congresses or parliaments.

Treaties: When enough countries have ratified the conventions, they enter into force as international treaties.

Modify Laws: It is incumbent upon each flag state member to modify its own national laws to:

- Meet the standards of the conventions; or
- Enact rules more stringent than the conventions

ISM: The International Safety Management (ISM) Code means the International Management Code for the Safe Operation of Vessels and for Pollution Prevention adopted by IMO by resolution A.741 and can be found in Annex 1 of SOLAS 1997 edition. The ISM Code requires that the owners or operators shall:

- Comply with the requirements of the ISM Code
- Hold a Document of Compliance
- Maintain its safety management system in accord with the ISM Code and be subject to periodic verifications

TSMS: Towing Safety Management System is to be used as part of the proposed Subchapter M requirements. The proposed requirements for the Towing Safety Management System (TSMS) contained in 46 CFR 138.220(c) (2) states: "Procedures must be in place to ensure safety of property, the environment and personnel." But the procedures have not been formalized by USCG to date.

- August 2011: The U.S. Coast Guard announced publication in the Federal Register of a notice of proposed rulemaking (NPRM) designed to improve safety on towing vessels.
- The NPRM provides a layered approach to towing vessel safety that includes the option of an audited safety management system or an annual Coast Guard inspection regime.

MARPOL 73/78: This acronym refers to the International Convention for the Prevention of Pollution from Vessels, (Marine Pollution) 1973 as modified by the Protocol of 1978. This convention covers pollution of the seas from all sources. The particular regulations are contained in the following annexes:

- Annex I: the Prevention of Pollution by Oil

  The revised MARPOL Annex I (Oil) Regulations for the prevention of pollution by oil was adopted in October 2004 and enters into force on 1 January 2007. It incorporates the various amendments adopted since MARPOL entered into force in 1983, including the amended regulation 13G (regulation 20 in the revised annex) and regulation 13H (regulation 21in the revised annex) on the phasing-in of double hull requirements

- Annex II: the Control of Pollution by Noxious Liquid Substances;

  The revised MARPOL73/78 Annex II (Noxious Liquid Substances) addresses discharge criteria and measures for controlling pollution caused by noxious liquid substances carried in bulk. About 250 substances have been evaluated and included in a list appended to the Convention. Annex II limits at sea discharges by requiring that discharge of residues be made to reception facilities, except under specified conditions.

Other MARPOL Annexes

- Annex Ill: the Prevention of Pollution by Harmful Substances in Packaged Forms
- Annex IV: the Prevention of Pollution by Sewage
- Annex V: the Prevention of Pollution by Garbage

United States: There are many laws and regulations in the United States that governs oil or petro chemicals shipping and Pollution.

- Oil Pollution Act of 1961
- The Federal Water Pollution Control Act
- The Clean Water Act
- The Ports and Waterways Safety Act
- The Port and Tanker Safety Act
- The Act to Prevent Pollution from Ships
- Regulations set forth by the government's regulatory agencies (Code of Federal Regulations, CFR); and
- State laws and local ordinances.

More Stringent: If a state or local regulation is more stringent than the national or international regulation, the more stringent regulation shall apply.

FWPCA: The Federal Water Pollution Control Act (FWPCA) was amended by the Clean Water Act (CWA) and both names are now in general use for the statute. The FWPCA was further amended by the passage of OPA90. It is codified at 33USC§1251etseq.This legislation prohibits discharges of oil or hazardous substances, in such quantities as may

- Into or upon the navigable waters of the U.S., adjoining shorelines, or into or upon waters of the contiguous zone or
- Which may affect natural resources in the U.S. Exclusive Economic Zone (EEZ)

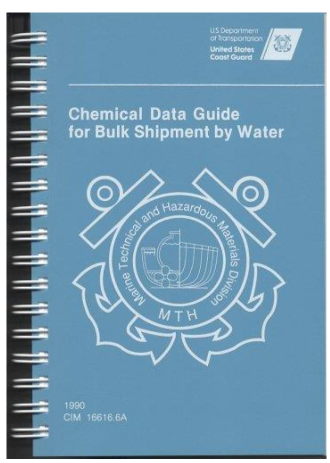
OPA 90: OPA90 revised the FWPCA to strengthen and expand the nation's oil and hazardous substances spill prevention, preparedness, and response activities. It further required the President to promulgate an amended National Oil and Hazardous Substances Pollution Contingency Plan (NCP) that expands the Federal government’s removal authority, increases the responsibility of Federal OSCs during responses, and broadens coordination and preparedness planning requirements. OPA90 requires that the NCP describe the duties and responsibilities assigned to new OPA90-created entities like the National Strike Force Coordination Center (NSFCC), for better coordination and execution of Federal response efforts.

Under OPA90, vessel and facility owners and operators must develop oil and hazardous substances response plans. It is part of the U.S. Code 33 USC 2701 and some of the mandates are as follows:

- All oil barges in U.S. waters will be double hulled by the year 2015
- Minimum under hull clearances are now specified in 33 CFR 157.455
- Escort tugs for single hull barges are mandated in certain waters
- Limitations on the hours of work for crewmembers

Chemical Data Guide for Bulk Shipment by Water:

This is published as COMDTINST M16616.6A and previously as CG-174. This guide was developed in the interest of safe water movement of bulk chemicals. It can help prevent or at least minimize the harmful effects of chemical accidents on the waterways. Although this guide is intended to be helpful in the initial stages of emergencies, users should seek more detailed, specific and competent emergency medical services as soon as possible. However, it is the publication the USCG uses in their deck examinations.



Dangerous Liquid

Definition of “Dangerous Liquid”- A dangerous liquid is a liquid which is classified as hazardous when transported in bulk by the USCG in 46 CFR 153.40 Every Subpart has a definition section. If it does not give you a Regulation the Table will be at the back.

46 CFR 153.40- Determination of materials that are hazardous.

THE COAST GUARD HAS FOUND THE FOLLOWING MATERIALS TO BE HAZARDOUS WHEN TRANSPORTED IN BULK:

(A) MATERIALS LISTED IN TABLE 30.25-1 OF THIS CHAPTER

(B) MATERIALS LISTED IN TABLE 151.05

(C) MATERIALS LISTED IN TABLE 1

(D) MATERIALS LISTED IN TABLE 4 OF PART 154

PART 151 BARGES CARRYING BULK LIQUID HAZARDOUS MATERIAL CARGOS

PART 153 SHIPS CARRYING BULK LIQUID, LIQUIFIED GAS OR COMPRESSED GAS HAZARDOUS MATERIALS

PART 154 SHIPS SAFETY STANDARDS FOR SELF PROPELLED VESSELS CARRYING BULK

CFR Defined:

The Code of Federal Regulations is the means by which the U.S. Code is implemented. Congress grants the agencies that will be enforcing the laws:

- The right to make the regulations; which
- Will force compliance with the intent of Congress.

CFR's of Concern:

The Coast Guard CFRs of most concern to tank vessel operators are:

- 33 CFR Subchapter M: Marine Pollution,
- Financial Responsibility and Compensation (Parts 130 to 138);
- 33 CFR Subchapter G: Pollution (Parts 151 to 159) ;
- 46 CFR Subchapter D: Tank Vessels (Parts 30 to 39); and
- 46 CFR Subchapter O: Certain Bulk Dangerous Cargoes (Parts 150 to 155).

Local Rules:

Many states and localities within the U.S. have their own regulations concerning barges. These rules are valid and must be followed unless the Federal Government has preempted them. State and local regulations can cover a variety of items, such as:

- Additional firefighting equipment
- Additional liability for pollution damage
- Escort tugs in certain areas
- Limitations on anchorage areas, and
- Activities that may be conducted in them

Company Policy:

Each company operating oil vessels, in meeting the ISM Code, will have a series of instructions on how they want their vessels operated incorporated in the companies Vessel Operating Manual. Some of the covered chapters would be:

- The pollution policy
- The quality policy
- In port operations
- Navigational policy
- Safety policy
- Emergency situation policies
- Training policy
- The duties of each rating on board

Stability Letter:

A Stability Letter listing the basic operation a limits and guidance in a few pages is common for smaller vessels and is typically posted in the wheelhouse. A Trim and Stability Booklet contains more detailed instructions and includes forms for the Master to actually calculate the weight and center of gravity of the vessel. Curves of the maximum allowable center of gravity are then used to determine if the loaded condition meets the required criteria.

Regulatory Compliance: Proof of a company or vessel to be in compliance with the regulations comes in the form of certificates. The flag state is responsible for issuing these certificates to the vessels. Some of these certificates are:

- Cargo Vessel Safety Construction Certificate with the oil vessel Supplement, states that compliance with the structural requirements of SOLAS 1974 is certified;

- Cargo Vessel Safety Equipment Certificate with the oil vessel Supplement, states that compliance with the equipment requirements of SOLAS 1974 is certified;

- The International Oil Pollution Prevention Certificate with Supplement B, states that compliance with construction and equipment requirements of MARPOL 73/78 is certified.

PIC Tankerman: The PIC-Tankerman of an oil or chemical vessel is responsible for the operational requirements of those regulations. The PIC-Tankerman will have the regulations in his CFR library for reference.

- In the U.S. PIC-Tankerman Tankship regulations (CFR's) require that officers in charge of cargo operations (generally deck officers) on self-propelled tank vessels must be certified as Tankerman PIC (Person In Charge).

- For the domestic inland oil barge service and PIC-Tankerman must hold a tankbarge rating on their MMD. With a DL (dangerous liquids) endorsement which covers both oil and chemical barges, and the LG endorsement which covers liquefied gas cargoes.

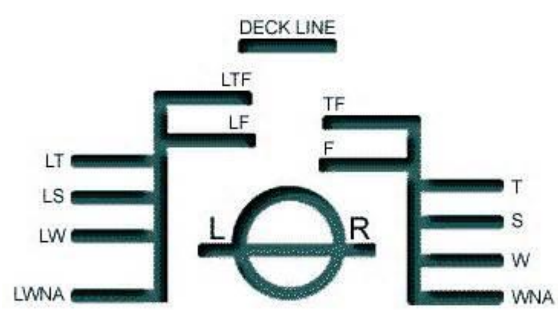
- No certificate maybe issue unless the student has successfully completed an approved course with the appropriate curriculum outlined in Table 13.121(e) or §13.121(f).

Pollution: For many reasons, oil vessels can cause marine environmental pollution. As per 33 CFR 2716 and OPA 90 Section 1016, the owner is financially liable for clean-up costs and other damages and also for:

- Being required to be insured against such damages by a number of maritime countries, Party to the International Convention on Civil Liability for Oil Pollution
- Having proof on board the vessel in the form of the Certificate of Insurance issued by the flag state
- The owner's limits of liability for oil pollution damage
- Being in accordance with her tonnage as set by the convention
- NOTE: The owner cannot limit his liability if an oil pollution incident occurred as a result of his fault or privy

Load Line Certificate: Load lines applicable to vessels engaged on ocean or ocean-and-Great Lakes voyages are indicated by a disk with a horizontal line through the center (Plimsoll mark). Refer to 46 CFR42.50-5

- Several terms constituting a description of the ship, such as name, official number, port of registry, length;
- Specification as to the vertical location of the load lines on the sides of the vessel and illustrations of the applicable load line marks;
- Specification of the voyages to which the load lines are authorized with restrictions as applicable; The period of time for which the certificate is valid including the dates of issuance and expiration. It must be renewed every 5 years.



1.1 Vessel Terminology and Arrangements

Introduction: Vessels used to be classified by their trade. Barges come in a variety of types and trades. Recently, with the increasing specialization of barges, the requirements of OPA 90.

Product Barges: These vessels carry finished products that are usually compatible hydrocarbon based products in coated tanks and they can:

- Carry a single lot or a multi-grade load
- Load or discharge in one or several destinations
- Backhaul cargo
- Have a more complex cargo systems than crude carriers
- Have more complicated carriage requirements
- Their operations are more complicated

Chemical Barges: These are the most complex of the traditional barge types. They carry finished products like the product carrier, but in smaller lots and usually many more grades. They have more potential problems than product carriers which include:

- Incompatibility between grades of cargo
- Loading multi-parcel cargoes from several docks
- Discharging to multiple docks
- A high risk of personnel exposure and fatigue is common

OPA 90/IMO: Under OPA 90 and similar IMO regulations vessels are classed as either single hull or double hull.

Single Hull: The single hull vessels have one layer of shell plating over its frames. The hull is the only barrier between the sea and the cargo. All of the hull's strength members are located within the tanks, such as the: Single skin barges are to be phase out for oil service by end 2015.

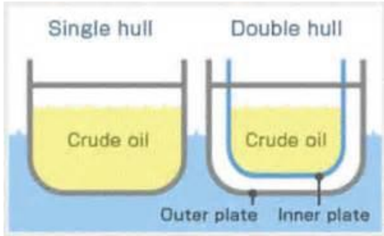
Double Bottom: Over the last twenty-five years many single hull vessels were built with double bottoms for use as ballast tanks. Even though these vessels have double bottoms, they are still classed as single hull. Essentially, double hull vessels have a second hull with the entire cargo tank block surrounded by bulkheads and a bottom, creating a void space between the cargo spaces and the external hull. This void space usually contains:

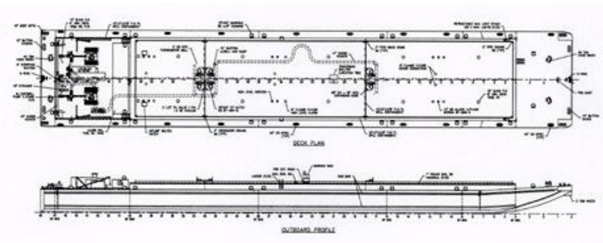
- Clean segregated ballast;
- Ballast piping; and
- The vessel's internal framework and structural members.

Double Hull: Vessels have a second hull with the entire cargo tankblock surrounded by bulkheads and a bottom, creating a void space between the cargo spaces and the external hull.

This void space usually contains:

- Clean segregated ballast
- Ballast piping, and the vessel’s internal framework and structural members
- A lesser chance of a pollution incident
- Easier cargo tank cleaning





Advantages:

- Ballasting can be done concurrently with the cargo operation
- Easier rescue of personnel injured in a cargo tank
- A lesser chance of pollution from routine ballasting
- The vessel is in regulatory compliance

Disadvantages

- The major disadvantage of the double hull is that stability becomes a concern.
- It is possible to have a negative stability situation arise during the cargo/ballast operation because there are no center cargo tanks.
- If the operation is not carefully planned and carried out to avoid excessive free surface, disaster could be the result.

Arrangements: The arrangement of most cargo tank blocks are one in which there are three tanks across:

- Port wing tanks
- Starboard wing tanks
- Center tanks

Two Across: Many barges and most double hull vessels have an arrangement of just two wing tanks, leaving out the center tank.

Three Across: The three tanks across arrangement greatly reduces the free surface effect.

Containment: Every vessel is required to have oil spill containment on board the vessel. Parts of these systems are:

- The fishplate around the cargo deck
- The manifold drip pans
- Scupper plugs
- Empty barrels
- A portable pumps on the cargo deck with a hose attached
- Absorbent pads
- Spill cleanup gear

Barge hull classifications

As per 46 §151.10:

- Type I barge hull. Barge hulls classed as Type I are those designed to carry products which require the maximum preventive measures to preclude the uncontrolled release of the cargo. These barges are required to meet:

- Type II barge hull. Barge hulls classed as Type II are those designed to carry products which require significant preventive measures to preclude the uncontrolled release of the cargo. These barges are required to meet:

- Type III barge hull. Barge hulls classed as Type III are those designed to carry products of sufficient hazard to require a moderate degree of control

Hull structural requirements:

- Types I, II, and III barges shall comply with the basic structural requirements of the American Bureau of Shipping for barges of the ordinary types and the applicable supplementary requirements of this section.

- Types I and II barges in inland service: A grounding condition shall be assumed where the forward rake bulkhead rests upon a pinnacle at the water surface.

- Independent tanks supported by only two saddles do not contribute to the strength and stiffness of the barge hull.

- Independent tanks supported by three or more saddles contribute to the strength and stiffness of the hull.

Cofferdam: The term cofferdam means a void or empty space separating two or more compartments for the purpose of isolation or to prevent the contents of one compartment from entering another in the event of the failure of the walls of one to retain their tightness.

46 CFR 30.10-13

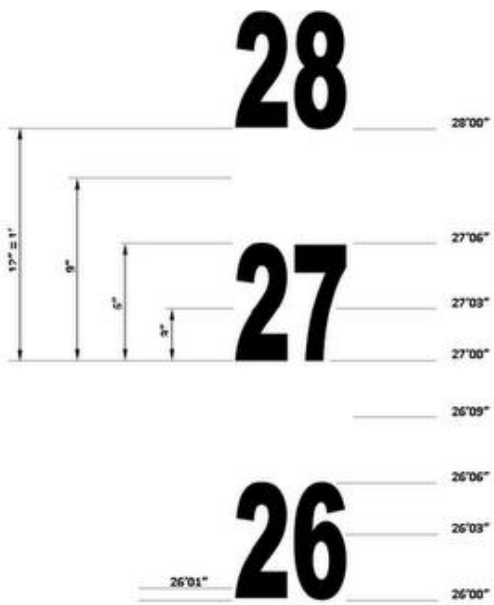
Products to be Carried

The products carried by a barge are listed on the Certificate of Inspection for that particular barge as per 46 CFR 151.04-1(c)

Draft Marks:

Are located on both sides bow and stern of the vessel. The example below is calibrated in one foot increments.

- The numbers are six inches in height.
- The space between each number is six inches.



All tank barges require draft marks.

46 CFR 151

Title 46 → Chapter I → Subchapter O → Part 151 Is where you will find information concerning —Barges Carrying Bulk Liquid Hazardous Material Cargoes

Cargo Heating: Many oils and products require heating in order for them to be pump able. Among these types of oil are:

- Asphalt (bitumen);
- Heavy lube oils;
- High pour point gas oils;
- Heavy fuel oils; and
- Some crude oils.

Cargo Heating: Except for asphalt cargoes, heating is usually done by means of steam or hot oil coils heating along the bottom of tank. The amount of heating required depends on several factors:

- The pour point of the cargo;
- The flash point of the cargo;
- The temperature limit for the tank coatings;
- The temperature at which the cargo ordered to be at;
- The ambient temperature; and
- The daily temperature readings.

Problems: Heating coils can be a real problem on the vessels and some of these are:

- Overheating the cargo;
- Excessive fuel oil consumption;
- The coils can put water in the cargo; and
- The return line can introduce oil into

Other Types: Another type of heating arrangement is the heat exchanger rather than the traditional coils. A heater is placed on the deck and cargo is pumped:

- From the tank;
- Through the exchanger; and
- Back to the tank.

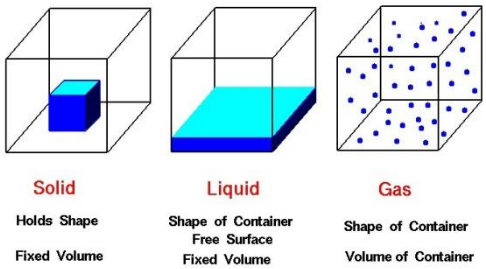
Slop Tanks: Heating systems can be placed in slop tanks to make the separation of oil/water more efficient.

Section 2

Basic Characteristics of Petroleum and Its Measurement

Purpose:	A general knowledge of the basic material with which we work will help us to better perform our duties in relation to petroleum. This module will give the student a basic understanding of just what petroleum is and information on its basic properties.
Composition:	Petroleum is a chemical compound made up of various arrangements of hydrogen and carbon atoms.
Structure:	The structure consists of hydrogen atoms linked in many different ways to carbon atoms. The nature of these links determines the type of the hydrocarbon compound. Hydrocarbons can be defined in terms of their molecular weight, but for practical purposes we would only be concerned with whether at normal atmospheric temperatures and pressures that the compound is:

- A gas; In a gas the molecular forces are very weak. A gas fills its container, taking both the shape and the volume of the container
- A liquid; In a liquid the molecular forces are weaker than in a solid. A liquid will take the shape of its container with a free surface in a gravitational field. In microgravity, a liquid forms a ball inside a free surface. Regardless of gravity, a liquid has a fixed volume
- A solid; In a solid the molecules are closely bound to one another by molecular forces. A solid holds its shape and the volume of a solid is fixed by the shape of the solid.



Matter can change state to solids, liquids, and gases and has different properties controlled by heating or cooling. (Water is the only substance that naturally changes into all three states of matter and makes life possible on earth). Heating involves melting or evaporation, depending on the substances melting point or boiling point, respectively.

Carbon Atoms: It is the number of carbon atoms in each molecule that determines the normal physical state of the hydrocarbon molecule and this relation vessel is:

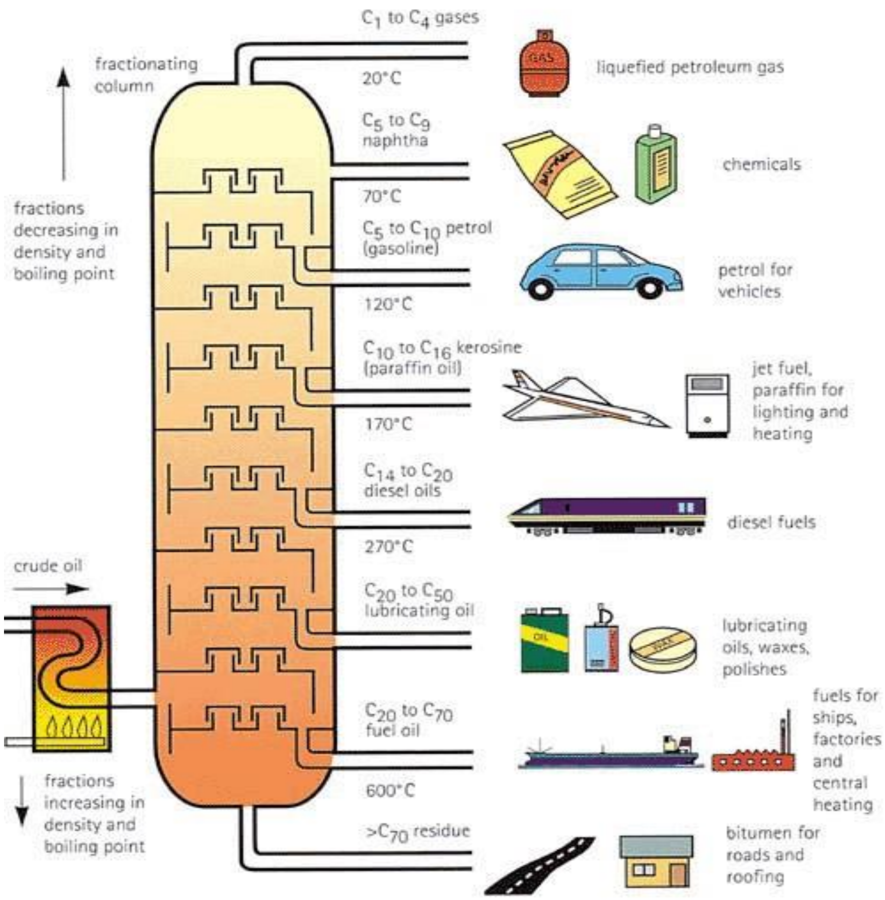
- 4 carbon atoms is a gaseous state
- 5-24 carbon atoms is a liquid state
- More than 24 carbon atoms is solid state

Viscosity: Is the amount of the resistance to flow in a fluid

Sour crude oil: Contains high quantities of hydrogen sulfide

Refining: Refining is the process where the crude oil is:

- Separated into fractions of petroleum molecules;
- Where each fraction is a range of petroleum molecules of similar weight; and
- The molecular structure remains unchanged.



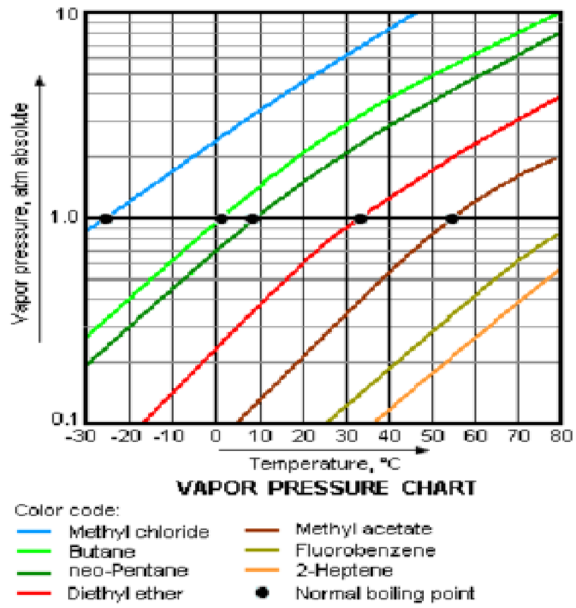
Cracking: Cracking changes the hydrocarbon molecules by using molecular structure of the various chemical processes. Long chains of hydrocarbon molecules are broken up into shorter ones creating lighter fractions

Fractional distillation: The first step in the refining process is the separation of crude oil into various fractions or straight-run cuts by distillation in atmospheric and vacuum towers. The main fractions or "cuts" obtained have specific boiling-point ranges and can be classified in order of decreasing volatility into gases, light distillates, middle distillates, gas oils, and residuum

Chains Broken Demands: Refiners are able to change their output to meet seasonal demands through this process

Boiling Point: All of the crude oils and most refined products are mixtures of a wide range of hydrocarbon compounds. The boiling points of these compounds range from -162°C to well in excess of 400°C.

Volatility (chemistry): In chemistry and physics, volatility is the tendency of a substance to vaporize. Volatility is directly related to a substance's Vapor Pressure. At a given temperature, a substance with Higher Vapor Pressure vaporizes more readily than a substance with a Lower Vapor Pressure.



- A typical vapor pressure chart for various liquids

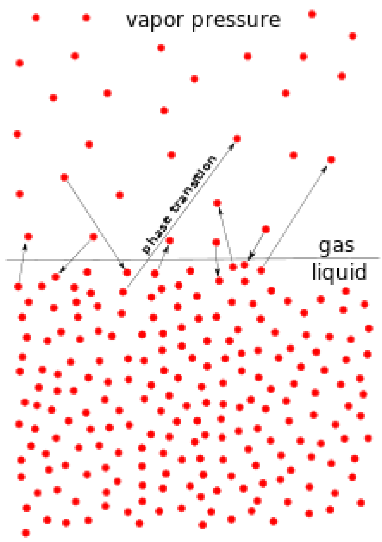
For example, at any given temperature, methyl chloride has the highest vapor pressure of any of the liquids in the chart. It also has the lowest normal boiling point (−24.2 °C), which is where the vapor pressure curve of methyl chloride (the blue line) intersects the horizontal pressure line of one atmosphere (atm) of absolute vapor pressure

Flammable and combustible liquids do not burn or explode, but the vapors they give off do. Flammable liquids have a greater tendency to give off vapors than do combustible liquids, and this tendency is called volatility.

- Volatility is the tendency for a liquid to change phases and become a gas. It is measured by the True Vapor Pressure (TVP) of a petroleum mixture.
- However, there is a correlation between TVP and Reid Vapor Pressure (RVP), which is relatively easy to measure.
- Volatility is the flashpoint.

Equilibrium vapor pressure: Is defined as the pressure exerted by a vapor in thermodynamic equilibrium with its Condensed Phases (solid or liquid) at a given temperature in an enclosed system.

- The equilibrium vapor pressure is an indication of a liquid's Evaporation Rate.
- It relates to the tendency of particles to escape from the liquid (or a solid).
- A substance with a High Vapor Pressure at normal temperatures is often referred as volatile.



Vapor Pressure: At equilibrium the gas is evenly distributed throughout the space above the liquid. The pressure exerted by this gas is called the equilibrium vapor pressure of the liquid or the vapor pressure.

Compound's V.P. The vapor pressure of a pure compound depends only upon its temperature.

Mixture's V.P. A mixture's vapor pressure depends upon both:

- Its temperature; and
- The volume of the space into which vaporization occurs.

TVP: The true vapor pressure is the equilibrium vapor pressure when the gas/liquid ratio is zero. This is the highest vapor pressure possible at any given temperature.

Increase Temps: As the temperature of a petroleum mixture increases, its TVP also increases.

Boil Point: If the TVP increases to above atmospheric pressure the liquid will boil.

Emit Gas: The TVP of a petroleum mixture provides a good indication of its ability to emit gas.

TVP: The TVP of a petroleum mixture is extremely difficult to measure. It can be:

- Calculated from a chemical analysis of the liquid; or
- It can be approximated from experimental observation of the conditions when the liquid has achieved a stable state.

RVP: The Reid Vapor Pressure is a vapor pressure measured by an easily repeated test to measure the volatility of a petroleum liquid. A sample of the liquid is introduced into the test container at atmospheric pressure and:

- The volume of the liquid is one fifth the internal volume of the container;
- The container is sealed and immersed in a warm 37.8°C
- Water bath;
- The container is shaken to bring about equilibrium;
- The pressure rises due to liquid vaporization; and
- The pressure is read from an attached pressure gauge.

Comparisons: RVP is useful for comparing the volatility of a wide range of petroleum liquids.

TVP & RVP: There is an excellent correlation between TVP and RVP. Calculations can be made or tables consulted to determine the TVP when the RVP and temperature are known.

Significance: Vapor pressure is critically important for both automotive and aviation gasoline as it affects:

- Starting an engine;
- Warming up; and
- The tendency to vapor lock an engine at high operating temperatures and altitudes.

Regulations: Maximum vapor pressure limits for gasoline are legally mandated in some areas as a measure for air pollution control.

Significance: The vapor pressure of crude oils is of importance to the crude producer and the refiner for general handling and initial refinery treatment.

Evaporation Vapor: Vapor pressure is used as an indirect measure of the evaporation rate of volatile petroleum solvents. On a vessel the vapor pressure of the cargo will determine the tendency of the cargo pumps to become vapor locked.

Flammability: Hydrocarbons will not ignite in less than 11% oxygen by volume atmosphere. The flammable limits for most crudes are:

- The LFL is 1% hydrocarbons by volume; and
- The UFL is 10% hydrocarbons by volume.

Chemistry: When hydrocarbon gasses burn they react chemically with the oxygen in the air forming:

- Carbon dioxide; and
- Water.

Heat: This reaction gives off enough heat that it is visible as a flame that can be seen traveling through the mixture of gas and air.

Sustaining: When gas above a liquid is ignited, the heat produced is usually strong enough to cause the liquid to give off enough additional gas to sustain the fire.

Replenishment: The liquid is constantly replenishing the burning gases due to its elevated temperature.

Explosion: What determines if the petroleum will burn or explode is a question that all Tankermen should know. When rapid combustion occurs, the ongoing chemical reaction produces principally:

- Carbon dioxide; and
- Water vapors that are superheated in relation to their surroundings.

Pressure Rise: The products of combustion must be vented or pressures will rise. The more rapid the combustion reaction, the faster the pressure will rise.

Explosion:	If the combustion products are not vented, or not vented sufficiently, pressure will eventually raise enough to cause a containing vessel to violently burst.
Limits:	Hydrocarbon gas and air mixture must be within a range of gas-to-air concentrations in order to ignite and burn.
LFL:	The lower limit of this range is the point at which there is just sufficient hydrocarbon gas in the air to support and propagate combustion. A higher percentage of hydrocarbon gas will support combustion and a lower percentage will not.
UFL:	The upper limit of this range is the point at which there is just sufficient hydrocarbon gas in the air to support and propagate combustion. A lower percentage of hydrocarbon gas will support combustion and a higher will not.
Limit Tables:	Flammable limits vary for different petroleum liquids. Tables are available showing the flammable limits for: • Different crude oils; and • For various products.
Flashpoint:	Flashpoint is defined as the lowest temperature at which a liquid gives off sufficient gas to form a flammable gas mixture near the surface of the liquid. It is measured in a lab in a standard apparatus using a prescribed procedure.
Flashpoint Test:	To test for flashpoint, a sample of the liquid is heated and a small flame is momentarily applied to the surface of the liquid. The flashpoint is the temperature of the liquid at which there is a flash of flame across the liquid surface.
Density Vapors:	The densities of the undiluted hydrocarbon gasses given off from petroleum products are greater than air.

Sink Vapor Layers: Hydrocarbon vapors will collect at the bottom of an empty tank or at the surface of a liquid because of their densities.

Two Methods: There are two test methods for determining this:

- The open cup method; and
- The closed cup method.

Open Cup Test: The open cup method is the least accurate of the two. The cup is open to the air so atmospheric dilution affects the measured flashpoint.

Closed Cup Test: The closed cup method eliminates this variable and makes the test more reliable.

Difference Auto-ignition: The open cup flashpoint is generally about 6°C (10°F) higher than the closed cup flashpoint. The auto-ignition temperature is a temperature above the flashpoint at which:

- A combustible material will ignite, without initiation by a spark or flame; and
- Self-sustaining combustion occurs.

Classification: Petroleum is classed in various ways by different countries and classification societies. All systems seek to differentiate petroleum according to whether or not a flammable gas/air mixture will exist above the liquid at ambient temperature.

United States (USCG): In the U.S. there are two broad divisions based on flashpoint and within these two broad divisions are five grades

Flammables: Flammable liquids have an open-cup flashpoint at or below 80°F and are sub-divided into three grades:

- Grade A has a RVP of 14 pounds or more;

- Grade B has a RVP under 14 pounds and over 8% pounds; and
- Grade C has a RVP of 8% or less pounds.

Combustibles

Combustible liquids have an open-cup flashpoint above 80°F and are sub-divided into two grades:

- Grade D- flashpoint below 150°F and above 80°F; and
- Grade E- flashpoint of 150°F or above.

USCG Classification of Flammable Liquids
Flash Point at or below 80°F (26.7°C)

Grade	*Flash Point*	*Reid Vapor Pressure*	*Examples*
A	80°F or below	14 psi and above	Natural gasoline, naphtha
B	80°F or below	More than 8.5 but less than 14 psi	Most commercial gasoline
C	80°F or below	8.5 psi and below	Most crude oils Aviation gasoline

USCG Classification of Combustible Liquids
Flash Point above 80°F (26.7°C)

Grade	*Flash Point*	*Reid Vapor Pressure*	*Examples*
D	Above 80°F but below 150°F	N/A	Kerosene Commercial jet fuels
E	150°F and above	N/A	Heavy fuel Lube oils Asphalt

The flammable and combustible liquids are subdivided into grades based on their flash points and Reid vapor pressures as prescribed in 46 CFR 30.10.15 and 30.10.22

Dilution:

As the vapors mix and dilute with air they will tend to layer in correlation with their densities. When the vapors are diluted by air the density of the gas above the liquid:

- Becomes less;
- Will eventually approach the density of air; and
- At the lower flammable limit is indistinguishable from air's density

Static Electric Discharge Hazard

The Four Conditions Required for Explosive Ignition

The clearest description of the required conditions for electrostatic hazard is perhaps in NFPA 77, which states:

The development of (static) electrical charges may not be in itself a potential fire or explosion hazard. There must be a discharge or a sudden recombination of separated positive and negative charges. In order for static to be a source of ignition, four conditions must be fulfilled:

- There must first of all be an effective means of static generation,
- There must be a means of accumulating the separate charges and maintaining a suitable difference of electrical potential,
- There must be a spark discharge of adequate energy, and
- The spark must occur in an ignitable mixture.

Mechanisms for Producing Hazardous Conditions

Static generation two differing substances in contact with each other will often become charged as one surrenders electrons to the other. Although the net charge remains constant, an electrical double layer is formed along the adjoining surfaces. The separation of the two substances often causes them to remain disparately charged, an effect which is exaggerated by increased speed of separation and increased mechanical work (friction).

Piping of oil products Charge generation and separation occur when liquids move in contact with other materials, as in operations involving piping, filtering, mixing or agitating. Mechanisms which exacerbate static separation in cargo loading operations are the following:

- Turbulence and splashing of the fluid at the beginning of tank loading operations when the pipe opening is not yet covered with cargo, especially since it is most likely at this time for water to mix with incoming oil.
- Any mixing or filtering of the cargo, particularly micropore or clay filtering.
- Impurities such as water, metals, rust, or other product in the cargo.
- Disturbance of water "bottom".
- Pumping of entrained air or other gases bubbling in the tank.

The cargo is also disturbed during unloading operations, as the fluid moves past hull structure, piping, etc., particularly during stripping when tank levels are at their lowest. Discharge of slops and contaminated ballast also generates high amounts of static charge.

Displacing of lines using air and water is a static charge generator.

Water mist and steam Mists formed during water washing or from the introduction of steam can become electrostatically charged. The charge associated with water washing may be much higher if cleaning chemicals are used.

Steaming produces mist clouds much more highly charged than water washing, much more quickly, and can also cause the release of gases due to the heat and disturbance of the process.

Potentials are higher in large tanks than small ones, a fact borne out by several serious accidents in the early VLCCs.

Loading overall (from the top of the tank) can deliver charged liquid into a tank which breaks up into small droplets and splashes into the tank. This can produce a charged mist and an increased hydrocarbon gas concentration.

Air release in bottom of tanks Air or inert gas blown into the bottom of a tank can generate a strong electrostatic charge by bubbling action and agitation of the fluid.

Crude oil washing (COW) Mixtures of crude oil and water can produce an electrically charged mist if used for COW operations.

Accumulation of charge and potential

Static accumulator and non-accumulator oils.

The conductivity of a liquid determines whether or not it retains the generated static charge. A non-accumulator oil, defined by an electrical conductivity of greater than 50 (pS/m) [5] will relax quickly because it transmits the charge to the steel hull, which is grounded in the water. Accumulator oils are defined as having a conductivity of less than 50 pS/m [5]; these oils relax (dissipate charge) slowly.

When accumulator oil is loaded, charges of similar sign repel from each other toward the liquid's outer surfaces, including that in contact with air. The latter is called the "surface charge" and is usually of most concern.

ISGOTT states that, in general, black oils do not accumulate static charge and clean oils (distillates) do. It classifies several oils as follows:

<u>Non-accumulator oils Crude oils</u>

Residual fuel oils

Black diesel oils

Asphalts

<u>Accumulator oils</u>

Natural gasolines

Kerosenes

White spirits

Motor and aviation gasolines

Jet fuels

Naphthas

Heating oils

Clean diesel oils

Lubricating oils

Charges which 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 is 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 conducting 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.

- Discharge: Electrostatic breakdown between any two points, giving rise to a discharge, is dependent upon the strength of the electrostatic field.

Bonding and Grounding

The most important measure to prevent electrostatic hazard is to bond all metal objects together, eliminating risk of discharge between objects, and to assure that all components in the cargo handling system are at the same, electrical potential. Grounding to earth is not necessarily desirable for all forms of transport; airplanes and tank trucks are insulated from ground by their tires and may be at a vastly different potential. In the case of tank vessels, grounding (or earthing) is effectively accomplished by bonding to the hull, which is naturally earthed through the water. Equipment should be designed to facilitate bonding and, in particular, to avoid the insulation of any conducting metal.

- Bonding of cargo transfer piping Hoses used in terminal transfer operations must be continuously bonded, and grounded to the hull.

It is important to note that cargo transfer piping must be insulated from the land-side terminal since electrical potential may differ from that of the vessel due to stray current or cathodic protection of the pier. Insulating flanges, joints, or sleeves are sometimes used to divide the cargo hoses into electrically isolated halves - onboard and shore side. Each half is bonded and grounded to its respective base potential.

Static Electricity:

Static electricity presents fire and explosion hazards during the handling of petroleum, and tanker operations. Certain operations can give rise to accumulations of electric charge which may be released suddenly in electrostatic discharges with sufficient energy to ignite flammable hydrocarbon 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 static hazard: charge separation, charge accumulation and electrostatic discharge. All three of these stages are necessary for an electrostatic ignition.

- Charge separation;
- Charge accumulation; and
- Electrostatic discharges.

Pumping Oil into Tanks

Petroleum distillates often have electrical conductivities less than 50 pico Siemens/meter and thus fall into the category of accumulators. Since their conductivities are not normally known, all distillates must be treated as static accumulators unless they contain an antistatic additive. During and for some time after entry into the tank a static accumulator oil may carry sufficient charge to constitute a hazard.

The charge may arise through one or more of several different processes:

- Flow of the oil through the pipeline system into the tank. Charge generation is enhanced if water droplets are suspended in the oil as it flows through the pipes.
- Flow through a micro pore filter of the kind used for aircraft jet fuels. These filters have the ability to charge fuels to a very high level, probably because all the fuel is brought into intimate contact with the filter surface, where charge separation occurs.
- Turbulence and splashing in the early stages of pumping the oil into an empty tank.
- The settling of water droplets, rust or other particles entering the tank with the oil or stirred up by it in the tank.

The generally accepted method for controlling electrostatic generation in the initial stages of loading is to restrict the flow rate of the static accumulator oil into the tank until all splashing and surface turbulence in the tank has ceased. At the commencement of loading an empty tank the linear velocity in the branch line to each individual cargo tank should not exceed 1 meter/second. The reasons for such a low rate are twofold:

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

During subsequent loading, the limitations on flow rate imposed by the design of pipeline systems, coupled with precautions in the introduction of dipping, ullaging and sampling equipment and the avoidance of electrically isolated conductors, have proved sufficient to maintain operational safety. If, however, markedly different pipeline or pumping systems were to be introduced, enabling higher flow rates or velocities to be achieved, then flow rate limitations might have to be imposed throughout loading.

Oxygen Deficiency:

The oxygen content of the atmosphere in enclosed spaces may be low for several reasons. The most obvious one is if the space is in an inert condition, and the oxygen has been displaced by the inert gas. Also, oxygen can be removed by chemical reactions such as rusting or the hardening of paints or coatings.

As the amount of available oxygen decreases below the normal 21% by volume, breathing tends to become faster and deeper. Symptoms indicating that an atmosphere is deficient in oxygen may give inadequate notice of danger. Most persons would fail to recognize the danger until they were too weak to be able to escape without help. This is especially so when escape involves the exertion of climbing.

While individuals vary in susceptibility, all will suffer impairment if the oxygen level falls to 16% by volume.

Exposure to an atmosphere containing less than 10% oxygen content by volume inevitably causes unconsciousness. The rapidity of onset of unconsciousness increases as the availability of oxygen diminishes, and death will result unless the victim is removed to the open air and resuscitated.

An atmosphere containing less than 5% oxygen by volume causes immediate unconsciousness with no warning other than a gasp for air. If resuscitation is delayed for more than a few minutes, irreversible damage is done to the brain even if life is subsequently restored.

Entry into oxygen deficient spaces must never be permitted without breathing apparatus until such spaces have been thoroughly ventilated and test readings indicate an oxygen level of 21% by volume throughout.

2.1 Explosive Range:

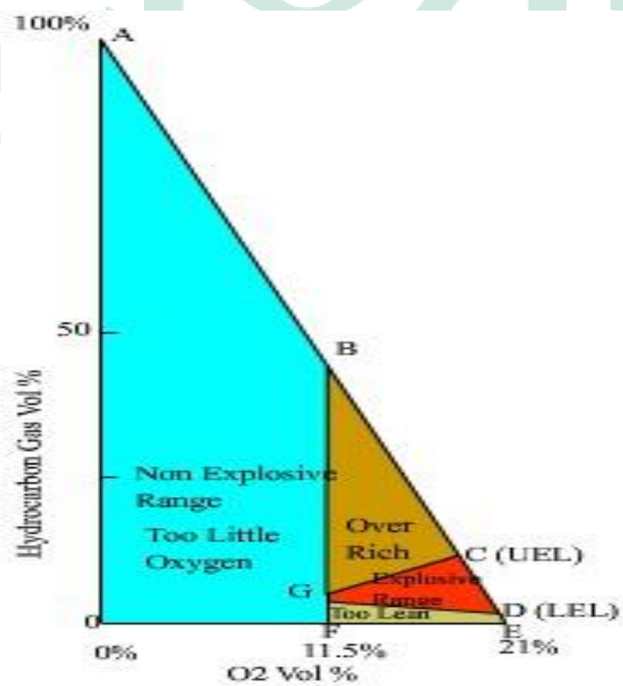


Fig. 1-1

We have to consider the tank atmosphere which may contain any one of three gases such as hydrocarbon gas, inert gas and fresh air.

Then we have to pay attention to hydrocarbon gas and oxygen in fresh air which are necessary to explosion. As oxygen content in fresh air is approx. 21 % we can draw the graph shown in Fig. 1-1 which shows hydrocarbon gas with the range from 0% to 100% in the vertical axis and oxygen content with the range from 0% to 21% in the horizontal axis.

- Point "A" in Fig. 1-1 means the tank atmosphere which consists of 100% hydrocarbon gas.
- Point "O" means the tank atmosphere which consists of 100% inert gas.
- Point "E" means the tank atmosphere which consists of 21 % oxygen.

From the above we can consider any kind of tank atmosphere which consists of three gaseous bodies such as hydrocarbon, inert gas and fresh air according to this Fig. 1-1. This means, in other words, that the tank atmosphere lies within the triangle AOE.

Explosive Range, UEL and LEL

(Also termed as UFL and LFL):

Under the tank atmosphere which consists of hydrocarbon gas, inert gas and fresh air, the range of mixture of oxygen and hydrocarbon gas which can be ignited by an external ignition source is called the "Explosive Range" or "Flammable Range".

Volume percentage of hydrocarbon gas and oxygen are called "Oxygen content" and "Hydrocarbon gas content".

This explosive range is shown in Fig. 1-1, the area surrounded by points CGD (Flammable envelope).

The highest point of hydrocarbon and oxygen mixture gas in this area is called the Upper Explosive Level (UEL) and the lowest point is called the Lower Explosive Level (LEL).

Non-Flammable Range:

In Fig. 1-1 no ignition can occur in the area which is outside the explosive range because of inadequate mixture of hydrocarbon gas and oxygen. This area is called the "Non-Flammable Range" or "Non-Explosive Range". This area is shown in Fig. 1-1

A. Too Little Oxygen:

Assuming that the oxygen content is less than the point G (less than 11.5%) no explosion can occurs even regardless hydrocarbon gas content in a tank. So we call this area surrounded by points AOFB as Too Little Oxygen condition.

The purpose of I.G.S. installation and the main points of I.G.S. operation is to ensure the tank atmosphere is in the Too Little Oxygen condition.

B. Over Rich and Too Lean:

Compared with the volume of oxygen, the volume of hydrocarbon gas is too much in the area surrounded by points BGC and no explosion occurs in this area so referred to as the Over Rich condition. On the other hand, the area surrounded by points GFED shows that the volume of hydrocarbon gas is too little compared with the volume of oxygen and no explosion occurs in this area called the Too Lean condition.

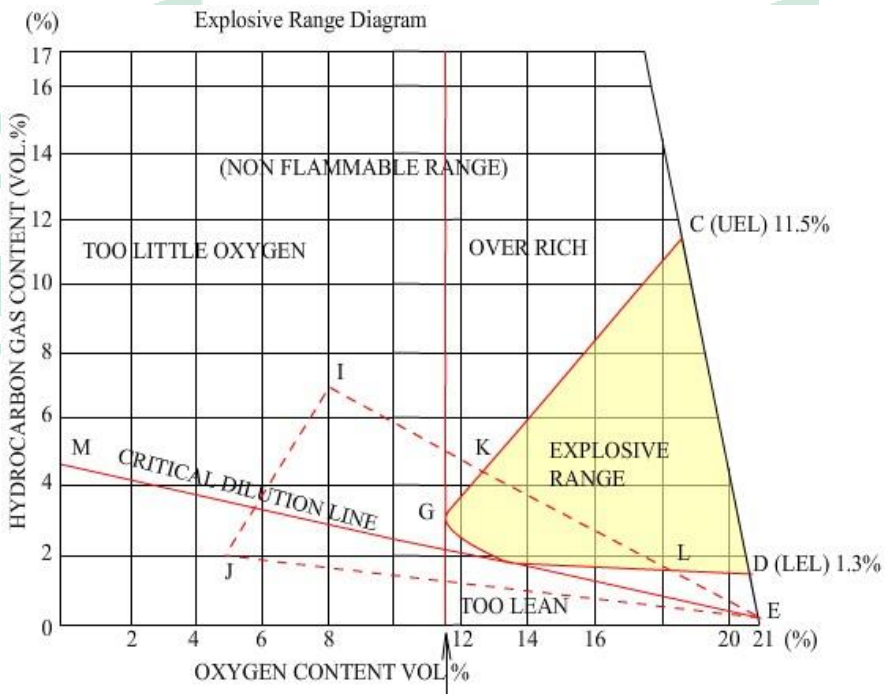
How to Use the

Explosive Range Diagram: The tank atmosphere which is not supplied with inert gas is to be considered on the line AE (Fig. 1-1) and it may come into the explosive range (Line CD). The vessel which is installed with I.G.S. can keep the tank atmosphere within the Too Little Oxygen condition by supplying inert gas.

The hydrocarbon composition of crude oil is various between the different grade and there is only a small variation in their explosion range. Therefore, in order to have the desired margin of safety, the point UEL is taken as 11.5% by hydrocarbon, LEL is 1.3% and the point of too little oxygen is 11.5% so we can draw boundary of the explosive range as shown in Fig. 1-2.

Keep tank atmosphere less than 8% of oxygen content:

Fig. 1-2. Is a magnified view of Fig. 1-1. (Area of hydrocarbon content from 0% to 17%).



(Fig. 1-2)

When we want to know what the tank atmosphere condition is, we find it out by plotting oxygen and hydrocarbon content as in Fig. 1-2.

Assuming at the end of tank washing, a cargo tank atmosphere is measured and found to contain 7% hydrocarbon and 8% oxygen.

Plotted on the Explosive Range Diagram this is point (I). If gas freeing was then carried out, the hydrocarbon content would decrease and the oxygen content increase, while passing along line IE.

However, on reaching point K on the flammability envelope the tank atmosphere enters the explosive range and remains in this condition to point L. In order to avoid such a condition, it is therefore necessary to purge with Inert Gas before gas freeing with air.

Purging the tank atmosphere with good quality Inert Gas will reduce the oxygen content as well as reducing the hydrocarbon content, passing along line IJ.

Once at J i.e. 2% hydrocarbon and 5% of oxygen, the gas freeing operation can begin and the addition of air will them keep the tank atmosphere outside the explosive range by moving along line JE.

If we draw a line from point E to the tangent point of explosive range so we get the line EM which is called the Critical Dilution Line. Since the tank atmosphere comes below the Critical Dilution Line there is no possibility of explosion when we supply fresh air into the tanks.

We must therefore carry out gas freeing after confirmation of the tank atmosphere that it is below the Critical Dilution Line after measuring the tank oxygen content and hydrocarbon content.

2.2 Sources of Ignition

Smoking: There are frequently local regulations about smoking which must be rigidly observed. Smoking may be permitted but only under controlled conditions at times and in places specified by the Master. Personnel when working aboard must not carry matches or more particularly lighters, and the risk of doing so is to be impressed on all.

Portable Electrical Equipment**:**

Only approved Safety flashlights are to be used. Portable Electric Equipment self-contained or on extension cables are not to be used in a gas dangerous place or zone unless the equipment is intrinsically safe. Portable domestic radios, electronic calculators, tape recorders and other non-approved battery equipment are not to be used in a gas dangerous place or zone.

Communication Equipment:

When berthed normal communication equipment is not to be used unless certified safe. This does not apply to permanently and correctly installed VHF equipment or Satellite communication systems

Hot Work: Before any hot work, hammering, chipping, or power tools are used the responsible officer is to examine the area to be worked and satisfy himself that such work can be safely undertaken and a hot work permit certificate issued. Non - sparking tools are not to be used as they do not significantly reduce the risk of igniting a flammable vapor.

Shore Bonding: Cargo hoses and loading arms are to be fitted with an insulating flange to ensure discontinuity between the vessel and shore.

Auto - Ignition: The vapors from flammable liquids including fuel and lubricating oil may ignite if the liquid comes into contact with any surface heated above the auto - ignition temperature e.g. exhaust manifolds, over heated equipment. Immediate steps are to be taken to rectify any leakage and to remove any soaked rags on other material including lagging.

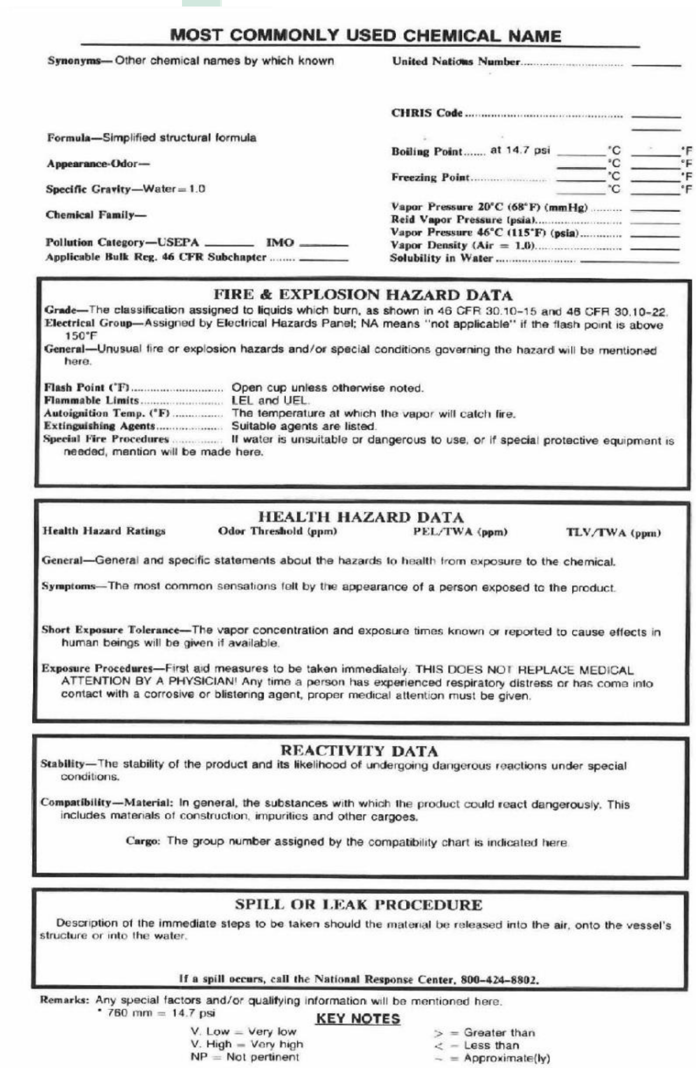
Static Electricity: Static Electricity can cause sparks capable of igniting a flammable gas. The cargo system of a gas carrier is electrically bonded to the ship's hull to prevent any buildup of charges; bonding connections must be maintained in good order.

2.3 Chemical Data Guide for Bulk Shipment by Water

The number and variety of unconventional liquid cargos being transported in bulk by water continues to steadily increase. Although the transportation hazards of common petroleum products are generally well understood, newer commodities often have unusual fire and explosive properties such as wide flammable range, low ignition temperature and foam incompatibility in addition to other hazards such as toxicity and dangerous reactivity. It became increasingly evident that a convenient reference guide listing properties and emergency procedures for bulk liquid cargos was needed by personnel concerned.

- Data sheets are arranged alphabetically by the most commonly-used chemical name. Following the data pages is a synonym index which shows other names for the products.
- A standard form is used for each product to permit rapid reference and to group data in a logical manner.
- General information on identification and physical properties is given at the top of the page.
- Data pertaining to the three basic types of hazard (fire, health and reactivity) are given in separate blocks below. Suggested action in the event of a spill or leak is given in the bottom block. Regulatory classifications are included in the top section, while special information is given at the bottom of the page under "Remarks".

Explanation of Terms:



MOST COMMONLY USED CHEMICAL NAME

Synonyms—Other chemical names by which known

United Nations Number..........

CHRIS Code..........

Formula—Simplified structural formula

Appearance-Odor—

Specific Gravity—Water = 1.0

Chemical Family—

Pollution Category—USEPA ______ **IMO** ______

Applicable Bulk Reg. 46 CFR Subchapter .... ______

Boiling Point....... at 14.7 psi ______ °C ______ °F
______ °C ______ °F

Freezing Point.......... ______ °C ______ °F
______ °C ______ °F

Vapor Pressure 20°C (68°F) (mmHg) .... ______
Reid Vapor Pressure (psia).......... ______
Vapor Pressure 46°C (115°F) (psia).......... ______
Vapor Density (Air = 1.0).......... ______
Solubility in Water.......... ______

FIRE & EXPLOSION HAZARD DATA

Grade—The classification assigned to liquids which burn, as shown in 46 CFR 30.10-15 and 46 CFR 30.10-22.
Electrical Group—Assigned by Electrical Hazards Panel; NA means "not applicable" if the flash point is above 150°F
General—Unusual fire or explosion hazards and/or special conditions governing the hazard will be mentioned here.

Flash Point (°F).......... Open cup unless otherwise noted.
Flammable Limits.......... LEL and UEL.
Autoignition Temp. (°F).......... The temperature at which the vapor will catch fire.
Extinguishing Agents.......... Suitable agents are listed.
Special Fire Procedures.......... If water is unsuitable or dangerous to use, or if special protective equipment is needed, mention will be made here.

HEALTH HAZARD DATA

Health Hazard Ratings **Odor Threshold (ppm)** **PEL/TWA (ppm)** **TLV/TWA (ppm)**

General—General and specific statements about the hazards to health from exposure to the chemical.

Symptoms—The most common sensations felt by the appearance of a person exposed to the product.

Short Exposure Tolerance—The vapor concentration and exposure times known or reported to cause effects in human beings will be given if available.

Exposure Procedures—First aid measures to be taken immediately. THIS DOES NOT REPLACE MEDICAL ATTENTION BY A PHYSICIAN! Any time a person has experienced respiratory distress or has come into contact with a corrosive or blistering agent, proper medical attention must be given.

REACTIVITY DATA

Stability—The stability of the product and its likelihood of undergoing dangerous reactions under special conditions.

Compatibility—Material: In general, the substances with which the product could react dangerously. This includes materials of construction, impurities and other cargoes.

Cargo: The group number assigned by the compatibility chart is indicated here.

SPILL OR LEAK PROCEDURE

Description of the immediate steps to be taken should the material be released into the air, onto the vessel's structure or into the water.

If a spill occurs, call the National Response Center, 800-424-8802.

Remarks: Any special factors and/or qualifying information will be mentioned here.
* 760 mm = 14.7 psi

KEY NOTES

V. Low = Very low
V. High = Very high
NP = Not pertinent
> = Greater than
< = Less than
~ = Approximate(ly)

Synonyms:	Alternate and common names are listed. In general, proprietary and trade names are not used.
Formula:	The constituent elements and a simplified structural formula.
Appearance-Odor:	A brief descriptive statement of these properties.
Specific Gravity:	This is the ration of the weight of a volume of the cargo to the weight of an equal volume of water. In the case of liquids of limited solubility, the specific gravity will predict whether the product will sink or float on water; for example, if the specific gravity is greater than 1, the product will sink, and if the specific gravity is less than 1, the product will float.
Chemical Family:	A general category which facilitates the use of the compatibility chart (Appendix A) for predicting the type of reactions which can be expected.

Pollution Category is USEPA and IMO In the blanks

- Are indicated the category assigned by the EPA for domestic used information, and the Noxious Liquid Substance (NLS)

Pollution category assigned by the IMO for international Shipment on oceangoing vessels:

Chemical Data Sheet:

- USEPA.X, A, B, C, and D Category associated with reportable quantities of 1, 10, 100, 1000, and 5,000 pounds, respectively. See 40 CFR Table 302.4 (List of Hazardous Substances and Reportable Quantities).
- IMOA, B, C, D   NLS category of Annex II of MARPOL 73/78
- III Appendix III of Annex III (non-NLS cargos) of MARPOL 73/78. I Considered an oil under Annex I of MARPOL 73/78.
- #No determination of NLS status. For shipping on oceangoing vessels see 46 CFR 153.900 (c).
- @The NLS has been assigned by the USCG, in absence of one assigned by the IMO.
- Gas The IMO generally does not assign pollution categories to gases as these cargos present little to no hazard to the aquatic environment.

Applicable Bulk Registration 46 CFR Subchapter: In the blank is the CFR reference for the carriage of the commodity

United Nations Number: Self-explanatory.

CHRIS Code: The three letter designation assigned to every entry in the Chemical Hazard Response Information System (CHRIS).

2.4 Toxicity and Petroleum

The toxic hazards to which personnel are exposed in transfer operations arise almost entirely from contact with gases of various kinds.

The toxicity of hydrocarbons is directly related to their physical properties, specifically the viscosity, volatility, surface tension, and chemical activity of the side chains. The viscosity is a measure of resistance to flow. Substances with a lower viscosity (e.g., turpentine, gasoline, naphtha) are associated with a higher chance of aspiration. The surface tension is a cohesive force between molecules and is a measure of a liquid's ability to “creep.” Like the viscosity, the surface tension is also inversely related to aspiration risk; the lower the viscosity, the higher the risk of aspiration.

Hydrocarbons with a high volatility can vaporize and displace oxygen, which can lead to a transient state of hypoxia. Not surprisingly, the degree of volatility is directly related with the risk of aspiration. The amount of hydrocarbon ingested has not consistently been linked to the degree of aspiration, and hence pulmonary toxicity.

Toxicity from hydrocarbon ingestion can affect many different organs, but the lungs are the most commonly affected organ. The chemical properties of the individual hydrocarbon determine the specific toxicity, while the dose and route of ingestion affect which organs are exposed to the toxicity.

Toxicity from hydrocarbon exposure can be thought of as different syndromes, depending on which organ system is predominately involved. Organ systems that can be affected by hydrocarbons include the pulmonary, neurologic, cardiac, gastrointestinal, hepatic, renal, dermatologic, and hematologic systems.

Typical Effects of Exposure to Petroleum Gases	
Concentration	**Effects**
0.1%vol.(1,000ppm)	Irritation of the eyes within one hour
0.2% (2000ppm)	Irritation of the eyes, nose and throat; dizziness and unsteadiness within 30 minutes
0.7% (7000ppm)	Symptoms of drunkenness within 15minutes
1.0% (10,000ppm)	Rapid onset of drunkenness which may Lead to unconsciousness and death if exposure continues
2.0% (20,000ppm)	Paralysis and death occur very rapidly

THE ABSENCE OF SMELL SHOULD NEVER BE TAKEN TO INDICATE THE ABSENCE OF GAS

Risk: The risk of swallowing liquid petroleum during normal vessel operations is slight.

Eyes: Most petroleum mixtures cause eye injuries through splashing.

Skin Contact: Petroleum products act differently when they come in contact with human skin. The higher volatile products can:

- Remove essential oils from the skin
- Cause dermatitis
- Cause other irritants to the skin

Chronic Protection: Many of the heavier oils can have chronic effects upon the skin after repeated and prolonged contact.

Gas: Direct contact should be avoided by wearing protective equipment when appropriate, especially gloves and goggles.

Effects: The initial effect that petroleum gas has on a person is a feeling of:

- Intoxication
- Dizziness
- Eye irritation
- Headache

Gas Exposure: Exposure to a high concentration of gasses can have an effect on a person as follows:

- Paralysis
- Unconsciousness
- Eventually death

Toxicity: The toxicity of petroleum gasses varies widely depending upon the particular hydrocarbon compounds contained in them.

Aromatics: The presence of aromatic hydrocarbons in a product present serious hazards to health. The aromatics are:

- Benzene
- Toluene
- Xylene

Increased Toxins: Minute amounts of the aromatics will increase the toxicity of a petroleum gas significantly as shown in the greatly reduced threshold limit value for these hydrocarbons.

Three types of TLVs for

Chemical substances are defined:

Threshold limit values are a measure of the relative toxicity of a substance to which a worker can be exposed without adverse health effects. Expressed as part per million (ppm), these values represent a maximum value in an atmosphere that should be safe.

TLV-TWA: Threshold Limit Value - Time Weighted Average (TLV-TWA) average exposure on the basis of a 8h/day, 40h/week work schedule

TLV-STEL: Threshold Limit Value - Short Term Exposure Limit (TLV-STEL) spot exposure for a duration shorter than 15 minutes that cannot be repeated more than 4 times per day

TLV-C: Threshold Limit Value - Ceiling (TLV-C) absolute exposure limit that should not be exceeded at any time

Normal TLV: Most cargoes carried in barges have a TLV of about 300ppm and are safe, provided there are no:

- Aromatic hydrocarbons
- Hydrogen sulfide
- Other toxins present

Test for Toxins: Before you allow entry into a tank that has been blown gas free you must test for the toxins that were in the product carried. Consult the Material Safety Data Sheet for that product and you can ascertain:

- Which detector tube needs to be used;
- What the TLV is for that product; and
- If personal protective equipment must be worn.

Benzene: Benzene is an aromatic hydrocarbon seen on barges, either as the cargo itself or as a part of a product.

Aromatic's TLV: The TLV of aromatic hydrocarbons is much lower than that of other hydrocarbons.

Chronic Disease: Exposure to benzene over the TLV leads to chronic disease of the:

- Bone marrow
- Blood

Benzene Program: Any mariner who carries benzene or a product containing more than 0.5% benzene must take part in the federal benzene monitoring program, where you are required to:

- Have your blood tested annually; and
- Your pulmonary function tested every three years.

Hydrogen Sulfide: (H2S) Many crudes have a high concentration of hydrogen sulfide leaving the well and it is so dangerous that some crudes are stripped off the hydrogen sulfide before being loaded.

Hydrogen sulfide will first kill your sense of smell and then in one hour:

- At 50 ppm will irritate the eyes and respiratory tract;
- At 200 ppm will markedly irritate eyes and respiratory tract;
- At 500 ppm consciousness will be lost after 15 minutes; and
- At 700 ppm rapid unconsciousness will occur and death follows a few minutes later.

2.5 Measurement of Petroleum Cargoes

Introduction: The measurement of oil cargoes is important to the Person-In-Charge. As the vessel owner's representative, he is responsible for the accurate gauging of the vessel and for the accuracy of the subsequent cargo calculations.

Type of Measure: Two types of measurement can be used to determine the level of cargo in a tank:

- Sounding, which is the distance from the bottom of the tank to the surface of the liquid; and
- Ullage, which is the distance from the measuring point at the top of the tank to the surface of the liquid.

Unit of Measure: The measurement taken may be in either:

- Metric units (meters and centimeters);or
- English units (feet and inches).

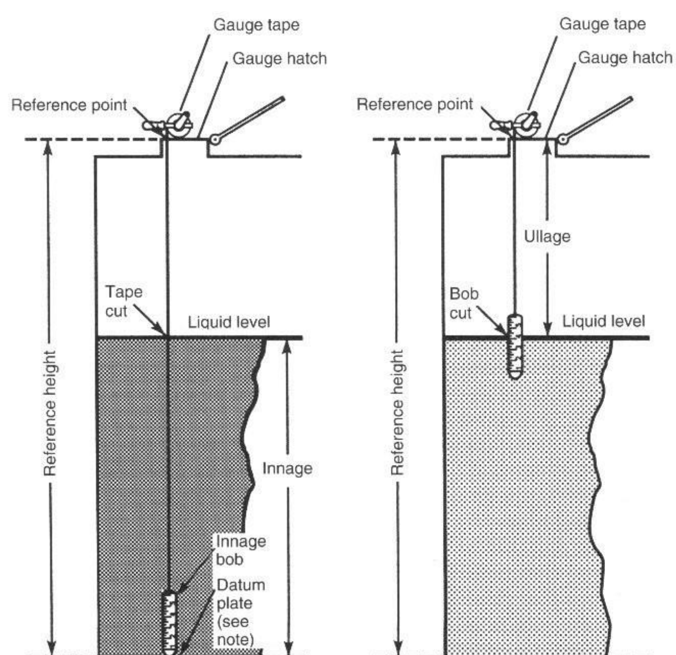
Development: Over the years different means have been developed to perform these measurements but must meet §153.404 standards for containment systems having required closed gauges, and §153.407 special requirements for sounding tube gauges.

Steel Tapes: These tapes are similar to the common measuring tape found in hardware stores and will be marked in either:

- Meters and centimeters
- Feet and inches

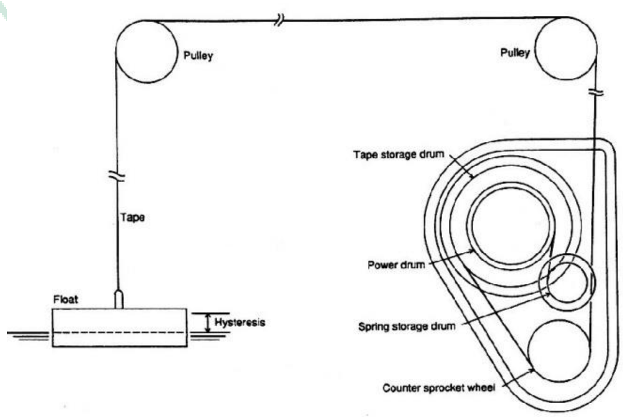
The Measure: A plumb bob is attached to the end of the tape and lowered into the tank. The measurement is read off the tape when the bob just touches the surface of the cargo.

Open Gauge: This is very accurate, but the ullage space is open to the atmosphere and can only be done when open gauging is allowed. The regulations requiring inert gas and vapor emissions control will eventually cause a phase-out of this method of gauging.



Float Indicators:

In this type of gauge, the detecting element is a float. The power to actuate the mechanism comes partly from the movement of the float and partly from the balancing mechanism. The float is connected to the mechanism by means of a tape or other mechanical or magnetic linkage. The figure below shows a typical arrangement of a gauge of this type. The float is connected to the measuring tape, which runs over a pulley system to enter the gauge head. Inside the gauge head the tape passes over a sprocket wheel driving a counter mechanism, and thence on to a storage drum. A spring, which winds off storage drum on to a power drum connected to the mechanically-operated

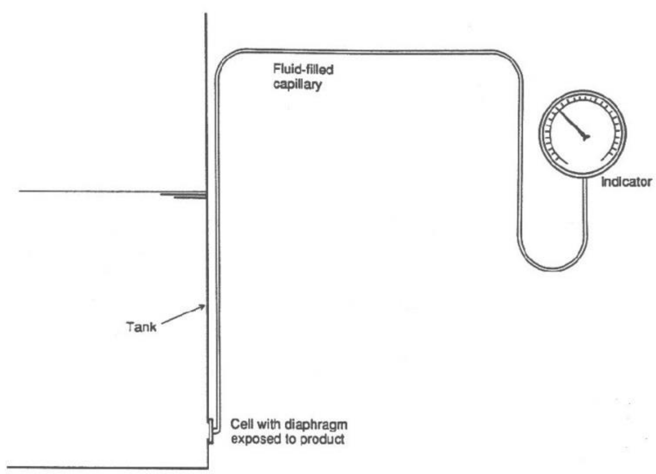


float gauge tape storage drum, keeps the tape under tension without lifting the float clear of the product. As the liquid level in the container rises, the tension applied to the tape by the spring takes up the slack on the tape. On the better types of gauge, the spring tension increases as the liquid level falls, in order to compensate for the additional weight of tape used.

Transmits: As the float moves up and down the shaft with the surface of the cargo, it continuously transmits a signal to remote ullage readout in the cargo control room.

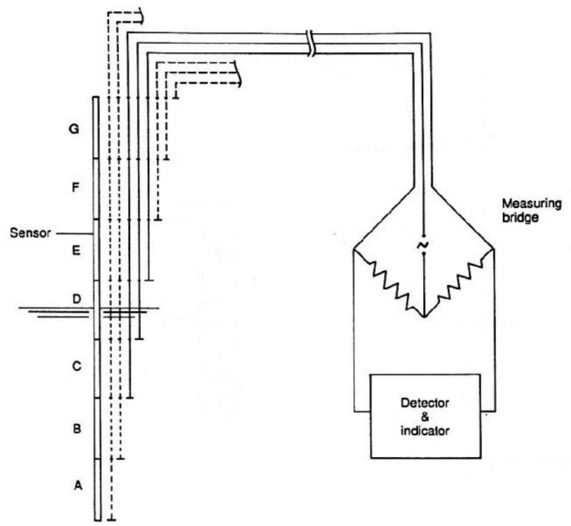
Pneumatic: Air is pumped at a constant positive pressure through a flow restrictor into a pipe that extends from the top to the bottom of the tank. As the level of the cargo in the tank increases:

- The head pressure exerted against the flow of air is measured by an attached pressure gauge;
- The gauge transmits a signal to the cargo control room; and
- The readout would indicate the ullage or its liquid volume.



Capacitance:

These gauges measure the liquid level by comparing the electrical capacitance of a partially immersed element with that of a fully immersed, similar element by means of a bridge circuit. The figure shows a gauge of this type. The detector compares the partially immersed element D with the fully immersed element C. The number of fully immersed elements is also counted. 'The level of the liquid can then is computed as indicated.



Electrical capacitance gauge–comparative type

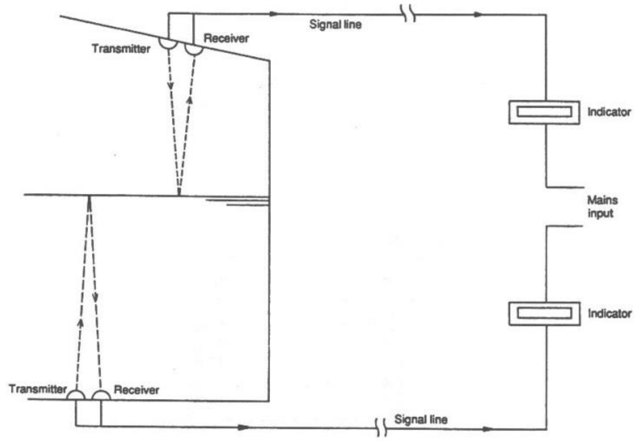
An electrical capacitance gauge measuring tape extends from the bottom to the top of the tank. Two wires within the tape carry an electrical resistance signal that is directly proportional to the tank ullage.

Compression: When the sensor is submerged, the weight of the liquid compresses the sensor causing an increase in the resistance and as:

- The height of the cargo increases;
- The resistance increases; and
- A readout can be provided at the tank top or remotely to the cargo control room.

Sonic gauges

There are several types of level gauges in this principle. The most commonly available types measure the time difference between a transmitted signal and its reflection from the liquid surface. Gauges can be mounted on the tank top or at the bottom of the tank. The principle is illustrated.



Ultrasonic level gauge

Radar Gauge: Phase modulated radar gauges bounce a signal off the liquid surface and measures the phase difference between the outgoing and incoming signals.

Precise Measure: This gives a very precise measurement of the time difference, which allows calculation of the distance between the radar head and the liquid's surface.

Versatility: Some of these units can also monitor:

- Cargo temperature;
- Inert gas pressure; and
- Oxygen levels in a tank atmosphere.

Multi-function: A multi-function tape can measure more than one physical parameter. The tapes used for closed gauging are usually multi-functional tapes and they can measure:

- Ullages:
- Cargo temperatures; and
- The oil water interface.

Where Read: The readings are taken from the tape housing itself.

Factors Affecting

Accuracy and Repeatability:

The user must be careful not to confuse the terms 'accuracy' and 'repeatability', and cautious about manufacturers' claims of accuracy.

Fundamental measuring accuracy is important, but it is less vital to the user than good repeatability, which is the ability of an instrument to reproduce results under all conditions. An instrument with good repeatability may have a considerable constant error, for which allowance can be made. On the other hand, an instrument with very good statistical accuracy may have poor repeatability; in this case many readings may have to be taken before any reliance can be placed on the results.

Friction: Friction, the cause of hysteresis in mechanical systems, may increase during the life of a level gauge owing to corrosion, wear, lack of lubrication, etc. The effects of changes in friction will be minimized in a well-designed instrument. One must not forget that some systems also suffer from hysteresis in resolution, although servo-operated gauges are free from this source of error. (Hysteresis: the lagging of an effect behind its cause, as when the change in magnetism of a body lags behind changes in the magnetic field.)

Manufacturing tolerances: These are always present in both mechanical and electronic systems; indeed, tolerance variations of 20% are common in electronic components. Mechanical apparatus and electronic circuits should be designed to minimize errors from this source. Where necessary, selected low-tolerance components must be used.

Product density: Changes in product density affect many types of gauge; float gauges will require correction and capacitance gauges will need to be re-calibrated unless they are of the comparative type, as will any type using a pressure head. Radioactive gauges are also affected by density.

2.6 Common Gauging Terms

Calibration Tables: Calibration tables (ullage/innage) are tables developed by recognized industry methods that represent the volumes in each tank according to the liquid (innage) or empty space (ullage) measured in the tank. The tables are entered with linear measurements (i.e., feet, meters) to obtain calibrated volumes such as gallons, barrels, cubic meters, or cubic feet.

Reference height is the distance from the tank bottom and/or datum plate to the established reference point or mark.

Observed reference height is the distance that is actually measured from the tank bottom or datum plate to the established reference point.

Reference point (gauging point) is the point from which the reference height is determined and from which the ullages/innages are taken. Historically, most tank vessels use the rim of the ullage opening in the hatch as the reference point for gauging the tank.

Ullage: Ullage (also referred to as "outage") is the measured distance from the surface of the liquid to the above deck reference point or datum. In other words, it is the measurement of free space above the liquid in a tank

Innage: Innage (also referred to as "dip" or "sounding") is the measured distance from the surface of the liquid to a fixed datum plate or to the tank bottom.

Volume: The amount of space occupied by a fluid at certain conditions of temperature and pressure. Various types of VOLUMES used in marine custody transfer are defined as follows:

- Gross Observed Volume (GOV) - The total volume of all petroleum liquids and sediment and water, excluding free water, at observed temperature and pressure.
- Gross Standard Volume (GSV) - The total volume of all petroleum liquids and sediment and water, excluding free water, corrected by the appropriate volume correction factor (VCF) for the observed temperature and API gravity, relative density, or density to a standard temperature such as 60°F or 15°C and also corrected by the applicable pressure correction factor (Cpl) and meter factor.
- Net Standard Volume (NSV) - The total volume of all petroleum liquids,

excluding sediment and water and free water, corrected by the appropriate volume correction factor (VCF) for the observed temperature and API Gravity, relative density, or density to a standard temperature such as 60°F or 15°C and also corrected by the applicable pressure correction factor (Cpl) and meter factor.

On Board Quantity: (OBQ) - The material remaining in vessel tanks, void spaces, and/or pipelines prior to loading. On-board quantity includes water, oil, slops, oil residue, oil/water emulsions, sludge, and sediment.

Remaining On Board: (ROB) - The material remaining in vessel tanks, void spaces, and/or pipelines after discharge. Remaining on board quantity includes water, oil, slops, oil residue, oil/water emulsions, sludge, and sediment.

Total Calculated Volume: (TCV) - The total volume of all petroleum liquids and sediment and water, corrected by the appropriate volume correction factor (VCF) for the observed temperature and API gravity, relative density, or density to a standard temperature such as 60°F or 15°C and also corrected by the applicable pressure factor (Cpl) and meter factor, and all free water measured at observed temperature and pressure (gross standard volume plus free water).

Total Observed Volume: (TOV) - The total measured volume of all petroleum liquids, sediment and water, and free water at observed temperature and pressure.

Calculations: Once the measurements are taken it is necessary to calculate the following quantities for each tank:

- Gross volume;
- Cargo temperature;
- Net volume; and
- Tons

Gross Volume: The total quantity found by taking the ullage or sounding measurement and looking up the corresponding quantity in the vessel's ullage tables.

Trim Correction: Trim correction will be applied to the measurement before the quantity is determined and may be stated in terms of:

- Barrels;
- Cubic meters; or,
- Cubic feet.

One Barrel: There is 42 U.S. gallons @ 60º per one barrel of liquid.

Factor: In the English system this is accomplished by using the factors obtained in the API tables while the metric system uses density.

Multiply Factor: You usually multiply this factor with the gross figure and the result is the net volume at standard temperature.

Tonnage: The weight of the cargo, expressed as either long tons or metric tons, is determined from the API tables in the English system or from the density in the metric system.

The API Tables: The API tables are divided into two parts:

- Crude oils; and
- Generalized petroleum products.

Different Tables: Within each part are tables listing API Gravity against specific gravity and density. A partial listing of the tables barges most commonly use are as follows:

- Table 1 the Units of Measurement Conversion;
- Table 2 the Temperature Conversions;
- Table 3 the API Gravity to Specific Gravity and Density;
- Table 6A (crude oils) or 6B (products) the Correction for Volume to 60°F;
- Table 8 the Pounds per U.S. Gallon and U.S. Gallons per pound;
- Table 11 the Long Tons per 1000 U.S. Gallons and per Barrel; and
- Table 13 the Metric Tons per 1000 U.S. Gallons and per Barrel

Reduction: Use the observed temperature and the API gravity of the cargo and enter the volume reduction table SA or 6B.

Factor: Find the factor to be used to reduce the gross volume to the net volume.

Multiply: Multiply this factor by the gross barrels and the result will be net barrels.

Weight Tables: To calculate the weight of the cargo enter the weight table 11 or 13 with the API gravity and find the factor to convert from net barrels to tons.

Factor: Multiply this factor by the net barrels to determine the tons.

Example: A vessel has loaded 24,000 barrels of crude oil at a temperature of 78°F with an API of 32.8. What are the net barrels and tons?

- Gross barrels: 24,000
- Temperature: 78°
- API : 32.8
- From table 6a: 0.9949
- From table 11: 0.13446
- 24,000 x 0.9949 = 23,877.60 net barrels
- 23,877.6 x 0.13446 = 3210.58 tons

Section 3

Safe Operation

Introduction:

Petroleum vessels are inherently hazardous places to work. While we all recognize the dangers of fire and explosion aboard tank vessels, other dangers are not so readily apparent to us. The most common cause of injury on barges are:

- Slips
- Trips
- Falls

Development: The crew's wellbeing will be enhanced by the development of safe operations on our vessels by:

- Making the crew more aware of the hazards
- Standardizing the reporting of hazards
- Reporting unsafe operations on the vessels

1978 Report: Annually the Coast Guard's Marine Investigation Division publishes a summary of commercial vessel casualties of various types. The statistics from the national and International sources indicate that 85% of accidents are caused by human error. In 1978 there were:

- 5,606 vessels involved in 3,693 accidents
- 462 accidents resulted in a total loss
- 252 of the total losses were fishing vessels
- 192 lives were lost at sea

Definitions: Dangerous liquid cargoes can be defined as a cargo that:

- Is flammable
- Is combustible
- Poses some danger to human life or health; or
- Is designated by the IMO as a marine pollutant

PIC: A Person in Charge can be defined by

- The person in charge of a DL transfer;
- Has a Tankerman-PIC endorsement on his MMD

Liquefied Gas: A liquefied gas is the liquid form of a substance which, at ambient temperature and at atmospheric pressure, would be a gas.

Hazards: There is a large number of petroleum based products and each can have its own particular hazard. Dangerous liquids have many traits in common and some of these are that dangerous liquids are:

- Toxic
- Asphyxiating
- Flammable
- Combustible
- A pollutant

Toxic Liquids: Dangerous liquids are toxic which means they are poisonous. Toxic effects may be described as either acute or chronic. Most dangerous liquids are toxic and have both acute and chronic effects. Some of these products are but not limited to:

- Gasoline
- Benzene
- Naphtha
- Crude oil

Acute Effect: Acute as it pertains to dangerous liquids, means the liquid can cause violent illness coming to crisis speedily. The more acute the liquid is, the time you can be exposed to it becomes shorter and death becomes the end result. Examples of these liquids are:

- Hydrogen sulfide
- Aromatic hydrocarbons
- Benzene

Chronic Effect: Chronic refers to effects that are usually produced over long term exposure to a dangerous liquid or vapor. Many petroleum based products are carcinogens for long term exposure.

3.2 Operational Safety

Monitoring: In order to reduce personnel exposure, the Coast Guard has set up a benzene monitoring program for all vessels that carry products containing 0.5% benzene by volume or more. This program can be found in 46 CFR 197.500 and consists of:

- Testing each vessel for hot spots (regulated areas)
- Cordoning off the manifold and regulated areas
- Displaying warning signs
- Crew is fit tested for their respirators
- Respirators are worn by crew in regulated areas
- Personnel are tested by a physician annually

PPE: Vessel operators should supply the crew with Personal Protection Equipment (PPE) and disposable suits to reduce their exposure to dangerous liquids. Some of this PPE gear consists of:

- Rubber gloves and boots
- Disposable suits
- Respirators
- Hard hats
- Dragger tube monitoring devices

PPE Maintenance All PPE should be inspected and maintained according to manufacture recommendations. If and PPE is found to be defective in any way it should be taken out of service and replaced with appropriate approved PPE.

IG Dangers: During tank washing operations, the action of the water going through the nozzles at high pressure and hitting a steel bulkhead can produce static electricity. IG must be running into the tanks being washed at all times, keeping:

- A positive IG pressure in the tanks; and
- The tank atmosphere at or below 8% 0_2.

Safer: This makes things safer because:

- Static electricity can cause no harm; and
- The positive pressure produces a better bottom wash.

Skin Contact: The crew must be made aware of the dangers of the products they are carrying and what to do if their skin comes into contact with the liquid hydrocarbon product during:

- Hose hook ups
- Butterworth operations
- Pump room entry
- Tank entry

EM Shower:

The MSDS sheets for each product are made readily available to the crew and will give them instructions on what to do if they come into skin contact with the products. They will also be able to find on deck:

- Emergency showers
- Eye wash facilities

Fire Prevention:

Fire requires a combination of fuel, oxygen and a source of ignition. Most combustible or flammable substances, only when heated, give off gas vapors which burns if ignited when mixed with an appropriate quantity of oxygen, as in air.

Fires can be controlled and extinguished by the removal of heat, fuel or air. The main aim when fighting fires must therefore be to reduce the temperature or to remove the fuel or to exclude the supply of air with the greatest possible speed.

The three elements that are necessary to produce fire are:

- Fuel
- Oxygen; and
- An ignition source

Industrial Hygiene:

Good housekeeping plays an important role in preventing fires other than the cargo deck.

The PIC Tankerman 's Sanitary Inspections should be made to ensure:

- The paint locker is secure with all fume sources closed
- The engine spaces are cleaned and maintained
- Oily rags are properly disposed of

Classes of Fire:

CLASS	MATERIAL	EXTINGUISHING METHOD/AGENT

A	Ordinary Combustibles	Cooling with water or water Fog. C02 and all-purpose dry chemical are less effective, but can
B	Flammable liquids	Smothering with foam, C02, inert gas or steam. Dry chemical is also effective.
C	Live Electrical Equipment	Extinguishing agent must be non-conducting: C02 or dry chemical. Water or foam must not be used.

Shutdowns: As per 46 CFR 35.35-40, transfer operations shall not commence or if started shall be shut down under the following circumstances:

- During severe electrical storms
- If a fire occurs on the wharf or on the vessel or in the vicinity

Spill Shutdowns: As per 33 CFR 155.780, every vessel with a capacity of 250 or more barrels of oil must have onboard an emergency means to enable a person to stop the flow of oil. The means to stop the flow must be operable from the cargo deck, cargo control room or the usual operating station of the person in charge and the means to stop the flow may be:

- A pump control
- A quick acting power actuated valve; or
- An operating procedure Safety and Training

3.3 Safety and Training

Safety Culture: The development of a safety culture aboard tank vessels will do much to enhance safety. The increased awareness and open reporting of hazards can only make operations safer. The elements of a safety culture are:

- Training
- Communication

- Contingency planning
- Situational awareness

Training: Training is formally done:

- On board the vessels
- Ashore in schools set up for it
- At the home office

Documentation: Documentation of successfully completing all the required training is a must with the implementation of:

- The STCW codes
- The Coast Guard's Prevention through People
- The ISO/ISM code
- Sub-Chapter-M

Shore Courses: Ashore seamen will be formally trained and documented in various courses such as:

- PIC Dangerous Liquid Cargo
- Bridge Team Management
- Firefighting
- GMDSS
- Survival Craft

Vessel Training: Onboard the vessel, training will go on as it always did but it will be documented more finally. Some of this onboard training is:

- Vessel specific orientation
- Fire and lifeboat drills
- Emergency medical drills
- Pollution control drills
- Emergency gear drills

Communications: Communications in regard to vessel operations may be divided into the following communication forms:

- External
- Internal
- Written
- Verbal

External communications: External communications are generally dealing with persons not of the vessels crew, such as:

- Cargo orders from company
- Procedure changes from company
- The PIC Tankerman and Pilot conference
- The pre-transfer conference
- Conferences between the dock and the vessel during the transfer

Internal : Internal communications onboard the vessel can be between:

- The cargo team
- The bridge team
- The emergency squad
- The medical emergency team
- The normal watches

Information: Communications always involves an exchange of information. This information may be about:

- Current or future operations
- The thoughts and ideas of the crew involved

Effective communications: Effective communications occur when the receiver interprets the sender's message the way it was intended to be understood. Effective communications includes:

- Verbal signals
- Non-verbal signals
- Uncluttered diagrams
- Written orders

- Precise wording
- Short sentences

Communications: The ABC's of good communication are

- Accuracy
- Brevity
- Clarity

Situational Awareness and

Error Chains Awareness: Situational awareness is an accurate perception of what is going on around you at all times. The factors included are conditions that affect:

- The vessel
- The terminal
- The surrounding area
- The cargo handling team during the operation

Seaman's Eye: The "Seaman's Eye" is a form of situational awareness. The development of situational awareness in an individual takes:

- Time
- Experience
- Training

Development: A capable and concerned individual will develop adequate situational awareness much faster than a person who does not put forth an effort to learn.

Series: Accidents are not caused by a single catastrophic event but are led to the accident by a series of:

- Acts
- Events
- Omissions

Error Chain: A series of actions, which together lead to an accident, is called an error chain. Changing any of the elements of the series breaks the error chain and the accident will not happen.

Recognition: The recognition of an error chain in development and being able to determine how to break it is an important part of situational awareness. Some ways to recognize if an error chain is developing are if:

- The checklist to start an operation was not done
- Something is out of phase
- The pre-calculated conditions do not jibe with reality
- Shut down the operation and reassess

3.4 Planning and Checklists

Situations: Many vessels have made contingency plans to deal with some or all of the following situations:

- Communications failure
- Mooring failure
- Inert gas system failure
- Hydraulic or control air failure
- Enclosed space entry
- Enclosed space rescue
- Personnel evacuation
- A fire or explosion on board the vessel

Checklists: Each of the above contingency plans has its own checklist.

Drills: Drills must be conducted to test a contingency plan. If the plan is not drilled, there is no way to tell if the contingency plan will work. It is through drills that contingency plans are refined.

Memory Aids: The effective use of checklists as a memory aid in complicated or stressful operations has been proven to work well in the aviation community.

Examples: The Declaration of Inspection is a very detailed checklist we must complete before transferring cargo. Some other areas where checklists are required are:

- Fire and boat drill
- Inspecting lifeboat gear
- Inspecting fire equipment
- Sending a distress message
- Receiving a distress message

SDS: The Safety Data Sheet, required by 46 CFR153.907, for each dangerous liquid product the vessel is carrying must be readily available to the crew. Most vessels display them in the:

- Bridge
- Crew lounge
- Galley

Information: These sheets must have the name of the product as listed in Table 1of 46 CFR 153 and the following information.

- IMO category
- UN number
- Description of the cargo's appearance
- Hazards in handling the cargo
- Any special handling procedures such as inserting
- Procedures to follow if cargo spills or leaks
- Procedures for treating a person exposed to the liquid
- A list of firefighting procedures and extinguishing agents effective with cargo fires
- Vessel's name
- Loading point
- Approximate quantity of cargo

Liquefied Gas: The PIC Tankerman shall ensure that the following information for cargoes listed in 46 CFR 154 are readily available on the vessel:

- The name of the cargo listed in table 4 of Part 154
- The name of the cargo listed in 46 CFR 30.25-1
- The name of a cargo prescribed in the letter authorizing carriage of the cargo
- The vessels name for the cargo
- The name of the vessel if the cargo is neither hazardous nor flammable

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3.5 Tank Entry

Introduction:

Entry into cargo tank spaces is an operational requirement and a frequent operation on most barges. It can be done safely when all personnel are properly trained, instructed and follow the appropriate procedures. Entry into cargo tanks and other confined or remote spaces expose crewmembers to the potential of:

- Fire
- Explosion
- Exposure to toxins
- Asphyxiation

Why Enter:

It may be necessary to have personnel enter enclosed spaces to:

- Inspect
- Clean
- Conduct repair or maintenance work
- Retrieve objects

- To attempt rescue of co-workers

Training: All vessel board personnel should have training and a working knowledge of the following:

- Recognizing what a confined space is by definition
- Identifying what confined space hazards are
- Evaluating the hazards once they are identified
- Knowing the physical symptoms associated with exposure to hazardous materials
- Knowing the control procedures for the space during the time it is occupied
- Being prepared for tank rescue

Confined Space: According to the Osha standard 29CFR1910 and The National Fire Protection Agency Standard 350, these organizations defines a confined space as one that is big enough and so configured to permit entry and allow work to be done. The confined space is not designed for continuous human occupation. It has:

- Limited or restricted means of entry
- Limited or restricted means of exit
- It has inadequate natural ventilation

Examples: If you are not sure that a space is a confined space, you must assume it is one and act accordingly. The following are some examples of vessel board confined spaces.

- Cargo and ballast tanks
- Peak tanks
- Cofferdams

Hazardous Space: A hazardous confined space is one that presents an atmospheric or physical hazard to human life. The space may cause injury, illness or death because it may contain an environment that is:

- Explosive
- Poisonous
- Corrosive
- Irritating
- Asphyxiating
- Otherwise harmful

Risk of Entry: A hazardous atmosphere is one that may expose employees to the risk of:

- Death
- Incapacitation
- Impairment of ability to self-rescue
- Acute illness

Atmosphere: The risk of entry, due to a hazardous atmosphere can be from one or more of the following causes:

- Flammable gas in excess of 10% of its LFL
- Airborne combustible dust at a concentration that meets or exceeds its LFL
- Atmospheric c oxygen concentration below 19.5% or above 22.0%
- Atmospheric concentration of any substance for which the permissible exposure limit is exceeded
- Any other atmospheric condition that is immediately dangerous to life or health

Adjacent Spaces: Atmospheric hazards may not end in the confined space that they originated in. Explosive, flammable or toxic vapors might migrate and displace the oxygen content in adjacent spaces such as:

- Engineering spaces
- Cargo tanks
- Storerooms
- Living quarters

Physical Hazard: There are three types of physical hazards associated with confined spaces and those are:

- Engulfment
- Entrapment
- Slips, trips and falls

Engulfment: If a person entered a confined space containing grain and the grain shifted that person might be engulfed by the grain and killed. Engulfment may be by any movable solid or liquid, which can cause death through:

- Suffocation
- Constriction
- Crushing

Trips and Falls: A crewman walking on the bottom of a cargo tank could trip and a fall over the longitudinal because of

- Vessel movement
- Poor lighting
- Carelessness

02 Absorption: Oxygen deficiency should be suspected in all enclosed spaces. Oxygen depletion by absorption in a space can take place through several methods such as:

- Fermentation of fruit
- Decomposition of wood
- The oxidation of metal forming iron oxide

02 Excess: There is a hazard in an oxygen enriched atmosphere were the oxygen content exceeds 22.0% oxygen. A confined space can become oxygen enriched through leaks from an oxygen line.

02 Danger: An atmosphere that is oxygen enriched has the danger of fire and explosion within that space. Personnel should be restricted or removed from the space until the oxygen content can be lowered to normal levels.

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3.6 Guidelines for Safe Tank Entry

Introduction:

No confined space should be entered before the atmosphere within it has been comprehensively tested and analyzed. The senior officer present is responsible to ensure the tank is properly tested in the order given:

- Oxygen content
- Explosive vapors
- Toxic vapors

Meter

MSA Altair 4 The ALTAIR 4X is an extremely durable Multigas Detector that simultaneously measures up to four gases from a wide range of XCell(R) sensor options including combustible gases, O_2, CO, H_2S, SO_2 and NO_2.

Test Procedure

Bump Test

This is a qualitative function check in which a challenge gas is passed over the sensor(s) at a concentration and exposure time sufficient to activate all alarm settings. The purpose of this check is to confirm that gas can get to the sensor(s) and that all the instrument's alarms are functional. The bump test or function check does not provide a measure of the instrument's accuracy. When performing a bump test, the challenge gas concentration should trigger the DRPGM's alarm(s).

Calibration Check or Full Calibration

There are two methods for verifying DRPGM accuracy: a calibration check and a full calibration. Each method is appropriate under certain conditions.

A calibration check verifies that the sensor(s) and alarms respond within the manufacturer's acceptable limits by exposing the instrument to a test gas. The operator compares the reading to the test-gas concentration (as indicated on the cylinder containing the test gas). If the instrument's response is within the acceptable range of the test-gas concentration (typically ± 10-20% of the test-gas concentration), then the calibration check verified the instrument's accuracy. (Note: OSHA recommends that operators check with the instrument's manufacturer for the acceptable tolerance ranges.) An operator should "zero" an instrument (reset the reference point, in some cases "zero air" gas may be needed) before conducting the calibration check to ensure that the calibration check results are accurate. When performing a calibration check, the test-gas concentration should be high enough to trigger the instrument's alarm(s).

If the calibration-check results are not within the acceptable range, the operator should perform a full calibration. A full calibration adjusts the instrument's reading to coincide with a known concentration (i.e., certified standard) of test gas. Test gas used for calibration gas should always be certified using a standard traceable to the National Institute of Standards and Technology (NIST).[3]

When to Perform a Bump Test and / or

When to Perform a Full Calibration

In the past, there has been some confusion regarding proper calibration procedures and frequency. To clarify this issue, ISEA updated its position statement on instrument calibration in 2010, stating, "A bump test . . . or calibration check of portable gas monitors should be conducted before each day's use in accordance with the manufacturer's instructions." If an instrument fails a bump test or a calibration check, the operator should perform a full calibration on it before using it. If the instrument fails the full calibration, the employer should remove it from service. Contact the manufacturer for assistance or service.

Training: The person using the equipment must have been properly trained in its use and the equipment must be Coast Guard approved.

Portable Venting: Oxygen samples are taken through the butterworth openings and at various depths throughout the tank. If the tanks are being ventilated with portable blowers and the samples are taken from the deck level you should:

- Stop the ventilation; and
- Wait at least 10 minutes to start testing.

IG Fan Venting: If the displacement method of ventilation is being used with the IG fans, the samples should be taken from the deck level while the fans continue to run. This is done because:

- The fan will be running when men are in the tank; and
- You want to ensure that no gas is leaking from the inert system.

Still not Safe: Personnel should still not enter the space until it has been tested for a flammable or explosive atmosphere and for toxic substances.

Hydrocarbon Test: The next test to be conducted, after the oxygen content has been determined, is to test for hydrocarbon vapors. The testing for the hydrocarbon is done from the deck with combustible gas indicator and you must ensure that:

- The oxygen content is above 14% by volume in the tank;
- The testing is done through all openings; and
- The testing is done at different levels in the tank.

Explosive Range: The explosive range is considered to be when a flammable vapor of a liquid has mixed with the proper proportion of air to make an ignitable mixture. The explosive range has a:

- Lower explosive limit; and
- An upper explosive limit.

Too Lean: The LEL is when there are not enough of the hydrocarbon vapors in the air mixture to reach the ignition point so that the atmosphere is too lean to burn.

Too Rich: The UEL is when there is too much of the hydrocarbon gas mixed with air in the atmosphere to ignite so that the atmosphere is too rich to bum.

Static Electricity All equipment that is capable of generating a static charge has to be grounded and bonded

Catalytic Sensor: The combustible gas indicator reads up to 100% of the LEL. The sensor works on the principle of catalytic combustion where a sample of the gas:

- Is drawn into the sensor
- Where it is burned
- This creates an imbalance in the sensing head
- This is proportional to the concentration of gasses

Toxicity Test: If the last cargo had benzene or hydrogen sulfide in it, you must test for traces of these vapors with a toxicity meter. If any hydrogen sulfide is detected entry should be denied until the vapor is gone. If benzene is detected, entry may be allowed only if it is:

- Below the recommended permissible exposure limit
- The proper testing was done for benzene

Detector Tubes: Detector tubes are designed to be worn in the space entered to monitor for a specific toxic agent. They must be easy to use and read. They are operated by:

- Breaking the tips off both ends
- Drawing a sample of the gas through the detector tube
- The reagent in the tube will react with the sample gas
- A color stain will develop at the inlet of the detector tube
- The gas concentration is measured at the interface
- The reagents are sensitive to particular gasses
- React to provide a length of stain indication

Calibration Scale: There is a calibration scale on the tube, which is matched against the length of the stain indication in the tube. This scale will read the parts per million of the gas sampled for, if found in the atmosphere being tested.

The Goal: The goal is to obtain readings throughout the entire compartment as follows:

- Less than 10% of the LEL
- 21.0% oxygen;
- The permissible exposure limits for toxic vapors

Supervisor: If the test results are within the proscribed parameters for oxygen, flammability, and toxicity, preparations for tank entry by an entry supervisor can commence. An entry supervisor as per 29 CFR 1910.146 can be any of the crew who is:

- Suitably trained in the dangers of enclosed space entry
- Fully conversant with test procedures
- Is trained for the test equipment used for enclosed space entry

Entry Procedure: The tank may still contain pockets of vapors that were not detectable from the deck level. This will require entry into the space to continue testing the tank as per 46 CFR 153.934. This requires the following:

- The PIC Tankerman 's approval for tank entry
- Completion of an enclosed space entry permit
- The donning of protective equipment
- SCBA worn
- A lifeline rigged
- A standby crew posted with safety gear
-

In the Tank: Once you have posted the standby crew the approved person may enter the space. The person should walk throughout the entire space and check all the nooks and crannies for:

- Hidden pockets of hydrocarbon vapor
- Deficient oxygen content
- Toxic vapors
- Damaged ladders and slippery surfaces
- Missing or poor lighting
- Cargo leaks from an adjacent tank
- Leaks from the inert gas system
- Cargo residues on the tank surfaces

Tank Passes: If you have reached your goal and the tank has passed, you can begin the task that you gas freed the tank for. You must:

- Issue the proper permits
- Continue to ventilate
- Constantly monitor the atmosphere

Tank Fails: If you found pockets of hydrocarbons, toxic vapors or deficient oxygen, you will have to:

- Wash the tank again
- Ventilate until the tank passes inspection

Permit Space: According to 29 CFR 1910.146 a permit must be written before anyone can enter a permit required confined space. These spaces have the following characteristics:

- Contains or has the potential to contain a hazardous atmosphere
- Contains materials that could engulf an entrant
- Has an internal configuration that could entrap an entrant
- Contains any other recognized serious safety or health hazard

Entry Permit: The permit is the written or printed document provided or approved by the company to allow and control entry into an enclosed space after the space is tested for:

- Oxygen concentration
- Flammable atmosphere
- Toxic atmosphere

3.7 Safe Tank Entry-Definitions

MSDS: Those that make, distribute, and use hazardous materials are responsible for supplying Material Safety Data Sheets. These sheets have descriptive data that is concisely outlined on them. These sheets will identify the material and will give the following information:

- IMO and UN numbers
- Occupational exposure limits
- TWA
- STEL
- TLV
- Physical data
- Fire and explosion data
- Reactivity data
- Health hazard data

PEL: The permissible exposure limit is different for each product. It is the maximum exposure to a toxic substance that is allowed by the regulatory authorities. PEL's are usually expressed in:

- TWA
- STEL

TWA: The time weighted average is the airborne concentrations of a toxic substance averaged over an 8 hour period and usually expressed as ppm.

STEL: Short term exposure limit is the airborne concentrations of a toxic substance averaged over any 15 minute period and usually expressed as ppm.

TLV: The threshold limit value is the time weighted average concentration of a substance to which workers may be repeatedly exposed to, for a normal 8-hour workday or a

40-hour workweek without adverse effect.

3.8 Regulations for Confined Space Entry

Introduction: According to 46 CFR 153.934 no person may enter a cargo tank, cargo handling space, pumproom or enclosed space in the cargo area without the permission of the PIC Tankerman .

Equipment: Protective equipment would also include equipment found as part of the emergency and safety equipment under 46 CFR 153.214 such as:

- Two stretchers or wire baskets for confined space rescue
- Equipment for lifting an injured person out of the pumproom or a cargo tank
- An approved 30 minute SCBA
- 5 refills for SCBA
- A set of overalls
- Boots
- Long sleeved gloves
- Goggles
- A steel-cored lifeline with harness
- An explosion proof lamp
- A first aid kit

Toxic Testing: As per 46 CFR 153.526 when you are required to test for a specific cargo's toxic vapors, the vessel must have two toxic vapor detectors, at least one of which must be portable, with each of them able to:

- Measure the vapor concentrations in the range of the TWA for the cargo
- The portable detector may be a direct reading detector tube instrument
- These detectors may be combined with the flammable vapor detector

Hot Work: As per 46 CFR 35.01-1 the NFPA publication No. 306 shall be used as the guide in conducting inspections and the issuance of Hot Work Certificates. This publication is required as part of the vessel board reference materials.

Pre-inspection: As per 46 CFR 35.01-1, until an inspection has been made to determine that such an operation can be undertaken safely, no alterations, repairs or other such operations involving riveting, welding, burning or similar fire-producing actions shall be made within the boundaries of:

- The cargo tanks which have been used to carry flammable or combustible liquid
- The spaces adjacent to such cargo tanks
- The boundaries of fuel tanks
- Pipeline and heating coils
- Other appurtenances connected to such cargo or fuel tanks

Marine Chemist: If these inspections are made in the ports, places in the United States or its territories and possessions, the inspection shall be made by a Marine Chemist certificated by the NFPA as per 46 CFR 35.01.

The Inspection: If the inspection indicates that such operations can be undertaken with safety, a certificate shall be issued by the Certified Marine Chemist or the authorized person before the work is started. The certificate shall:

- Set forth the fact in writing that hot work is permitted
- Qualified as may be required

Qualifications: Such qualifications shall include any requirements as may be deemed necessary to maintain the safe conditions in the spaces certified, throughout the operation and shall include:

- Additional tests and certifications as required
- Precautions necessary to eliminate or minimize hazards that may be present from protective coatings or residues from cargoes

Outside the USA: When not in such a port or place, as per 46 CFR 35-01-1c2, and a Marine Chemist or such person authorized by the OCMI is not reasonably available, the inspection shall be made by the senior officer present and a proper entry shall be made in the vessel's logbook.

Responsibility: It shall be the responsibility of the senior officer present to:

- Secure copies of certificates issued by the Certified Marine Chemist
- Maintain a safe condition on the vessel
- Fully observe all the qualifications and requirements listed by the Marine Chemist who wrote the certificate

Length of Permit: Work authorized by the Certificate shall commence within 24 hours unless otherwise noted on the Certificate providing:

- The condition of the vessel remains unchanged
- The qualifications remain the same

Open Tanks: According to 46 CFR 35.30-10, no cargo tank hatch, or Butterworth plates shall be opened or shall remain open unless:

- The flame screens are in place
- It is under the supervision of the senior members of the crew on duty
- The tank opened is gas free

Open Covers: The requirements as set forth in 29 CFR 1910.146 require that any conditions making it unsafe to remove an entrance cover shall be eliminated before the cover is removed. When entrance covers are removed the opening shall be promptly guarded by:

- A railing
- A temporary cover
- A temporary barrier that will prevent an accidental fall through the opening

3.9 Marine Chemist's Certificates

Introduction: The Marine Chemist shall personally determine the vessel's conditions and he shall be permitted to issue a Certificate in writing that the prescribed work to a vessel can be undertaken safely.

Visual Test: The Marine Chemist shall, whenever possible, physically enter each compartment or space and conduct visual inspections to the extent necessary to determine the atmospheric or fire hazards that exist.

Actual Tests: The Marine Chemist shall carryout tests within each compartment or space, ensuring compliance with the minimum applicable requirements prior to issuing a Certificate.

Prior to Issue: The Marine Chemist's determinations shall include a visual inspection and tests of the spaces to be certified and the spaces adjacent thereto. The determinations shall include:

- The three previous cargoes
- The nature and extent of the work
- Starting time and duration of the work
- Tests of cargo and vent lines at the manifold and accessible openings
- Verification of the pipelines that could release hazardous materials into the work space have been blanked off or blocked off in a positive manner
- Tests of the heating coils

Writing the Certificate: When the Marine Chemist is satisfied that the related requirements necessary for the safe conduct of the work have or have not been met, a Certificate shall be prepared and the Certificate shall include:

- The frequency and type of additional tests, inspections or other qualifications the Marine Chemist specifies
- The conditions under which the Chemist is to be consulted or recalled
- Controls, qualifications and requirements, including PPE and devices to eliminate or minimize hazards and of limits to where the crew can work
- The instrument test results of the Marine Chemist's inspections and tests

Issuance: The Certificate shall be completed and a signature for receipt of the Certificate shall be obtained from the vessel's PIC, signifying the understanding of the conditions and limitations under which it was issued.

Additions: Any additions to or deletions from an issued Certificate after obtaining a signature for receipt shall render the Certificate invalid and require re-issuance.

Safe for Workers: The standard safety designation Safe for Workers as per NFPA No 306 and 29 CFR 1910.146 requires that the compartment or space so designated the following criteria shall be met:

- The oxygen content of the atmosphere shall be at least 19.5% and not greater than 22% by volume
- The concentration of flammable materials shall be below 10% of the lower explosive limit
- Any toxic materials in the atmosphere shall be within permissible concentrations at the time of inspection
- The residues or materials associated with the work authorized shall not be capable of producing uncontrolled toxic materials under existing atmospheric conditions

Control Measures: Once the Certificate has been issued and the proper control measures have been put into place, men can enter the space. Some of these controls may be as follows:

- IG. Or cargo lock-out, tag-out
- Forced ventilation
- Staging of rescue equipment
- Placement of a SCBA at the tank top
- Placement of SCBA within the tank
- Proper protective clothing must be worn
- Issuance of emergency escape breathing devices
- Personnel entry/exit time log is kept

No Hot Work: The space can now be considered safe for workers but the space is not safe for hot work.

Periodic Testing: The atmosphere within the space shall be periodically tested as necessary to ensure that the continuous forced air ventilation is preventing the accumulation of a hazardous atmosphere. If a hazardous atmosphere is detected you must:

- Have each worker leave the space immediately
- Evaluate the space to determine how the hazardous atmosphere developed
- Measures shall be implemented to protect employees from the hazardous atmosphere before any subsequent entry takes place

Hot Work Defined: You are doing hot work when you are making alterations, repairs, or other such operations and you are involved with:

- Riveting
- Welding
- Burning
- Grinding
- Drilling
- Any other operation that may cause a spark or other like fire-producing actions

Testing: The Marine Chemist shall carryout tests within each compartment or space, ensuring compliance with the minimum applicable requirements prior to issuing a Safe for Hot Work Certificate.

Procedures: The Certified Marine Chemist would follow the same procedures for a Hot Work Certificate as he would for any other Certificate. The only difference is the safe criteria to allow hot work in a compartment or space.

Criteria: The Safe for Hot Work Certificate as per NFPA No 306 and 46 CFR 35.01 requires that in the compartment or space so designated the following criteria shall be met:

- The oxygen content of the atmosphere shall not exceed 22% by volume;
- The concentration of flammable materials shall be below 10% of the lower explosive limit
- The residues, scale or materials shall be cleaned sufficiently to prevent the spread of fire and shall not be capable of producing a higher concentration than permitted under existing atmospheric conditions
- All adjacent spaces, containing or having contained flammable or combustible material shall be sufficiently cleaned of residues and scale to prevent the spread of fire or shall be inerted.

Not Safe: If any of the above conditions are not met, the designation Not Safe for Hot Work shall be used.

Chemist Options: The Marine Chemist has latitude with the adjacent space criteria and the hot work area. Whatever his decision is, it must be:

- Considered safe
- He must put it in writing on the certificate

Firewatch: Immediately before hot work is started the officer responsible for safety precautions should examine the area where hot work is to be undertaken. The following steps should be taken to help ensure safety:

- Fire-fighting equipment laid out and be ready for immediate use
- Fire watch posted at hot work sight
- Fire watch posted in adjacent space where heat could be a factor
- Monitoring of the area should be continued for sufficient time after completion of hot work

Welding Machine: Welding and other equipment employed should be carefully inspected before each occasion of use to ensure it is in good condition as per NFPA No 306 and 46 CFR 35.01. Where required it must be correctly grounded. Special attention must be paid when you are using electric equipment ensuring that:

- The electrical supply connections are made in a gas free space
- The existing supply wiring is adequate to carry the electrical current demanded without overloading
- The insulation of flexible electric cables laid across the deck is in good condition
- The cable route to the work site is the safest possible, only passing over gas free or inerted spaces
- The grounding connection is adjacent to the work site with the earth return cable led directly back to the welding machine

3.10 Emergency Procedure Tank Rescue

Introduction: Most fatalities in enclosed spaces have resulted from individuals entering the space without proper supervision or adhering to agreed upon procedures. Of those killed in confined spaces due to atmospheric conditions:

- 40% were the original victims entering into the space
- 60% were their would-be rescuers

Fatalities: There have been a great deal of fatalities due to the reaction of would be rescuers coming to the aid of their friends and becoming victims themselves. This initial reaction to attempt a rescue may cause one crewman after another to become victims in their attempts to rescue each other.

Rescue: If you were on deck and noticed a shipmate at the bottom of a tank apparently unconscious, the following should take place:

- The alarm raised
- Check tank atmosphere
- Ventilation to tank is checked
- The person reporting the emergency correctly states the location, nature of emergency and number of casualties involved
- The emergency squad is mustered
- The communication signals are reviewed
- The hoisting equipment is rigged
- Two persons enter the tank with a litter and SCBA's if required
- All persons entering and leaving tank are recorded
- The victim in the tank is put into the litter
- The victim is carefully hoisted from tank
- Commence immediate resuscitation treatment if required
- The emergency squad thoroughly searches tank for other casualties, unless all men are accounted for

All the emergency equipment is re-stowed and ready for immediate use.

Section 4

Pollution Regulations

Introduction:

For the most part, International and U.S. regulations are identical, with a few minor differences. In some cases the U.S. regulations are more stringent than the IMO rule. In those cases all vessels in U.S. waters must:

- Follow the more stringent U.S. regulation; except
- In specific instances where the CFR states that vessels following MARPOL are exempt, such as 33 CFR 157.12.

MARPOL 73-78:

As mentioned earlier in this course the International Regulations that govern vessel operations in regard to pollution prevention are contained in MARPOL 73/78. The annexes we are concerned with are:

- Annex I, covering pollution by oil
- Annex II, covering pollution by NLS
- Annex IV, containing the sewage regulations
- Annex V, referring to garbage

Regulations: OPA 90 and the Clean Water Act of 1970 as amended are the principal governing U.S. laws for water pollution. Some of OPA 90's changes are:

- Established work hours for crew members
- Established in port bottom clearances for single hulled barges as in 33 CFR 157.455
- All barges plying U.S. waters will be double hull by 2015

Subchapter 0: Subchapter 0 Pollution in 33 CFR contains the majority of U.S. National laws as well as the international laws found in MARPOL 73/78. Some of these rules are as follows:

- Part 151, vessels carrying oil, NLS, garbage, municipal or commercial waste and ballast water
- Part 153, the control of pollution by oil and hazardous substances, discharge removal
- Part 155, oil or hazardous material pollution prevention regulations for vessels
- Part 156, oil and hazardous material transfer operations
- Part 157, the rules for the protections of the marine environment relating to tank vessels carrying oil in bulk
- Part 159, marine sanitation devices

Regulations: In Subchapter 0 of 46 CFR you will find the rules for certain bulk dangerous cargoes. We are interested in:

- Part 150, compatibility of cargoes
- Part 153, vessels carrying bulk liquid, liquefied gas or compressed gas hazardous materials
- Part 154, the safety standards for self-propelled vessels carrying bulk liquefied gases

Discharge: Discharge is defined by 33 CFR 151.05 as any release, however caused, from a vessel and includes any:

- Escape
- Disposal
- Spilling

- Leaking
- Pumping
- Emitting
- Emptying

Marpol: MARPOL differs only slightly with the CFR definition of discharge. MARPOL defines discharge as related to harmful substances or effluent containing such substances, means any release, however caused from a vessel, and includes any:

- Escape
- Disposal
- Spilling
- Leaking
- Pumping
- Emitting
- Emptying

Declaration of Inspection

After an inspection under 35.3520, but before a transfer of cargo, fuel oil, or bunkers may commence as described in this section and 33 CFR 156.120 and 156.150, the person in charge of the transfer shall prepare, in duplicate, a Declaration of Inspection. The original must be kept aboard the vessel, and the duplicate provided to the terminal supervisor or that person's representative. The supervisor or the representative may, upon demand, inspect the vessel to determine whether its condition is as stated on the Declaration of Inspection.

The Declaration of Inspection may be in any form, but must contain at least: Declaration of Inspection Before Transfer of Liquid Cargo in Bulk Date____________________ Vessel____________________ Port of____________________ Product[s] being transferred(Classification[s] and Kind[s]) ____________________

The person in charge of the transfer of liquid cargo in bulk about to begin, do certify that I have personally inspected this vessel with reference to the following requirements set forth in 46 CFR 35.3520, and that opposite each of the applicable items listed below I have indicated whether the vessel complies with all pertinent regulations.

- Are warnings displayed as required?
- Is there any repair work in way of cargo spaces being carried on for which permission has not been given?
- Have cargo connections been made as described in 46 CFR 35.3515 and are cargo valves set?
- Have all cargo connections been made to the vessel's pipeline and not through an open-end hose led through a hatch?
- Are there any fires or open flames present on the deck or in any compartment which is located on, open or adjacent to or facing the main deck of the vessels on which the cargo connections have been made?
- Has the shore terminal or other tank vessel concerned reported itself in readiness for transfer of cargo?
- Are sea valves connected to the cargo piping system closed?
- If Grades, A, B, or C cargoes are to be loaded and boiler fires are lighted, has an inspection been made to determine whether these fires may be maintained with reasonable safety?
- If Grades A, B, or C cargoes are to be loaded and galley fires are lighted, has an inspection been made to determine whether the galley fires may be maintained with reasonable safety?
- If Grades A, B, or C cargoes are to be loaded, has an inspection been made to determine whether smoking is to be permitted in areas not on the weather decks?

4.2 Oil Record Book:

MARPOL 74/78 ANNEX I REVISED, REGULATION 36 (OIL RECORD BOOK, PART II - CARGO/BALLAST OPERATIONS)

Every oil tanker of 150 gross tonnage and above shall be provided with an Oil Record Book Part II (Cargo/Ballast Operations). The Oil Record Book Part II, whether as a part of the ship's official logbook or otherwise, shall be in the Form specified in appendix III to this Annex.

The Oil Record Book Part II shall be completed on each occasion, on a

tank-to-tank basis if appropriate, whenever any of the following cargo/ballast operations take place in the ship:

- loading of oil cargo;
- internal transfer of oil cargo during voyage;
- unloading of oil cargo;
- ballasting of cargo tanks and dedicated clean ballast tanks;
- cleaning of cargo tanks including crude oil washing;
- discharge of ballast except from segregated ballast tanks;
- discharge of water from slop tanks;
- closing of all applicable valves or similar devices after slop tank discharge operations;
- closing of valves necessary for isolation of dedicated clean ballast tanks from cargo and stripping lines after slop tank discharge operations; and
- disposal of residues.

For oil tankers referred to in regulation 34.6 of Annex I (< 150 GT), the total quantity of oil and water used for washing and returned to a storage tank shall be recorded in the Oil Record Book Part II.

In the event of such discharge of oil or oily mixture as a result of accidental or other exceptional discharge of oil not excepted by that regulation, a statement shall be made in the Oil Record Book Part II of the circumstances of, and the reasons for, the discharge.

Each operation described in this regulation shall be fully recorded without delay in the Oil Record Book Part II so that all entries in the book appropriate to that operation are completed. Each completed operation shall be signed by the officer or officers in charge of the operations concerned and each completed page shall be signed by the master of ship. The entries in the Oil Record Book Part II shall be at least in English, French or Spanish. Where entries in an official language of the State whose flag the ship is entitled to fly are also used, this shall prevail in case of dispute or discrepancy.

Any failure of the oil discharge monitoring and control system shall be noted in the Oil Record Book Part II.

The Oil Record Book shall be kept in such a place as to be readily available for inspection at all reasonable times and, except in the case of unmanned ships under tow, shall be kept on board the ship. It shall be preserved for a period of three years after the last entry has been made.

4.3 Air Pollution

This is a matter of growing international concern. Rules to control air pollution are included in Annex VI to MARPOL. Students should be aware that there may be local or national rules which must be complied with.

No international regime to control air pollution from ships applies today, although strict national rules apply in some ports. Air pollution from oil tanker operations may be caused by the loading and ballasting of tanks, as these operations result in inert gas and hydrocarbon gas being vented to the outside atmosphere.

Another operation resulting in air pollution is gas-freeing. If local regulations limit air pollution, special measures must be taken. These can take two forms, a vapor-return line or gas-vapor displacement. Vapor return entails transferring all gas displaced from cargo tanks to the installation ashore, this requires special provisions that are not normally found on oil vessels.

Gas-vapor displacement is not always possible. If a vessel is being discharged and cargo tanks are being ballasted, it is possible to contain the gas-vapor. In this case the venting system is closed to the outside atmosphere and the inert gas will be driven from the tanks being ballasted to those being discharged. The supply of inert gas must be adjusted to keep a slight positive pressure in the tanks.

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4.4 Water Pollution

RULES AND REGULATIONS

MARPOL ANNEX I (REVISED) REGULATION 34 (Cargo area of tanker)

Discharges outside special areas

Subject to the provisions of regulation 4 of this Annex and paragraph 2 of this regulation, any discharge into the sea of oil or oily mixtures from the cargo area of an oil tanker, shall be prohibited except when all the following conditions are satisfied:

OIL TANKERS OF ALL SIZES **Control of discharge of oil from tank areas including cargo pump room**	
Within special areas OR outside special areas, within 50 nautical miles (nm) from the nearest land	ANY DISCHARGES IS PROHIBITED, except clean or segregated ballast
Outside special areas, more than 50 nm from the nearest land	ANY DISCHARGE IS PROHIBITED, except clean or segregated ballast, or when: 1. the tanker is proceeding en route, and 2. the instantaneous rate of discharge of oil does not exceed 30 litres/nm, and 3. the total quantity of oil discharged into the sea does not exceed - 1/15,000 (for existing tankers) and/ - 1/30,000 (for new tankers) of the total quantity of the cargo which was carried on the previous voyage, and 4. the tanker has in operation a monitoring and control system for the discharge of oil, and slop tank arrangements as required by Regulation 15.

The tanker is not within a special area;

The tanker is more than 50 nautical miles from the nearest land;

The tanker is proceeding enroute;

The instantaneous rate of discharge of oil content does not exceed 30 liters per nautical mile;

The total quantity of oil discharged into the sea does not exceed for tankers delivered on or before 31 December 1979, as defined in regulation 1.28.1, 1/15,000 of the total quantity of the particular cargo of which the residue formed a part, and for tankers delivered after 31 December 1979, as defined in regulation 1.28.2, 1/30,000 of the total quantity of the particular cargo of which the residue formed a part; and

The tanker has in operation an oil discharge monitoring and control system and a slop tank arrangement as required by regulations 29 and 31

General requirements

Whenever visible traces of oil are observed on or below the surface of the water in the immediate vicinity of a ship or its wake, the Governments of Parties to the present Convention should, to the extent they are reasonably able to do so, promptly investigate the facts bearing on the issue of whether there has been a violation of the provisions of this regulation. The investigation should include, in particular, the wind and sea conditions, the track and speed of the ship, other possible sources of the visible traces in the vicinity, and any relevant oil discharge records.

No discharge into the sea shall contain chemicals or other substances in quantities or concentrations which are hazardous to the marine environment or chemicals or other substances introduced for the purpose of circumventing the conditions of discharge specified in this regulation.

The oil residues which cannot be discharged into the sea in compliance with this regulation shall be retained on board for subsequent discharge to reception facilities.

MARPOL ANNEX II (REVISED) REGULATION 13 (Noxious Liquid Substances)

Group	In all areas	
A, B and C	- ship is proceeding en route - minimum speed 7 knots (self-propelled) or 4 knots (not self-propelled) - at least 12 nautical miles from the nearest land - discharge below the waterline - minimum water depth 25 metres	
and	outside special areas	within special areas
A	Maximum concentration of tank washings 0.1 percent by weight	Maximum concentration of tank washings 0.05 percent by weight
B	- per tank max. 1 cubic metre or 1/3,000 of the tank capacity in cubic metres - concentration of the substance in the wake astern of the ship max. 1 ppm	- the tank has been precleaned, and the washings have been discharge to a reception facility - concentration of the substance in the wake astern of the ship max. 1 ppm
C	- per tank max. 3 cubic metres or 1/1,000 of the tank capacity in cubic metres - concentration of the substance in the wake astern of the ship max. 10 ppm	- per tank max. 1 cubic metre or 1/3,000 of the tank capacity in cubic metres - concentration of the substance in the wake astern of the ship max. 1 ppm
D	in all areas - ship is proceeding en route - minimum speed 7 or 4 knots - at least 12 nautical miles from the nearest land - max. one part of the substance in ten parts of water	

Discharge standards

Where the provisions in this regulation allow the discharge into the sea of residues of substances in Category X, Y or Z or of those provisionally assessed as such or ballast water, tank washings or other mixtures containing such substances the following discharge standards shall apply:

The ship is proceeding enroute at a speed of at least 7 knots in the case of self-propelled ships or at least 4 knots in the case of ships which are not self-propelled;

The discharge is made below the waterline through the underwater discharge outlet(s) not exceeding the maximum rate for which the underwater discharge outlet(s) is (are) designed; and

The discharge is made at a distance of not less than 12 nautical miles from the nearest land in a depth of water of not less than 25 meters.

Section 5

System Components, Pump Designs & Instruments

Introduction:

There are several piping systems to be found onboard tankers:

- Cargo systems
- Inert gas
- Vapor emissions
- Water in the firemain
- Water in the foam main

Each piping system has its own purpose and was designed to meet the needs of the system it serves. Each system was designed regarding the expected operating pressures and vacuums. Safety factors are designed such that the pipes will:

- Be stronger than needed for their designed use

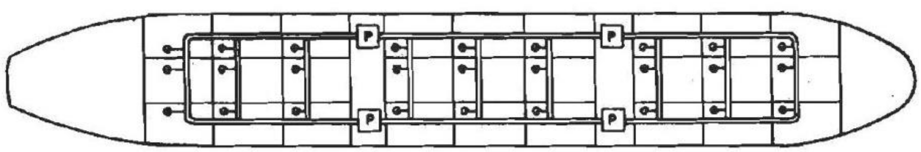
- Allow for wastage as the system ages
- Be in compliance with the regulations

However, exceeding the designed working pressure or the designed working vacuum may cause:

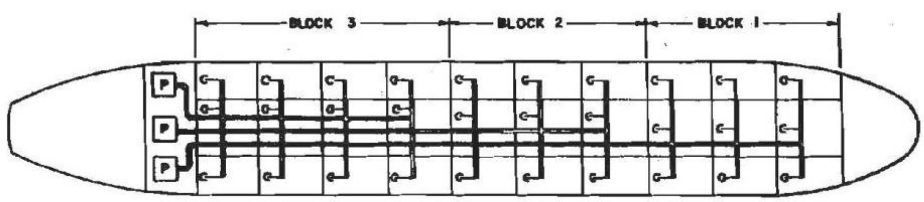
- Immediate failure of the system
- A pollution incident
- A shortened lifespan of the system

The pipe on most U.S. flag tankers is USCG/ABS Class II piping with a maximum working pressure of 225 psi. On initial outfitting the ABS requires that the cargo system piping be tested at 1.5 times the designed working pressure. The USCG requires annual testing of discharge piping at 1.5 times the maximum working pressure and stenciled with the date and pressure the piping was tested (33 CFR 156.170).

As well as the piping being designed for 1.5X the designed working pressure, relief valves are designed to open at a given set pressure and release the excess pressure. They must be fitted on the cargo pumps if the pumps are capable of exceeding the piping's maximum design pressure.



MODIFIED RING-MAIN SYSTEM FOR SPLIT GRADE CARGOES, WHICH CAN BE PUMPED INDEPENDENTLY.



DIRECT SYSTEM WITH THREE BLOCKS OF TANKS. EACH BLOCK IS SERVED BY ITS OWN PIPING SYSTEM AND CARGO PUMP.

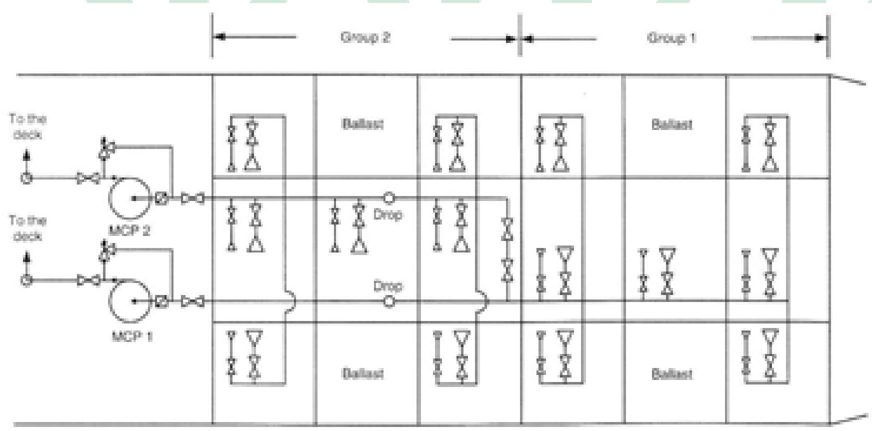
The traditional top and bottom cargo line configuration has the cargo pumps located in the pumproom which is normally aft. Cargo suction pipelines run from the pumps through the tank bottoms and connect to the cargo tank suction valves. Piping on the discharge side of the pumps carry the cargo up to the main deck via pumproom risers and deck discharge lines to the manifold.

Drops are usually fitted to the deck discharge lines between the manifold and the pumproom risers. They drop into the cargo suction pipelines.

Loading is carried out via the Mixmaster crossovers at the manifold, through the drops and the liquid is directed to the appropriate tank via the bottom suction lines, bypassing the pump. The pumps take suction on the cargo tanks through the tank bellmouths and the suction lines then pump it up the risers to the appropriate manifold cargo connection.

Bottom piping:

The cargo piping that network through the bottom of the tanks is called bottom piping. The two piping configurations that predominate on tank vessels equipped with this system are the direct piping system and the loop (ring main) system.



Deck piping:

Above deck piping generally consists of one or more discharge mains connecting the cargo pumps to the athwart ships manifold piping. The cargo manifold is the bitter end of the on-deck piping that forms the interface between the vessel and the shore facility. The manifold is generally located amidships and equipped with valves and blanks.

It is sound practice to always close the manifold valves when there is no active transfer of cargo. Securing the vessel piping in this manner is a precautionary measure against the possibility of cargo movement (gravitation) when the transfer has ceased. The end of the manifold is flanged to permit connection to the shore facility via flexible cargo hoses or mechanical arms.

Hydraulic Pipe

There is a hydraulic piping system on vessels with hydraulic:

- Deep well pumps
- Mooring winches;
- Cranes and davits

Exceeding DWP

Exceeding the designed working pressure or the designed working vacuum may cause:

- Immediate failure of the system
- A pollution incident
- A shortened lifespan of the system

Annual Test

The USCG requires annual testing of discharge piping at 1.5 times the maximum working pressure and stenciled with the date and pressure the piping was tested at as per 33 CFR 156.170.

Relief Valves

Relief valves are valves designed to open at a given set pressure and release that excess pressure and they must be fitted on the cargo pumps if the pumps are capable of exceeding the piping's maximum design pressure.

Hoses

Cargo hoses are designed to withstand the cargo pump relief valve setting, less static head, but never less than 150 psi as 33 CFR 154.500.

Traditional

The traditional top and bottom cargo line configuration has the cargo pumps located in the pumproom which is usually aft.

Suction Lines

Cargo suction pipelines run from the pumps through the tank bottoms and connect to the cargo tank suction valves.

Discharge Lines

Piping on the discharge side of the pumps carry the cargo up to the main deck via:

- The pumproom risers;
- The deck discharge lines; to
- The manifold.

Drops

The drops are usually fitted to the deck discharge lines between the manifold and the pumproom risers. They drop into the cargo suction pipelines.

Loading

Loading is carried out via the mix crossovers at the manifold, through the drops and the liquid is directed to the appropriate tank via the bottom suction lines, bypassing the pumproom.

Discharging

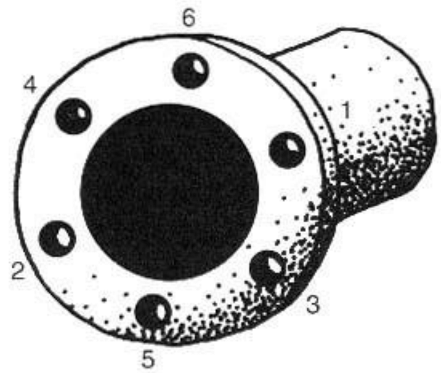
The pumps take suction on the cargo tanks through the tank bellmouths and the suction lines then pump it up the risers to the appropriate manifold cargo connection.

Flanges

When connections are made using bolted flanges, the following requirements must be met:

- Suitable gasket material must be used in the joints and couplings to make a leak-free seal. It is not advisable to double up on gaskets or to reuse them. Gaskets are generally constructed of a fiber or neoprene material; however, Teflon may be used in certain cargos.
- When ANSI flanges are employed, a bolt must be placed in every other hole at a minimum, and in no case should less than four bolts be used in the connection. Be aware that company policy usually specifies that a bolt be installed in every hole.
- When using non-ANSI flanges, a bolt must be placed in every hole.
- For permanently connected flanges, a bolt must be placed in every hole.
- Each nut and bolt should be uniformly tightened to distribute the load and ensure a leak-free seal. Any bolt exhibiting signs of strain, elongation, or deterioration should be removed from service.

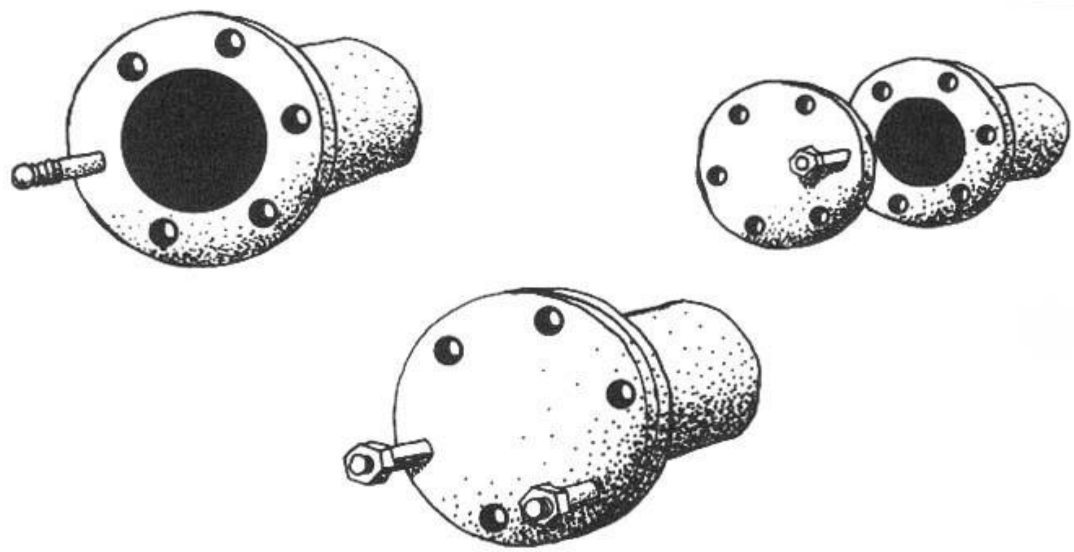
The proper sequence of tightening a typical bolt connection is shown.



Tightening a bolt circle

The proper way to tighten up a ring is to take the slack up evenly, then tighten gradually, alternating back and forth as shown in the drawing. Don't overdo it. Remember that a riser flange can be easily cracked by tightening the bolt circle unevenly; and that a little excess pressure on the wrench can strip the bolt threads or pull out the stud.

When it is necessary to install a blank (blind) flange on the manifold, refer to the figure below.



Blind flange

There is a right way and a wrong way to put a blind flange on a cargo riser. The wrong way produces damaged fingers and dented toes. This is unnecessary. Do it the right way:

1. Stick a bolt through in a bottom off-center hole.
2. Pick up the flange with both hands and hang it on the bolt using any hole in the flange. Start a nut on the bolt. The flange is now completely under control and cannot be dropped.
3. Rotate the flange and stick a bolt through in the other bottom off-center hole. These two bolts will catch the gasket.
4. Put gasket in place.
5. Insert remainder of bolts and tighten.

5.1 Cargo Hoses and Mechanical Loading Arms

Examination before Use:

It is the responsibility of the terminal to provide hoses which are in good condition but the PIC-Tankerman may reject any which appear to be defective.

Before being connected, hose strings should be examined for any possible defect which may be visible in the bore or outer covers such as blistering, abrasion, flattening of the hose or evidence of leaks.

Hoses to be used should have been pressure tested to manufacturer's specifications at intervals which are in accordance with the manufacturer's recommendations. Intervals between tests should not in any case exceed one year. The date of such pressure testing should be indicated on the hose. Hoses for which the rated pressure has been exceeded must be removed and retested before further use.

Handling, Lifting and Suspending:

Hoses should always be handled with care and should not be dragged over a surface or rolled in a manner which twists the body of the hose. Hoses should not be allowed to come into contact with a hot surface such as a steam pipe. Protection should be provided at any point where chafing or rubbing can occur.

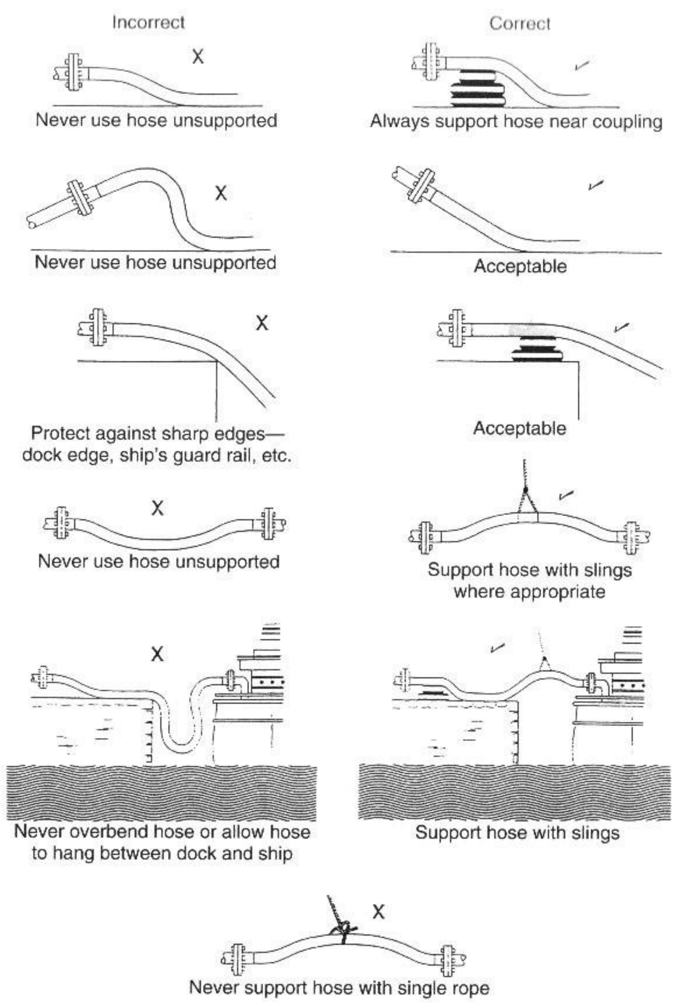
Lifting bridles and saddles should be provided. The use of steel wires in direct contact with the hose cover should not be permitted. Hoses should not be lifted at a single point with ends hanging down but should be supported at a number of places so that they are not bent to a radius less than that recommended by the manufacturer.

Excessive weight on the vessel's manifold should be avoided. If there is an excessive overhang, or the vessel's valve is outside the stool support, additional support should be given to the manifold. A horizontal curved plate or pipe section should be fitted at the vessel's side to protect the hose from sharp edges and obstructions.

Adequate support for the hose when connected to the manifold should be provided. Where this is a single lifting point, such as a derrick, the hose string should be supported by bridles or saddles.

Adjustment During Cargo Handling Operations:

As the vessel rises or falls a result of tide or cargo operations, the hose strings should be adjusted so as to avoid undue strain on the hoses, connections and ship's manifold and to ensure that the radius of curvature of the hose remains within the limits recommended by the manufacturer.



Mechanical Loading Arms:

Shore facilities that accommodate large vessels and have high cargo transfer rates frequently use mechanical loading arms, which are steel pipes that telescope to make the connection with the vessel manifold. These are often referred to as "chicksans."

Mechanical arms are controlled hydraulically and employ swivel joints which enable them to follow the movement of the vessel at the berth. Although steel arms are capable of handling greater pressures and flow rates than hoses, the person-in-charge should be aware of several concerns with their use.

Mechanical arms have limited operating envelope, which means they are much less forgiving than cargo hoses when the vessel begins to surge or drift at the dock. The facility PIC should take this into account when spotting the vessel and properly tend the moorings to ensure the vessel stays in position at the berth.

- Most mechanical loading arms employ some form of quick-connect coupling such as hydraulic clamps or Cam-Locks when connecting to the manifold. As in the case of cargo hoses, it is imperative that suitable gasket material or O-rings be installed in the connection to maintain a leak-free seal.
- In the United States mechanical loading arms must meet the design, fabrication, material, as well as inspection and testing requirements.
- At the end of a cargo transfer there must be a means to drain or close off the arm prior to breaking the connection.

Operating Envelope:

Each installation of metal arms has a designed operating envelope which takes into account the elevation changes resulting from the tide, the freeboard of the largest and smallest tankers for which the berth was intended, minimum and maximum manifold setbacks, limited changes in horizontal position due to drift off and ranging, and maximum and minimum spacing when operating with other arms in the bank. The limits of this envelope should be thoroughly understood by operators because operating outside it can cause undue stress. Metal arm installations should have alarms for excessive range and drift.

The PIC-Tankerman at the berth should ensure that the vessel's manifolds are kept within the operating envelope during all stages of loading and discharging operations.

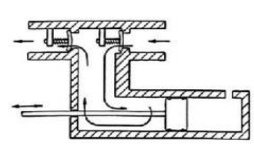
Forces on Manifolds:

Most arms are counterbalanced so that no weight other than that of the liquid content of the arm is placed on the manifold. As the weight of oil in the arms, particularly the larger diameter arms, can be considerable it may be advisable for this weight to be relieved by a support or jack. Some arms have integral jacks which are also used to avoid over stressing of the tanker's manifold by the weight of the arm or other external forces such as the wind.

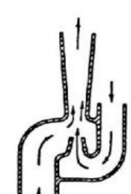
5.2 Pumps:

On any vessel it is possible to have several types of cargo pumps for the many required uses. Some of these pumps and services are:

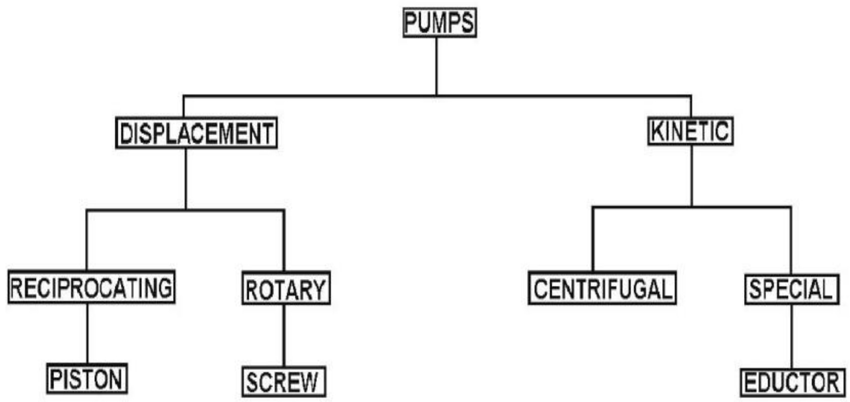
- Centrifugal pumps would be used for the discharge of the bulk of the cargo;
- Stripping pumps would be used for pumping the last of the cargo ashore; and
- Eductors would be used for stripping and tank cleaning.



RECIPROCATING PUMP



EDUCTOR



Common Pump Types

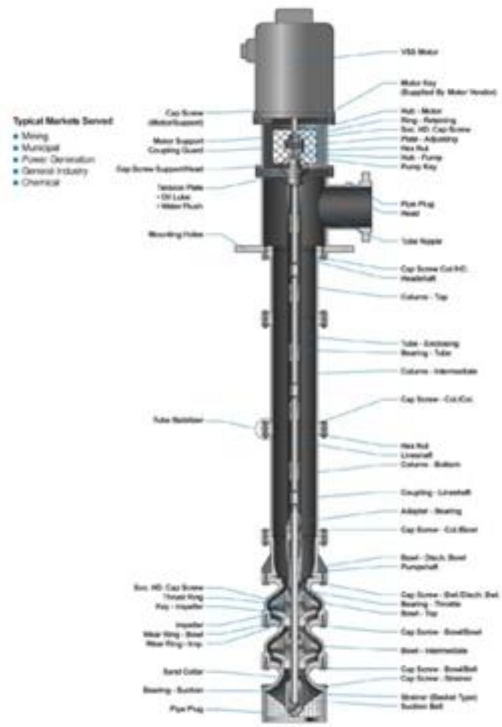
Common Pump Designs

Centrifugal Pump:

The centrifugal pump is the most commonly used pump today for transferring cargo. Centrifugal force is the basis for the operation of the pump. The impeller rotates at a high speed and:

- The liquid is fed in at the pump's center;
- The spinning of the impeller forces the liquid toward the periphery; where
- The shape of the pump casing causes the liquid to flow into the discharge piping.

Centrifugal pumps are most efficient when pumping large volumes at low to moderate pressures. Deepwell pumps are centrifugal, hydraulically or electrically driven submerged cargo pumps. The bottom of the pump is usually submerged in a sump in the after bottom of a tank. The pumps are totally enclosed with the impeller at the bottom of the pump and they are usually placed in each cargo tank, eliminating the need for bottom piping and the pumproom. Ships fitted with deepwell pumps have no bottom lines. Each tank has an encased deepwell cargo pump located at the after inboard section of each tank. Each pump has its own discharge pipe running to the manifold. When the pump is running it will pump cargo up the pump casing to the manifold via the discharge pipe.



Centrifugal pumps may be classified in several ways. For example, they may be either single-stage or multi-stage. A single-stage pump has only one impeller; a multistage pump has two or more impellers housed together in one casing. In a multistage pump, each impeller usually acts separately, discharging to the suction of the next stage impeller. Centrifugal pumps are also classified as horizontal or vertical, depending on the position of the pump shaft. Impellers used in centrifugal pumps may be classified as

single-suction or double-suction, depending on the way in which liquid enters the eye of the impeller.

Positive Displacement Pump:

A positive displacement pump will discharge the volume of liquid it suctioned through it during each cycle of operation. If the liquid flow is blocked, the pressure will rise rapidly in the positive displacement pump. Examples of these pumps are:

- Reciprocating pumps
- Screw pumps
- Lobe pumps

Positive displacement pumps are generally used as stripping pumps because they are most efficient at pumping small volumes at high pressures.

Eductors make use of a physical phenomenon known as the venturi effect. A driving fluid is pumped through a nozzle that creates:

- A radical increase in the fluid's velocity
- A vacuum near the nozzle
- A suction at the nozzle

Eductors are self-priming and efficient in stripping systems, but the driving fluid and the fluid being pumped must be compatible because they will become common and discharge into the same tank.

5.3 Pump Theory

Pump Theory:

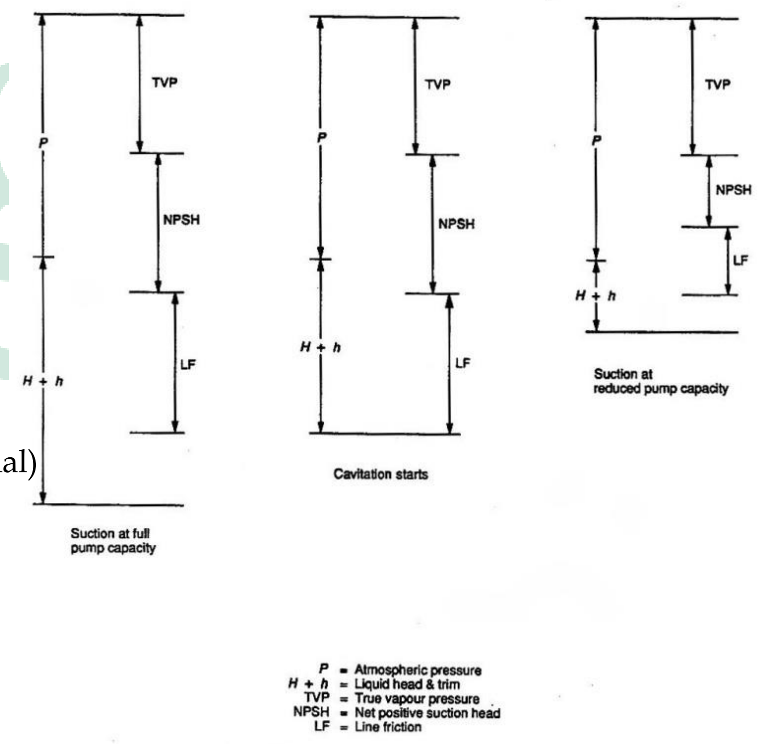
Strictly speaking, a pump does not draw up a liquid, but rather creates a vacuum on the suction side, allowing atmospheric pressure to push the liquid into the pump. In theory, a pump could therefore draw up a liquid column corresponding to the atmospheric pressure, which equals about 10 meters of water (for which the relative density is 1)

In practice, the situation is different. Theoretically suction height is influenced in a positive way by atmospheric pressure, inert gas pressure and the height of liquid in the tank; it is negatively influenced by the net ***positive suction head*** (NPSH) of the pumps, frictional losses in the pipelines, true vapor pressure of the liquid being pumped, and the height of pump and suction piping above the tank bottom. All these can be expressed in meters liquid column.

The NPSH of a pump is a combination of friction and vacuum losses associated with a particular pump on board. These losses can be reduced by decreasing fluid velocity (the flow) through a pump.

Piping friction is caused by the liquid passing through the suction piping, and depends on the length of piping, the number of valves, bends and fluid velocity. Again, frictional losses may be reduced by decreasing the flow. The height of the liquid column can be improves by trimming the vessel. The order of magnitude of the different factors involved is shown below. Disregarding the column of liquid in the tank, the sum of negative factors will equal or nearly equal 10 meters for a liquid of relative density of 1, whatever combination of factors is taken.

To appreciate the significance of the factors involved, the figure below shows them balanced against each other. It is clear that there will be suction when positive factors are larger than the negative ones. If the opposite holds true, there will be cavitation, and suction stops.



P+ H+ h > NPSH+ LF+TVP(pumping normal)

P+ H+h = NPSH+LF+TVP(cavitation)

P+ H+h < NPSH+LF+TVP(no suction)

Factors Affecting Suction

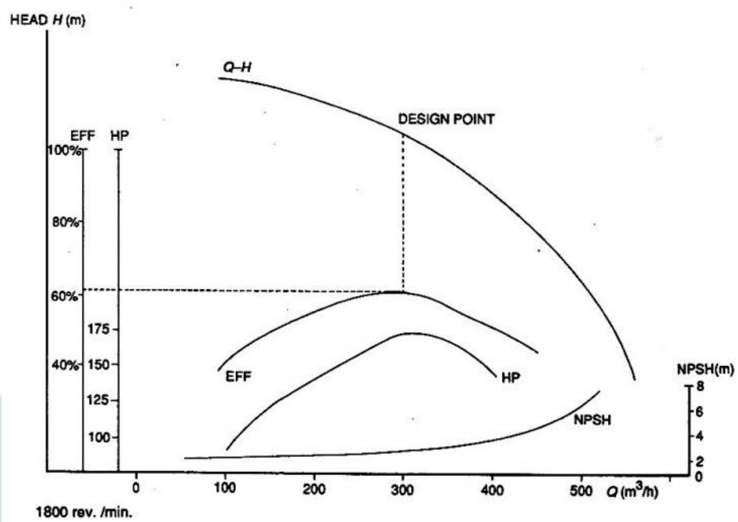
Factor	Liquid Column	Remarks
NPSH	4-5m	Single-stage pump
Line friction (LF)	1-5m,ormore	Depending on tank, number of valves and bends
Vapor pressure(TVP)	5-9m	Gulf area crudes
Pump+line above bottom	2-2.5m	Depending on ship type
Trim(h)	0-3.5m	Depending on location of tank and phase of discharge
Liquid level (H)	0-tankheight	Depending on phase of discharge
Atmospheric pressure(P)	10m(32.81ft)	Depending on weather, inert gas

As the maximum available suction head is approached, bubble pressure is reached and vapor forms thorough out the liquid, i.e. the liquid boils. During a short period of time a liquid/vapor mixture of varying relative density is created. The resulting fluctuations in pressure (caused by the liquid column being drawn in) and in pump power can be observed as fluctuations in discharge pressure and in revolutions of the pump.

Cavitation occurs and the rattle of imploding bubbles can be heard distinctly. Since a mixture of liquid and vapor is being pumped, the liquid velocity in the suction piping decreases, line resistance decreases and suction is maintained for a short while. Soon only vapor will be drawn in and the flow will stop, even though a considerable quantity of oil may remain in the tank.

If the pump is to be kept working, both NPSH and line resistance may be influenced by reducing the discharge rate. The lower liquid velocity reduces both line resistance and NPSH, ensuring that the bubble- point pressure is not reached.

The characteristics of a given pump can best be seen in a set of curves for a set pump speed; several sets are usually given to cover a range of speeds. The figure shows such pump characteristics of a centrifugal pump running at 1800 rpm.



Q = Discharge rate
EFF = Pump efficiency
HP = Power consumption
(R.D. of liquid = 1.0)
NPSH = Net positive suction head

The vertical axis shows the scales for the various curves, while the horizontal axis shows the discharge rate as a function of head, expressed in meters of liquid column. To every pump speed there is a Q-H curve which gives the relationship between head and discharge rate. If the head is known, it is possible to determine the discharge rate. Head, it should be noted, is not equal to backpressure. To convert backpressure into head, the difference between backpressure and suction pressure should be converted into meters water gauge and divided by the relative density of the liquid being pumped. The design point marked on the curve represents the most economical working condition of the pump. This is also reflected in the efficiency curve (EFF). Other curves to be seen are NPSH and power consumption of the pump in horsepower (HP)

At 1800 rpm, the pump is operating somewhere along curve Q-H curve. The actual point depends on where the Q-H curve crosses the shore curve, which represents the pressure a pump has to work against. The pressure is partially static, depending on the difference in height between liquid levels ashore and on board, and partially dynamic, owing to line resistance.

Pumps running in parallel have a common Q-H curve which can be constructed by adding the curves horizontally. It is interesting to note that if the shore curve is steep, i.e. if backpressure is high, the difference in output between one pump and more than one pump is not great, in contrast to the situation where the shore curve is more gradually inclined, representing low backpressure.

5.5 Pressure Surge:

A pressure surge is generated in a pipeline system when there is an abrupt change in the rate of flow of liquid in the line. In tanker operations it is most likely to occur as a result of one of the following during loading:

- Closure of an automatic shutdown valve.
- Slamming shut of a shore non-return valve.

- Slamming shut of a butterfly type valve.
- Rapid closure of a power operated valve.

If the pressure surge in the pipeline results in pressure stresses or displacement stresses in excess of the strength of the piping or its components, there may be a rupture leading to an extensive spill of oil.

Generation of Pressure Surge:

When a pump is used to convey liquid from a feed tank down a pipeline and through a valve into a receiving tank, the pressure at any point in the system while the liquid is flowing has three components:

- Pressure on the surface of the liquid in the feed tank. In a tank with its ullage space communicating to atmosphere this pressure is that of the atmosphere.
- Hydrostatic pressure at the point in the system in question.
- Pressure generated by the pump. This is highest at the pump outlet, decreasing commensurately with friction along the line downstream of the pump and through the valve to the receiving tank.

Of these three components, the first two can be considered constant during pressure surge and need not be considered in the following description, although they are always present and have a contributory effect on the total pressure.

Rapid closure of the valve superimposes a transient pressure upon all three components, owing to the sudden conversion of the kinetic energy of the moving liquid into strain energy by compression of the fluid and expansion of the pipe wall. To illustrate the sequence of events the simplest hypothetical case will be considered, i.e. when the valve closure is instantaneous, there is no expansion of the pipe wall, and dissipation due to friction between the fluid and the pipe wall is ignored. This case gives rise to the highest pressures in the system.

When the valve closes, the liquid immediately upstream of the valve is brought to rest instantaneously. This causes its pressure to rise by an amount P in any consistent set of units:

$P = WAV$

- Where: W is the mass density of the liquid.
- A is the velocity of sound in the liquid.
- V is the change in linear velocity of the liquid i.e. from its linear flow rate before closure.

The cessation of flow of liquid is propagated back up the pipeline at the speed of sound in the fluid, and as each part of the liquid comes to rest its pressure is increased by the amount P. Therefore a steep pressure front of height P travels up the pipeline at the speed of sound; this disturbance is known as a pressure surge.

Upstream of the surge, the liquid is still moving forward and still has the pressure distribution applied to it by the pump. Behind it the liquid is stationary and its pressure has been increased at all points by the constant amount P. There is still a pressure gradient downstream of the surge but a continuous series of pressure adjustments takes place in this part of the pipeline which ultimately result in a uniform pressure throughout the stationary liquid. These pressure adjustments also travel through the liquid — at the speed of sound.

When the surge reaches the pump the pressure at the pump outlet (ignoring the atmospheric and hydrostatic components) becomes the sum of the surge pressure P and the output pressure of the pump at zero throughput (assuming no reversal of flow), since flow through the pump has ceased. The process of pressure equalization continues downstream of the pump. Again taking the hypothetical worst case, if the pressure is not relieved in any way, the final result is a pressure wave that oscillates throughout the length of the piping system.

In this simplified description, therefore, the liquid at any point in the line experiences an abrupt increase in pressure by an amount P followed by a slower, but still rapid, further increase until the pressure reaches the sum of P and the pump outlet pressure at zero throughput.

In practical circumstances the valve closure is not instantaneous and there is thus some relief of the surge pressure through the valve while it is closing.

At the upstream end of the line some pressure relief may occur through the pump and this would also serve to lessen the maximum pressure reached. If the effective closure time of the valve is several times greater than the pipeline period, pressure relief through the valve and the pump is extensive and a hazardous situation is unlikely to arise.

Downstream of the valve an analogous process is initiated when the valve closes, except that as the liquid is brought to rest there is a fall of pressure which travels downstream at the velocity of sound. However, the pressure drop is often relieved by gas evolution from the liquid so that serious results may not occur immediately, although the subsequent collapse of the gas bubbles may generate shock waves similar to those upstream of the valve.

5.6 Cargo Pump Definitions

Design Point: The design point is the point on the pump performance curve that corresponds to the Best Efficiency Point.

Head: The head is the vertical distance between the level of the pump and the top level of the liquid in the tank being discharged.

Suction Head: Suction head is the term expressing positive pressure at the pump suction.

NPSH: Net positive suction head is the positive head of fluid required at the pump suction over and above the liquid vapor pressure to prevent capitation at the pump impeller.

Velocity Head: The velocity head is equivalent backpressure due to the movement of a fluid. It is calculated by dividing the velocity in ft. /sec by twice the acceleration of gravity.

Discharge Head: The discharge head is the amount of pressure due to the sum of discharge factors:

- The vertical height of discharge
- The velocity head
- Any friction losses

Suction Lift: The suction lift is the sum of losses at the suction that must be overcome by the pump. It consists of the sum of:

- Vertical lift
- Friction losses
- Entrance losses

Total Head: Total head is the sum of suction lift and discharge head.

Static Head: Static backpressure or static head is the difference in the liquid levels of the tank being pumped from and the tank being pumped into.

Dynamic BP: Dynamic backpressure is the static backpressure plus the total resistance to flow in the connecting pipeline.

Cavitation: Cavitation is a process that occurs within the impeller of a centrifugal pump when the pressure at the inlet falls below the vapor pressure of the liquid being pumped. Vapor bubbles form:

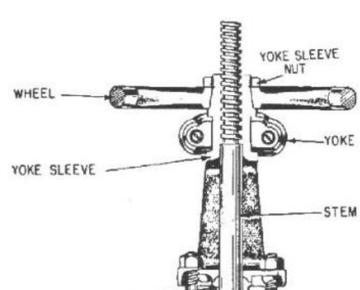
- In the lower pressure regions of the impeller
- Collapse in the higher pressure regions

Collapse: The vapor bubbles collapse with considerable impulse force. This force can be strong enough to cause the impeller to self-destruct.

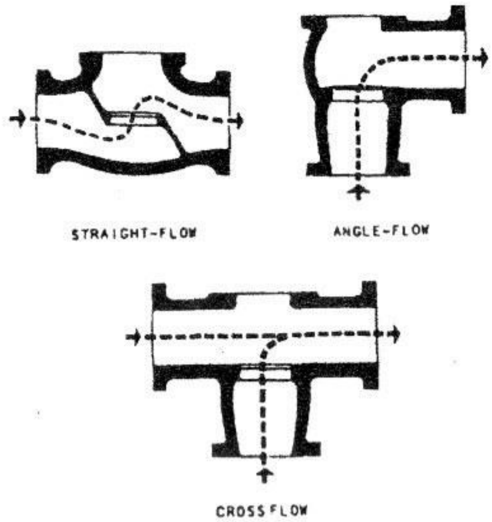
5.7 Valves

Introduction: Numerous types of valves are available for vessel systems designers to choose from. They may be classified according to construction or the manner in which they operate.

Gate Valve: Gate valves are what most people think of when they think of a valve. A flat plate in the body of the valve seals off liquid flow when fully closed and allows full flow when fully opened. This type of valve may be throttled to allow partial flow.

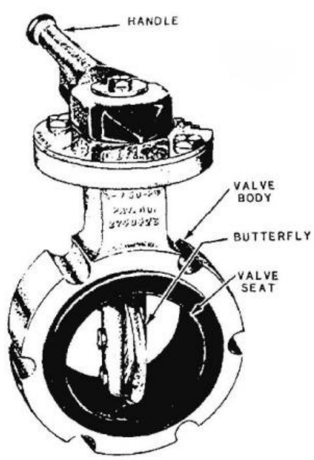


Globe Valve: Globe valves have a circular seat upon which a globe sits to close the valve. Since this design requires a 90° change of direction for the flowing liquid, friction within the valve is higher than in a gate valve.



The globe valve does not throttle as well as a gate valve but it provides a more positive closed seal when the valve is in good condition.

Butterfly Valve: The working parts of butterfly valves are entirely enclosed within the cross section of a pipe. A disc is rotated in a plane 90° to the direction of flow.

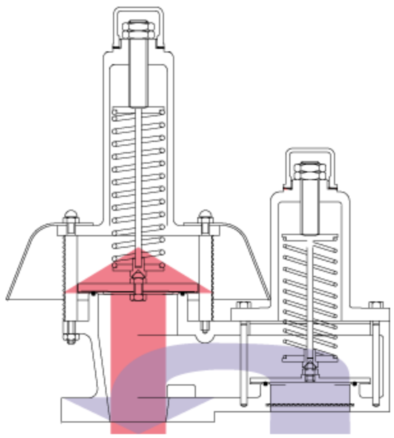


Open or Closed: The butterfly valve is either:

- Fully open; or
- Fully closed.

No Throttling:	Throttling is not really possible and the closed seal is not as good as the globe or gate valves.
Quick Action:	The advantage to the butterfly is that they are naturally quick acting and their operation is easily automated.
PV Valve:	A PV valve is a self-actuated valve that will operate in response to an overpressure or a vacuum in excess of the set points. It is really two valves in one in that it responds to the forces of:

- Pressure; and
- A vacuum.



Manual:	Manually operated valves are valves actuated by hand either at the valve itself or remotely by means of a reach rod.
Quick Close:	A quick closing valve is any valve that is designed or modified to move to the closed position quickly.
Naturally Quick:	The butterfly valve is naturally quick closing whether operated manually or by remote control.
Spring Modified:	A manual gate or globe valve can be made quick closing by adding a spring mechanism to make the valve close automatically when a holding lock or pin is released.

Remote Control: A remote control valve is any valve where the operation of which has been automated, so that it may be actuated from a remote location. Some vessel's cargo control rooms have controllers where they can open and close valves such as:

- Tank suction valves
- Manifold valves
- Drop valves

Most Common: The most commonly found remote control valve is the butterfly valve because of the ease with which it can be automated.

Pneumatic: Pneumatic valves are those automated valves controlled by high pressure airflow.

Motor: Motor operated valves are controlled by a motor and are usually installed on large valves.

Excess-flow: Excess-flow valves are hydraulic valves kept under a constant pressure. Variations in the pressure control the valve's position.

Normally Closed: The most common configuration is to have the valves set to be normally closed so that if pressure is lost, all valves on the system will close.

Relief Valves: Safety relief valves are valves that are closed under normal conditions of operation. The valve will automatically open if pressure exceeds a certain value and relieve the pressure.

Safety Valve: A safety valve on a cargo system would have its relief pressure set just above the maximum allowable working pressure

5.8 Instrumentation

Introduction: Modern technology has given systems designers the capability to remotely measure any number of physical states and quantities. The most common remotely measured items on barges are:

- Cargo tank levels
- Cargo temperatures
- Tank atmospheres
- Pipeline pressures
- Pump performances
- Drafts

Read-outs: The measured quantities can be used to automatically calculate others. The cargo tank level readout can be calibrated to read out as a tank volume in barrels or meters.

Telemetry: The transmission of the measured data from the remote location to the readout is known as telemetry. Components of telemetry systems are the:

- Transducer
- Measuring transmitter
- Controller
- Pneumatics

Transducer Transmitter: The transducer is a device which converts information from one physical form at its input to another at its output.

Types: A measuring transmitter is a device that converts the measured quantity into a signal that is easily transmitted long distances with little signal loss.

- Both pneumatic and electrical transmitters are used on vessels.

Controller: The controller is a device that compares the signal from the transmitter to:

- A signal representing the set-point
- Automatically operates the controlling mechanism to adjust the manipulated device

Span: The span is the range of values over which a meter is set to indicate, or a device is set to operate.

Adjustment: A span adjustment is part of the calibration process.

Zero: Zero is the minimum value of the measurement or control range.

Pneumatic: Pneumatic means air operated.

Electronic to Air: This converter is typically used to convert a control signal for a valve into an air signal used by the valve's positioner.

Value Converted: All values that are measured remotely are converted into a signal, either:

- Pneumatic; or
- Electrical

Control Signal: The signal for any of the measured values can also be used as a control signal for other equipment. The signal corresponding to a certain level in the tank can be tapped to:

- Ring an alarm
- Shut down pumps
- And close valves

Activate Alarm: In the first case the measurement signal has been used to activate a high level alarm and in the second case for an emergency shutdown.

Shut Down: Any of the measured values can be used to provide a signal that will shut off a system or any part of it.

Section 6

Loading and Discharging Operations

Introduction:

In this section we will look at loading the vessel and take you from receiving the cargo orders through finishing the load and preparing the vessel to get underway. Some of these steps we will go through are:

- Planning the load
- Preparing the vessel for dock arrival
- Preparing for loading at the berth
- Loading
- Transferring cargo custody
- Securing from the loading operations;
- Preparing to get underway

Voyage Orders: The first step in planning the load is a careful examination of the cargo or voyage orders. The information should be explicit and you should have no questions. Your voyage orders should contain the following:

- Loading terminal and port
- Volume to load
- Product grade
- API
- Cargo temperature
- Special terminal requirements
- Heating requirements
- Any product special properties
- Discharge terminal and port
- Volume to discharge

Sources: If any of this information is missing you will have to find it from other sources such as:

- Your files from past voyages
- Who issued the cargo orders?
- The loading terminal

Develop a Plan: Developing the loading plan is one of the PIC Tankermen most challenging tasks. Information must be gathered from a variety of sources and placed in a comprehensible form from which the final loading plan is developed. You must determine if the vessel can:

- Cargo specifications and preferred order of loading
- Whether or not the cargo includes toxic components, for example H_2S Benzene, etc.
- Tank venting requirements
- Any other characteristics of the cargo requiring attention, for example high true vapor pressure
- Flashpoints (where applicable) of products and their estimated loading temperatures, particularly when the cargo is non-volatile
- Nominated quantities of cargo to be loaded
- Maximum shore loading rates
- Standby time for normal pump stopping
- Maximum pressure available at the berth cargo connection
- Deal with cargo expansion during the voyage
- Load the cargoes simultaneously
- Discharge the cargo in the ordered sequence

Revise Plan: If one or more of the above is negative, you will have to work out a different load from the orders as close to the ordered volumes as you can. After doing this you will have to:

- Present the reasons the orders cannot be complied with
- Wait for new cargo orders from the charterer
- Work on the new plan when the orders come in

Accept Orders: Once it has been determined that the vessel can carry the revised cargo deadweight and volume, then the:

- PIC Tankerman will formally accept the orders
- The plan will start to fall into place
- The final layout of the cargo can begin

Load Planning: The proposed cargo layout is now finished and the final planning can continue. To finalize the load plan you must:

- Calculate the stop ullages
- Determine the manifolds you will use
- Determine the loading sequence
- Assign the maximum loading rate
- Assign the spill tanks

Load Plan: The load plan should also contain the following:

- The total quantity of each grade
- The final ullage for each tank
- The segregations for each grade (if any)
- The pipelines to be used for each grade
- Precautions to be taken to prevent cross-contamination
- The maximum and desired loading rates
- Operating pressure
- Any final tank preparations to be taken prior to loading
- Vessel or shore stop information

Custodial Duties: Custodial duties should be written into the plan such as:

- The amount of samples to take
- Information on gauges and gauging
- The vessel's record keeping requirements

6.1 Pre-Arrival Preparations for Dock

Preparations:

This section discusses the physical preparations that are carried out prior to arrival at the load port. The actions may include such items as:

- Details of last cargo carried, method of tank cleaning (if any) and state of the cargo tanks and lines
- Where the vessel has part cargoes on board, grade, volume and tank distribution
- Maximum acceptable loading rates and topping off rates
- Maximum acceptable pressure at the barge/shore cargo connection during loading
- Cargo quantities acceptable from terminal nominations
- Proposed disposition of nominated cargo and preferred order of loading
- Maximum acceptable cargo temperature (where applicable)
- Maximum acceptable true vapor pressure (where applicable)
- Proposed method of venting
- Quantity, quality and disposition of slops
- Quality of inert gas (if applicable)
- Lineup of the cargo systems
- Preparing the manifold
- Check the vapor emissions control
- Line up the firefighting equipment
- Check the containment systems are in compliance
- Ensure that pollution prevention requirements are met

Inspection of Cargo Tanks Before Loading:

Where possible, inspection of vessel's tanks before loading cargo should be made without entering the tanks.

A tank inspection can be made from the deck using ullage or sighting ports with, where applicable, the inert gas within the tank maintained at its minimum positive pressure. Care must be taken by the person inspecting not to inhale vapors or inert gas when inspecting tanks which have not been gas freed.

Frequently tank atmospheres which are, or have been, inerted have a blue haze which, together with the size of the tanks, makes it difficult to see the bottom even with the aid of a powerful torch or strong sunlight reflected by a mirror. It may sometimes be necessary to remove tank cleaning opening covers to sight parts of the tank not visible from the ullage ports but this should only be done when the tank is gas free, and the covers must be replaced and secured immediately after the inspection.

If, because the cargo to be loaded has a critical specification, it is necessary for the inspector to enter a tank, all the precautions must be followed. Before entering a tank which has been inerted, it must be gas freed for entry and, unless all tanks are gas freed and the IGS completely isolated, each individual tank to be entered for inspection must be isolated from the IGS.

Inert Arrivals:

If the vessel is to arrive with the tanks stripped and in the inserted condition you must do thing a little differently. You should insure the tanks are:

- Stripped dry
- Purged of the hydrocarbon content down to 40% or less of the LFL with IG
- At an 0_2 content of 8% or lower
- There is positive IG pressure in the tanks

Final Checks: To save time and confusion at the dock you should do your final checklist prior to berthing. Some of these final checks are:

- Mooring lines are pulled and ready
- Reducers and spool pieces are in place
- Manifold's mix-PIC Tankerman is lined up correctly
- Main deck crossovers and blocks are lined up correctly
- Valves are positioned correctly
- Vapor control system is lined up correctly
- Check the high level alarms
- Firefighting equipment is lined up
- Containment system is properly set up
- Oil spill gear is in place

6.2 Loading the Vessel

Gaugers Aboard: Once the vessel is securely moored the tank inspectors will board the vessel. They will inspect the tanks for cleanliness; and suitability to receive the intended cargo.

Connect Hoses: The hoses must be connected to the proper manifolds. The Person-In-Charge should be present while the hoses and ground wire are connected and must verify that they have been properly connected as per 33 CFR 156.160.

Conference: The Pre-transfer Conference is the regulatory requirement 33 CFR 156.120 and it states the items that must be covered during this conference between the Persons-In-Charge of the transferring and receiving units shall:

- Identify the product(s) to be transferred
- Name the sequence of transfer operations
- Agree on the transfer rate
- Identify the persons or title and location of each person participating in the transfer operation
- Give details of the transferring and receiving systems
- State the critical stages of the transfer operation
- Acknowledge the federal, state and local rules that apply to the transfer
- Display the emergency procedures
- Confirm the spill containment procedures
- Confirm spill reporting procedures
- Confirm the watch or shift arrangements
- Agree that the Persons-In-Charge may begin the transfer operation

The Declaration:

You must fill out the DOI or the equivalent Vessel/Shore Safety Checklist recommended prior to loading. Both Persons-In-Charge are required to:

- Check off all items on this checklist
- Sign off on this checklist
- All reliefs must also sign at each watch change
- Check off each item on the checklist

The purpose of the Check List is to ensure the safety of both vessel and terminal and of all personnel and it should be completed jointly by a responsible officer and the terminal representative. Each item should be verified before it is ticked. This will entail a physical check by the two persons concerned and will be conducted jointly where appropriate. It is of no value if it is merely regarded as a paper exercise.

Communications: 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 adequately tested. A secondary stand-by system should also be established and agreed. Allowance should be made for the time required for action in response to signals. These systems should include signals for:

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

Start of Cargo: When you are ready to start the load you should start with one product into one tank. Open that tank valve and then:

- Open all valves between tank and manifold
- Open the manifold valve last
- Inform the shore that you are ready to begin
- Start cargo flow slowly into one tank
- Get a header sample for the product
- Verify that cargo is only flowing to that tank

Cushioning: Filling slowly to cover the bell mouth is called bottom cushioning. Coast Guard guidelines advises a slow flow starting rate for most petroleum based products to test the system prior to bringing it up to the agreed upon rate. When putting the cushion in you should:

- Check the opposite manifold for leaks
- Check the hose connections for leaks
- Check the pipelines for leaks
- Check the pump room for leaks
- Get your bottom samples

Increase Rate: Once satisfied, slowly increase the cargo flow until the full loading rate is achieved.

Loading Cargo: The start-up procedures, mentioned above, will be repeated for each grade to be loaded. Once all grades to be loaded simultaneously have been started, the bulk of the load continues until the topping off phase is reached. During loading, the Person-In-Charge is responsible for:

- Tending to the moorings and gangway frequently
- Making frequent rounds of the deck and checking for leaks
- Checking the nearby water frequently looking for oil on the water
- Making rounds throughout the house and other spaces as an hourly fire watch
- Enforcing the visitor policy
- Monitoring pressure at the manifold
- Performing ballast/DE ballast operations as required
- Monitoring ullages
- Performing any checks as the situation dictates

Spill Tank: At least one tank for each grade should have been shut off at about halfway full while you loaded into the others. This tank is called the spill tank. The space in this tank is saved for emergency use to ensure you have an extra space for cargo in case:

- A valve fails to close on a tank you are topping
- The shore fails to shut down when ordered
- Other unforeseen emergencies

Overfill devices.

As per 46 CFR 155.480

(b) Each tank vessel with a cargo capacity of 1,000 or more cubic meters (approximately 6,290 barrels), loading oil or oil residue as cargo, must have one overfill device that is permanently installed on each cargo tank and meets the requirements of this section.

(2) On a tank barge, each cargo tank must be equipped with an overfill device that—

(i) Meets the requirements of 46 CFR 39.20-7(b)(2) and (b)(3) and (d)(1) through (d)(4), and 46 CFR 39.20-9(a)(1) through (a)(3);

(ii) Is an installed automatic shutdown system that meets the requirements of 46 CFR 39.20-9(b); or

(iii) Is an installed high level indicating device that meets the requirements of 46

CFR 39.20-3(b)(1), (b)(2), and (b)(3).

(c) Each cargo tank of a U.S. flag tank vessel must have installed on it an overfill device meeting the requirements of this section at the next scheduled cargo tank internal examination performed on the vessel under 46 CFR 31.10-21.

Stick Gauge Overfill Devices:

A. 1-meter stick gauges are normally located forward of each ullage hatch. They provide a visual indication of high level and overfill in the cargo tank. Follow these checks before a transfer:

1. Uncap the stick gauges

2. Grasp the gauge firmly and pull it up carefully to the fully raised position.

3. Lower the stick until it engages the float magnet. This will be near at the bottom of the stick's travel. The stick must engage the magnet in each tank in order to begin the transfer.

4. When the cargo in each tank reaches approximately 1-meter ullage, the float and gauge stick will begin to rise. It is important to make sure that the stick continues to rise as the tank fills. This will help provide the best indication of the internal cargo level.

5. The gauge sticks are normally marked with a green band which extends to the 6" before overfill level, followed by a 6" yellow band extending to the overfill level. The remainder of the stick is colored red. When loading cargo, the green color on the stick indicates the normal loading of the tank, the yellow indicates near over fill (high level) and the red means a dangerous over fill condition and the compartment cargo valve should be closed immediately.

B. ALARM SYSTEM: Each cargo tank is equipped with cargo tank High Level/Overfill Shutdown sensors. The High Level sensors will activate when the product level reaches 96.5 percent of its capacity. This will occur when the product level in the tank is approximately 10" below the deck. The Overflow Shutdown System will activate at 98 percent capacity or 60 seconds before the tank becomes 100% full at the maximum transfer rate. This will occur when the product level in the tank is approximately 6" below the deck. These sensors must be connected to the appropriate system before a visual or audio alarm will activate.

C. GAUGE TREE

1. Each cargo tank is equipped with a gauge tree located directly under each sight glass. This tree will indicate the product level while the vessel is being loaded. The top rung of the gauge tree is at deck level. The space between each descending tab is 6" with the bottom rung being 6" above the deck level.

2. Each cargo tank is also equipped with a High Level and Overfill "Paddle" located so as to be visible from each sight glass. The tree lower paddle indicates the product level at the "High Level" setting of the alarm and the upper paddle indicates the product level at the "Overfill" setting of the alarm.

Topping Off:

This is the most critical time during bunkering operations, with respect to accidental oil pollution. The vessel should advise the terminal when the final tanks are to be topped off and request the terminal, in adequate time, to reduce the loading rate sufficiently to permit effective control of the flow on board the vessel. After topping off individual tanks, master valves should be shut, where possible, to provide two valve segregation of loaded tanks. As the load progressed, the ullages should have been stepped to allow you to top the tanks in the sequence you choose. As the oil level near their stops, you are ready to commence topping off the tanks. You should:

- Slow the loading rate down to your comfort zone
- Call out the crew you planned on for topping off
- Top off one or two tanks at a time
- Shut the valves to the tanks you are not topping
- Crack open the valves to the next tank for topping
- Monitor the next tanks for their ullages
- Monitor the topped tanks for creepage
- As you close one valve down you are opening another
- Keep in constant communication with your team and the terminal
- Give the terminal sufficient notice for shut down
- Finish the load into the spill tank

Displacements:

At the pre-load conference you should have been told if the shore will require a line displacement and received the volume they need to displace. You will have some concerns during this operation, they are:

- Is there enough space in the tank for the displacement; and
- Will the displacement contaminate the tanks the product is entering?

Slowdown: You must make allowances for the shore to blow down their hoses in order to disconnect them. They will either:

- Blow the hoses to you; or
- Drain the hoses back ashore.

Final Gauging: The gaugers will board the vessel and will first meet with the PIC Tankerman then they will:

- Gauge the ullages together
- Read the temperatures together
- One or the other will obtain the samples

Calculations: After the gauging is completed, the PIC Tankerman and the surveyors will independently of each other, calculate each of the products:

- Gross barrels
- Net barrels
- Long tons

Release: When these calculations are made and all is in agreement the surveyor or terminal representative will release the vessel.

Documentation: There are many documents which become part of your voyage files and some of these are as follows:

- Notice to Readiness
- Ullage and Deadweight report
- Certificate of Quantity and Quality
- Certificate of Origin
- Bill of Lading
- Cargo Manifest
- Letter of Protest
- Samples and Documents Receipt

Securing for Departure: After the vessel has been released and the hoses are away, the crew prepares the vessel for getting underway:

- Closing all cargo valves
- Draining the manifold drip pans into the slop tank
- Stowing the containment and cleanup gear
- Ensuring all the paperwork is on board

Log Entries: Part of the custodial duties the watch officers incur are the log entries to be made. Some of the standard entries are:

- Arrival
- First line
- First hose connected
- Commence load
- Any stops of the load
- Any resumes of the load
- Completions of load
- Last hose off
- Last line
- Departure

Underway: Cargo care and custodial duties during the loaded passage are usually accomplished by daily inspections of the deck. Some of these items are:

- Maintaining positive IG pressure (if required)
- Maintaining temperature if required
- Checking on expansion of cargo
- Ensuring PN valves are freed up

Void Spaces: On the loaded passage, the void spaces should be checked daily for leakage by:

- Soundings; or
- By sight

6.3 Cargo Discharging Operations

Introduction: In this section we will look at discharging the vessel and take you from planning the discharge through finishing the discharge and preparing the vessel to get underway. Some of these steps we will go through are:

- Planning the discharge
- Preparing the vessel for berthing
- Preparing for discharging at the berth
- Discharging
- Transferring cargo custody
- Securing from the discharge operation
- Preparing to get underway

Discharge Orders: The first step in planning the discharge is a careful examination of the discharge orders. The information should be explicit and you should have no questions. Your discharge orders should contain the following:

- Discharge terminal and port
- Volume to discharge
- Product grade to discharge
- Special terminal requirements
- Number of hoses
- The size of the connections

Sources: If any of this information is missing you will have to find it from other sources such as:

- Your files from past voyages
- Who issued the discharge orders
- The discharge terminal

Develop a Plan: Developing the discharge plan is a very challenging task. Information must be gathered from a variety of sources and placed in a comprehensible form from which the final discharge plan is developed. You must determine what is:

- Size of the shore lines
- Length of the shore lines
- The cargoes they can take simultaneously
- The sequence for discharge

Discharge Plan: To finalize the discharge plan you must:

- Calculate the stop ullages
- Determine the manifolds you will use
- Determine the stripping sequence
- Assign the maximum discharge rate
- Assign the prime tanks
- Determine the deck lineup

Custodial Duties: Custodial duties should be written into the plan such as:

- The amount of samples to take
- Information on gaugers and gauging
- The vessel's record keeping requirements

6.4 Pre-Arrival Preparations

Deck Preparations: This section discusses the physical preparations that are carried out prior to arrival at the discharge port. The actions may include such items as:

- Breaking out mooring lines
- Lineup of the cargo systems
- Lineup of the pumps
- Preparing the manifold
- Line up the firefighting systems

- Check the containment systems are in compliance
- Breakout the spill cleanup gear
- Ensure that pollution prevention requirements are met

Final Checks: To save time and confusion at the dock you should do your final checklist prior to berthing. Some of these final checks are:

- Mooring lines are pulled and ready
- Reducers and spool pieces are in place
- Main deck crossovers and blocks are lined up correctly
- PN-valves are positioned correctly
- Tank IG inlet valves are correctly lined up
- The IG system is correctly lined up
- The IG supply valve at the deck seal is closed
- Test the high level alarms
- Firefighting equipment is lined up
- Containment system is properly set up
- The oil spill gear is in place

Gaugers Aboard: Once the vessel is securely moored the tank inspectors will board the vessel. They will inspect the tanks for:

- Ullages
- Temperatures
- Samples

Calculations: The PIC Tankerman and gaugers will calculate the cargo on board and the samples will be sent ashore to the lab for testing.

6.5 Discharging the Vessel

Figures Agree: Once the calculations are done and:

- There is agreement with the load port figures;
- The final paperwork can be completed; and
- You will be cleared to start the discharge.

Connect Hoses: Hoses must be connected to the proper manifolds. The Person-in-Charge should be present while the hoses and the bonding wire are connected and must verify that they have been correctly connected.

Conference: The Pre-transfer Conference is a regulatory requirement of 33 CFR 156.120 and states the items that must be covered during this conference between the Persons-In-Charge of the transferring and receiving units. They shall:

- Identify the product(s) to be transferred
- Name the sequence of transfer operations
- Agree on the transfer rate
- Identify the persons or title and location of each person participating in the transfer operation
- Give details of the transferring and receiving systems
- State the critical stages of the transfer operation
- Acknowledge the federal, state and local rules that apply to the transfer
- Display the emergency procedures
- Confirm the spill containment procedures
- Confirm spill reporting procedures
- Confirm the watch or shift arrangements

- Agree that the Persons-In-Charge may begin the transfer operation

The Declaration:

You must fill out the DOI or the equivalent Vessel/Shore Safety Checklist recommended by Coast Guard Guidelines prior to discharging. Both Persons-In-Charge are required to:

- Check off all items on this checklist
- Sign off on this checklist
- All reliefs must also sign at each watch change
- Check off each item on the checklist

155.750(a) (6) EMERGENCY SHUTDOWN AND COMMUNICATIONS

Emergency Shut Down:

Vessels equipped with a pump driven by a diesel engine; in the event of an emergency during unloading operations, the transfer of cargo may be stopped by pulling the remote shut down cable normally located near the center of the barge and marked with a sign. The Tankerman must verify the shutdown operates before each transfer.

The Tankerman shall discuss emergency shutdown procedures with the vessel or facility prior to the transfer of cargo. This discussion should include:

- Circumstances requiring the transfer to stop immediately
- Primary and secondary means of communication
- Valves to be closed, location of the shutdown cable, and other actions to be taken in the event of an emergency
- How long it will take for the shutdown to take effect (is it immediate or does it take several minutes in order to avoid rupturing lines)

Communications:

Communications shall be established, between the terminal (or vessel) and the barge before the transfer hoses are hooked up. Communications must be maintained until the transfer is complete and hoses are disconnected. PIC must routinely check communication at least every 2 hours. If portable radio devices are used, they must be intrinsically safe and meet the requirements of 46 CFR § 110.15-100(I) Class I, Division I, Group D as defined in 46 CFR § 111.80

Start of Cargo: When you are ready to start the discharge you should start with one product from one tank. Open that tank valve and then:

- Open all valves between tank and manifold
- Open the manifold valve last and only when all the shore valves have been opened
- Inform the shore that you are ready to begin pumping
- Start a pump slowly from one tank
- Get a header sample for the product
- Test the emergency stop
- Resume pumping
- Check the opposite manifold for leaks
- Check the hose connections for leaks
- Check the pipelines for leaks
- Check the pump's for leaks

Increase Rate: Once satisfied, slowly increase the pump speed until the full discharge rate is achieved.

Discharge: The start-up procedures, mentioned before, will be repeated for each grade to be discharged. Once all grades to be discharged simultaneously have been started, the bulk of the product is discharged until the stripping phase is reached. During the discharge, the Person-In-Charge is responsible for:

- Tending to the mooring lines and gangway frequently
- Making frequent rounds of the deck and pumps checking for leaks
- Checking the nearby water frequently looking for oil on the water
- Making rounds throughout the house and other spaces as an hourly fire watch
- Enforcing the visitor policy
- Monitoring pressure at the manifold
- Performing ballast operations as required
- Monitoring ullages
- Performing any checks as the situation dictates

Older Vessels: The division of duties between the Person-In-Charge and his PIC Tankerman Assistants is vessel specific. On older vessels that have replaced open gauging with remote gauges located on the deck, the Person-In-Charge will:

- Stand most of his watch on the deck

- Do the required monitoring from the deck
- Double check things from the deck

Newer Vessels: Most automated vessels may require the Person-In-Charge to remain in the Cargo Control Room most, if not all, of the time. In this situation, the Person-In-Charge must rely on his PIC Tankerman-Assistants out on the deck to:

- Monitor
- Check
- Report
- Correct, where necessary, conditions on the deck

Team Work: A team approach to conducting cargo operations becomes more of a necessity when the Person-In-Charge is more or less isolated in the Cargo Control Room.

Tank: For vessels with a pumproom aft and bottom cargo lines, at least one tank for each grade should have be shut off at about halfway full while you discharged from the others. This tank is:

- The center after most tank in the segregation
- Called the prime tank
- Is saved for priming the pumps during the stripping operation if needed

MCP Stripping: As the discharge progressed, the ullages should have been stepped to allow you to strip the tanks in the sequence you choose. As the oil level near the bottom, you are ready to commence stripping the tanks. Specific stripping procedures vary from vessel to vessel depending on system requirements and capabilities. If you are stripping with centrifugal main cargo pumps, you should:

- Slow the pump down
- Squeeze the discharge valve for back pressure
- Call out the crew you planned on for stripping
- Strip one tank at a time
- Shut the valves to the tanks you are not stripping for each grade of cargo
- Keep in constant communication with your team and the terminal
- Give the terminal sufficient notice for shut down
- Finish the discharge with the prime tank

Stripping Pump: If you have a separate stripping pump, you will be able to:

- Strip tanks internally
- Utilize the prime tanks to strip into, while
- You pump ashore from the other tanks

Deep Well Pump: If you have deep well pumps, they will run until the tank is almost dry. You would then slow the pumps down to complete stripping the tanks empty.

Displacements: At the pre-load conference you should have been made aware if the shore requires a line displacement and received the volume they need to displace. You will have some concerns during this operation, they are:

- You could discharge too much and miss the stop; or
- The displacement will interfere with your final stripping operation.

Blowdown: The shore will request either one of the following:

- They will blow the hoses to you; or
- They will drain the hoses back to themselves

Final Gauging: The gaugers will board the vessel and will first meet with the Mate then they and vessel's officers will gauge the vessel for any remaining product, known as ROB or remaining on board.

Zero ROB: If there is no product found you will be issued:

- Empty or
- A certificate stating the ROB is pump able

Some ROB: If there is ROB left, you will be issued an ROB or an On Board Quantity (OBQ) statement.

Release: This paperwork is done and all is in agreement the surveyor or terminal representative will release the vessel.

Documentation: There are many documents which become part of your voyage files and some of these are as follows:

- Notice to Readiness
- Empty Certificate
- Ullage and Deadweight report
- Certificate of Quantity and Quality
- Letter of Protest, and
- Samples and Documents Receipt

Log Entries: Part of the custodial duties the watch officers incur are the log entries to be made. Some of the standard entries made in the logbook are:

- Arrival
- First line
- First hose connected
- Commence discharge
- Any stops of discharge
- The resumption of discharge
- Completion of discharge
- Last hose off
- Last line
- Departure

Securing for Departure: After the vessel has been released and the hoses are away, the crew prepares the vessel for sea by:

- Closing all cargo valves
- Draining the manifold drip pan into a cargo tank
- Stowing the containment and cleanup gear
- Ensuring all the paperwork is on board

Void Spaces: The cargo tanks and the void spaces should be checked daily for leakage by:

- Soundings; or
- By sight.

6.6 Inert Gas Operations

Introduction:

Although some flue gas systems differ in detail, certain basic principles remain the same and these are:

- Starting up the inert gas plant
- Shutting down the inert gas plant
- Safety checks

Safe Atmosphere:

When used properly, inert gas will maintain a safe atmosphere for explosive vapors by reducing the oxygen content in the tanks to 8% by volume or below.

Starting up:

The start-up procedures should be as follows:

- Ensure the boiler is producing 02 at 5% or less as per 46 CFR32.53-10 b
- Ensure that power is available to all control, alarm and automatic shutdown operations
- Ensure the deck seal and the scrubber are getting the proper amounts of water
- Test the operation of the alarms for the water supplies to the scrubber and the deck seal
- Check that the fresh air inlet is shut off and secured
- Shut off air supply to any air sealing arrangement for the flue gas valve
- Open the flue gas valve
- Open the blower suction valve
- Start the blower
- Test the blower failure alarm
- Open the blower discharge valve
- Open the recirculating valve
- Open the gas regulating valve
- Check that the 02 is at 5% or less
- The system is now ready to deliver IG to the cargo deck

During Discharge:

The inert gas system will be kept running during the entire discharge or washing operation. Gas flow of good quality must be continued throughout the discharge to replace the cargo volume as it is pumped from the tanks. You must constantly monitor the following:

- IG pressure
- 02 content at 8% or below;
- The alarms

Finish Discharge: Atmospheric control is a little more complicated on the ballast passage than it is when loaded because the volume is very large and has much more hydrocarbon vapor in the tanks. The tanks have been discharged and are now empty except for:

- Some cargo residues
- Hydrocarbon vapors

Hydrocarbons: The hydrocarbon level will be quite high and should be purged with IG to reduce those levels and still maintain the 8% or lower 2% atmosphere in the cargo tanks.

Purging: First you must force a large volume of inert gas through the tank to reduce the hydrocarbon level to 2% by volume or less. This will keep the tank out of the explosive range. This process is called purging and the tanks are fitted with Individual purge pipes. See page 9-21 for flammability diagram.

Requirement: Under SOLAS, purging is a requirement prior to gas freeing any tank that has contained hydrocarbons and ISGOTI recommends this procedure.

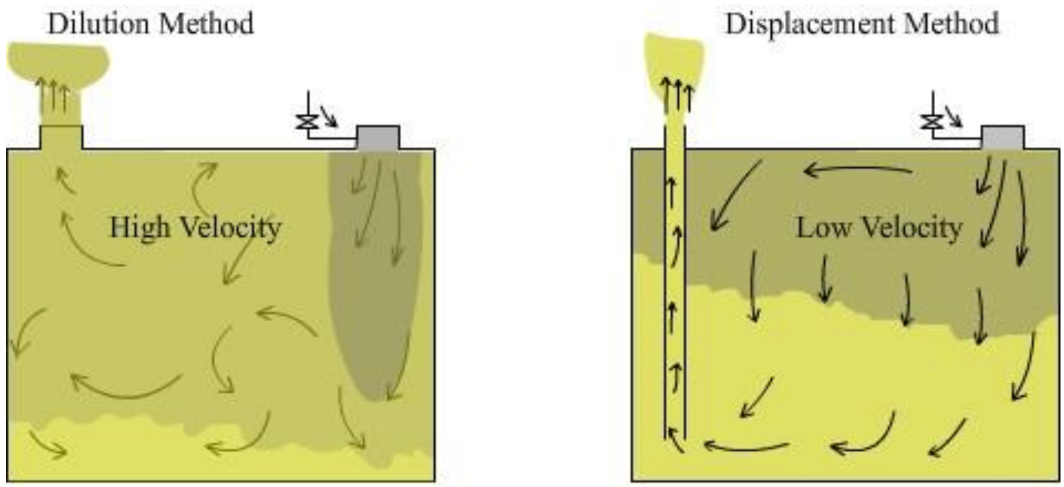
Dilution Method: The dilution method works by introducing inert gas into the tank at the highest possible velocity. This will cause the maximum amount of atmospheric agitation within the tank and mixes:

- The incoming inert gas; with
- The gas already in the tank.

The Results: This dilutes any concentration of hydrocarbons or oxygen within the tank.

Excess Pressure: The excess pressure within the tank will be vented through the purge pipe. This method requires 4 to 6 atmosphere changes before the tank is fully purged.

Purge Technique: Only a few tanks can be purged at one time using this method. If too many tanks are opened at once, the velocity of flow will be reduced and the efficiency of the purging process will be ineffective.



Purging

Dilution Displacement

Operating Manual: Systems operating manuals will state the maximum number of tanks simultaneously as well as how long the process should take.

Displacement: The displacement method works by introducing the inert gas at a low velocity, avoiding atmospheric agitation.

IG Heavy: IG is heavier than air and it will settle to the bottom of the tank, forming an interface with the tank atmosphere. As the IG flows in, the former tank atmosphere flows out the purge pipe. This method requires that the atmosphere be changed about 2 to 3 times.

Air Changes 02 Levels Low: Once the tanks have been purged of hydrocarbons, the oxygen levels should also be at or near the lowest practicable level that can be achieved

Seal the Tank: When the purging is done you must secure the deck to keep the tanks sealed. You should ensure that:

- The purge pipes are closed tight
- The ullage caps are secure
- All the Butterworth plates are tight

Positive Pressure: Positive pressure must be maintained for the rest of the passage to preclude any fresh air from entering the tanks.

Shutting Down: Shutdown procedures should be as follows:

- All tank pressures are positive
- All tank atmospheres are at 8% or lower 0_2
- Secure the deck isolating valve
- Open the vent to atmosphere valve
- Secure the gas regulating valve
- Secure the inert gas blowers
- Secure the blower suction and discharge valves
- Open the blower washing system as per manufacturer recommendations
- Secure the flue gas valve
- Keep the water supply to the scrubber
- Insure the water supply remains going to the deck seal

Ballast Passage: You may have tank cleaning and repairs to do on the ballast leg. It is important to keep the positive pressure of inerted gas in the cargo tanks that you achieved when purging the tanks after discharge.

Re-purge: If the pressure falls below positive you will have to purge the tanks again.

Maintaining: Maintaining the atmosphere in the tanks is one of the more important safety functions. It provides a safeguard against:

- Fire; and
- Explosion.

First Level: The first level of precautions against ignition hazard are the:

- Smoking regulations
- Hot work permits
- Non-sparking devices

Second Level: Maintaining the tank atmospheres so that fire cannot be supported provides a second level of protection.

Before Loading: Before loading begins, the tank atmospheres must have been brought below the 8% oxygen level and the:

- IG system will have been shut down; and the deck isolation valve closed

During Load: The IG pressure must be monitored closely during loading and the excess gas, displaced by the incoming cargo, vented either to:

- The atmosphere via the mast riser; or
- Through the vapor emissions control system.

Pressure Falls: If the Person-In-Charge allows the inert gas pressure to fall too low then:

- Loading must be suspended until the pressure has been brought above 100 mm water gauge as per 46 CFR 32.53- 30; and
- The oxygen content of the tanks ascertained.

Purging: Purging will have to be performed if any of the tanks contain above 8% oxygen before loading may be resumed.

Loaded Passage: Most of the time atmospheric maintenance on the loaded passage consists of maintaining a positive pressure on the tanks.

High Oxygen: If the oxygen level in a tank exceeds 8%, then that tank will have to be purged to bring the level back within parameters.

COW Operations: The inert system must be fully operational when performing crude oil washing procedures as per 33 CFR 157.164 with the tanks at 8% oxygen or below and with a positive pressure in the tanks.

Regulations: Regulations for the fitting of IGS on barges are found in the:

- SOLAS Convention of 1974, Chapter 11-2; and46 CFR 32.53.

IG Required: Almost all barges of 20,000 DWT and above must have an inert gas system and the regulations call for inert systems on all:

- New ship's crude oil carriers of 20,000 DWT and above
- Existing product barges of 40,000 DWT and above
- Existing product barges of 20,000 DWT and above up to 40,000 DWT that are fitted with high capacity (60 m3/h and higher) tank washing machines
- Barges, regardless of size, that are fitted with crude oil washing machines

IG Not Required: Existing product carriers of less than 40,000 DWT with low capacity tank washing machines are not required to have inert gas systems.

6.7 Precautions When Using Inert Gas

Introduction: Inert gas poses several hazards both to personnel and the environment. Even though inert gas greatly increases the operational safety of tank vessels, it is a hazard

Exhaust Gas: Inert gas is an exhaust gas from a combustion process, it is in the same category as automobile exhaust. In many areas it is illegal to exhaust it into the atmosphere

Personnel: The personnel hazards with IG fall into two categories and they are:

- The gas is non-breathable
- It is an asphyxia

Warning: Never enter a tank that is inerted. Prior to entering a tank you must:

- Purge the tank with fresh air
- Test for 21% 0_2

Riser Height: The height of the mast riser or the exit velocity of the bullet valves helps minimize the IG vapors that will appear on the deck.

The Scrubber: The scrubber and the waste water that it discharges present hazards to personnel. The scrubber wastewater contains many contaminants and among them are:

- Sulfur dioxide
- Soot

Sulfur Dioxide: The sulfur dioxide will cause burns when dissolved in water.

Confined Space: The scrubber is a confined space and all precautions for confined space entry must be taken before personnel enter the scrubber tower for inspection or maintenance.

Scrubber Leaks: The scrubber tower should be checked to ensure it is not leaking gasses to the atmosphere it is in.

Contamination: To prevent cargo contamination, the IG branch line valves to tanks containing the sensitive cargo may have to be kept closed or even blanked off.

Complications: This will complicate atmospheric maintenance during the loaded passage as it will be necessary to:

- Top off the IG in the majority of cargo tanks
- Close the valves to them
- Purge the IG line of any cargo vapors
- Open the sensitive product tanks
- Top them off with IG
- Isolated them from the system again

Rust: When cargoes containing hydrogen sulfide are carried special hazard is created. In an inerted tank, the hydrogen sulfide given off by the cargo can combine with iron oxide already present in the tank. The resulting product is iron sulfide.

Clean ballast: Definitions Clean ballast is water with an oil content of less than 15 ppm.

Discharge: A discharge is any release of effluent or harmful substance, however caused, from the vessel into the water and includes any:

- Escape
- Disposal
- Spilling
- Leaking
- Pumping
- Emitting
- Emptying

An oily mixture is a liquid with any oil content, including:

- Tank washings from oil tanks
- Bilge slops
- Oily wastes
- Dirty ballast
- Sludge

Oily Mixture: A special area is a sea area where the adoption of special mandatory methods for the prevention of sea pollution by oil, NLS or garbage is required. These areas can be found in:

- Annex I of MARPOL for oil pollution
- Annex II of MARPOL for NLS
- Annex V of MARPOL for garbage

Special Area: The slop tank is the tank where oily mixtures generated on board are transferred for:

- Settling
- Processing
- Separating
- Decanting

Cargo Monitor: The cargo monitor is designed to measure and record the oil content of cargo residues. The monitor can:

- Calculate the ppm of the discharged liquid
- Calculate the rate of discharge
- Shut down the discharge when the oil content exceeds the regulatory maximum

Segregated: Segregated ballast is the ballast water introduced into a tank that is completely separated from the cargo and fuel oil systems and that tank is permanently allocated to the carriage of ballast.

Dedicated Clean: Dedicated clean ballast is ballast carried in a tank that is set aside for the carriage of ballast. The tank is not totally separated from the cargo system but is connected to the least practicably numbers of cargo pumps and amount of pipeline as possible.

6.9 Requirements for Ballast

Introduction: The loading and discharge of ballast is one of the more important supporting operations in vessel practice since it can take place in load ports, discharge ports and at sea. There are many reasons for taking ballast, such as:

- To enhance stability
- To reduce hull stress and bring it within hull parameters
- To improve vessel handling response
- To meet draft restrictions
- To meet air draft restrictions
- Heavy weather

Minimum Draft: Most segregated ballast barges sailing today were converted from barges that had no segregations when they were built. They carry just enough ballast to make the minimums required in 33 CFR 157.1Ob. The formulae for these minimums are as follows:

- The molded a mid-vessels draft will be no less than 2 meters plus 0.02 times the length between perpendiculars in meters for vessels of 150 meters or more
- The draft in meters at the forward and aft perpendiculars must correspond with the amid vessels draft with a trim by the stern of no more than 0.015 times the length between perpendiculars in meters
- The minimum draft aft shall be enough to obtain full immersion of the propeller

Segregated: Segregated ballast is loaded and discharged during cargo operations. A ballast plan is still required and requires close monitoring by the PIC. This ballasting will help you:

- Maintain proper trim for stripping
- Maintain an even keel for topping
- Keep the vessel in the proper stress condition
- Keep the vessel at the desired draft marks

The Plan: On segregated ballast barges, the ballasting is done concurrently with the cargo operations. On the ballast section of the written plan, you would want to include:

- When to start the ballast
- What pumps you want to use
- The amount of ballast to be loaded or discharged
- The maximum drafts allowed during the operation
- The maximum trim and stress tolerances
- The sequence

Considerations: In running a concurrent cargo and ballast operation, you must consider the following:

- Stripping or topping times will not be interfered with
- The limitations of the manpower you have available
- The rate your cargo and ballast pumps will do
- Free surface

Non-segregated: On non-segregated ballast barges, ballasting is not done concurrently with the cargo operation. Normally you must wait until you have received a dry certificate from the tank inspector before you can start ballast. The planning is the same.

Differences: The big difference between the non-segregated ballast vessel and a segregated ballast vessel is that you load and discharge the ballast through the cargo piping system. The non-segregated ballast vessel is usually at a high hogging stress when in a very light condition and is vulnerable to be blown off the dock in high winds. You would want to:

- Start the ballast as soon as possible
- Get the bow draft down as soon as you can

Hazards: The non-segregated ballast vessel presents some additional pollution hazards for pollution control. Some of these are:

- You are loading ballast through the cargo system;
- It is possible to have a discharge of oil into the water when you open the sea valve to start the ballast; and
- You are mixing oil residues with ballast water creating a disposal problem.

The Oil Record Book

The Book: Each oil tanker of 150 gross tons and above, ship of 400 gross tons and above other than an oil tanker, and manned fixed or floating drilling rig or other platform shall maintain an Oil Record Book Part I (Machinery Space Operations). An oil tanker of 150 gross tons and above or a non-oil tanker that carries 200 cubic meters or more of oil in bulk, shall also maintain an Oil Record Book Part II (Cargo/Ballast Operations) as per 33 CFR 151.25.

NLS Book: A similar Cargo Record Book is required to be carried on board vessels carrying Noxious Liquid Substances (NLS) as per 46 CFR 153.909.

Required Entries: The required entries are listed in the front of each book and MARPOL contains the regulations concerning the required entries and they are:

- Regulation 20 of Annex I for oil
- Regulation 9 of Annex II for NLS

Part I: The required entries for machinery space operations in part I of the Oil Record Book are as follows:

- Ballasting or cleaning of fuel oil tanks
- Discharge of dirty ballast or cleaning water from fuel oil tanks
- Disposal of oily residues (sludge)
- Discharge overboard or disposal otherwise of bilge water

Part II: The required entries for cargo/ballast operations in part II of the Oil Record Book for oil barges are as follows:

- Loading of oil cargo
- Internal transfer of oil cargo during voyage
- Unloading of oil cargo
- Ballasting of cargo tanks
- Ballasting dedicated clean ballast tanks
- Cleaning of cargo tanks including crude oil washing
- Discharge of ballast except from segregated ballast tanks
- Discharge of water from the slop tank
- Closing of all applicable valves or similar devices after the slop tank discharge
- Closing of valves necessary for isolation of dedicated clean ballast tanks from cargo and stripping lines after the slop tank discharge operations
- Disposal of residues

NLS: Barges are required to keep a Cargo Record Book in lieu of Part II of the Oil Record Book when they are carrying NLS cargo in bulk. The required entries are as follows:

- Loading of cargo
- Internal transfer of cargo
- Unloading of cargo
- Mandatory pre-wash
- Cleaning of cargo tanks
- Ballasting of cargo tanks
- Discharge of ballast from cargo tanks
- Accidental or other exceptional discharge
- Controlled by authorized surveyor
- Additional operational procedures and remarks

Signatures: Each entry in the Oil Record Book or Cargo Record Book must be signed by the officer or officers in charge of the operation concerned and each completed page shall be signed by the PIC Tankerman .

On Board: These books are required to be retained on the vessel for three years as per:

- 33 CFR 153.26 k for the Oil Record Book; and
- 46 CFR153.909 e-1 for the NLS Cargo Record Book.

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Oily Discharge: The most common discharge of an oily mixture into the sea is the discharge of water from the slop tank. A vessel must meet several requirements to discharge an oily mixture legally and some of them are:

- The vessel is not within a special area
- The vessel is more than 50 nautical miles from the nearest land and the vessel is proceeding enroute
- The instantaneous rate of discharge of oil content does not exceed 30 liters per nautical mile
- The total quantity of oil discharged into the sea does not exceed:
    - 1/15000 of the total quantity of the particular cargo of which the residue formed a part for existing barges;
    - 1/30000 of the total quantity of the particular cargo of which the residue formed a part for new barges;
- The vessel has in operation an oil discharge monitoring and control system
- A slop tank arrangement as required by Regulation 15 of Annex I.

Not Allowed: Barges used to carry ballast water in cargo tanks but now carrying ballast in cargo tanks is not allowed on SBT and DBT vessels under normal conditions as per 33 CFR 157.35.

When Allowed: The carriage of ballast in cargo tanks is allowed in those cases where it is necessary for the purpose of securing the safety of a vessel or saving life at sea.

Regulation: Regulation 13 of Annex I of Marpol 73178 allows the taking of ballast in cargo tanks by SBT and DBT barges in two circumstances:

- On those rare voyages when weather conditions are so severe that, in the opinion of the PIC Tankerman , it is necessary to carry additional ballast water in cargo tanks for the safety of the vessel

- In exceptional cases where the particular character of the operation of an oil vessel renders it necessary to carry ballast water in excess of the quantity required as segregated ballast, provided that such operation falls under the category of exceptional cases as established by the IMO.

Complying: If you do carry ballast water in the cargo tanks, you must adhere to the regulations for the discharge of an oily mixture into the sea and you should:

- Obtain the interface to prove that separation has occurred
- Ensure that the oil level is high enough in the tank so that it will not be discharged

Start Up: Great care must be taken when starting to load ballast into a cargo tank. Residual oil in the cargo pipelines might drain into the water when the valves for taking ballast are first opened. A proper sequence of operations can prevent this discharge, such as the following:

- Strip the pumproom pipeline risers and drops to the slop tank
- Drop all deck cargo lines into the tanks
- Strip all deck pipelines into the slop tank
- Keep the sea suction valve closed
- Lineup all the valves necessary for taking the ballast
- Start the pump
- When there is a vacuum at the sea suction valve, open it
- As the sea valve opens, speed up the pump
- Once flow is established and the sea valve is fully open, the loading rate may be regulated as needed

Ballast Planning: The PIC Tankerman is responsible for the amount of ballast to be taken. When developing a ballast plan consideration should be given to several items such as:

- The draft and trim requirements for departure
- Air draft requirements
- The requirements for stability and stress
- Cleaning tanks for repairs
- Cleaning tanks for normal maintenance
- Heavy weather planning
- Arrival draft requirements

In Compliance: The ballast plan must be discussed with the terminal at the Pre-transfer Conference. The ballast plan must be written with all the regulations in mind and you should be able to meet all of your requirements for a safe ballast voyage.

Section 7

Emergency Procedures

Introduction

Failures and emergencies are an everyday part of life onboard the vessel. Day to day operations require constant:

- Vigilance
- Preparedness
- Situational awareness

Examples

There are specific emergencies that are now covered in the Company Operations Manuals (COM) and Oil Spill Response Plans (OSPR). Examples of failures and emergencies requiring contingency planning include the following:

- Communication failures
- Emergency shutdowns
- Oil spills
- Fire
- Collision
- Grounding
- Confined space rescue
- Mooring breakaways
- Equipment failure
- Structural failure
- The emergency discharge of cargo

Communication

Communications is one of the most important things we do. During an emergency, events must be communicated precisely. A communication failure can lead to an emergency or compound an ongoing emergency.

Breakdown

Whether it is verbal or written, communications can breakdown in the following areas:

- Shore to vessel
- Vessel to shore
- Onboard the vessel

Procedures

Communication procedures are incorporated into the COM and OSRP and outline:

- The companies policies
- Alternative communication methods
- A contact list

Emergency Shut Down:

In the event of an emergency during unloading operations, the flow of cargo may be stopped by pulling the remote shut down cable located near the center of the barge and marked with a sign. The Tankerman PIC must verify the shutdown operates before each transfer.

The Tankerman PIC shall discuss emergency shutdown procedures with the vessel or facility prior to the transfer of cargo. This discussion should include:

- Circumstances requiring the transfer to stop immediately
- Primary and secondary means of communication
- Valves to be closed, location of the shutdown cable, and other actions to be taken in the event of an emergency
- How long it will take for the shutdown to take effect (is it immediate or does it take several minutes in order to avoid rupturing lines)

Communications:

Communications shall be established, between the terminal (or vessel) and the barge before the transfer hose is hooked up. Communications must be maintained until the transfer is complete and hoses are disconnected. PIC must routinely check communication at least every 2 hours. If portable radio devices are used, they must be intrinsically safe and meet the requirements of 46 CFR § 110.15-100(I) Class I, Division

I, Group D as defined in 46 CFR § 111.80

If at any time during transfer operations communications are interrupted, STOP ALL

TRANSFER OPERATIONS and do not resume until communications have been reestablished.

The vessel's emergency shutdown as required by 33 CFR 155.780 is tested within 24 hours prior to the vessel beginning a discharge. This is covered in the COM and OSRP and also should be:

- Incorporated into a separate emergency drill
- The crew will then know when it should be used

Shore EM

The shore emergency shutdown required by 33 CFR 154.550 requires the shore to stop the flow of cargo within 30 seconds. The vessel's PIC and shore PIC arrange for the test of the shutdown at the start of the load. The means of this shutdown must be:

- An electronic, pneumatic or mechanical linkage to the facility
- Continuous voice communication to a person who can stop the flow of oil

Shutting Down

The shutdown can be initiated by anyone concerned and all of the cargo team should be trained in its use. After the shut down and the situation has been assessed by the PIC's, an agreement to resume the operation can be completed

Cargo Spill

A cargo spill would be covered in the COM and the OSRP with drills being held on a monthly basis as per 33 CFR 15.1060 to simulate an oil spill.

Fire Drills

Fire Drills shall be held weekly as per 46 CFR 78.17-50 and they should be conducted as if a real fire existed. SOLAS in regulation 18, Part B-Chapter Ill recommends monthly drills.

Collision

The COM and OSRP would contain contingency plan for collision. There would be a checklist for:

- Ascertaining the damages
- What you should do for damage control
- Who to call

Equipment Failure	The general category for equipment failure is drilled monthly on the vessel as per 33 CFR 155.1060 with specific quarterly equipment drills such as:

- Steering gear loss
- Loss of propulsion
- Loss of power

Checklist	Each equipment drill should have its own checklist.
Structure Failure	Damage control drills are held on a quarterly basis. Each drill has the same type checklist but with different items to drill with. The checklist would contain:

- Emergency signals
- Crew mustered at their stations
- Emergency squad is briefed on the damage
- Proper tools are gathered
- Repairs simulated and completed
- A safety watch is set

Emergency Discharge of Cargo	If the vessel or lives are imperiled; the regulations allow for an emergency discharge of cargo. You will find this in the Company Operating Manual and the Oil Spill Response Plan. There will be a checklist to

- Tell you who to call
- The information you will need

Cargo Spill Reporting	PROCEDURES FOR REPORTING DISCHARGES OR OIL OR HAZARDOUS MATERIAL 155.750(a) (9)

In the event of any emergencies on board, during or after cargo transfer operations, immediate notice must be given to

In the event of a cargo spill into the water immediately notify:

1. The receiving vessel or facility to stop the transfer.

2. U.S. Coast Guard National Response Center (800) 424-8802

3. Company 24-Hour Emergency Contact

7.1 Contingency Planning

Planning — It is necessary to develop a methodology of contingency planning that is applicable in developing appropriate responses to failures and emergencies. Each emergency topic would have:

- Its own procedure
- A corresponding drill
- Items that should be performed
- A contact list with home phone numbers

Home Office — Today the shore side personnel take a much more active participation in the day to day life of a working vessel. With the advent of ISM each home office has to implement standards for:

- Vessel board policies
- Compliance with the regulations
- Vessel's performance
- Crew responsibilities
- A designated person for the vessel's first emergency contact at the office 24 hours a day
- A home office chain of command with office and home phone numbers
- Non-conformance reporting system
- The office itself has to be in compliance

ISM — The implementation of the ISM Code requires a compact to adopt a management system that incorporates contingency planning with associated policy that support it.

Sources — When these policies are being written, many different sources are used. Some of these are:

- Previous manuals
- ISM code
- USCG regulations
- Their own experiences

System — When the planning is done, the company will put together, a Company Standard Operating Manuals. These manuals define the operational system and company policy on:

- Safety

- Pollution
- Vessel cargo operations
- Bridge Watchkeeping
- Engine room operations
- Duties underway and in port
- Near miss accidents
- Dealing with non-conformities
- Maintaining of vital systems
- Drills and inspections
- Emergency situations

Training

Once manual has been developed, crew training and practice drills should be implemented. Information gained from conducting these drills will provide:

- How well they work
- If any refinements need to be made to the operating manual

Vetting

When the vessel is undergoing a vetting, the COM will be the centerpiece of this inspection. The entire crew should know:

- Where the manuals are kept
- What their duties are
- Where in the manual they can find their responsibilities and duties
- What the company policies are
- How to file a non-conformance report
- What happens to those reports

7.2 Oil Spill Response Plan

Introduction Emergencies: One of the prime concerns of the PIC-Tankerman and crew is to operate the vessel in a safe and efficient manner having due regard to the protection of the marine environment. All vessels must conduct the following operations within the regulations:

- Cargo
- Tank cleaning
- Ballasting
- Bunkering
- Garbage disposal

MARPOL: The International Convention for the Prevention of Pollution from Vessels (MARPOL 73/78) as amended is the international law for protecting the marine environment

MARPOL: Plan The requirement for the Vessel Response Plan is found in MARPOL Annex I, chapter IV, Regulation 26.

Plan Required: A response plan is required per 33 CFR 155.1010 for any vessel that carries oil in bulk and:

- Is a U.S. flag vessel
- Operates on the navigable waters of the U.S.
- Transfers oil in a part or place subject to the jurisdiction of the U.S.

Response Plan: You should understand the purpose and the content of the response plan and this plan should cover the following areas:

- Identify equipment used onboard barges to prevent and respond to an oil spill
- The procedures to respond to oil spills

The emergencies included in the plan are grounding, collision and fire and it must state the crew responsibilities as per 33 CFR 155.1035 c-1 and where the following can be found:

- Damage stability information
- Location of vessel plans
- Oil transfer procedures
- Emergency towing procedures

Sections: The Response Plan as per 33 CFR 155.1030 must be written in English and understood by the crew and it should be divided into the following sections:

- General information and introduction
- Notification procedures
- Vessel board spill mitigation procedures
- Shore-based response activities
- List of contacts
- Training procedures
- Drill procedures
- Plan review and update procedures
- Geographic specific appendix for each COTP zone in which the vessel operates
- An appendix with vessel-specific information

Information: The general information in the plan must contain the following:

- Vessel name, registry, call sign
- Office phone number
- Owner's and contact's phone numbers
- COTP zones in which the vessel will operate
- A table of contents for the record of changes

Notification: A checklist with all notifications in order of priority to be made by vessel board and shore-based personnel is required. Notifications of a spill or a potential spill as per 33 CFR 155.1035 must include:

- Which regulatory bodies to call
- Identities of the persons to be notified of a discharge or substantial threat of a discharge
- The individuals to be notified by the vessel
- The individuals to be notified by the shore-based personnel

- Procedures for notifying the qualified individual
- Description of primary and secondary means of communication
- Information to be provided for the first and the follow-up notification

The Initial Call: The initial call must include at least the following information:

- Vessel name and country of registry
- Vessel call sign and official number
- Date and time of incident
- Location of incident
- Intended track, course and speed of vessel
- Radio stations guarded
- Type and quantity of oil onboard
- Nature and details of the incident
- Details of pollution or threat of pollution
- Weather and sea conditions
- Vessel's size and type
- Actions taken or planned to be taken by persons on scene
- Current condition of the vessel
- Number of crew and details of injuries, if any

Assessing a Spill: If a spill occurs, its severity must be assessed and a plan of action determined. The initial assessment would include:

- Type of oil, persistent or non-persistent
- Quantity of pollution
- The estimated size of the slick
- Is the pollution moving, if so what direction
- Can the vessel provide positive action
- Is mitigation possible

The 2nd Call: With the second call as much information for the protection of the marine environment must be relayed. This must include:

- Additional details of the type cargo onboard
- Additional details of the vessel's condition and ability to transfer cargo, bunkers and ballast
- Additional details of the quantity, extent and movement of the pollution and whether the discharge is continuing
- Any changes in the on-scene weather
- Actions being taken with regard to the discharge and movement of the vessel

Order of Priority: If you have a spill you must prioritize how the spill will impact your surroundings. You would look to the first priority first and work your way to the last in your report. The order would be:

- The immediate personnel safety and hazard potential
- Vessel safety
- Safety and impact on the environment
- Economic impact to the company and owners

Mitigation: The procedures for the crew to mitigate or prevent any discharge of oil resulting from vessel board operational activities are included in the Oil Spill Response Plan. The responsibilities are identified by job title and the plan must address the following:

- Transfer system leak
- Tank overflow
- Suspected cargo tank casualty
- Hull leak casualty
- Bunker spills
- All other emergencies

Drills: Specific scenario mitigation drills are to be held monthly as per 33 CFR 155.1060 on the vessel and you should:

- Log the drill
- Report the drill to the home office during the monthly communication drill

Equipment: Vessels 400 feet in length or greater must have appropriate equipment and supplies as per 33 CFR 155.205 for the containment and removal of onboard deck spills of at least 12 barrels including the following equipment:

- Sorbents
- Non-sparking hand scoops, shovels, buckets
- Containers suitable for holding recovered waste
- Emulsifiers for deck cleaning
- Protective coating
- Minimum of 1 non-sparking portable pump
- Scupper plugs

EM Towing Oil Barges of 20,000 DWT to less than 50,000 DWT must provide an emergency towing wire on one end of the vessel. Oil Barges of 50,000 DWT or more or any oil vessel older than 20 year must provide an emergency towing wire on both ends of the vessel.

Containment: Vessel as per 33 CFR 155.310 with a capacity of 250 or more barrels must have the following:

- Containment under each loading arm and manifold
- 4 barrels or more per hose with 12" id
- Means of draining the loading arm without discharge of oil into the water
- Combing around the cargo deck
- At least 4" but not more than 8" high enclosing the deck
- Is able to contain at least % barrel per hatch, manifold and connection in all conditions of list and trim encountered during the loading operation
- Mechanical means of closing each drain and scupper

During Transfer: During transfer operations, equipment and supplies must be set out and remain ready for immediate use. Most vessels have set aside a locker or space for this purpose.

Internal Transfer: Vessels that do not have suitable piping to internally transfer cargo throughout its owns tanks must carry:

- Suitable hoses
- Reducers for internal transfer within the vessel

Shore Response I: In an emergency one of your first calls would be to the QI. He would be responsible for:

- Procedures for transferring responsibilities from vessel personnel to the shore-based spill management team
- Procedures for coordinating with the federal on-scene coordinator

List of Contacts: The name, location and 24 hour contact information for the following key individuals or organizations must be included in the response plan, as follows:

- Vessel owner or operator
- Qualified individual or alternate
- Applicable insurance representatives and surveyors
- Agents
- Persons to notify for activation of the oil spill removal organization
- The spill management team
- Persons to obtain additional response resources

Shore Structure: The organizational structure that will be used to manage the response actions would include:

- Command and control
- Public information
- Safety
- Liaison with government
- Spill response operations and planning
- Logistics support and finance

Training: This plan must include the training that the crew having responsibilities must perform. The plan must state where the training records are being retained, which must be:

- Aboard the vessel
- With the qualified individual

- The U.S. location of the spill management team

Drills: The regulation 33 CFR 155.1060 calls for periodic drills, announced and unannounced, to ensure the oil spill response plan will function properly. Some of these drills are as follows:

- Vessel onboard emergency procedures and qualified individual notification drills must be conducted monthly
- Shore based spill management and oil spill removal deployment is done yearly
- A full drill is done every 3 years

Plan Review: The plan must be reviewed annually by the owner or operator. The entire plan should be submitted to the Coast Guard for re- approval after the review along with any changes in the plan such as:

- Geographic specific appendices for each COTP zone in which vessel operates
- List of areas the vessel will operate with appropriate COTP
- Volume and type of oil now carried
- Any other significant changes in the plan

Damage Stability: Vessels must have 24 hour access to shore based damage stability and residual structural strength calculation programs. These programs must show the following:

- Residual hull girder strength based on the reported extent of the damages
- Residual stability when compartments are breached
- Most favorable offload, ballast and cargo transfer sequence to improve the situation
- The bending and sheer stresses caused by pinnacle loads from grounding or stranding

QI: Response plan must identify a qualified individual and at least one alternate and he must:

- Speak fluent English
- Be located in the U.S. 24 hours a day
- Be familiar with implementing the response plan
- Be trained in the responsibilities of the Q.I.

QI Authority: The Q.I. will be furnished with a document from the owners giving him full authority to:

- Activate and engage in contracting with the oil spill removal organizations
- Act as a liaison with federal on-scene coordinator (osc)
- Obligate funds required to carry out the response activities

Organization QI: The company may designate the use of an organization as QI and an alternate QI and list the company named in the response plan but they also must:

- Specifically name a person as QI
- Name a person as alternate QI
- List them in the response plan - QI liability
- The qualified individual is not responsible for:
  - The adequacy of the response plan prepared by the company
  - Obligating funds beyond the full authority contained in the designation from the owner or operator

Geographic: The plan must have a specific appendix for each of the COTP zones covering:

- All the geographic areas in the U.S. where the vessel intends to operate
- The appendix must provide a port specific plan

Appendices: The appendix contains a list of vessel's characteristics which would include:

- Capacities of all cargo, fuel, lube oil, ballast and fresh water tanks
- Volume and types of oil cargo carried
- Diagrams showing location of all tanks
- General arrangement plans
- Mid-vessels section plan
- Cargo and fuel piping diagrams
- Pumproom plan
- Damage stability data
- Location of cargo and fuel storage plan

- Material safety data sheets for the cargo carried

Prevent Spills: Preventing spills from reaching the water will save a lot of paperwork and headache. Some of this prevention is listed below:

- Ensure all scuppers are securely plugged
- Small deck spills are usually cleaned-up with oil-absorbent pads, rags and "speedy dry" type sawdust
- Large spills require immediate action

Casualty Report: As per 46 CFR 4.05, immediately after addressing the safety concerns, the owner, agent, PIC Tankerman , operator or person in charge, shall notify the nearest Marine Safety Office whenever a vessel is involved in a marine casualty consisting in:

- An unintended grounding or striking of a bridge
- An intended grounding or striking of a bridge that creates a hazard to navigation
- A loss of main propulsion or steering gear
- An occurrence that materially and adversely affecting the vessel's seaworthiness
- A loss of life
- An injury that requires professional medical treatment
- An occurrence causing $25,000 property damage

Good Judgment: In case of emergencies according to 46 CFR 35.35-75, nothing in the regulations in this subchapter shall be construed as preventing the senior officer present from pursuing the most effective action in his judgment for rectifying the conditions causing the emergency

Section 8

Vapor Emissions Control

Purpose: Vapor emission control was instituted as a means of combating air pollution from barges and oil terminals while handling petroleum oils and NLS cargoes.

IG: Pollution Inert gas is a combustion product and it falls into the same category as stack emissions or automobile exhaust.

Hydrocarbons: Hydrocarbon vapors are:

- A pollutant
- Flammable
- Toxic

Other Vapors: Other vapors given off by petroleum products are also toxic.

Recover Vapors: VEC was started to recover these emissions rather than let them to be continuously emitted to the atmosphere.

Improved Air: By utilizing a totally enclosed load and discharge method, the pollution from barges and the refineries is greatly improved.

Type Emissions: When a tank, either ashore or afloat, is being filled with product the atmosphere in the tank is displaced. Without vapor emission control it must be vented outside to the atmosphere. Some of those emissions would be:

- Inert gas vapors
- Hydrocarbon vapors
- Any other impurity from the product

Principles: There are three basic principles of vapor emission control and they are:

- Collection
- Control
- Processing

Collection: A vapor collection system is an arrangement of piping and hoses used to collect vapor emitted from a vessel's cargo tanks and to transport the vapor to a vapor processing unit.

Control: A vapor control system is an arrangement of piping and hoses used to collect vapor emissions collected from a vessel. It includes:

- The vapor collection system
- The vapor processing unit

Processing: A vapor processing unit means the components of a vapor control system that takes the collected vapors from a vessel and either:

- Recovers them
- Destroys them
- Disperses them

8.1 Hazards of Vapor Emission Control

Introduction: By controlling vapors you introduce another set of hazards to the transfer operation. To control the vapors you must have a closed system and it becomes imperative that you follow the correct procedures. Some of these hazards are as follows:

- Vapor over and under pressurization
- Cargo tank overfill
- Fire and explosion
- Liquid condensate build up
- Electrostatic discharge

Pressure: The connection to a vapor emission control system results in pressures within the vessel's vapor spaces being directly influenced by any changes that may occur in the facilities system.

Avoiding Hazards: In order to avoid these hazards the vessel shall ensure:

- The PN screens are clear of debris
- The PN valves are working
- That the maximum allowable loading rate is not exceeded
- The pressures within the vapor system are constantly monitored
- The high and low pressure audio and visual alarms were tested and are

working properly

Overfill Risk:	The risks of overfilling a tank are much greater when close loading than when open loading a vessel. To minimize this hazard the vessel shall ensure:

- The closed gauge system was tested and is in good working order
- The back-up gauge system was tested and is in good working order
- The high level alarms were tested and are in good working order
- The overfill alarms were tested and are in good working order

Explosion: During the transfer of hydrocarbon products there is always the danger of explosion or fire and the inter-connection of the vapor systems between the vessel and shore, introduces significant additional hazards.

Arrestor: A detonator arrestor fitted in close proximity to the terminal vapor connection provides the primary protection from fire and explosion for the vessel and the facility.

Other Methods: If the terminal system does not handle the vapors through a detonator arrestor, they will continuously monitor the stream and include provisions for either:

- Inerting the vapor stream
- Diluting the vapor stream
- Enriching the vapor stream

Condensate: Liquid condensate can build up in the vapor line and impede the passage of vapors which can:

- Build up the line pressures
- Generate significant electrostatic charges on the water's surface

Low Point Drain: Frequent checking the low point drain for accumulated water ensuring that no liquid is present helps minimize this hazard.

Electrostatic: Having an inert atmosphere will eliminate electrostatic discharge fears. There are other procedures and fixtures that help alleviate this charge and they are as follows:

- A slow initial loading floe rate to cushion the bottom
- Following the procedures for measuring and sampling for static accumulating cargoes
- The vapor piping is electrically bonded to the vessel's hull
- The piping is electrically continuous

Insulating Flange: Large currents can flow between vessel and shore in electrically conducting pipe work and flexible hose systems. An insulating flange breaks the electrical current between the vessel and the terminal at the loading arm connection. According to ISGOTT, the insulating flange is recommended for use in cargo connections rather than bonding cables.

Connections: The terminal vapor connections should be electrically insulated from the vessel vapor connection by the use of:

- An insulating flange
- A single section of insulating hose

Heavy Vapors: Petroleum based products emit vapors and for the most part they are toxic and flammable. High vapor pressure products emit vapors that are heavier than air. Some of these products are:

- Crude oils
- Motor gasoline
- Aviation gasoline
- Natural gasoline
- Distillate feed stocks
- Naphtha

Vapor Clouds: When these vapors are being discharge from a purge pipe they will settle down from the pipe outlet and form into a cloud near the lowest horizontal surface they can drift to.

Layering: If you have gas freed a cargo tank that had these products, the upper section of the tank may be at 21% oxygen and you could have a hydrocarbon vapor cloud sitting at the bottom of the tank reading 10% oxygen.

Know Migration: It is important that you know how the vapors migrate when you are ready to test an atmosphere. The vapors can:

- Form into pockets at the bottom after end of the tank
- Pocket on one of the shelves in the tank
- They can roam the deck, seeking a lower level

Multi-level Test: Before entering the tank you should test each tank opening at multiple levels for:

- Oxygen content
- Hydrocarbon content

Atmosphere: Oxygen should be at 21% and the hydrocarbon content less than 10% of the LEL.

Introduction:

Tank vessels in U.S. waters must comply with the regulations set out in 33 CFR 154.800 and 46 CFR 39 if they are collecting the vapors emitted from a vessel's cargo tanks through a vapor control system and those vapors being:

- Crude oil
- Gasoline blends
- Benzene

The System:

Each vessel that has a vapor collection system must have the following installed:

- Permanent vapor collection piping
- Closed cargo gauging system
- High level alarms
- An overfill alarms

Legal Transfer:

Vapor may not be transferred from a vessel to a facility that does not:

- Meet the requirements of 33 CFR 154.800
- Have its letter of adequacy endorsed

Loading Rate:

The facility and the vessel must agree on the rate the cargo will be loaded but in no case shall the rate exceed:

- 80% of the total venting capacity of the vessel's pressure relief valves
- The total vacuum relieving capacity of the vessel’s vacuum relief valves
- The rate based on the pressure drop calculations at which the pressure at any of the vessel's cargo tanks exceeds 80% of the relief valve's settings
- Each system has defined rates in its operating manual

High Load:

Vessels must not load cargo higher than 98.5% of the cargo tank's volume as per 46 CFR 39.30-1-e-1.

Isolating Valve: The IG isolating valve must be closed during the vapor transfer operation.

Alarm Test: The high level alarms and the overfill alarms must be tested within 24 hours prior to the cargo transfer as per 46 CFR 39.40-1-k.

Open Gauge: A cargo tank must not be opened to the atmosphere during cargo transfer operations except that it may be opened for gauging and sampling while the vessel is connected to a vapor control system if the following conditions are met:

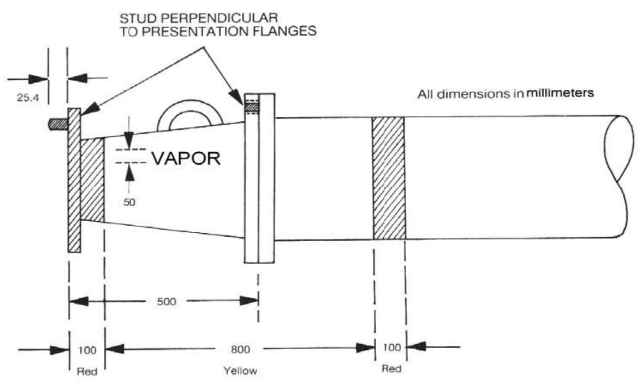
- The cargo tank is not being filled
- The tank pressure is reduced to atmospheric
- You wait 30 minutes for a non-inerted tank before you gauge it
- The cargo is not required to be closed gauged as per 46 CFR 151.05 and 46 CFR 153
- For static accumulating cargoes, all metallic equipment used in gauging and the sampling are electrically bonded to the vessel

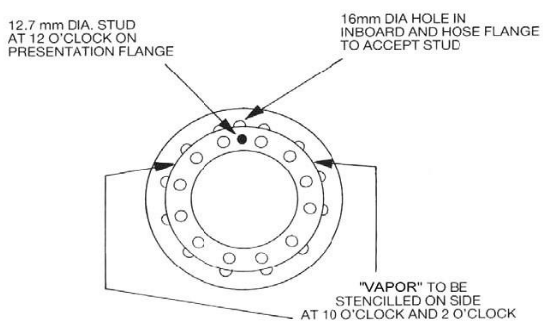
8.3 Vapor Collection System Passive Components

Piping: A vessel's vapor connections will usually be found at the forward and after ends of the cargo manifold on both sides. The vapor collection piping installed on tank vessels must meet the following requirements:

- The piping must be permanently installed
- The connection must be as close as practicable to the cargo manifold
- The piping must be electrically bonded to the hull
- The piping must be electrically continuous
- There must be a means to isolate the inert gas supply from the vapor collection system
- The piping must not interfere with the operation of the cargo tank venting system

Drain:	Each line must have a low point drain to eliminate any liquid condensate which may collect in the system.
Manifold Valve:	The system must have an isolation valve fitted at the vessel's vapor connection that has an indicator that clearly indicates whether the valve is open or closed unless the valve handle or stem clearly indicates the valve's position.
Incompatible:	If the vessel collects vapors from incompatible cargoes simultaneously, it must keep the incompatible vapors separate throughout the entire vapor collection system.





Vapor Control Hose Connection

Marking: The last meter of the piping, which includes the valve flange and a reducer, must be marked as follows:

- Painted in the sequence of red/yellow/red. The width of the red bands must be 0.1 meter (0.33 foot) and the width of the middle yellow band must be 0.8 meter (2.64 feet)
- Labeled with the word "VAPOR" painted in black letters at least 50.8 millimeters (2 inches) high

Vapor Stud: The valve flange and all the vapor recovery reducers must have a permanently attached 0.5 inch diameter stud, at least 1 inch long, projecting outward from the vapor connection flange face. The stud must be located at the 12 o'clock position, midway between the bolt holes and in line with the bolt hole pattern as per 46 CFR 39.20-1 (h)

NLS Cargo: Vapor connections may be located in the vicinity of each tank in order to preserve segregations of cargo systems, in lieu of common header piping for NLS cargoes.

Vapor Hose: If a vessel is carrying its own vapor transfer hose it must comply with the following:

- Have a design burst pressure of at least 25 psig
- Have a maximum allowable working pressure of at least 5 psig
- Be able to withstand at least 2.0 psi vacuum without collapsing or constricting
- Be electrically continuous at a maximum resistance of 10,000 ohms
- Have flanges with a bolt hole arrangement complying with 150 pound class ANSI 816.5 flanges
- Have one or more 0.625 inch diameter holes in the flange, midway between the bolt holes and in line with the bolt hole pattern
- Be abrasion and kink resistant
- Have the last meter of each end marked with red, yellow and red bands in the same manner as the vapor collection pipeline
- Have hose saddles which provide adequate support to prevent kinking or collapse of the hose

Gauging System: Each cargo tank of a vessel that is connected to a vapor collection system must, as per 46 CFR 39.20-3, be connected to a cargo gauging device which:

- Provides for closed gauging and does not require opening the tank to the atmosphere during cargo transfer operation
- Allows the operator to determine the liquid level in the tank for the full range of possible liquid levels
- Indicates the liquid level in the tank at the location where the cargo transfer is controlled

Protection: Each cargo tank of a tank vessel must be equipped with an intrinsically safe high level alarm and a tank overfill alarm. These two alarms must:

- Be independent of each other
- Alarm in the event of a loss of electrical power
- Be able to be checked at the tank for proper operation prior to each transfer
- Be fitted with an electronic self-testing feature which monitors the condition of the alarm circuitry and sensor

High Level Alarm: The high level alarm as per 46 CFR 39.20-9 Tank barge liquid overfill protection

A system meeting the requirements of 46 CFR 39.20-7 that

- Includes a self-contained power supply
- Is powered by generators on the barge

An intrinsically safe overfill control system that

- Is independent of the cargo-gauging device required by 46 CFR 39.20-3(a)
- Activates an alarm and automatic shutdown system at the facility overfill control panel 60 seconds before the tank is 100 percent liquid-full during a facility-to-vessel cargo transfer
- Activates an alarm and automatic shutdown system on the vessel discharging cargo 60 seconds before the tank is 100 percent liquid-full during a vessel-to-vessel cargo transfer
- Can be inspected at the tank for proper operation prior to each loading

Labeled “Connector for Barge Overflow Control System”

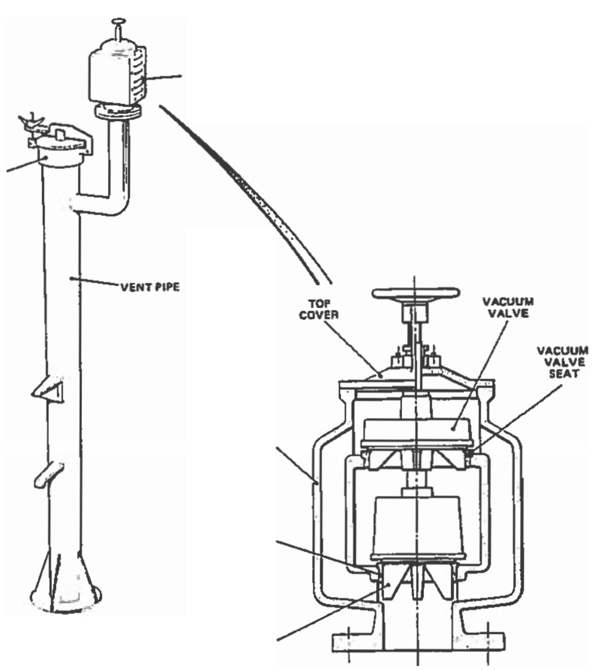
Overfill Alarm: The overfill alarm as per 46 CFR 39.20-7 d in each cargo tank of a vessel must:

- Be independent of the cargo gauging system
- Have audible and visible alarm indications that can be seen and heard where the cargo transfer is controlled and in the cargo deck area
- Be identified with the legend "tank overfill alarm" in black letters at least 50 mm high on a white background
- Alarm early enough to allow the person-in-charge to stop the transfer operation before the cargo tank overflows

Venting System: The separate cargo tank venting system required by 46 CFR32.55 must:

- Be capable of discharging cargo vapors at 1.25 times the maximum transfer rate
- Not relieve at a pressure of less than 1.0 psig
- Prevent a vacuum in the cargo spaces
- Not relieve a vacuum of less than 0.5 psi below atmospheric pressure

PV Valve — Each pressure-vacuum valve at each cargo tank must have the means to check if the device is operating freely and does not remain in the open position.



Pressure	Each vessel vapor collection system must be fitted with a pressure sensing device that senses pressure in the main vapor collection line, which:

- Has a pressure indicator located on the vessel where the cargo transfer is controlled
- Has a high pressure alarm
- Has a low pressure alarm
- The alarms are audible and visible on the vessel where the cargo transfer is controlled

8.4 Vapor Control System Active Components

Shutoff Valve: A remotely operated cargo vapor shutoff valve must be installed in the vapor collection line between the facility vapor connection and the nearest point where any:

- Inerting
- Enriching
- Diluting gas is introduced into the vapor collection line or
- Where the detonation arrestor is fitted.
- Shutoff rules this shut off valve must
- Close within 30 seconds after the detection of a shutdown condition by a component of this system
- Close automatically if the control signal is lost
- Activate an alarm when the signal to shutdown is received
- Be capable of manual operation or activation
- Have a local position indicator so the valve's position can be readily determined

Overfill: Each facility that receives cargo vapor from a vessel with a gauging system complying with 46 CFR 39.20-3, must have an overfill control panel on the dock capable of powering and receiving an alarm and shutdown signal from the vessel's cargo tank level sensor system that will:

- Close the remotely operated cargo vapor shutoff valve
- Activate an alarm that can be seen and heard to the vessel personnel and the facility personnel
- Have the means to electrically and mechanically test the alarms and automatic shutdown systems prior to the commencement of transfer

Overpressure: A facility's vapor collection system must have the capacity for collecting cargo vapor at a rate not less than 1.25 times the facility's maximum transfer rate for cargo that requires vapor collection.

Stable Pressure: A facility vapor collection system must maintain the pressure in a vessel's cargo tanks between 80% of the highest setting of any of the vacuum relief valves and 80% of the lowest setting of any of the vessel's pressure relief valves.

Alarms: Pressure sensing devises must be provided by the facility that will activate an alarm when:

- The pressure at the vapor connection exceeds the 80% of the vessel's highest vacuum relief setting
- The vacuum at the vapor connection falls below the lowest setting on the vessel's vacuum relief valves

EM Shutdown: Pressure sensing devices must be provided which activates the emergency shutdown system and closes the remotely operated cargo vapor shutoff valve when:

- The pressure at the vapor connection exceeds 2.0 psi or the pressure agreed upon at the pre-transfer conference
- The vacuum at the vapor connection falls below 1.0 psi or a value set at the pre-transfer conference

Independent: The shutdown sensors must be totally independent from the alarm sensors.

Protection: A vapor control system that receives vapor from a vessel and processes that vapor with a vapor destruction unit must:

- Have a detonation arrestor located not more than 6 meters from the facility vapor connection
- Have an inerting, enriching or diluting system that meets the regulations in 33 CFR 154.824

Detonator: Each detonation arrestor used by vapor control systems must:

- Be capable of arresting a detonation from either side of the device
- Be acceptable to the commandant

Others: A vapor control system which uses inerting, enriching or diluting gas must be capable of inerting, enriching or diluting the vapor collection line before receiving cargo vapor.

Inlet to Unit: The inlet to a vapor recovery unit which receives cargo vapor that has not been inerted, enriched or diluted must be fitted with one of the following:

- A detonation arrestor
- A flame arrestor
- An explosion suppression system acceptable to the commandant

Seal & Valves: The inlet to a vapor destruction unit must:

- Have a liquid seal

- Have two quick closing stop valves installed in the vapor line

Destruction Unit: A vapor destruction unit must:

- Not be within 30 meters of any tank vessel berth or mooring at the facility
- Have a flame or detonation arrestor fitted in the vapor line
- Alarm and shutdown when a flame is detected on the flame or detonation arrestor

Flame-out: When a vapor destruction unit shuts down or has a flame-out condition, the vapor destruction unit control system must:

- Close the quick closing stop valves
- Close the remotely operated cargo vapor shutoff valve

Section 9

Gas Freeing

Why Gas Free	Most vessels today have their tanks inerted so that the oxygen content in the tanks is always at or below 8%. There are three main reasons why a vessel would want to gas free and that is: • When changing to some cargo grades • When tanks need inspection or repairs • When preparing for the shipyard
Replacing IG	To get from an inerted atmosphere to a gas free atmosphere, the: • Inert gas • Hydrocarbons • An inert gas hydrocarbon mixture has to be replaced with fresh air
Gas Freeing ISGOTT	This The International Safety Guide For Oil Barges and Terminals describes tank cleaning and gas freeing as the most hazardous period of vessel operations replacement is called gas freeing.
USCG	Gas free is described in 46 CFR 30.10-29 as the state of being free from dangerous concentrations of flammable and toxic gases.
IG Dangerous	IG is considered a dangerous concentration because of its asphyxiating characteristic and it could contain hydrogen sulfide
Regulations	According to 46 CFR 35.01-1a the provisions of Standard for the Control of Gas Hazards on Vessels to be Repaired NFPA No. 306, published by the National Fire

Protection Association, shall be used as a guide in conducting the inspections and issuance of certificates required by this section.

9.1 Gas Freeing Terms

Flammability	Petroleum vapors are highly flammable and when mixed with at least 11% by volume oxygen they will form explosive mixtures.
Toxic	Petroleum vapors are also toxic. They contain the inherent capacity to produce injury to a biological system.
Tank Entry	Before you can safely put men in a tank that carried flammable and toxic materials, you must get the vapors out of the tank.
Gas Free	There are three levels of tank conditions for gas freeing purposes and they are:

- Safe to load
- Safe for men
- Safe for hot work

Cargo Needs

A tank that is required to be gas free for receiving cargo should be vented until tests confirm that the hydrocarbon gas concentration throughout the tank to does not exceed 40% of the LFL.

Safe for Men

To have a tank safe for men as per NFPA 2-3.1means you have vented the tanks until tests confirm that:

- The hydrocarbon content throughout the tank is no more than 10% of the LFL
- There is sufficient oxygen (19.5% to 22%)
- You have completed the appropriate toxic gas tests

Hot work

Hot work is defined by the National Fire Protection Association, as any operation or repair that utilizes:

- Riveting
- Welding
- Burning
- The use of power actuated fastening tools
- Grinding
- Drilling
- Abrasive blasting, unless deemed otherwise by a marine chemist

Safe Hot Work

Under the same NFPA 306 and ISGOTT guidelines the term safe for hot work, requires for the following conditions to exist:

- The oxygen content of the atmosphere shall not exceed 22% percent by volume
- The concentration of flammable materials in the atmosphere shall be less than 10% of the LFL
- Residues and scale shall be cleaned sufficiently to prevent the spread of fire
- The adjacent space atmospheres are purged of hydrocarbons, down to 2% by volume
- The adjacent spaces are kept inerted and secure
- The adjacent spaces and the space shall be sufficiently cleaned of residues or scale to prevent the spread of fire

Adjacent Spaces

An adjacent space is a particular concern when you are going to perform hot work in and enclosed space. NFPA306 defines an adjacent space as those spaces in all directions from subject space, including all points of contact, comers, diagonals, decks, tank tops and bulkheads.

9.2 Gas Freeing Operation and Equipment

Planning:

Before you gas free a tank you will have to write a cleaning plan in order to get to your objective. This plan should include the following:

- Which tanks need to be butterworthed
- The method of purging the hydrocarbons
- The line flushing you want done
- The number of Butterworth hoses to be used
- The pressure and temperature for the wash water
- The length of time for the drops
- The distance for each drop
- Stripping instructions
- The method of blowing air into each tank

Purging:

If the cargo tanks were inerted and you used the inert system throughout the discharge, you must purge the hydrocarbon content of the tanks down to below 2% by volume before you start the wash

Tank Washing:

Tank washing is the first step of the gas freeing operation. It is necessary to remove the free light oils from the cargo tank through the use of tank cleaning machines and the line flush.

Scale & Gas:

In gasoline and other light oil products, the oil will remain soaked into the scale or behind it after the discharge. This residual oil will regenerate hydrocarbon vapors in the tank if they are not removed.

Loose Scale:

The loose scale will be knocked down during the tank washing by the high pressure stream hitting them.

Portable: With portable tank cleaning machines, a pressure of a 120 psi and a water temperature of 120°F should be used when cleaning coated tanks. (see tank cleaning module)

Other Machines: Higher pressures and temperatures may be needed then those stated above when:

- Fixed machines are used
- When tank coatings have failed or are non-existent

Tank Clear: After you have washed the tank, it should be free of oil and debris.

development the general procedures for gas freeing tanks set forth by ISGOTT were developed through studying the history of vessel explosions and by regulation.

Isolation Fans: When a tank has been inerted before starting to gas free, it should be isolated from tanks you are not going to gas free.

IG Fans: When either portable fans or fixed fans connected to the cargo pipeline system are used to introduce air into the tank, the tank's IG inlet should be isolated and closed.

If you are going to use the IG fans with fresh air to gas free, then the:

- IG line back to the inert gas source must be isolated and closed
- The IG inlets into each tank being kept inerted must be isolated and closed

Tank Covers: The lids of all tank trunks should be kept closed until the ventilation of the individual tank is about to commence for:

- Inerted
- Non-Inerted vessels

Portable Fans: The portable fan is designed to be move about the vessel and is used primarily on the deck tank cleaning openings and their construction materials should be such that no hazard of incendiary sparking arises if the impeller touches the inside of the casing.

Bonded: These fans must be electrically bonded to the vessel's deck.

Fan Capacity: The capacity and penetration of portable fans should be such that the entire atmosphere of the tank on which the fan is employed can be made non-flammable in the shortest possible time.

Power Source: Portable fans or blowers should only be used if they are driven by:

- Hydraulics
- Pneumatics
- Steam

IG Fans: Where cargo tanks are gas freed by means of one or more permanently installed IG blowers, all connections between the cargo tank system and the blowers should be blanked off when they are not in use.

Flush Pipes: Ventilation All the cargo piping must be flushed with clean seawater before using permanent blowers

Vapor Entry: Central air conditioning or mechanical ventilating systems should be adjusted to prevent the entry of petroleum gases into the living spaces during gas freeing operations.

Inert Purging: If vapor entry of the living spaces should occur:

- The air conditioning system should be shut down
- Vent intakes covered or closed
- A/C window units must unplugged
- Have their intakes covered

Change to Air: Under SOLAS Regulation 59 tanks that are equipped with an inert gas system must be purged of hydrocarbon vapors through its venting system with IG. The inlet of the purge pipe may be located either at either:

- Deck level
- At no more than 1 meter above the bottom of the tank
- Have an exit velocity of at least 20 meters per second at least 2 meters above the deck

Outlet Position: IG purging must continue through the system until the remaining vapors in the tank fall below 2% by volume and then gas freeing may take place at the deck level with air.

Non-Inert Purging: On non-inerted vessels, the vapors shall be purged through the vessel's venting system and the:

- Outlets must be at least 2 meters above the tank deck level
- Vertical efflux velocity is at least 30 meters per second
- You vent with this method until the vapors are at 30% of the LFL

On individual cargo tanks the gas outlet pipe shall be positioned as far as practicable from the inert gas or air inlet.

Connector: If there is a connection fitted between the inert gas supply mains and the cargo piping system shall be made to ensure an effective isolation because of the large pressure difference which may exist between the systems . This shall consist of:

- Two valves with an arrangement to vent the space between the valves
- A spool piece with associated blanks

Valves: If the valves are used, the valve on the cargo main side shall be a non-return valve with a positive means of closure.

Openings Gas freeing involves the escape of gas at deck level. 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.

Light Winds: If wind conditions are too light to carry vented gases away from the vessel the gas freeing operation :

- Should be stopped; until
- The wind is able to break any heavy concentrations of the gases and carry them away from the vessel.

Vapor Clouds: Hydrocarbon gases are heavier than air and will flow like a liquid around vent openings forming vapor clouds.

Inert Gas: Inert gas is also heavier than air and only slightly lighter than the hydrocarbon vapors.

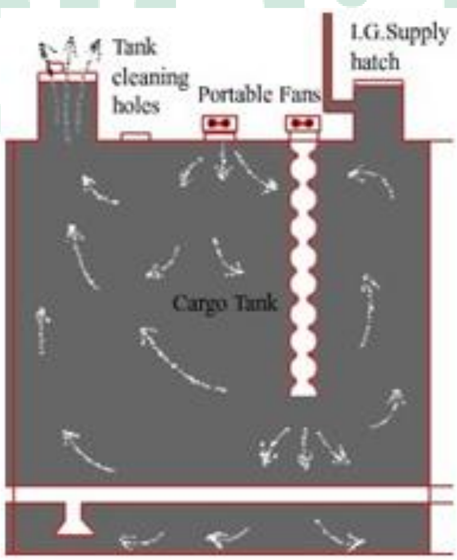
Grounded: Portable blowers become static accumulators and must be grounded to the vessel before use.

Horn Blower: Horn type gas ejectors should be avoided in gas freeing a space for entry if the air is supplied to this blower by a diesel compressor . The air could be contaminated.

Dilution Method: The dilution method forces air into the bottom of the tank and out through the deck opening. The blowers must have enough force to ensure air flow to the bottom of the tank.

Air Column: This will require a column of air, moving at a rate of 30 to 40 meters per second from the blower's exhaust point.

Mixture Purged: Air mixes with the gases in the tank and both are forced out tank openings at the deck level that should be located at the furthest distance form were the blowers are located.

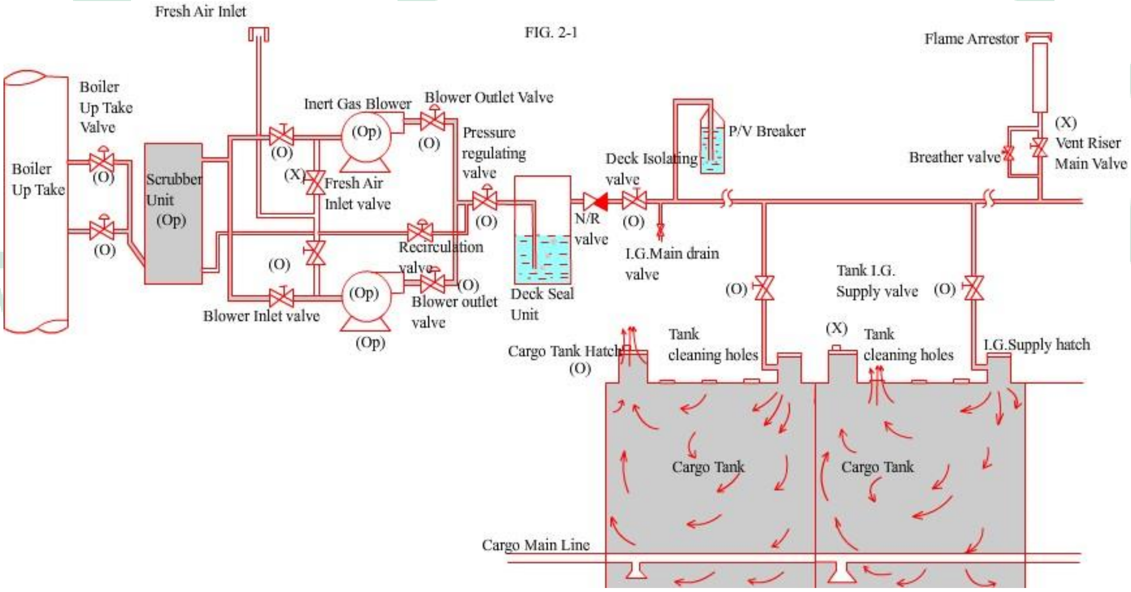


Fresh air is blown in by a fan on the tank deck.

Testing: This process should be continued until you have tested the air leaving the tank at:

- 21% oxygen by volume; for
- at least 30 minutes.

Displacement:	The displacement method requires that your vessel is equipped with purge pipes in the tanks that are to be gas freed.
Blanket:	The displacement method works by displacing the inert and hydrocarbon gases with a blanket of air. Because of the difference in their densities, the air will form a blanket on top of the IG hydrocarbon mixture.
Forced Venting:	The hydrocarbon and inert gases are forced out through the standpipe opening of the tank and vented to the atmosphere through the opening at the deck level.



Introduction of fresh air by moderate blowing from the tank top and discharge through purge pipe.

Turbulence:	Air turbulence must be kept to a minimum because you are depending on the difference in the densities of the air and the inert gas hydrocarbon mixture to purge the tank of the heavier unwanted gases.

IG Blower: When IG blowers are used to gas free a tank they must be isolated from the scrubber.

Kept Running: When the IG blower is used it is kept running while testing the oxygen content in the tank.

Portable Blower: Once the oxygen content has reached 21% at the outlet and you are using a potable blower you must:

- Secure the blower; and
- Test the tank for 0_2 at different levels in the tank.

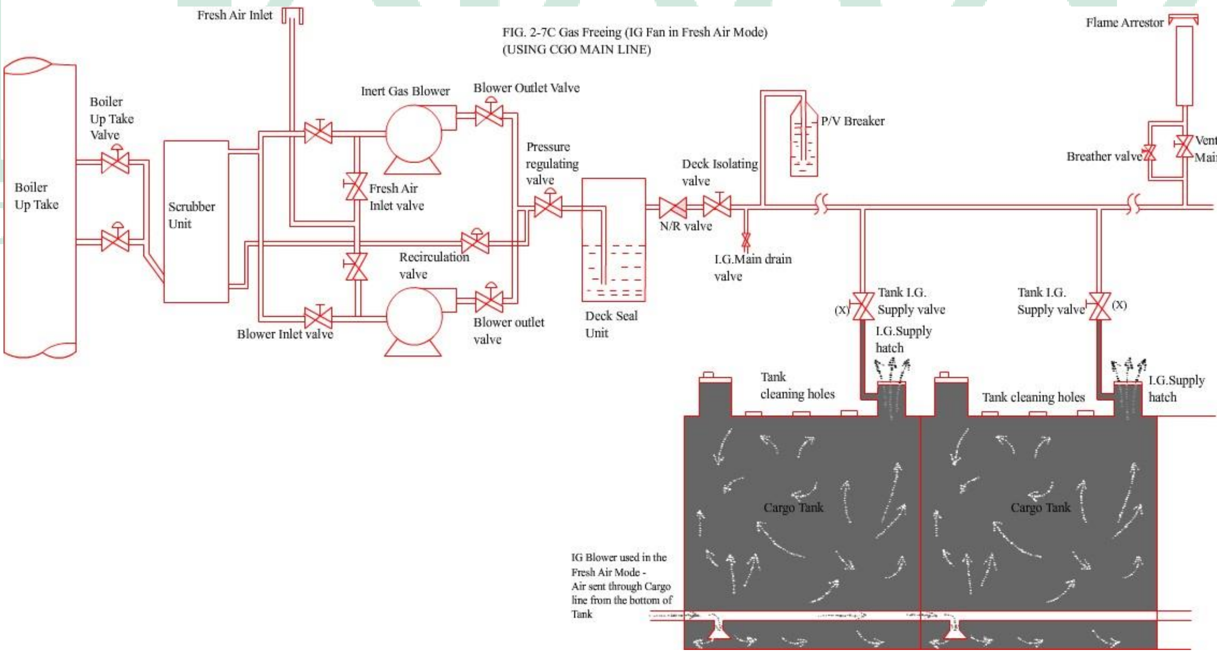


FIG. 2-7C Gas Freeing (IG Fan in Fresh Air Mode)
(USING CGO MAIN LINE)

9.3 Gas Freeing Precautions

Tank Monitoring:	The blowers should always be running when men are working in the tanks and the tank atmosphere should be constantly monitored for the unexpected release of gas.
Check Flow:	Care must be taken to insure that the airflow into the tank is effecting the entire tank and just not the atmosphere at the top of the tank.
Short Circuit:	Short circuiting is when:

- The air being injected into the tank is flowing across the top of the tank;
- Then out of the vent at deck level; and
- Has little impact on the rest of the tank's atmosphere.

Check Levels: Tank reading must be taken at different levels within the tank to ensure that proper gas freeing has taken place.

Isolation: You must ensure the tank is properly isolated and the adjacent tanks and spaces are in the proper condition for the operation you will be doing.

Deck Control: You must maintain control of the deck throughout the entire operation. The condition of the deck should not deviate from what you planned from the time you start gas freeing until you are finished. You should:

- Utilize the lock out tag out procedures on the valves you do not want opened
- Set up a control area with boundaries
- Designate a watch to ensure the area remains secure
- Allow no other work to be done in the control area. The control area can be the entire deck or one tank
- When finished the person in charge shall designate when the condition of the deck can be changed and when the gas freeing is done

9.4 Tank Cleaning

General after inert or

This Section deals with procedures and safety precautions for cleaning cargo tanks the discharge of volatile or non-volatile petroleum carried in non-gas free, non-inert tanks. Guidance is also given on the cleaning of contaminated ballast spaces.

Tank Washing

Risk Management

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

In planning tank washing operations, the prime risk is fire or explosion arising from simultaneous presence of a flammable atmosphere and a source of ignition.

The focus therefore should be to eliminate one or more of the hazards that contribute to that risk, namely the sides of the fire triangle of air/oxygen, ignition source and fuel.

Inert Tanks

The method that provides the lowest risk is washing the tank in an inert atmosphere. The inert condition provides for no ambiguity; by definition, to be deemed inert, the tank MUST meet the SOLAS requirement for inerting of the cargo tanks and reducing the oxygen content of the atmosphere in each tank to a level at which combustion cannot be supported.

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

Non-Inert Tanks

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

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

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

Supervision and Preparation

A Responsible Officer must supervise all tank washing operations.

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

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

Preparation

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

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

The appropriate personnel ashore should be consulted to ascertain that conditions on the jetty do not present a hazard and to obtain agreement that operations can start.

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

Tank Atmospheres

Tank atmospheres can be either of the following:

Inert

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

Non-Inert

A non-inert atmosphere re is one in which the oxygen content has not been confirmed to be less than 8% by volume.

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

Tank Washing

Washing in an Inert Atmosphere

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

Washing in a Non-Inert Atmosphere

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

Before Washing

- The tank bottom should be flushed with water so that all parts are covered, and then stripped. This flush should be undertaken using the main cargo pumps and lines. Alternatively, permanent pipework extending the full depth of the tank should be used. This flush should not be undertaken using the tank washing machines.

- The piping system, including cargo pumps, crossovers and discharge lines, should also be flushed with water. The flushing water should be drained to the tank designed or designated to receive slops.

- The tank should be ventilated to reduce the gas concentration of the atmosphere to 10% or less of the Lower Flammable Limit (LFL). Gas tests must be made at various levels and due consideration should be given to the possible existence of pockets of flammable gas, in particular in the vicinity of potential sources of ignition such as mechanical equipment that might generate hot spots, e.g. moving parts such as found in-in tank (submerged) cargo pump impellors.

- Tank washing may only commence once the tank atmosphere reaches 10% or less of the LFL.

During Washing

- Atmosphere testing should be frequent and taken at various levels inside the tank during washing to monitor the change in LFL percentage.

- Consideration should be given to the possible effect of water on the efficiency of the gas measuring equipment and therefore to suspension of washing to take readings.

- Mechanical ventilation should, whenever possible, be continued during washing and to provide a free flow of air from one end of the tank to the other.

- The ability to mechanically ventilate concurrent with tank washing is recommended but, where mechanical ventilation is not possible, the monitoring of the tank atmosphere should be more frequent as the likelihood of rapid gas build up is increased.

- The tank atmosphere should be maintained at a level not exceeding 35%

LFL. Should the gas level reach 35% LFL at any measured location within a tank, tank washing operations in that individual tank MUST immediately cease.

- Washing may be resumed when continued ventilation has reduced and is able to maintain the gas concentration at 10% or less of the LFL.

- When cleaning a tank by the Butterworth process, you should begin to pump out the slops when the process is started.

Precautions for Tank Washing

Portable Tank Washing Machines and Hoses

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

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

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

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

Portable Hoses for Use with both Fixed and Portable Tank Washing Machines

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

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

Testing of Tank Cleaning Hoses

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

Tank Cleaning Concurrently with Cargo Handling

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

Free Fall

It is essential to avoid the free fall of water or slops into a tank. The liquid level
should

always be such that the discharge inlets in the slop tank are covered to a depth of at
least

one meter to avoid splashing. However, this is not necessary when the slop and
cargo

tanks are fully inerted.

Spraying of Water

The spraying of water into a tank containing a substantial quantity of static
accumulator

oil could result in the generation of static electricity at the liquid surface, either by agitation or by water settling. Tanks that contain static accumulator oil should always be

pumped out before they are washed with water, unless the tank is kept in an inert

condition.

Use of Chemicals in Tank Cleaning Wash Water

Constraints on the use of chemicals in tank cleaning wash water will depend on the type of tank atmosphere.

If tank cleaning chemicals are to be used, it is important to recognize that certain products may introduce a toxicity or flammability hazard. Personnel should be made aware of the

Threshold Limit Value (TLV) of the product. Detector tubes are particularly useful for detecting the presence of specific gases and vapors in tanks. Tank cleaning chemicals capable of producing a flammable atmosphere should normally only be used when the tank has been inerted

Use of Chemicals for Local Cleaning of Tanks

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

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

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

Removal of Sludge, Scale and Sediment

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

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

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

Section 10

Stability & Trim

Stability-Concepts and Definitions

Introduction: Stability, trim, and stress calculations continue to be one of the most important and challenging jobs that the chief mate has on a vessel. These calculations go hand in hand with the cargo load plans.

Mistakes: The following are some of the possibilities that may result by ignoring or miscalculating the vessel's stability, stress or trim:

- Over stressing the vessel causing permanent structural damage;
- Endangering the vessel with rolling over due to a negative gm;
- The inability of your vessel to enter or leave port because of air height or under keel clearance restrictions; and
- Loading the vessel beyond her marks.

PIC Tankerman 's Review: Once the vessel has received cargo orders pre-calculation of the load takes place. When the plans are completed, they should be submitted for review by the vessel's PIC Tankerman .

Stability: Stability is the ability of a vessel to return to its original condition or position after it has been disturbed by an outside force.

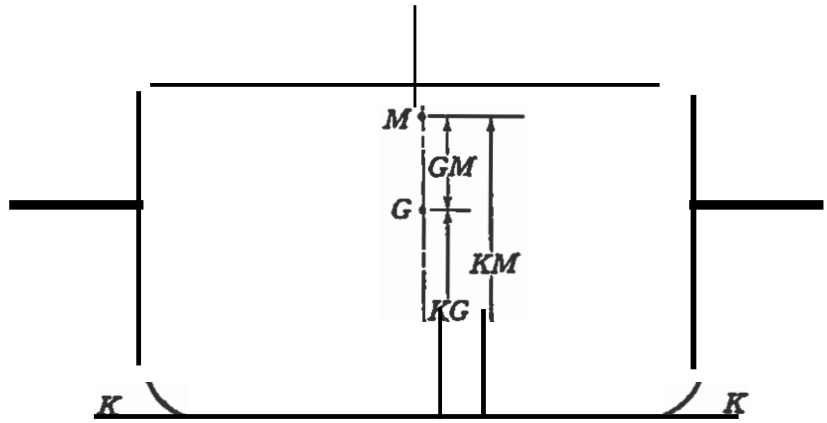
Transverse: Transverse stability is the tendency for a vessel to:

- Remain upright;
- Resist rolling due to external forces ; and
- Return to the upright after being inclined.

KG: KG is the height of the center of gravity on a vessel above the keel and it is:

- The function of the light vessel characteristic; and
- The principle variable under the control of the individual planning the load.

KB: KB is the height of the center of buoyancy above the keel and is a function of draft and underwater hull form.



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M: M is the transverse metacenter and is the point of intersection of the verticals through the center of buoyancy at two different angles of heel.

KM: KM is the height of the metacenter above the keel and is:

- The sum of KG + GM
- It varies with the draft of the vessel

GM: GM is the height of the meta center above the center of gravity and is:

- The difference in height between KM and KG
- The primary goal of vessel's stability calculations
- Is a significant indicator of initial stability

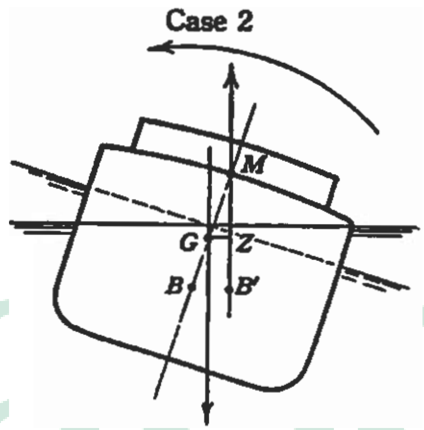
BM: BM is the height of the transverse meta center above the center of buoyancy and it is a function:

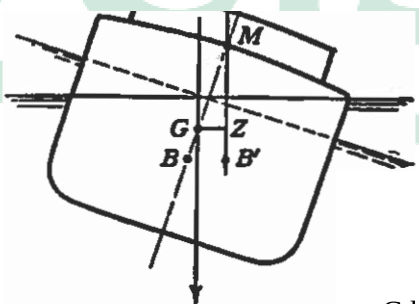
- Of the water plane geometry
- The volume of displacement

GZ: GZ is the righting arm and is the horizontal distance between the downward force of gravity and the upward buoyant force and it:

- Varies with angle of heel and the GM
- It can be determined from the Cross Curves of Stability

Case 1 Case 2

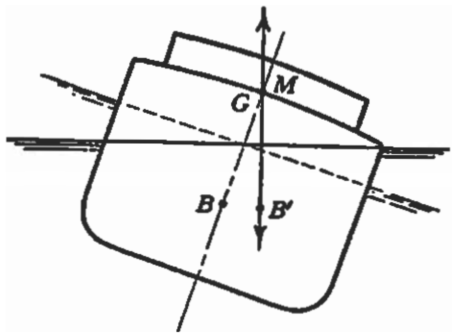




G below M

Stable Equilibrium

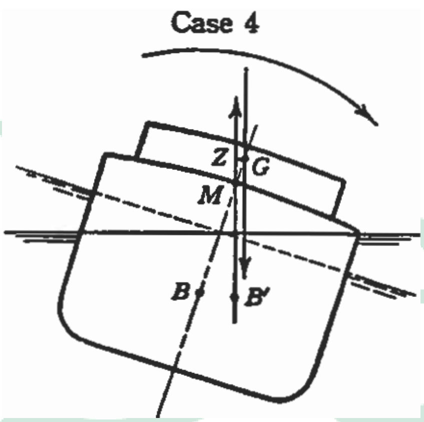
Case 3

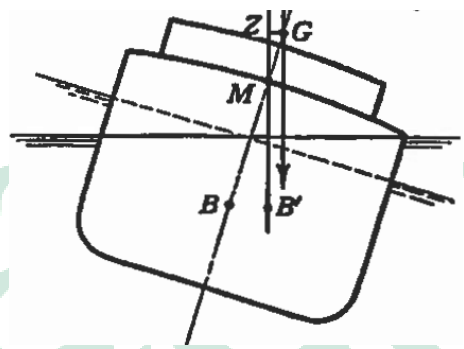


G coincides with M

Neutral, Equilibrium

Case 4





G is above M

Unstable Equilibrium

Pitching: Longitudinal Stability is the tendency of a vessel to return to its original longitudinal position.

LCB: The longitudinal center of buoyancy is required for trim calculations and it:

- Is a function of underwater hull form
- Varies with draft
- It is determined by looking it up in the hydrostatic table or curves

LCF: The longitudinal center of floatation is the tipping center where the vessel:

- Trims about
- Is a function of water plane area

Free Surface: Whenever the surface of a liquid within a vessel is free to move, the condition known as free surface is present. Free surface can:

- Reduce the GM
- Reduce transverse stability
- Be a significant stability factor in full breadth cargo tanks

List: List is the inclination of a vessel due to internal force

Heel: Heel is the inclination of a vessel due to external force

Bending Moment: The bending moment is the measure of the tendency of the hull girders to bend and it is:

- The sum of the moments causing a deflection of the hull girders
- It is calculated in the terms of the maximum allowable bending moment expressed in foot-tons

Shear Stress: Shear stress is the result of two forces:

- Acting in opposite directions
- Along parallel lines

Deflection: Deflection is the bending of the hull and can be found by noting the difference between:

- The computed mean draft
- The measured mid-vessel draft

Sag: If the mean draft is less than the actual mid-vessel draft you are sagging

The normal tendency for a loaded tank barge is to sag.

Hog: If the mean draft is greater than the actual mid-vessel draft you are hogging

Stability Curves: The stability curves allow you to find the various righting arms for all displacements and angles of inclination of the vessel. These ordinates are:

- The angles of inclination
- The vessel's displacement

Motions: There are six principle motions of vessels when they are in the water and they are:

- Rolling about its longitudinal axis
- Pitching about its transverse axis
- Yawing about its vertical axis
- Heaving or the vertical body motion of a vessel
- Swaying or the side to side motion of a vessel
- Surging or the longitudinal bodily motion of a vessel

Relation vessels: A listing of the six vessel's motions matched with its governing stability is as follows:

- Rolling is governed by transverse stability
- Pitching is governed by longitudinal stability
- Yawing is governed by directional stability
- Heaving is governed by positional motion stability
- Surging is governed by stability in motion ahead or astern
- Swaying is governed by lateral motion stability

Tons Per Inch: The TPI curve is the hydrostatic curves in a tank barge's plans, gives the number of tons necessary to further immerse the tank barge 1 inch at a given draft.

10.1 Stability Requirements

Regulations Requirements: The regulations regarding stability can be found in 46 CFR parts 170 to 174.The stability requirements vary with the hazardous nature of:

- The cargo carried
- The geographic area of the operation

Defined By: These hazards and geographic rules are defined by the:

- IMO Code
- CFR parts
- International Load Line Convention 1966
- Marpol 73/78
- The Chemical Code IBC And BCH

Stress: Longitudinal stress is a major concern of the chief mate when loading or discharging operations are underway and stress calculations should be checked hourly during these operations.

Computer: Computer based stability and trim programs are based on the Stability Book information and they can calculate the:

- Bending moments
- Stability curves
- The vessel's deflection

Sea Condition: These calculations will show if the vessel will be within the normal operating perimeters for which the vessel was designed. They also may calculate stress limits for:

- At sea conditions
- Still water conditions

Provided By: These computer programs should be approved and are:

- Provided by your company or the vessel builder
- Based on the stability booklet

- Relatively easy to use

Transverse: In the traditional single hulled vessel, transverse stability is not a critical factor in planning the load or in transfer operations. The significant factors are:

- Trim
- Draft
- Stress

Double Hull: The introduction of double hull barges without center tanks has added transverse stability to the long list of items of significance for the vessel mate.

Lolling: Lolling is a relatively new phenomenon that effects the vessel's intact stability. Some double hull barges have experienced a sudden list of up to ten degrees due to this condition.

Prevent Lolling: To prevent lolling you must ensure that you:

- Keep the weights evenly distributed on both side of the centerline
- Monitor the operation frequently
- Keep free surface tanks to a minimum

List: List is an inclination of a vessel due to internal forces.

Heel: Heel is an inclination due to external forces and is frequently experienced on light barges that:

- Present a high profile
- Have a large sail surface area
- The wind can act on it

Natural List: Most barges have a natural list to one side or the other in their light condition. This can be used to the mate's advantage when stripping tanks.

Loading: While loading, lists should be avoided as the cargo will have a tendency to quickly gravitate to the lower side of the vessel and make a list worse.

Cause of List: The cause of a vessel listing becomes of paramount importance when damage stability is of concern.

Damage: The term damage stability is the stability of a vessel after flooding. The unspecified term stability includes transverse and longitudinal stability.

Equilibrium: The chief mate should review and be familiar with damage stability for his vessel. When a vessel is damaged and open to the sea its natural tendency is to seek an equilibrium condition and it may also:

- Gain in draft
- Increase the transverse stability
- Change the trim
- May lose longitudinal hull strength

Assessment: Once the Exxon Valdez had sustained her damage by running aground on Bliegh reef, the chief mate commenced the damage assessment of the vessel. He sounded each tank and:

- Established which tanks had been compromised
- Used this data to complete the damage stability of the vessel
- Concluded the vessel would rollover and sink if it were pulled off the reef in the condition it was in

Part of OSRP: Damage control calculations are incorporated as part of the vessel's Oil Spill Response Plan and training exercises.

Unexpected Lists: The reason for an unexpected list must be found before corrective action can be taken. The vessel's officer should check:

- The empty cargo wings
- The ballast wing tanks
- The fuel oil tanks

Cargo Shift: List can be caused by the center of gravity shifting off the centerline of the vessel. This may be a result of cargo shifting between tanks.

Lists: The reduction in metacentric height caused by raising the center of gravity will cause a list. Gravity might rise because of:

- The free surface effect
- A compartment has a side penetration allowing free communication with the sea

Repairing Meta center: This condition is very dangerous and should be rectified by repairing the ruptured compartment as soon as possible

- The meta center may shift owing to an increase in displacement which could be caused by a bottom penetration of a tank allowing free communication with the sea.

Survival: The survival capability requirements under MARPOL regulation 25.3 (c), for standard barges requires that:

- The range of stability be based through an angle of 20 degrees beyond the position of equilibrium
- The maximum residual righting lever must be at least 10 centimeters

Dock Depths:	While loading a vessel care must be taken to confirm the depth limitations at the berth. A list may be due to the vessel resting on a sloped bottom.
Lead Line:	The depth alongside is best checked with a lead line.
Stability Book:	Every vessel must be provided with a stability book. These books are prepared and supplied by the vessel builder.
Regulations:	The book must contain sufficient information to enable the PIC Tankerman to operate the vessel in compliance with regulations set forth in 46 CFR parts 170 and 172.
Instructions derived	Instructions for the use of the book are included with example stability solutions from:

- Tables
- Graphs
- Formulas

Arrangement:	General arrangement plans are included in the stability book showing: • Watertight compartments • Closures • Vents • Down flooding angles • Allowable deck loads
Capacity Plans:	A capacity plan showing the vertical, longitudinal and transverse centers of gravity for each tank and cargo space onboard the vessel are included.
Ullage Tables:	The tank ullage or sounding tables show: • Capacities • Vertical centers of gravity • Longitudinal centers of gravity in graduated intervals • Free surface data for each tank
Stability Curves:	The stability book has included the:
Approval:	The book must be approved by the Commanding Officer, Marine Safety Center. The original red stamped copy must remain onboard the vessel.
Stability letter:	Each vessel that is issued a stability letter by the Coast Guard must post this letter under glass in the pilothouse of the vessel as per 46 CFR 35.08-1. This letter sets forth the stability conditions in which the vessel must operate under.
Not Required:	A stability letter is not required if the information can be placed on the Certificate of Inspection or the Load Line Certificate.

GLOSSARY

Arrival ballast	"Clean ballast" loaded in cargo tanks which have been crude oil washed and water rinsed to remove the last traces of crude oil prior to loading ballast. This ballast should not contain more than 15 ppm of oil, leaving no sheen on still water, and can be discharged before loading or concurrent with loading.
Atmosphere	Formation of flammable mixtures of cargo vapor and air inside cargo tank. If the tank is to be entered, particular attention has to be paid to the risks of lack of oxygen, toxic and/or explosive tank atmosphere. Always consider the tank 'dangerous' and act according to the Enclosed Space Entry procedures.
Barge vapor connection	means the point in a barge's piping system where it connects to a vapor

	collection hose or arm. This may be the same as the barge's cargo connection.
Barrel	There is 42 U.S. gallons @ 60º per one barrel of liquid.
Bottom washing	A portion of the crude oil washing process where the lower portion of the tank, and tank bottom, are crude oil washed when the tank is nearly empty. The input from the washing machines is controlled to enable the stripping system to keep the tank bottom dry.
Clean ballast	The ballast in a tank which, since oil was last carried therein, has been so cleaned that effluent there from if it were discharged from a ship which is stationary, into clean, calm water on a clear day would not produce either visible traces of oil on the surface of the water or on adjoining shore lines, or cause a sludge or emulsion to be deposited beneath the surface of the water or upon adjoining shore lines.
Cleaning facility	means a facility used or capable of being used to conduct cleaning operations on a tank barge.
Cleaning operation	means any stripping, gas-freeing, or tank washing operation of a barge's cargo tanks conducted at a cleaning facility.
Certifying entity	means an individual or organization accepted by Commandant (G-MOS) to review plans and calculations for VCS designs, and to conduct initial inspections and witness tests of VCS installations.
Clingage	The material clinging to all surfaces within emptied cargo tanks other than bottom surfaces.
Combustible liquid	means a liquid as defined in 46 CFR 30.10-15.

Crude oil washing	A process whereby part of the crude oil cargo is circulated through fixed tank cleaning equipment to remove hydrocarbon deposits from within the tank.
Departure ballast	Ballast taken into cargo tanks during, or upon completion of cargo discharge. This ballast can only be loaded into empty crude oil tanks providing proper segregation. The procedure for draining and stripping cargo lines must be completed before ballast is loaded into any cargo tank IMO defines departure ballast as ballast other than arrival ballast.
Dip/innage	The term that designates the depth of liquid in a tank.
Direct impingement	The hard and direct contact of the washing machine jet with the sides and bottom of a cargo tank.
Dirty ballast	Ballast which does not meet the criteria for clean ballast or segregated ballast.
Dry crude	Crude oil without measurable entrained water.
Electrostatic mist	Electrically charged particles arising from the spraying of water at high velocity.
Elevated temperature	means the temperature that exceeds 70% of the auto-ignition temperature of the vapors being collected.
Facility means	an onshore or mobile facility which includes, but is not limited to structures, equipment, and appurtenances thereto, used or capable of being used to transfer and control vapors.
Facility vapor connection	means the point in a facility's fixed vapor collection system where it connects to a vapor collection hose or the base of a vapor collection arm.

Fixed stripping line	means a pipe extending to the low point of each cargo tank, which is welded through the deck and terminates above the deck with a valve, plugged at the open end.
Flammable range	The limits between the minimum and maximum concentrations of vapor in air which form explosive or burnable mixtures. Usually abbreviated LFL (Lower Flammable Limit) and UFL (Upper Flammable Limit) These are synonymous with "Lower Explosive Limit" (LEL) and "Upper Explosive Limit" (UEL).
Flammable liquid	means a liquid as defined in 46 CFR 30.10-22.
Flame arrester	means a device which is designed, built, and tested in accordance with Appendix B to 33 CFR 154 for use in end-of-line applications for arresting flames.
Fluid displacement	system means a system that removes vapors from a barge's cargo tanks during gas-freeing through the addition of an inert gas or other medium into the cargo tank.
Fluid injection connection	means the point in a fluid displacement system at which the fixed piping or hose that supplies the inert gas or other medium connects to a barge's cargo tanks or fixed piping system.
Full cycle path	The path traced by the crude oil washing machine nozzle, from its uppermost position to its lowest position, while rotating through 360 degrees.
Full cycle time	The time required for the crude oil washing machine nozzle to rotate in an arc 360 degrees around its axis both in a horizontal and vertical plane.
Gas-freeing	means the removal of vapors from a tank barge.

High flash point cargoes — means Grade E cargoes and cargoes having a closed cup flash point greater than 600 C, carried at a temperature no higher than 50 C below their flash points.

IMO — IMO International Maritime Organization.

Inerted — means the oxygen content of the vapor space in a barge's cargo tank is reduced to 8% or less by volume in accordance with the inert gas requirements of 46 CFR 32.53.

Innage — Innage (also referred to as “dip” or “sounding”) is the measured distance from the surface of the liquid to a fixed datum plate or to the tank bottom.

Kg/Cm2 — Kilograms per square centimeter.

Kg/Mm2 — Kilograms per square millimeter.

Lightering — The transfer of petroleum between a ship and another ship or barge

Liquid knockout vessel — means a device designed to separate liquids from vapors.

Maximum allowable gas-freeing rate — means the maximum volumetric rate at which a barge may be gas-freed during cleaning operations.

Maximum allowable — means the maximum volumetric rate at which a barge may

stripping rate	be stripped during cleaning operations prior to the opening of any hatch and/or fitting in the cargo tank being stripped.
Multiple facility vapor collection system	means the point in the vapor collection system where two or more branch lines connection originating from separate facility vapor connections are connected.
Multi-stage washing	In this method, the tank sides and structure are washed at a convenient time after the cargo has fallen below the level of the tank washing machines. The bottom is then washed in the conventional manner as the tank is emptied. The input from the washing machines is controlled to enable the stripping system to keep the tank bottom dry.
PSI	Pressure expressed in pounds per square inch PSIG Pounds per square inch gauge, referring to pressure read from a gauge where 0 psig indicates atmospheric pressure, which is itself approximately 14.7 psi.
Purging	The introduction of inert gas into a tank already in the inert condition with the object of further reducing the existing the existing hydrocarbon vapor content to a level below which combustion cannot be supported if air is subsequently introduced into the tank.
Remaining On Board residue, oil/water	(ROB) - The material remaining in vessel tanks, void spaces, and/or pipelines after discharge. Remaining on board quantity includes water, oil, slops, oil emulsions, sludge, and sediment.
Reception facilities	The capability at a terminal to receive, separate and subsequently dispose of oil-water mixtures in an approved manner.
Segregated ballast	The ballast water introduced into a tank which is completely separated from the cargo oil and fuel oil system, and which is permanently allocated to the carriage of ballast or to the carriage of ballast or cargoes other than oil or noxious substances.
Shadow areas	The areas of the tank not accessible by direct impingement.

Shadow diagram	Drawings for each tank presenting a view of the tank bottom and sides and each swash bulkhead, indicating the projected direct impingement pattern by the COW machines.
Single-stage washing	The single stage method is similar to the conventional water washing method. The tank is first emptied of the bulk of cargo, or nearly so. Crude oil washing is then carried out in the same way as water washing, and bottom accumulations are stripped out at the same time.
Slop tank	A tank specifically designated for the collection of tank draining's, tank washings and other oily mixtures.
Stripping in	means the removal, to the maximum extent practicable, of cargo residue remaining the barge's cargo tanks and associated fixed piping system after cargo transfer or during cleaning operations.
Top washing	A portion of the crude oil washing process in which the washing machine head is set to spray from a top angle of approximately 150 down to a lower angle of approximately 30°, or to just above the level of oil in the tank.
Ullage/outage	The distance from the reference point (e.g. the rim of the hatch) to the surface of the liquid in a tank.
Vacuum displacement system	means a system that removes vapors from a barge's cargo tanks during gas-freeing by sweeping air through the cargo tank hatch openings.
Vapor collection system	means an arrangement of piping and hoses used to collect vapor emitted from a barge's cargo tanks and transport the vapor to a vapor processing unit.

Vapor control system	(VCS) means an arrangement of piping and equipment used to control vapor emissions collected from a barge, and includes the vapor collection system and the vapor processing unit.
Vapor destruction unit	means a vapor processing unit that destroys cargo vapor by a means such as incineration.
Vapor dispersion unit	means a vapor processing unit which releases cargo vapor to the atmosphere through a venting system not located on the barge undergoing cleaning operations.
Vapor processing unit	means the components of a VCS that recovers, destroys, or disperses vapor collected from a barge.
Vapor recovery unit	means a vapor processing unit that recovers cargo vapor by a non-destructive means such as lean oil absorption, carbon bed adsorption, or refrigeration.
Vortexing	A whirlpool effect caused by suction.
Water flushing	The introduction of a quantity of sea water through the cargo system to remove residual oil that may have remained in the cargo system.
Water rinsing	A complete or partial washing of the tanks with sea water, done after crude oil washing, using the fixed tank cleaning machines through a complete or partial cycle.
Wet crude	Crude oil with measurable entrained water.

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