Drew Marine

TANK CLEANING MANUAL

ASHLAND

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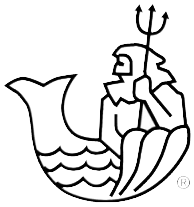

Drew Marine

TANK CLEANING MANUAL

FIFTH EDITION

Responsible Care®

Ashland is committed to the continuous evolution of technology and service solutions that promote health, safety and environmental protection around the world.

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INTRODUCTION

The information and facts contained in this manual have been researched and correlated employing chemists, industry experts and various users of tank cleaning chemicals. However, the information should not be construed as a definitive warranty for the guaranteeing of any specific tank cleaning process, especially during times of exceptional conditions or circumstances.

Tank cleaning, in general, is an expensive activity. However, the washing of tanks using chemicals is often a great aid to minimizing cleaning costs and achieving the desired degree of residue control.

The aim of each tank cleaning operation is to render every tank or hold suitable for immediate commencement of loading cargo or performing repairs available in the most efficient manner possible. This tank cleaning should be accomplished with the optimum combination of cost, time and manpower. In addition, ensuring that the environment remains uncontaminated by pollutants. The degree and extent of the type of cleaning required depends upon the exact nature of the product to be loaded and upon the characteristics of the cargoes which were previously carried, especially the last cargo. If the cargo to be loaded is of a similar nature to the cargo immediately discharged, then cleaning work is usually minimal. The type of cleaning chemical selected will also depend upon whether or not the tank has been coated.

Very often it is necessary to prepare the holds or tanks of a vessel to receive an entirely different cargo. This can often only be achieved in the time available by using a carefully selected chemical cleaning process which will aid the rapid and complete removal of tenacious residues and sediments.

Indispensable to the efficient cleaning of tanks is a clear understanding of the nature of the problems and the products involved. The essence, therefore, of good tank cleaning is to use the correct mechanical equipment with properly selected cleaning chemicals applied in the approved fashion for the type of residues to be removed and the cargo to be received.

CHAPTER I

TANK CLEANING SYSTEM COMPONENTS

The tank cleaning system often consists of the following components:

- Water supply pump
- Deck water supply distribution piping
- Tank cleaning water heater
- Deck access openings for portable machines
- Tank washing machines
- Stripping pumps or eductors

1. ASSOCIATED EQUIPMENT

- Quadrant saddles
- Wash hoses
- Couplings for hoses
- Air hoses
- Scrapers
- Mucking winches
- Brooms
- Squeegee mops
- Cargo clusters and lights (vapor proof)
- Torches (flashlights) (vapor proof)
- Spanners (spark proof)
- Oil absorbent material
- Rags

2. PUMP

Either an independent pump or a cargo pump can be used to supply water under pressure to the fixed or portable tank cleaning machines. The rated volume capacity of the pump should always be greater than the total discharge of all of the machines used at any one time. When one or two machines are used, this excess capacity should be about 10%, and when 4 or more machines are used simultaneously the excess capacity should be in the order of 5%. The pump should be able to maintain a constant output pressure of between 1000 kN/m^2 and 1300 kN/m^2 (10 kg/cm^2 and 13 kg/cm^2) for effectively cleaning the residues from bulkheads and frames. Standard tank cleaning machines discharge varying quantities of water depending upon the size of the nozzle(s) and water jet pressure.

Typical quantities for an average machine with 11 mm nozzles are shown below:

	MACHINE INLET PRESSURE kg/cm^2					
	3.5	5.3	7.0	8.8	10.5	12.3
Discharge (ltrs/min)	273	336	391	426	482	523
Discharge (m^3/hr)	16.3	20.4	23.4	26.5	28.5	31.6
Minutes/cycle	50	37.5	32	28	25	23
Nozzle rpm	1.3	1.7	2.0	2.3	2.6	2.8
m^3 cycle	13.7	12.7	12.5	12.2	12.1	12.0

Graphically shown below are the average discharge rates for various size nozzles at different pressures as well as the cycle times for BUTTERWORTH[1] K and SK tank cleaning machines.

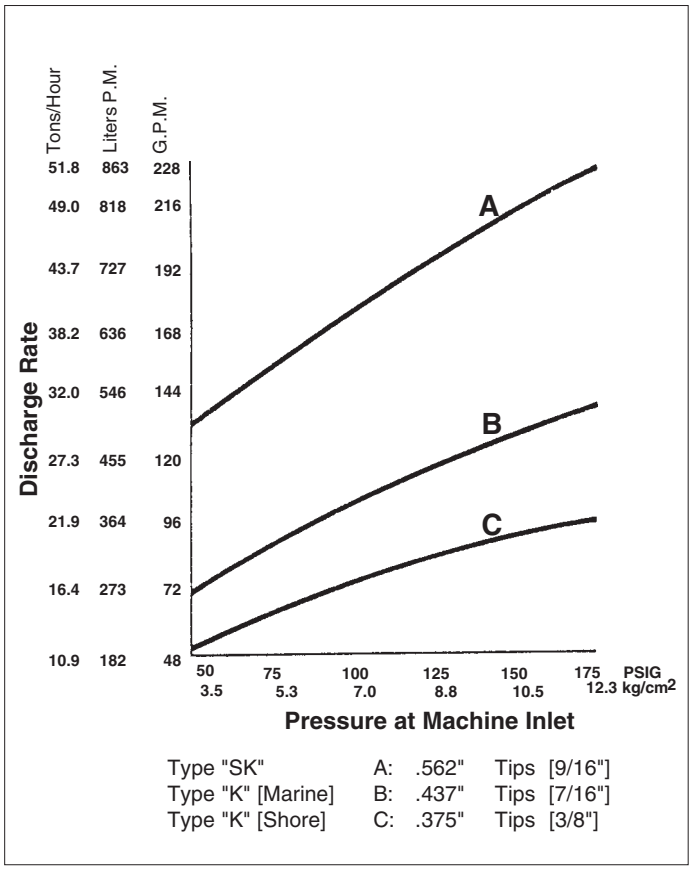


Figure 1
BUTTERWORTH TYPE "K" and TYPE "SK"
TANK CLEANING MACHINES

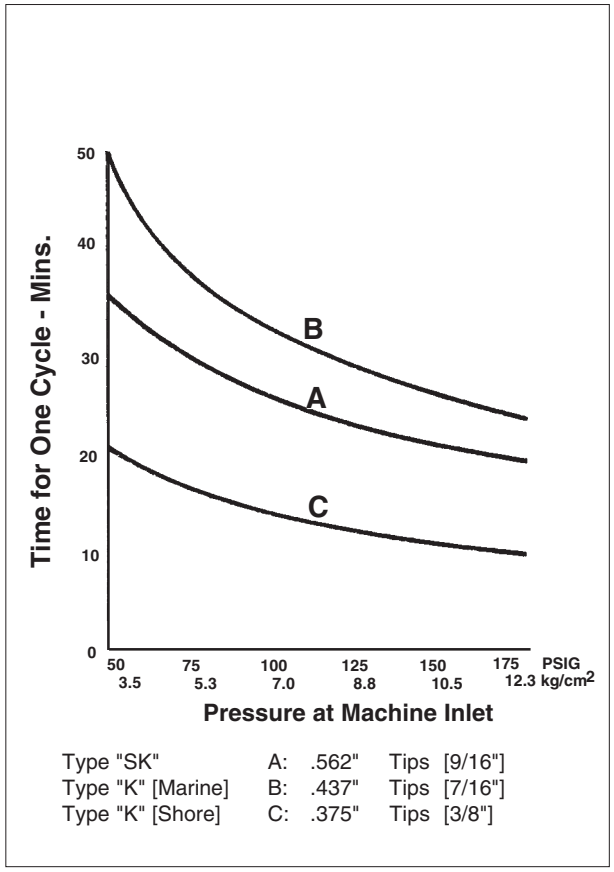


Figure 2
BUTTERWORTH TYPE "K" AND TYPE "SK"
TANK CLEANING MACHINES

Diagrammatically the BUTTERWORTH K and SK/SSK machines can be represented as shown below:

Figure 3
K MACHINE

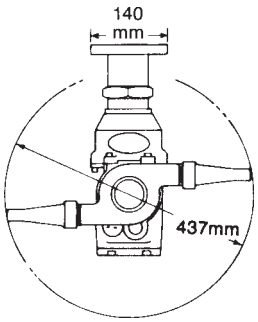


Figure 4
SK and SSK MACHINE

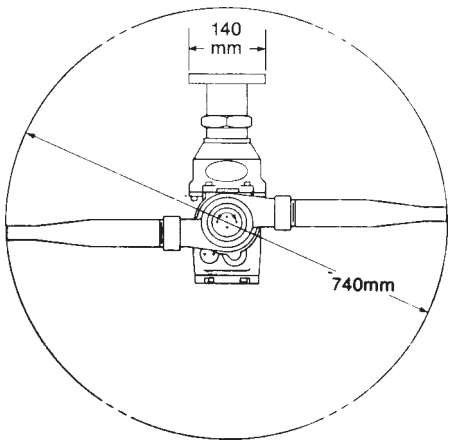
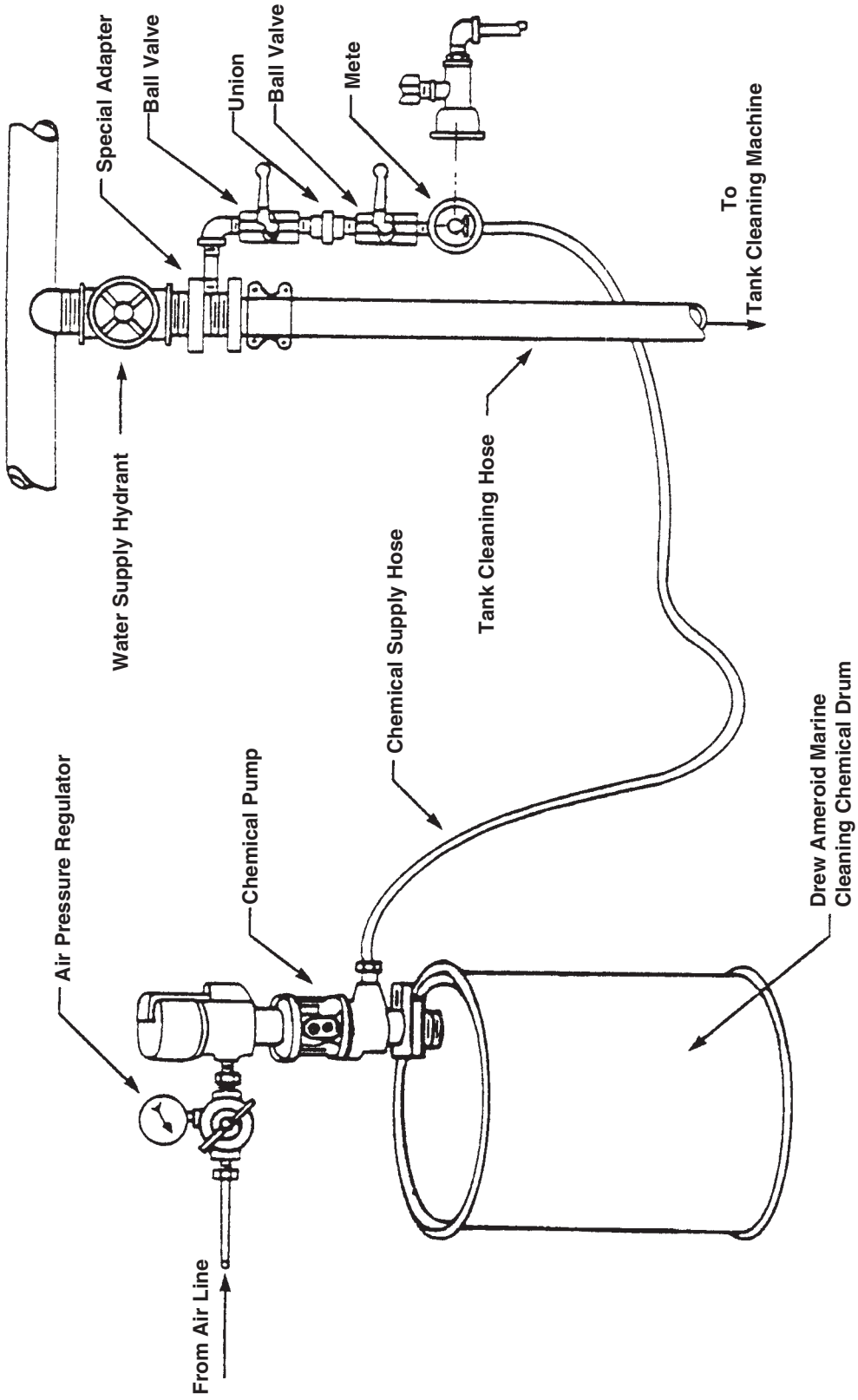


Figure 5

ARRANGEMENT FOR SUPPLYING DREW AMEROID CLEANERS THROUGH TANK CLEANING MACHINES



Below, shown for purposes of identification, are drawings of typical portable tank wash machines - the BUTTERWORTH[1] K and SK/SSK tank cleaning machines.

Figure 6

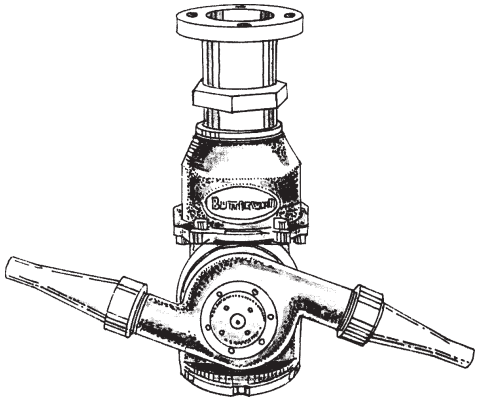
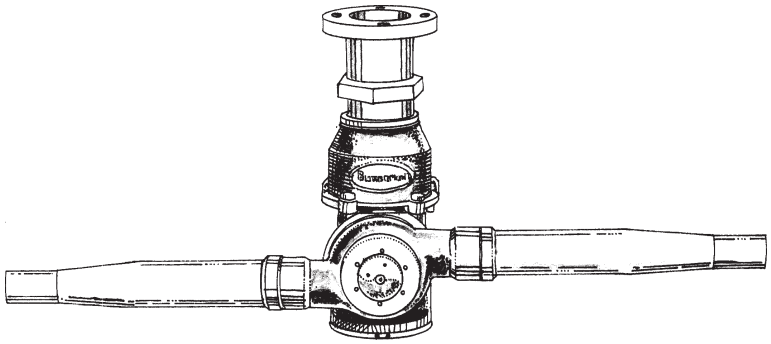


Figure 7



3. DECK WATER SUPPLY LINES

On deck the supply line generally runs from the top of the pump room or engine bulkhead to the forward-most (No. 1) tank. Smaller subsidiary lines supply, as required, any fixed machines installed in the tanks. Hydrants at convenient intervals are provided in order that the portable machines may be connected into the system. Quite often, where a high capacity of tank cleaning water is supplied, hydrants are fitted in pairs. The tank wash water lines should be capable of working at pressures up to about 14.7 bars (15 kg/cm^2)(213 psi) and should be able to carry the maximum discharge from the pump without such pressure loss as to cause ineffective cleaning. Thermometers and pressure gauges are normally fitted into the tank wash lines at strategic points in order to monitor operational conditions.

4. TANK CLEANING WATER HEATER

The heater should be situated on the discharge side of the pump and be fitted with a water bypass. It should be capable of heating seawater to a temperature of about 90° C (194° F) in order that the chemicals can be applied at optimum operating conditions and at the same time allowing for a certain acceptable temperature drop when discharged through the deck lines.

The heater shell is usually fabricated from mild steel, is of circular cross-section and is normally mounted horizontally. The heating surfaces of the tank cleaning heater generally consist of a multi-pass cupronickel tube bundle. The tube plates are generally constructed of a similar material and can be held in place by stay rods or sandwiched between heater cover and body which are secured by common bolts or studs. The heater cover, usually of mild steel construction, normally has horizontal division plates in order that several passes of the water through the heater can be achieved. The inlet and outlet pipes are mostly fitted into the end cover plates. Steam drains from the heater are led back to a drain cooler in order that a minimum of heat is wasted. Drains are usually maintained at a predetermined level in the heater and controls for this and water outlet temperature are normally fitted on deck for ease of operation.

The table on the following page shows the approximate quantities of steam and water required to raise the water temperature from 24°C (75°F) inlet to 88°C (190°F) outlet at a constant steam pressure of 12.5 bars (12.7 kg/cm^2) (180 psi).

No. of Machines	Discharge ltrs/min	Steam for Heat Exch. kg/hr	Water Supply Pipe diam.(mm)
1	525	3200	75
2	1050	6400	100
3	1575	9600	125
4	2090	12800	125
5	2615	16000	180
6	3140	19200	180

NOTE: Where possible it is always better to supply the tank cleaning water from the discharge of a condenser, as this will deliver water at a temperature several degrees higher than ambient seawater, thus effecting a considerable saving in heat.

5. TANK CLEANING MACHINE DECK ACCESSES

These deck accesses are of a standard 318 mm (12.5 inches) diameter and are installed for the use of portable tank wash machines. They are sometimes called butterworth holes. Each deck access should be located in a position such that the optimum cleaning of the tank sides, bottom and components is achieved. Usually the accesses are positioned between 6 to 10 meters (20-33 feet) from the tank bulkheads.

Deck accesses, properly located and in sufficient numbers will almost entirely obviate the necessity for tank cleaning machine spotting and hand cleaning. This will ensure efficient tank cleaning with accompanying savings in time and expense. When not in use, tank accesses are covered by plates bolted to the deck or quick closing covers which can be opened or shut with a minimum of delay, also thus economizing on time.

The effect of a water jet from a nozzle decreases with distance and, of course, is lessened if any obstruction is covering or shading the area to be cleaned. Careful positioning of deck accesses must, therefore, always be achieved in order that the areas located behind ladders, frames, etc., can be reached. When access holes are cut into the deck all of the above should be taken into account in order to select the best positions. A tank access should not be positioned in areas of enclosed space (under accommodation, etc.) unless it is unavoidable. Wherever possible they should be located on open deck where toxic or explosive gases can be dispersed quickly into the atmosphere.

6. TANK WASHING MACHINES

There are two basic types of tank cleaning machines, those with one nozzle and those with two or more nozzles usually 180° or 120° to each other. The machine nozzles can rotate in the vertical plane while the machine body turns in a horizontal plane in order that the entire tank surface can be cleaned. In the case of fixed machines a thorough rinse is quite often possible in one complete cycle sweep. Portable machines are usually lowered into the tank at predetermined levels or drops and thus the tank is cleaned section by section. It is usual to supplement fixed machine cleaning with portable machines lowered to clean those areas not covered by the jet from the permanent machine. The residues in each case are removed by direct impingement of water jets on the tank sides and internal structural components. The portable machine drops should be so planned that the tops of the tank's internal structures are cleaned one drop and the undersides cleaned on the next. It is usual to clean the bottoms twice when changing from crude oil to a clean oil cargo or grain. In this case it is also likely that any areas shadowed by the tank internals will have to be cleaned locally by full strength chemical spray application.

Tank washing machines have a compound rotary action in which the water flow under pressure activates a hydraulic turbine which causes the machine to rotate slowly about its vertical axis while simultaneously ejecting a high pressure water jet through a nozzle(s) revolving about a horizontal axis.

7. STRIPPING PUMP OR EDUCTORS

The stripping pump or eductors are essential for aiding the tank cleaning process. Without them proper tank cleaning would not be possible. It should be noted that any filters in the system should be kept scrupulously clean at all times. Eductors are much more efficient for tank cleaning purposes in that they allow large chunks of waxy solid material to be removed from the tank directly, thus obviating the necessity for manual mucking of the tanks or holds.

CHAPTER II

TANK CLEANING CLASSIFICATION AND CERTIFICATION REQUIREMENTS

1. PRECLEANING TANK SURVEYS

Unless a ship has been employed consistently on a run carrying known cargoes and a routine cleaning method has been satisfactorily established, a survey of the tanks will be necessary in order to determine the tank conditions and thus the method of cleaning to be adopted. Before commencing any survey, a tank should be proved gas free and fit to enter. It is therefore almost always necessary to water wash a tank before conducting a survey. A special note of any particularly heavy accumulations of tenacious residues should be made and also of any residues remaining from cargoes other than the last one loaded. Very heavy accumulations of sediment will generally have to be removed mechanically or by using full strength chemicals to loosen them in order that their removal during the cleaning operation will be simplified. The survey should ascertain if rust or scale adheres to the tank surfaces under the cargo residues for it is in these areas where contaminants accumulate which will pollute the following cargo. If a survey proves to be inconclusive, then samples of the residues and/or scale should be taken and analyzed to determine the cleaner to be used.

Tank cleaning and its related activities, such as slop disposal, entering of tanks, etc., are governed by certain international, national or local laws and port or company regulations and should be adhered to.

The holds or tanks of any ship must be cleaned after discharge in order that conditions of cleanliness required by the charterer or shipowner and consignee or receiver, are met in respect to carriage of the next cargo and its subsequent delivery in an uncontaminated state. The above applies particularly to edible cargoes and certain grades of chemicals and petroleum distillates which must be delivered not only in an uncontaminated condition with respect to discoloration, but also without traces of foreign odors.

Various certificates are issued to ships by independent or official classification societies and inspectors. Certain certificates are required for the vessel to trade internationally, others are issued to govern the entry into tanks by personnel and yet others to permit the loading of a cargo.

2. CERTIFICATE CLASSIFICATION

a. **Certificate of Class**: In order that a Certificate of Class be issued and thereafter renewed, every part of a ship must be surveyed within a specific period of time. This regulation applies equally to the holds and tanks of any ship as well as to other parts of its structure. In order that tanks and holds can be surveyed properly, they must be cleaned out to a degree where sediments and residues do not encumber the inspection. Furthermore, the tanks must be gas free in order that the surveyor may enter the tank without hazard.

b. **Gas-Free Certificate**: This certificate is issued by a licensed marine chemist whenever personnel are required to enter a tank for purposes of performing small repairs not requiring hot work, or for cleaning or inspection. The certificate is issued after the toxic and/or explosive gases have been removed from the tank by means of mechanical ventilation and/or tank cleaning with cold or hot sea water with or without the addition of a chemical.

   If a tank is to be gas free in order to perform hot work or shipyard repairs, then a more stringent cleaning is necessary. The Gas Free Certificate for hot work confirms that the tank is not only free from explosive and/or toxic gases, but it is also free of scale adhering to the top, sides or bottom of a tank. These may conceal pockets of oily or petrochemical matter which, under certain conditions, may give off combustible gases. It also confirms that all loose scale, oil, sludge and residues have been removed from the tank bottom and thus the danger of regenerated vapor or gases which may ignite on application of heat have been removed. The vessel carries its own gas monitoring meters in order that the operating staff can verify if a tank is fit for men to enter after gas freeing is accomplished.

c. **Coating Compatibility Certificate**: It is often necessary to obtain a certificate in order that certain chemicals or products can be carried in a tank that has been painted with an inorganic or organic coating. Coating resistance to various chemicals is an important factor when deciding which cargo can be loaded. Also, governmental authorities do maintain regulations governing the carriage of any dangerous material in tanks that may not be either properly prepared or "inerted."

d. **Certificate of Complete Cargo Discharge**: A certificate of discharge must be obtained at many ports when carrying certain dangerous cargoes to confirm that the shipment has been removed from the tank as completely as possible so that cleaning can therefore commence without likelihood of residues of a toxic cargo being pumped.

e. **Local Government Health Certificate**: When a cargo requiring special conditions of cleanliness for its carriage has to be loaded into a tank, it is usual to obtain a certificate indicating the condition of the tank with respect to its freedom from contaminants and odor. This certificate is usually issued by a Governmental or local health inspector.

f. **Independent Surveyor Certificate**: In the case where a vessel has to load a cargo which may or may not be compatible with a previous cargo, an independent survey of the tanks may be required to be done by a local expert. After a tank inspection he will give advice on the type and extent of cleaning required in order that the incoming cargo can be loaded and delivered to the receivers in an uncontaminated condition. In this case it is likely that the consignee will require a copy of the above certificate before he will accept delivery of the cargo.

CHAPTER III

TYPES OF LIQUID CARGOES

To clean the remains of a cargo from a tank or hold and to present it in a condition fit for loading a different cargo generally involves a considerable quantity of work.

The method adopted for cleaning any liquid cargo residues from a tank depends chiefly upon the type of cargo involved and its physical and chemical properties.

Some chemical cargoes are extremely toxic and thus dangerous to personnel when exposed to the fumes. Other cargoes are quick drying and their residues tenacious which can cause a cleaning problem unless approached in the correct manner. Other cargoes can be water soluble or highly volatile and require almost no special cleaning process to totally remove their presence from a tank. Physical removal of some products may be easy but they may leave a strong odor which must be displaced before the next cargo is loaded. To do this another special process must be employed.

From the above it can readily be seen that several different processes are required to remove the large variety of products carried by vessels today. For the purpose of tank cleaning, cargoes can be subdivided into three categories:

- Mineral oils
- Animal, fish and vegetable oils and fats
- Solvents and chemicals

The three categories above can be further subdivided into various groupings according to their origin, physical characteristics and chemical behavior, especially under varying atmospheric and thermal conditions.

1. MINERAL OILS

These oils may be divided into four groups based on their degree of distillation or refining:

- Petroleum-based heavy products
- Coal-based heavy products
- Distillates of petroleum
- Distillates of coal

2. ANIMAL, FISH AND VEGETABLE OILS AND FATS

These products can be divided into four groups according to their properties and behavior when exposed to atmospheric conditions and the effect that oxygen has upon each of the products. Fats are natural organic products with a freezing point at or below 20°C (68°F). In other respects they are similar to natural oils. The four groups are:

- Non-drying oils
- Semi-drying oils
- Drying oils
- Water soluble products

It must be noted that some vegetable oils have the property of absorbing or reacting with oxygen from the air around them. Vegetable oil residues remaining in a tank after pumping out can be affected in this way. Continuous ventilation preferable by means of mechanically operated power driven fans with a discharge to the tank bottoms should always be employed. This is especially true when a tank in which the residues of an oxygen scavenging oil remain and has to be inspected or the deposits removed from the tank bulkheads and frames.

Water soluble products, such as molasses, can be removed from the tank surfaces merely by washing with cold water.

3. SOLVENTS AND CHEMICALS

Today, chemicals and solvents include a vast and complex range of commodities. There are already several hundred which can be carried at sea in liquid form. Many of these are entirely harmless, while others can be extremely dangerous if mishandled. Some chemicals contain enough oxygen to enable them to burn without additional supplies from the air.

Certain chemicals are hazardous and very dangerous to handle. Some chemicals must never be inhaled, even in the smallest quantities. Others can be absorbed through the skin into the blood stream, and reach vital organs. Obviously, these should never be allowed to come into direct contact with the skin.

Finally, some chemicals are extremely corrosive. Hydrochloric acid is an obvious example, but there are others. Corrosive chemicals can cause severe burns if they contact the skin or cause blindness if they enter the eyes. Strong alkalies can have similar effects as those described for acids.

Protective clothing and goggles are essential when working with corrosive chemicals. A complete chemical resistant suit with helmet and respiratory equipment can be required when handling certain obnoxious products. Remember to follow the instructions and all precautionary warnings when dealing with or handling strong acids or alkalies.

Chemicals and solvents can be divided into two broad categories for the purpose of tank cleaning:

- Volatile liquids with high vapor pressure and low boiling point
- Low volatile liquids with low vapor pressure and low boiling point above 100°C (212°F)

CHAPTER IV

TANK CLEANING CHEMICALS

The action of chemicals used in tank cleaning can be divided into several different categories.

1. SOLVENTS

Solvents are chemicals which dissolve or solubilize other materials or chemicals. In this way residues and deposits are removed from the tank surfaces, permitting them to be pumped to slop tanks for disposal.

2. SURFACE ACTIVE AGENTS (Surfactants)

Surface active agents are usually detergents which act to reduce the surface tension of a liquid and thus to improve its wetting and cleaning capabilities. They are usually used together with solvents to produce a cleaning solution which aids in the complete removal of tank residues, such as hydrocarbons, liquid chemicals, etc.

3. EMULSIFIERS

An emulsifier is a surface active chemical which forms an emulsion of two liquids. One liquid is present as extremely small droplets, such that particles or globules of it are dispersed and suspended in the other, i.e., oil-in-water. This suspension often gives a milky appearance.

Emulsification is assisted and sustained by chemicals which consist of molecules with one end hydrophilic (water seeking) and the other end lipophilic (oil seeking). Utilizing this property, an emulsifier makes it possible to remove oily deposits with water. Many products acquiesce to this action, and several different types of emulsifiers are used for removal of a variety of materials. Emulsification does not usually involve chemical change of either solution but merely suspends particles of one product within the other, which in turn gives rise to the milky appearance of the solution.

4. SAPONIFIERS

A saponifier is an alkaline chemical which changes oils and fats into soaps by converting the fatty compounds into water soluble materials which are biodegradable and easily flushed away from the surfaces to which they adhere.

Strong alkali solutions (NaOH and KOH) are used as saponifying agents together with a variety of other compounds in order to deal effectively with the large variety of animal, fish and vegetable oils being transported around the world today. One minor problem with the above process is to estimate the exact quantity of saponifier required to neutralize these types of residues. Normally, the neutralized residues of this process are readily biodegradable. However, if an excessive quantity of alkali is used, not all of it will be chemically converted in the cleaning process. The excess remaining can be harmful to the environment.

5. DREW MARINE TANK CLEANING PRODUCTS

The product usually recommended by Drew Marine for removing mineral oil deposits include:

- **TC#4™ tank cleaner**

  A liquid oil solvent emulsifying detergent with hydrophilic properties used for the removal of petroleum product residues from tanks. TC#4 tank cleaner is used for cleaning crude oils and fuel oils.

- **DREW™ TC SEA tank cleaner**

  A strong emulsifying cleaner for removing heavy petroleum-based stains such as heavy crude oil, soot, asphalt and carbon black. Equally effective for cargo and storage tank washing and recirculation, direct injection and manual spray methods. It also works well with agitation from the ship's rolling motion to clean and gas-free double bottom tanks.

- **O&GR™ oil and grease remover**

  A neutral blend of active cleaning agents and emulsifying solvents. It penetrates and dissolves grease, oil and grimy soils forming a soluble mixture which can be rinsed away with water. It can be used as a cleaner for metal, parts and tools, painted and unpainted surfaces, decks, bulkheads, machinery, engines and wherever grease, oil and grimy soils are a problem.

- **ENVIROCARE® 370 heavy-duty solvent cleaner**

  A solvent-based coal tar solubilizer and emulsion cleaner for the removal of coal tar, crude benzene, bitumen and similar substances. It can be used for cleaning heavily contaminated metal parts as well as for tank cleaning. Upon sitting, a solution of water and ENVIROCARE 370 cleaner will separate, leaving water at the top while the cleaner and contaminants sink to the bottom.

- **ENVIROCARE 480 heavy-duty cleaner**

  An non-flammable, high-performing microemulsion cleaner with biodegradable components designed especially for removing difficult baked-on oils, carbonized deposits, paraffin waxes and heavy greases. It can be used neat or diluted with fresh or sea water.

- **HDE-777™ heavy duty emulsifier**

  A solvent solution of low foaming detergents and emulsifiers for cleaning petroleum product residues from cargo and oil tanks or holds. It is also suitable for cleaning oil product residues from the sides of cargo carrying tanks.

- **OSD/LT™ oil spill dispersant**

  A low toxicity blend of wetting agents and dispersants in a fast penetrating oil soluble liquid vehicle, specifically designed to disperse oil spills. It can also be used to remove oil residues from tanks and holds. OSD/LT dispersant is approved by 12 government bodies worldwide.

- **AMEROID® OWS quick separating degreaser**

  AMEROID OWS quick separating degreaser is a superior solvent emulsifying product for general engine room degreasing and for cleaning and gas-freeing of bilges. Its unique blend of surfactants, wetting agents and solvents results in a product which has exceptional cleaning properties, breaks quickly, and does not harm the operation of the oily water separators required under the Marpol regulations.

The products usually recommended by Drew Marine for removing the residues of animal, fish or vegetable oils are EDGE® heavy duty cleaner and LAC™ liquid alkaline cleaner.

- **EDGE heavy duty cleaner**

  This cleaner has been formulated specifically to meet the tank cleaning requirements of the marine industry with special attention to safety and environmental considerations. EDGE cleaner combines heavy duty cleaning chemicals with fast penetrating and wetting agents for the power required to remove stubborn soils while remaining sufficiently mild to cause no harm to almost all tank cleaning surfaces. EDGE cleaner provides an excellent alternative to traditional solvent-based and highly alkaline cleaners and can be used in a multitude of varying cleaning applications. EDGE cleaner is suitable for use in zinc silicate-coated tanks when diluted, preferably with fresh water.

- **LAC liquid alkaline cleaner**

  This product is a heavy duty liquid alkaline cleaner that can successfully clean non-drying, semi-drying and drying oils from cargo tanks or holds. It has excellent deodorizing properties and can also be used in a dilute solution as a final flush in preparation for the next cargo.

Other products available

- **MUD CONDITIONER™ ballast tank water treatment**

  A high weight polymer containing product specifically designed to condition mud and silt bearing water. MUD CONDITIONER reacts with the mud and silt to form large non-adhering particles which quickly settle to the bottom of the tank. The result is loosely dispersed particles that can be easily discharged with the ballast water.

- **ENVIROMATE® 2000 general purpose cleaner**

  A water-based cleaner formulated to meet the marine industry's strict requirements for safety and performance. With its unique blend of cleaning agents, it is a non-flammable, biodegradable general purpose cleaner perfect for a broad range of deck, offshore, hotel and galley applications.

- **DREW™ BC buffering cleaner**

  Removes traces of metal oxide stains from zinc-silicate coated tank surfaces. It is used as a final cleaning procedure when cargo residues must be removed or when the tank has to be completely chloride or sulfide free when shipping pure chemicals.

- **DREW ABD alkaline-based degreaser**

  A very strong alkaline liquid cleaner applied by injection or recirculation methods, that economically removes animal, fish, and vegetable oils and fats. Suitable for use on most common metals and tank coatings.

- **DREW NBD neutral-based degreaser**

  A neutral liquid degreaser safe for use on most metals including zinc silicate-coated tanks. An effective cleaner for animal, fish and vegetable oils and fats, this product is injected or circulated through mechanical systems and can be used undiluted for manual spraying. It can also be applied as a final treatment following hydrocarbon-free cleanings with emulsifying cleaning agents.

- **AMEROID® RSR rust stain remover**

  A liquid combination of rust dissolving acid, emulsifier and passivator for removing rust. Used for eliminating salt residue, it is injected into the automatic washing system.

- **DREW AF air freshener**

  A water-based liquid used to eliminate unpleasant odors in tanks and domestic areas. It is safe to use on most common metals and coatings.

Only cleaners listed on the IMO MEPC.2/CIRC.6 can be used and disposed of at sea for cargo tank cleaning when the cargo residue slops are disposable at sea.

CHAPTER V

TANK COATINGS

Large tankers and OBO vessels are usually constructed of mild steel. Parts of the tanks or holds are often coated with inert coatings to protect them from the more aggressive cargoes. It is common to find product carriers having their tanks and internals coated to render their surfaces inert and protect them from active chemical cargoes. Ships which carry the most highly aggressive cargoes have their tanks constructed from, or covered with, stainless steel sheathing in order that they are rendered passive and will not corrode excessively under the action of the more active chemicals.

1. THE PURPOSE OF TANK COATINGS

The internal lining of a ship's cargo and ballast tanks is a common practice undertaken in order to prevent corrosion, cargo contamination and to facilitate cleaning and sludge freeing.

In crude/refined oil tankers, coatings are intended to prevent corrosion, and reduced scantlings may be permitted when approved coatings are applied The main purpose of tank coatings in bulk chemical carriers is usually to prevent cargo contamination. Many chemicals are sensitive to contamination by iron, either from rust or from the steel of the tanks. Due to the fact that the standards regarding contamination of chemical cargoes are far stricter than those for oil and its products, it is essential to place a chemically inert barrier between the cargo and the tank surface when carrying active chemicals. Oil products do not consist of a single component, but rather are a blend of components giving the required properties. Therefore, a slight mixing of cargoes of different grades may be tolerated within defined parameters.

Chemical cargoes, however, are of a more specific nature and will not tolerate any contamination. In this context, the efficient cleaning of tanks is of considerable importance. An unlined tank will retain traces of cargo to a much greater extent than the smooth surface of a coated tank. Cargo is removed only with difficulty from pitted surfaces, and in addition to contamination, can also give rise to the risk of explosion and toxicity if cleaning and gas freeing are imperfectly executed.

2. THE ESSENTIAL COMPONENTS OF PROTECTIVE TANK COATINGS

Any coating - primer coat, body coat or finish - has four essential components:

- **Pigment** - The pigment contributes color (a coating's hiding power), and extender pigments are used to modify viscosity, film strength, hardness, abrasion resistance, protection from ultraviolet rays and rust inhibitive properties.

- **Solvent** - The solvent dissolves the resinous vehicle and turns it into a usable form. Solvents control the viscosity and the way the coatings brush or spray on, settle, level and dry. Typical solvents include mineral spirits, glycol, ethers and xylene.

- **Additives** - The additives impart properties which are not contained in the other three components. Additives serve as agents for drying, wetting, film build, and pigment suspension.

- **Vehicle** - The vehicle is the most important coating component. It is the binder or "film former" that binds pigments together and anchors the coating to the surface. The type of vehicle in a coating determines film thickness, adhesion, consistency, hardness, flexibility, durability, gloss and color retention, drying time and the coating's ability to resist corrosive agents such as water, chemicals and solvents.

  The vehicles are usually resinous substances. They are cured or transformed in the coating from a liquid or plastic state to a hard, protective film by one or more the following methods:

a. Polymerization (chemical conversion through interaction of components) primarily used for chemical resistant tank lining.

b. Evaporation of solvent (no chemical change in vehicle)

c. Oxidation (absorption of oxygen from exposure to air)

The four components listed above combine into a protective coating integrating physical-chemical complexes. Choosing the correct coating requires technical evaluation of many factors. In a typical marine situation, coatings are selected and applied as a complete system such as the following:

- Prime coat should have anti-corrosion, barrier protection and adhesion properties.
- Body coat(s) should contain film-building and intercoat adhesion properties.

Several systems are available today which incorporate the integrated components described above.

3. TYPES OF MARINE TANK COATINGS

- **Epoxy** - Provides good chemical resistance and is available in both low and high build forms. It is used in both oil and chemical carriers, and is the most frequently used tank coating in today's market.
- **Zinc Silicate** - Application of this coating requires special care, but it does give good resistance to most organic solvents and refined oil products. It does, however, cause slight contamination of distillate fuel oils and this may preclude its use, for example, with aviation turbine fuel. It is widely used for solvents and oil products.
- **Polyurethane** - Occasionally used where slightly superior resistance to organic fatty acids (vegetable, fish and animal oils) is required. However, it has less resistance to alkalies than an epoxy.

4. CARE AND MAINTENANCE OF TANK COATINGS

One of the advantages of lined tanks is ease of cleaning, and often water washing is sufficient. Detergents and steam may also be used without damaging the coating. However, if steam is used to remove toxic or flammable residues, care should be taken to prevent the steam from blistering the coating or the steel. If a tank is lined with zinc silicate, the detergents used should be neutral, because strong alkalies and acids will attack zinc. The normal safe pH range for zinc silicate coatings is between pH 5.5 and 11.0. Any deviation from this range increases the possibility of softening or stripping the coatings from the steel.

5. ADVANTAGES AND DISADVANTAGES OF DIFFERENT TANK COATING TYPES

TANK COATING TYPE	ADVANTAGES	DISADVANTAGES
Epoxy	• Good, hard, durable resistant film • Good chemical and solvent resistance • Good water and moisture resistance • High film build	• Two package coating • Limited pot life • Limited acid resistance • Film chalks and yellows on aging
Inorganic Zinc	• Excellent durability • Excellent heat resistance • Excellent abrasion resistance • One coat protection for many surface conditions • Hydrocarbon insoluble • Provides galvanic protection	• Not suitable for acidic or caustic service unless topcoated • Requires careful selection of prime and top coats • Specific temperature and humidity effects for different types used
Polyurethane	• Good chemical resistance to selected commodities • Good, hard film, durable	• Two package coating • Limited pot life • Critical recoat interval

6. COMPATIBILITY OF DREW MARINE PRODUCTS WITH VARIOUS MATERIALS ENCOUNTERED IN TANK CLEANING APPLICATIONS

The chart below shows the compatibility of several of Drew Marine recommended cleaning products in solution with various materials (generic forms). It can be used as a guide to indicate whether compatibility exists between the cleaner and such items as heating coils, wash hoses and other similar components.

Materials or coatings

Yes = Compatible; No = Not Compatible; * = See Footnote

Drew Marine Products	Ferrous Metals	Nonferrous Metals	Rubber Products	Plastic Products	Oil Based	Latex	Epoxy	Inorg. Zinc	Chlorinated Rubber
TC#4™ tank cleaner	Yes	Yes	*	*	*	*	Yes	Yes	No
HDE-777™ heavy duty emulsifier	Yes	Yes	*	*	*	*	Yes	Yes	No
OSD/LT™ oil spill dispersant	Yes	Yes	*	*	*	*	Yes	Yes	No
LAC™ liquid alkaline cleaner	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes
EDGE® heavy duty cleaner	Yes	*	Yes	Yes	Yes	Yes	Yes	*	Yes
AMEROID® OWS quick separating degreaser	Yes	Yes	*	*	*	Yes	Yes	Yes	No
AMEROID RSR rust stain remover	*	No	Yes	Yes	Yes	Yes	Yes	No	Yes
DREW™ ABD alkaline-based degreaser	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes
DREW BC buffering cleaner	*	*	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DREW NBD neutral-based degreaser	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
DREW TC SEA tank cleaner	Yes	Yes	*	*	*	*	Yes	Yes	No
ENVIROMATE® 2000 general purpose cleaner	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ENVIROCARE 370 heavy duty solvent cleaner	Yes	Yes	No	*	No	Yes	Yes	Yes	No
ENVIROCARE 480 heavy duty cleaner	Yes	No	Ys	Yes	Yes	Yes	Yes	*	Yes
DREW AF air freshener	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
O&GR™ oil and grease remover	Yes	Yes	*	*	*	*	Yes	Yes	No

*The products in this category can be considered as “mildly incompatible” when in contact with the materials or coatings indicated. The degree of attack which possibly may occur will depend upon the specific constituents, age and condition of the surface to be cleaned, the cleaner solution strength, its temperature, and contact time. A solution strength of 10% or less at the recommended temperature should ensure no deleterious effects on the tanks surfaces or coatings.

7. PROBLEMS ARISING WITH TANK COATINGS AND THE CARRIAGE OF CERTAIN CARGOES

The copper strip test for corrosive metals is conducted by exposing a copper strip to the liquid to be tested for a predetermined period, at either 50° C or 100° C (122° F or 212° F). It is then compared to standard test strips and graded from light orange to jet black on a scale ranging from No. 1 to No. 4.

Occasionally, after the carriage of certain cargoes that have a high sulfur compound impurity content (e.g., virgin naphtha), it is likely to find that the copper corrosion test is out of specification.

This negative result of the copper corrosion test can be attributed to the formation of corrosion products such as zinc and iron sulfides on the tank surfaces, especially in the micropores of the zinc silicate coating.

These sulfides require special treatment for removal, because zinc silicate coatings are sensitive to high pH range effects. The generally accepted method of cleaning is by using an acid cleaner limiting its concentration to a pH of 5.5 for zinc silicates. This particular concentration is important as the resistance to acid attack decreases rapidly at pH 4.9 and serious damage will therefore result to the coating.

Epoxy coatings are much less sensitive to the effects of wide range pH values and can be safely cleaned using an acid limiting its concentration to a pH of 4.5.

8. STAINLESS STEEL TANKS

Stainless steel is an alloy of iron containing a relatively high proportion of chromium (12-20%) and other metals such as nickel, vanadium and cadmium. The chromium in the alloy reacts with the oxygen of the atmosphere to create an inert oxide coating which will protect the metal from corrosion or attack by aggressive chemicals.

Before the protective chromium oxide layer can be created, it must be treated with a dilute solution of nitric acid (usual concentration about 10%). This solution is allowed to remain in contact with the surface for about two hours, after which it is flushed away with distilled water. Seawater should not be used for this task as it can generate chlorine and precipitate chemical salts in the process which activate the stainless steel so that it becomes active and therefore nonresistant to corrosion.

In order that the entire tank is rendered passive, the chromium oxide layer must completely cover the tank surface. With the entire tank surface in the passive condition, it will be protected from the attack of most aggressive cargoes. If the tank surface coating becomes damaged by mechanical abrasion, by welding or as a result of a chemical attack with such products as oleic acids, it will become active and require re-passivating by an oxidizing agent which greatly speeds up the natural oxide-producing process which occurs if the tank is untreated.

When using dilute nitric acid to passivate a stainless steel tanks, all safety recommendations should be observed. These involve the wearing of special protective clothing, face masks, rubber boots and breathing apparatus, where appropriate. To passivate new tanks or re-passivate damaged tanks, the surfaces must be sprayed or brushed with a 10% nitric acid solution (0.1N concentration) and allowed to soak the proper time interval before being flushed away using chloride-free water.

To determine if a tank fabricated of stainless steel is active or passive, a test using palladium reagent must be used. If the area tested is active, it will turn the palladium solution black. If the area is passive, the palladium reagent will be unaffected.

Tanks which have suffered damage in some way and have become partially active will return to a passive state naturally. However, this process will normally take far too long for commercial purposes and it must be aided by the application of an oxidizing agent in the manner described above.

CHAPTER VI

THE TANK CLEANING PROCEDURE

The procedure for tank cleaning can include all or a combination of some of the following stages:

- Precleaning (Tank washing with seawater)
- Cleaning (Tank washing with seawater and cleaning chemicals)
- Steaming (Introduction of steam and sometimes extra tank cleaning chemicals)
- Rinsing (Tank washing with seawater)
- Flushing (Tank washing with fresh water)
- Draining (Removing the last traces of liquids)
- Drying (Ventilating, deodorizing and drying)

1. PRECLEANING

Before commencing the precleaning operation, a careful study should be made of the internal tank structure from the ship's construction drawings. The depth of the portable tank wash machine drops must be established by noting the height of the intercostal transverse frames, bulkhead web frames, horizontal struts and any other internal encumbrances which may interfere with efficient cleaning. The portable tank wash machine should always be lowered to a position where it is approximately midway between beams so that the water will impinge progressively on both the top side and under side of the internal structures thus ensuring maximum cleaning area exposure.

Precleaning tanks (or holds) with fixed or portable tank cleaning machines, using sea or fresh water as the cleaning medium, is done to remove oil and other waxy residues from the frames, bulkheads, tank tops, tank bottoms and any pipework or other components within the tank. The remaining oil and/or chemical residues will be removed far more easily if cleaning is initiated immediately after the tank has been emptied and before these residues have been allowed to oxidize or polymerize and solidify.

The importance of precleaning cannot be overstressed. It is during this process that the heavy and by far the largest percentage of the deposits remaining are removed in order to ensure an effective cleaning operation (see "Cleaning" below). For precleaning drying oils, cold water (sea or fresh) should be used. For precleaning oils with a high pour point, use water a few degrees higher than the pour point. Oxidation and polymerization will cause drying oils to harden under the influence of heat and the resultant product will adhere to the tank bulkheads and be very difficult to remove.

Generally, tanks which have carried crude oils should be cleaned first with cold water for about two hours and then with warm water if required. Precleaning should be continued until the tanks are sufficiently clean to proceed with the main cleaning process. No precise time can be given as it depends entirely upon the type and grade of cargo to be removed and the size and condition of the tanks from which it is being removed. Large and small tanks generally take a similar time to clean due to the fact that small tanks tend to contain more obstacles, such as frames, girders, stringers, etc., which will encumber the cleaning operation. During the precleaning period the portable tank cleaning machines should be moved frequently around the tanks (horizontally and vertically) in order that all surfaces are reached. When precleaning has been completed, and when the tanks are deemed safe to enter, an inspection should be made to ascertain the condition and the degree of cleaning required to render the tanks acceptable for the next cargo. Particular attention should be given to the tank bottoms and any hidden areas.

2. CLEANING

For this process a dilute solution of a chemical is required. The solution is normally heated to a minimum temperature of 40° C (104° F) up to a maximum of 90° C (194° F) (higher temperatures are more effective) and stored (if the recirculation method is to be used) in either a special chemical tank, slop tank, or cofferdam,whichever is convenient and has a suction line to the tank cleaning pump and a return line from the tank(s) being cleaned. Correct preparation before commencing the chemical cleaning is essential for it is usually impossible to enter tanks once the operation has started. The chemical solution is applied by way of the tank cleaning machines, portable and fixed (if available).

The portable machines must be lowered and raised at regular intervals to achieve effective cleaning throughout the tank. Chemical cleaning is usually continued for one to four hours. The cleaning time involved depends to a great extent upon the cargo being removed and the cargo to be received, as well as the temperature of the cleaning solution. After the tank has cooled and it has been passed as fit to enter, it should be inspected. If traces of cargo remain, cleaning should be continued. Inspection of hidden spots is particularly important. Any shaded areas which have not been cleaned must be spot cleaned by hand using “neat” (full-strength) chemical and then flushed away by hand-held hoses.

3. STEAMING

If it is required to steam out a tank to free it of any last remnants of deposits, one of our solvent-type tank cleaning chemicals, toluene or chloride-free water should be sprayed on the tank surfaces and then steam hoses should be inserted into the tank or hold. All hatches and tank lids should be shut, but left loose in order that a high pressure does not build up. Tank vents should be held open. Steam is injected into the tank via open end hoses. The steam will condense on the sides, top and bottom of the tank and release the last remaining traces of the contaminant. Check to see that all steam line flanges are properly gasketed and tightly secured.

To remove all of the cargo residues from the pores of a tank coating, steaming should be carried out together with a cleaning chemical that is compatible with the tank coating.

4. RINSING

Immediately after the cleaning operation is concluded and the tanks have been completely stripped of the residues and slops, they should be rinsed using the tank cleaning machines and hot or cold seawater. Rinsing generally takes between one-half and two hours and is continued until no trace of cleaning detergent can be found.

5. FLUSHING

Flushing is effected using fresh water from the storage tanks. The water is sprayed on deckheads, bulkheads, tank tops, stringers, etc., through hoses fitted with special nozzles.

6. DRAINING

Tanks, lines and pumps should be drained completely. Plugs should be removed and the lines blown through with compressed air. An ejector can be used to remove any quantities of water remaining on the bottom of the tank.

7. DRYING

The tanks must be throughly ventilated and dried out, then inspected for any residues. Any remaining contaminants should be removed by wiping down with rags. Valves should be drained into a bucket. It is a good idea for those entering the tank, at this stage, to put shoe covers on or wrap clean lint-free rags around their shoes. The tank is now completely dried using air fans. As a safety precaution, the tank should be entered only if it is confirmed as safe for entry.

Valves and plugs are to remain open until the inspection by the surveyor is completed. Thoroughly ventilating the tanks will also aid in the deodorizing process.

Various combinations of the above processes are required to clean and remove the residues of different cargoes. A cross-reference table is given at the end of this manual detailing some of the combinations most commonly encountered today.

8. THE REASONS FOR TANK SURVEY FAILURES

- Wet tank bottom, sides or top (condensation)
- Scale adhering to the tank surfaces
- Bleeding of oil from behind scale or from cracked tank welds
- Dried or hard residue under beams, heating coils, frames, etc.
- Odor (This can be removed by rinsing with a dilute solution of DREW™ AF air freshener, EDGE® heavy duty cleaner or LAC™ liquid alkaline cleaner.)
- Sediment remaining on the bottom, especially beneath lightening holes

CHAPTER VII

METHODS OF USING CHEMICALS FOR CLEANING PURPOSES

The four methods of cleaning by chemical are listed below:

- Recirculation
- Hand spraying and atomization
- Rock and roll
- Direct injection and hot water cleaning

1. RECIRCULATION METHOD

A dilute chemical solution is prepared in a slop tank, cofferdam, cargo tank or specially provided tanks, circulated via the washing system line to the tank to be cleaned and then stripped back to the chemical holding tank (usually by a second pump). Personnel involved must wear protective clothing, shoes, goggles and gloves. The facilities available on board will determine which tank is used for holding the chemical solution. The best method of heating the chemical solution is to pass it through the tank cleaning heater. However, this is not always possible unless temporary connections are made. Other ways of heating the solution are by the tank heating coils (care must be taken if using LAC™ liquid alkaline cleaner to ensure that the heating coil material is compatible) or by the steam injection method, both of which can be slow and costly in terms of fuel oil used. Each batch of chemical cleaner should be renewed after cleaning three or four tanks (depending on solution condition). Adding neat chemical to a spent solution should not be practiced as it is both wasteful and inefficient. Each solution batch should be made fresh and heated (if possible) by the most efficient means.

2. HAND SPRAY AND ATOMIZATION METHOD

Undiluted liquid chemical is sprayed directly onto the tank surfaces and internal components using air operated drum pumps and hand spray guns. After a sufficient soaking period (during which the chemical reacts with the residues) the tanks are washed with fresh or sea water utilizing the tank washing machines or hand-held high pressure, large volume water hoses.

The hand spray method is generally the most economical in respect to chemical consumption, but it requires that the tanks are gas free to enable personnel to enter for spraying. This is a disadvantage in that the total time is considerably increased, and as the physical size of the tanks becomes greater, it becomes increasingly impractical. Vessels up to a size of about 30,000 dwt can be cleaned by this method if good equipment and crew are available. Above this size, mechanical cleaning systems become essential.

For personnel to enter a tank to accomplish this task, all safety instructions must be followed. They must wear protective clothing, shoes, goggles, gloves and respirators when required. Any chemicals inadvertently coming in contact with the body should be washed off using copious quantities of fresh water. Refer to the Material Safety Data Sheets for details.

When a very high standard of cleaning is required, (i.e., when upgrading—changing from crude oil to jet fuel or grain), hand spraying is usually necessary after the normal mechanical cleaning has been completed. This will remove the remaining residues that the tank cleaning machines could not remove. The tank is then washed down using hand-held hoses. TC#4™ tank cleaner is suitable for spot cleaning as described above.

Atomization is similar to hand-spraying except that the undiluted chemical is applied at high pressure through a lance lowered into the tank. After all surfaces have been covered and thoroughly saturated by a spray of controlled particle size, the tank is washed by hot sea or fresh water. Using the atomization method, it is not necessary to gas free a tank since personnel do not need to enter the tank beforehand. At the same time, full-strength chemical reaches all parts of the tank and will loosen deposits and scale which may shed oil deposits. This method is not suitable for very large tanks since complete saturation of all surfaces cannot be guaranteed. However, for small spaces and tanks it can be very effective when using cleaners like TC#4™ tank cleaner or DREW™ TC SEA tank cleaner.

3. ROCK-AND-ROLL METHOD

A. Tanks

In this method the chemicals are introduced into double bottom tanks at sea through the sounding pipes. The tanks are then partially filled with seawater to the desired level. The normal rolling motion of the vessel at sea provides the necessary agitation to the solution to bring it into contact with all tank surfaces. If the tank is fitted with heating coils, the solution should be kept as hot as is practical (up to 80° C or 176° F) to give the best possible cleaning effect. Rock and roll is usually only applied to small fuel oil deep tanks or double bottom tanks.

The entire description of cleaning and gas freeing techniques using this method can be found in the Drew Marine Product Data Sheet for TC#4™ tank cleaner (TC-PD-4).

The quantities of chemicals required to achieve satisfactory rock and roll cleaning are shown following this dialogue, in Figures 8 and 9.

Schedule A of Figure 8 gives the quantities required when heating facilities enable the solution to be raised above 38° C (100° F).

Schedule B of Figure 8 gives the quantities required when heating facilities are not available and the cleaning solution is maintained between 15° C (59° F) and 38° C (100° F). Below this temperature, effectiveness is reduced.

B. Bilges

Determine the amount of water required to fill the bilge to a level which provides complete coverage of all areas requiring cleaning. Based on the amount of water required, determine from Figure 10 the necessary dosage of AMEROID® OWS degreaser.

Example:

1. Bilge area is 23 x 23 meters (75 x 75 feet). Average depth of the water is 0.3 meters (1 foot). The total cubic meters of water in the bilge equals 23 x 23 x 0.3 or 159 cubic meters (5625 cubic feet). Refer to Figure 10 for the closest dosage of the selected product.

2. The dosage should be distributed at various points in the bilge, directly from the container. Where necessary, apply the product directly onto the vertical surface, utilizing a suitable pump to assure adequate distribution.

3. Add the previously calculated amount of seawater to the bilge, and allow the natural motion of the vessel to provide agitation for a minimum of 24 hours.

4. At the end of 24 hours, pump the bilge dry through the oily water separator or to shore reception facility, and as conditions require, repeat the treatment.

Figure 8

CHEMICAL DOSAGE TABLE FOR ROCK AND ROLL CLEANING

TC#4™ tank cleaner

Dosage Table (in liters) TC#4 tank cleaner For Cleaning Double Bottom Tanks at Sea

TANK CAPACITY		SCHEDULE A			SCHEDULE B		
		Solution Temperature 38° C (100° F) or above			Solution Temperature between 15° C (59° F) and 38° C (100° F)		
METRIC TONS	BARRELS	FIRST	SECOND	TOTAL	FIRST	SECOND	TOTAL
10	66	13	6	19	19	11	30
15	99	20	8	28	28	16	44
20	132	26	11	37	38	23	61
25	165	33	14	47	47	28	75
30	198	40	17	57	57	34	91
35	231	46	20	66	66	40	104
40	264	53	23	76	76	45	121
45	297	60	26	86	85	51	136
50	330	66	28	94	95	57	152
55	363	73	31	104	105	65	170
60	396	80	34	114	114	68	182
65	429	86	37	123	123	74	197
70	462	93	40	133	132	80	212
75	495	100	43	143	142	85	227
80	528	106	45	151	151	91	242
85	561	113	48	161	161	97	258
90	594	119	51	170	170	102	272
95	627	126	54	180	180	108	288
100	660	132	57	189	190	113	303
125	825	166	71	237	237	143	380
150	990	200	85	285	284	170	454
175	1155	232	100	332	330	200	530
200	1320	265	115	380	378	227	605
1000	6600	1325	565	1890	1890	1135	3025

Figure 9

CHEMICAL DOSAGE TABLE FOR ROCK AND ROLL CLEANING

DREW™ TC SEA tank cleaner

Dosage Table (in liters) DREW TC SEA tank cleaner For Cleaning Double Bottom Tanks at Sea

Tank Capacity										
Metric		Minimum			Normal			Maximum		
Tons	Barrels	First	Second	Total	First	Second	Total	First	Second	Total
2.5	17	1	1	2	3	1	4	4	2	6
5	33	3	1	4	5	3	8	7	5	12
10	66	5	3	8	11	5	16	14	10	24
15	99	8	4	12	16	8	24	21	15	36
20	132	10	6	16	22	10	32	28	20	48
25	165	13	7	20	27	13	40	35	25	60
30	198	16	8	24	32	16	48	42	30	72
40	264	20	12	32	43	21	64	56	40	96
50	330	25	15	40	53	27	80	70	50	120
75	495	40	20	60	80	40	120	105	75	180
100	660	53	27	80	105	55	160	140	100	240
200	1320	105	55	160	215	105	320	280	200	480
250	1650	133	67	200	265	135	400	350	250	600
300	1980	160	80	240	320	160	480	420	300	720
400	2640	215	105	320	425	215	640	560	400	960
500	3300	265	135	400	535	265	800	700	500	1200
600	3960	320	160	480	640	320	960	840	600	1440
700	4620	375	185	560	745	375	1120	980	700	1680
800	5280	425	215	640	855	425	1280	1120	800	1920
900	5940	480	240	720	960	480	1440	1260	900	2160
1000	6600	535	265	800	1065	535	1600	1400	1000	2400

Figure 10

CHEMICAL DOSAGE TABLE FOR BILGE CLEANING BY ROCK AND ROLL

BILGE CAPACITY			AMEROID® OWS degreaser DOSAGE		
CU. FT.	APPROX. GALLONS	APPROX. CU. METERS	APPROX. LITERS	U.S. GAL.	LITERS
2000	14,960	56	56,000	7	26
2400	17,900	68	68,000	8	30
3000	22,400	85	85,000	10	38
3600	26,900	102	102,000	12	45
4200	31,400	119	119,000	14	53
4800	35,000	136	136,000	16	60
5400	40,400	153	153,000	18	68
6000	44,880	170	170,000	20	75
6600	49,368	187	187,000	22	83
7200	53,856	204	204,000	24	90
7800	58,340	221	221,000	26	98
8400	62,832	238	238,000	28	106

4. DIRECT INJECTION METHOD AND HOT WATER CLEANING

A. Direct Injection Method

In this method undiluted chemical cleaner is injected into the seawater at a predetermined rate on the pressure side of the tank cleaning manifold or wash line on deck. Together with the seawater from the tank cleaning pump, it passes into the tank via the fixed or portable tank cleaning machines. This method has the advantage that the chemical can be introduced into hot tank cleaning water at a precisely calculated rate. An exact estimate of the chemical requirement can be made before commencing cleaning. It also reduces time and manpower for most tank cleaning jobs. The chemical feeding rate is usually 1 liter per 1 ton of water used (0.1%), but can be increased to 5 (or more) liters per ton of water (0.5%) when very dirty tanks are to be cleaned. When light cleaning is required, 1 liter per 2 tons (0.05%) of water may be adequate.

NOTE: 1 metric ton = 1000 kg = 1000 liters
1 long ton = 1016 kg = 1010 liters

B. Hot Water Cleaning

Hot water almost always improves the chemical action (except with drying oils and waxy crude oils) and accelerates the chemical cleaning process. As a general rule, the hotter the cleaning water, the better and more thorough the cleaning action of the chemical. Most oils are easier to detach from the tank sides under the influence of heat and if kept hot, can be made to flow continuously until they are removed from the tank without adhering to the bottom plates.

Two exceptions to the above are:

- Semi-drying and drying oils
- High wax content crude oils

It is imperative that the residues of the above oils be initially flushed from the tank by cold washing as soon as possible after discharge of the cargo. Oxidation and polymerization will cause drying and semi-drying oils to quickly harden to create a tough, tenacious, leathery coating which is very difficult to remove. Long exposure to circulating air enhances this reaction and causes the film to be even tougher and more adhesive. A cold preclean wash in this case is essential.

A good guide as to whether a hot or cold preclean wash should be given in the case of crude mineral oils, is indicated by the temperature at which the oil has been transported. If the cargo has required heating, then generally the tanks will require a cold preclean mechanical wash. The pour point of the oil can sometimes be a guide to its wax content. Generally, high wax content oils are those with a pour point above 20°C (68°F). It should always be remembered that for a high wax content oil with a high pour point and low API number, heat should never be applied to the tank before the cold preclean wash. If heat is applied, the chances are that the more volatile fractions will be flashed off leaving the heavier, more tenacious residues adhering to the tank sides. If it is not certain whether a cargo is a drying or semi-drying oil, consult the cargo loading/ handling specifications held by the ship's Master. If uncertainty still exists, preclean with cold water.

5. DETERMINATION OF THE MOST APPROPRIATE CLEANING PROCEDURE

Accumulate all preliminary information from the vessel and complete the questionnaire (Appendix G, page 89) which will aid the selection of the most appropriate program to determine the cleaning method best suited to the problem. A cross-reference guide can be found at the end of the manual (Appendix D, page 61) which lists the most common products and chemicals carried today and the most effective method of removing their residues in readiness for the next cargo.

6. CLEANING CARGO LINES AND SLOP TANKS

As the valves and line arrangements differ considerably from vessel to vessel, it is impossible to give precise instructions for this cleaning procedure. Each vessel's lines should be cleaned to the specific instructions of the officer in charge. The following is a general outline procedure which can be modified to suit most vessels. For vessels out-fitted with Crude Oil Washing, refer to the Crude Oil Washing Manual onboard.

Initially, all main cargo tanks and pipes should be stripped to the slop tanks before washing is commenced. This process should be helped by flushing the system with seawater and stripping through the main stripping lines.

It is recommended that the operation be performed from the forward tanks working back through the system. The main valves should be opened as little as possible to avoid starving the pumps and losing suction. With this process completed, all free oil should be removed from the main and stripping lines as well as ensuring that the tanks are as nearly dry as possible. The same operation should be repeated for any other lines in the tank, i.e., the athwartship lines. When this has been completed, the stripping pump filters should be inspected and cleaned if necessary. These filters should be kept clean during the tank cleaning program in order that the correct rate of stripping is maintained throughout. The cleaning process should be continued and the chemical solution passed through both the main and stripping lines. Finally, the lines are flushed with water.

A temporary line should be connected between the tank cleaning line and the deck lines with an outlet to the slop tanks in order that the loading and discharge lines and manifolds can be cleaned. The tanks and lines should finally be rinsed with fresh water to remove the last traces of the sediment, detergent and salt. All bottom, deck main and stripping lines as well as valves, filters, etc., should now be clean.

7. DETERMINING THE NUMBER OF TANK CLEANING MACHINE CYCLES FOR EACH CLEANING JOB

If specific data pertaining to the vessel's construction is not available, but is known that the vessel is equipped with BUTTERWORTH[1] K type tank cleaning machines, an estimate of the required minimum number of tank cleaning machine cycles can be made by using the following formula:

- Minimum number of tank cleaning machine cycles = $1.5\sqrt{\text{dwt}}$. (Essentially 1.5 times the square root of the vessels dead weight tonnage.)

  The number of tank cleaning cycles derived from the above formula is fairly accurate for vessels that have carried light to medium crude oil cargoes that have not been reduced, vacuum flashed or topped before they were loaded into the tanks.

- Medium to heavy crude oils will require the number derived from the formula to be multiplied by 1.25.

  Minimum number of tank cleaning machine cycles = $1.5\sqrt{\text{dwt}} \times 1.25$.

- Heavy crude oils and other waxy cargoes will require the formula to be multiplied by 1.5.

  Minimum number of tank cleaning machine cycles = $1.5\sqrt{\text{dwt}} \times 1.5$.

  As an example, if we take a tanker of 30,000 dwt, the following will be the minimum of machine cycles required commensurate with good cleaning:

  1. Light Crude Oil (N = Minimum number of tank cleaning machine cycles.)

     $N = 1.5\sqrt{\text{dwt}}$
     $N = 1.5\sqrt{30{,}000}$
     $N = 1.5 \times 173$
     $N = 260$

  2. Medium Crude Oil

     $N = 1.5\sqrt{\text{dwt}} \times 1.25$
     $N = 1.5\sqrt{30{,}000} \times 1.25$
     $N = 1.5 \times 173 \times 1.25$
     $N = 325$

3. Heavy Crude Oil

$N = 1.5 \sqrt{dwt} \times 1.5$
$N = 1.5 \sqrt{30,000} \times 1.5$
$N = 1.5 \times 173 \times 1.5$
$N = 390$

The above is only a guide to the specific number of cycles required when using BUTTERWORTH[1] K tank cleaning machines. The actual number depends upon many other extraneous factors. However, from the above calculations a fairly accurate assessment of the quantity of chemical to be used during the entire cleaning operation can be estimated. Using the information given on page 2 of the manual, it can be seen that at a pressure of 12 bar (176 psi) (12.3 kg/cm^2) a total of 12 tons of seawater is used on each BUTTERWORTH K tank cleaning machine cycle.

The strength of solution (seawater and tank cleaning chemical) depends upon these factors:

- The type of residue to be removed
- The degree of dirtiness of the tanks
- The degree of cleanliness required for the next cargo
- The temperature of the cleaning solution

Generally for the direct injection method, a solution strength of 0.1% is sufficient. The quantity of chemical required using this method is referred to as Qd. (Quantity Direct Injection).

Below is shown one method of calculating the quantity of tank cleaner required using 0.1% solution for a tanker of 30,000 dwt:

a. The total quantity of chemicals required (Qd) to clean the tanks of a vessel carrying light crude oil is:

   Total number of machine cycles (from No. 1 above) = 260. Total quantity of wash water used at 12 tons per cycle = 12 x 260 = 3120 tons.

   Solution concentration selected is 0.1% (1 liter per ton of water) Therefore, total chemical cleaner required:

   Qd = 3120 x 1 liter
   Qd = 3120 liters

b. For medium crude oil cleaning, the quantity of chemical required will be:

   Qd = 3120 liters x 1.25 = 3900 liters

c. For heavy waxy crude oil, the quantity of cleaner required will be:

   Qd = 3120 liters x 1.5 = 4680 liters

If heavy fouling of the tank has taken place and the residues are difficult to remove, the solution strength should be increased. This will, of course, increase the quantity of cleaning chemicals in direct ratio.

NOTE: The above computations are specific for BUTTERWORTH K tank cleaning machines.

The BUTTERWORTH SK tank cleaning machine has a maximum capacity of 53 cubic meters per hour with wash cycle times from 17 to 41 minutes, depending upon water inlet pressure.

The BUTTERWORTH SSK tank cleaning machine has a maximum capacity of 75 cubic meters per hour with similar wash cycle times, depending upon inlet pressure.

To calculate the quantity of chemical required using the BUTTERWORTH SK tank cleaning machine as well as any other type of tank cleaning machine, it is recommended that use be made of the method described on pages 31 and 32, in conjunction with the Tank Cleaning Product Cross-Reference Table in Appendix D.

8. CLEANING BALLAST TANKS

A. Removing mud

Mud and silt buildup can occur in a active ballast tank within a relatively short amount of time. If left in the tank, this buildup can result in a loss of cargo carrying capacity and even an increase in fuel consumption.

To minimize this problem, MUD CONDITIONER™ ballast tank water treatment should be used on a regular basis to treat the ballast water as it enters the ballast tank. The recommended level of treatment of MUD CONDITIONER treatment is 20-30 liters per 1,000 tons of ballast water.

In situations where the mud and silt has accumulated, an increase in dosage of MUD CONDITIONER treatment is required. For this, a dosage of 100-200 liters per 1,000 tons of ballast water is needed. Also, good agitation is needed in order to allow the MUD CONDITIONER treatment to penetrate the mud. A fire hose or portable tank cleaning machine can be used.

B. Removing Soft Coatings

The thickness that these products are applied will determine the method of cleaning. For those under 10 mils, EDGE® heavy duty cleaner can be hand sprayed, allowed to soak, and then followed with a water washing.

If the coating is greater than 10 mils, hand scraping of the material may be necessary. Once this has been accomplished, hand spray EDGE heavy duty cleaner, allow to soak and follow with a water washing.

Any oil film remaining in either case should be removed by adding 0.5% LAC™ liquid alkaline cleaner and fill the tank with seawater to 70% capacity. Allow it to rock-and-roll for a minimum of 24 hours.

CHAPTER VIII

THE CALCULATION OF CHEMICAL QUANTITIES AND CLEANING TIMES

The quantity of chemical to be used and the time required for the selected cleaning method should be calculated for each separate cleaning program phase. Each calculation is dependent upon the following factors:

- Number and size of tanks to be cleaned
- Quantity of water and pressure available for tank cleaning system
- Complexity of tank internals and position of frames, etc.
- Number and condition of tank cleaning machines available (fixed and portable)
- Cycle time at the available water pressure for the tank wash machines
- Degree of cleanliness required, i.e., upgrading or cleaning for an edible cargo, to gas free or for hot work

1. CLEANING TIME CALCULATIONS

The tank cleaning pump delivery rate and the output of the tank cleaning machines will determine the number of machines that can be used simultaneously. Most portable tank cleaning machines will use approximately 25-30 tons of water/hour (12-15 tons/cycle), but this figure should always be checked. The above will determine the number of tanks that can be cleaned at the same time. The time to clean the calculated number of tanks simultaneously will be dependent on the cycle time of the machines, the number of washes required and the number of drops (in the case of portable machines) required to cover completely the depth of the tanks and the internal structures.

For example, to clean a single tank using 4 machines with 3 drops at 4 meters each with the last drop just above the tank bottom plus one extra washing of the bottom with a machine cycle time of 30 minutes, the total time required per tank is 4 x 30 min = 2 hours, (i.e., each drop is one cycle duration plus one extra washing of the bottom plates).

As the tanks increase in size, the number of drops necessary also increases. For VLCC's as many as 6 or 7 drops may be required.

2. QUANTITY OF CHEMICAL REQUIRED

A. Direct Injection Method

Using the above information, the quantity of chemical required per tank can be calculated.

To calculate the quantity of chemical (Qd) necessary, the following information is required:

(P) = Quantity of chemical to be used per ton of water (1 liter/ton, i.e., solution strength 0.1%)
(M) = Number of machines to be used per tank
(C) = Output of each machine (tons/hour)
(T) = Total time to clean the tank (hours)

Using the above data we have:

i.e., $Qd = P \times M \times C \times T$
$Qd = 1 \times 4 \times 25 \times 2 = 200$ liters/tank

For a total of 12 similar-sized tanks to be cleaned, the chemical required is 12 x 200, i.e., 2,400 liters DREW™ TC SEA tank cleaner or TC#4™ tank cleaner.

B. Recirculation Method

For this method, a solution of seawater and tank cleaning chemical is mixed in a slop or cargo tank. The solution strength depends upon the quantity of water required to circulate the system and maintain adequate suction at the pumps.

The quantity of chemical cleaner required for this method is referred to as: Qr (Quantity Recirculation Method). To establish the quantity of tank cleaning chemical (Qr) required, use the following formula:

Qr = Solution strength (1.25 to 1.4 x P) x Tons of water (1.5 $\sqrt{dwt}$ X C)

In the recirculation cleaning, the very nature of the method does not lend to efficient use of the product, and each batch of solution mixed will not perform as efficiently as will the cleaner when introduced directly into the tank cleaning water. For this reason, the total quantity of product estimated should be increased by between 25% and 40% over the direct injection method to produce equivalent results.

Therefore, in the example given on page 28 and 29 for the cleaning of 30,000 dwt tanker using a 0.1% solution of tank cleaner, the calculated total quantity required, 3,120 liters in this case, should be increased by, on average, 33% to obtain the correct quantity of product necessary to conduct efficient recirculation cleaning, i.e., liters required for cleaning a 30,000 dwt tanker using the recirculating method is as follows:

Qr = 3,120 x 1.33 = 4,150 liters

The solution concentration will be increased accordingly.

For each recirculation process, it has been found that in order to maintain adequate suction and supply and return to and from the tank being cleaned, 250 tons of solution should be made up. However, this quantity can be varied in order to match the proposed number of batches and the solution strength required.

After each recirculation cycle is completed, the chemical solution containing the residue of the cleaning process should be removed to a slop tank for separation and the procedure repeated using a fresh batch of solution. The temperature of the solution should be maintained at 40° C (104° F) or above if possible, preferably at 80° C (176° F). (See the Tank Cleaning Product Cross-Reference Tables in Appendix D.)

C. Rock and Roll Method

The quantity of product required to clean by this method is given in either Figure 8 or 9 depending on whether you are using DREW™ TC SEA tank cleaner or TC#4™ tank cleaner.

D. Hand Spray and Atomization Method

After cleaning by either direct injection, recirculation or rock and roll methods, spot cleaning may be required using hand sprayed full strength chemical (DREW TC SEA tank cleaner or TC#4 tank cleaner) on any hidden spots which have not been satisfactorily cleaned. After suitable soaking time, the chemical and residues should be washed off by hand hosing.

The quantity of preferred chemical (DREW TC SEA tank cleaner or TC#4 tank cleaner) required for undiluted application for hand spray or lance injection can be verified by the following formula:

Required chemical in liters = tank surface area (m^2) (tank bottom, sides, frames, etc.) x 0.2

i.e., Area m^2 x 0.2 = liters of product (DREW TC SEA tank cleaner or TC#4 tank cleaner)

Alternatively:

Chemical in liters = volume of tank (m^3) x 0.15. If only light contamination of the tank surfaces exists, the above quantities can be reduced by up to 30%.

The above cleaning quantity data is recommended for small cargo tanks only, it being almost physically impossible to clean large tanks by hand spray or lance injection.

After cleaning the tank, the accumulated sediment and rust should be removed from the tank bottom. This is normally achieved by hand mucking the tanks by the vessel's crew using mops, buckets, etc.

CHAPTER IX

INTRODUCTION TO COW AND IGS

1. WHAT ARE COW AND IGS?

The following gives a brief description of crude oil washing (COW) and inert gas systems (IGS). The aim is to reduce the likelihood of accidental explosions and minimize the amount of pollution from oily ballast water. This, of course, has a direct effect upon the discharge of slops from the tank cleaning or the tank washing process.

COW is a tank cleaning system in which cargo (crude oil) is used as a washing agent as opposed to water and chemicals. Oil residues are sprayed by fixed cleaning machines so that they dissolve back into liquid suspension and are discharged with the cargo, not later with the ballast. This also increases the cargo out-turn from the vessel.

Other advantages of using COW include: reduced tank corrosion, quicker preparation for dry docking and repair, and reduced need for oily water reception facilities.

Offsetting these are certain disadvantages, among which are: COW is not possible with some crudes; it requires trained and qualified operatives; it may increase hydrocarbon emissions with the attendant risk; it increases the discharge time at the terminal; and it is costly in terms of installation and maintenance.

Overall, though, it is the most economic alternative to meet the Marine Pollution Convention (MARPOL) and has been chosen by the great majority of operators of existing crude oil tankers.

Due to terminal schedules and demurrage costs, 100% crude oil washing is not always possible. This necessitates a return to water washing with chemicals, especially when gas freeing for maintenance or changes in cargo.

Water washing is accomplished with the fixed COW machines. These machines have a larger capacity in tons per hour than portable machines and, by design, have no heater in the system.

While COW was originally adopted for commercial reasons (greater cargo out-turn) inert gas has always had a major safety function. Initially used to prevent explosions in partially filled tanks of hydrocarbons (removing one side of the fire triangle of fuel, oxygen, and ignition source) it came to prominence as the major preventative measure for tankers while washing with water.

Water washing of tanks was found, following three VLCC explosions, to create large electrostatic charges in tanks and the use of inert gas prevented an explosion from occurring. Obviously COW creates much larger quantities of hydrocarbon gas and the use of inert gas (IG) is a necessity.

Crude oil washing was first adopted by tanker owners in the early 1970's basically for commercial reasons, achieving a greater outturn of cargo and greatly reducing the quantities of oil retained onboard as part of the load on top operation, eliminating problem sludge buildup in tanks and reducing corrosion. Through the various IMCO, MARPOL, and TSPP (Tanker Safety and Pollution Prevention) conventions, crude oil washing has now become accepted as the alternative to segregated ballast tanks (SBT) in an effort to minimize oil pollution from tankers, and it is mandatory in the UK, U.S.A. and Holland.

Apart from the specific requirements for COW equipment, including suitable washing machines at strategic locations in the tanks and an effective stripping system, an inert gas system is crucial to lower the oxygen content and eliminate the risks of explosion. Crude oil washing is not permitted without an inert gas system. For each ship there will be predetermined procedures for crude oil washing and only properly qualified personnel with experience in participating in crude oil washing programs and having full knowledge of the ship's systems and its operation will be able to carry it out. In this respect, it should not be forgotten that crude oil washing is undertaken during cargo discharge, a busy enough time for any tanker crew, and the work load could be so much increased that safety could be compromised.

2. CRUDE OIL WASHING (COW)

Crude oil carrying vessels have traditionally cleaned their tanks by washing with jets of water. Such methods of washing produce large quantities of oil in water which must be separated. The separation process is complicated by the oily water emulsions which are produced during the washing. This has led to the retention onboard of quantities of water along with the slop oil, recovered by the Load On Top procedure. In the Load On Top procedure, new cargo is mixed with the retained slop oil/water mixture, and the combined product is discharged as cargo at the receiving port.

After discharge of a cargo, a ship's tanks which have held crude oil, usually contain deposits of sediment on the tank bottoms and other horizontal surfaces. This sediment, which has settled from the cargo, consists mainly of waxy and asphaltic substances. If allowed to remain, it will build up after several voyages and impede drainage and reduce the cargo carrying capacity. All oil and sediment must be removed from the cargo tanks which are to be used for clean ballast.

In crude oil washing, part of the cargo (containing all of the volatile components) is circulated through the fixed tank cleaning equipment to remove, by impingement, the waxy asphaltic deposits. This is normally carried out during discharge. Crude oil washing has proved to be more effective than water washing for this purpose, because the crude oil acts to disperse and suspend sediments and tends to restore the cargo to its as-loaded condition. If, due to insufficient impingement velocity or the existence of shaded areas in a tank, thorough cleaning is not achieved, the use of AMERGY® 222 fuel oil conditioner will greatly assist the breakdown and removal of waxy deposits. If a vessel is experiencing difficulty in obtaining good results in their COW operations, it is recommended that AMERGY 222 conditioner be added to assist in the break up of tank residues before pumping the oil ashore. The AMERGY 222 conditioner should be added at a ratio of 1 liter AMERGY 222 conditioner to 10 tons of cargo remaining onboard at the commencement of the crude oil washing. Before adding AMERGY 222 conditioner or any other chemical to a crude oil cargo, it must be established whether or not the refinery can handle the product in their refining process.

After crude oil washing, both water washing of tank bottoms and flushing of cargo lines are required if the tank is to receive clean ballast or if gas freeing is required for any reason.

Without crude oil washing, large quantities of water are required to clean cargo tanks. The resulting oily mixtures and emulsions, together with dirty ballast, must be retained onboard until they have been settled and separated. This process is much simplified when tanks have first been crude oil washed. The oil content of dirty ballast is greatly reduced as a result of this procedure. Cargo tanks which are to be used for clean ballast need only a short rinse with water after crude oil washing. However, pumps and lines must be thoroughly flushed with water. Tanks which are not required for ballast need not be water washed during normal trading as sediment can be kept under control by crude oil washing. Cargo tanks of segregated ballast vessels fall into this category.

By this method, not only is the quantity of residue in the ship greatly reduced, but the quantity of oil/water mixture produced is much smaller and the operation itself is shortened. These factors reduce the potential for pollution.

Crude oil washing is carried out by means of properly designed, permanently piped, fixed in place tank cleaning machines. All, or most, of these will be high capacity type (60 cubic meters per hour or greater). Crude oil washing is carried out during cargo discharge or may be, to a limited extent, carried out at sea between discharge ports. It must be completed before departure from the final discharge port. Ballast should not be loaded into a tank that has not been crude oil washed where the system is available. Clean ballast should be loaded only into tanks that have a water rinse or flush after crude oil washing.

In terms of equipment, there are perhaps a half a dozen major manufacturers. Most produce single nozzle machines, or guns which are programmable so as to devote all their cycle time to those areas which usually are more affected by residue. However, to effect this washing procedure, each machine deck control unit must be operated once, perhaps twice, during the wash cycle.

The alternative approach is the twin nozzle machine which overall entails about half the number of manual operations to carry out a wash program and relies on "two shots" per revolution.

As essential to satisfactory crude oil washing as the installed tanks washing machines, is the design and installation of a stripping system that is capable of maintaining the tank bottom free of standing oil during the bottomwashing operation.

Hydraulic stripping eductors have been found to be the best equipment for this service. To assure continued reliable performance without undue maintenance, eductors are specified to have bodies of nickel-aluminum-bronze and nozzles of monel metal.

3. LOAD ON TOP METHOD (LOT)

Usually any tanker or oil bulk ore (OBO) vessel which has carried a crude oil cargo will depart the discharge port with several of its tanks, holds or double bottoms ballasted.

Any empty tanks, if not previously crude oil washed, should be cleaned using the usual processes. These tanks, once cleaned, are filled with ballast water and the original tanks, first ballasted, are emptied and cleaned. In this way, the vessel arrives at its loading port solely with clean ballast to discharge. Disposing of the oily water resulting from the cleaning operation and the contaminated oily ballast water, poses a problem because the maritime law today permits oil discharge of one fifteen thousandth (one ton of oil for each 15,000 dead weight tons) of the vessel's tonnage to be discharged during the cleaning operation. For example, a vessel of 30,000 dwt is permitted to discharge a maximum of only 2 tons of oil during any one cleaning operation.

Since oil generally weighs less than water, it will gradually float to the top of the water in the slop tank. It is possible on a long voyage to rely on the natural process of separation (some of today's residual oils are much heavier than seawater and those with an API number of 10, i.e. SG 1.00 or above, are impossible to separate with the LOT system). With the LOT process, the bulk of the original ballast and cleaning water can be discharged to the sea. The water is discharged and the oil removed by the cleaning is retained, thus minimizing pollution. A residue of oil mixed with water remains in the tank.

Using the LOT system, the residues from the washed tanks are gathered together in a slop tank. This is usually a special tank or a designated cargo tank. After a period of settling in the slop tank, more water can be discharged leaving a final residue of oil and oil partially contaminated with seawater. The next cargo is loaded on top of this residue, and the entire mixture is pumped ashore to the refinery at the next discharge port where the sea water is separated from the oil physically and/or chemically in a desalter.

The salt water content of the crude oil cargoes poses a continuing problem for oil refineries. The elimination of water from cargo only tanks and the reduction in the quantity of slops after crude oil washing, reduces salt water contamination of the subsequent cargo.

In the Load On Top procedure, the ship's capacity to load new cargo is reduced by the weight of the retained slops and sediments on board. A typical oil/water quantity for a 215,000 dwt tanker after water washing is 1,200/2,300 tons, and for a vessel of the same size on which a full crude oil wash is carried out, a typical figure is 360 tons. This increases the effective cargo capacity of the vessel.

The Load On Top procedure has been recognized for several years as the most effective method of reducing oil pollution at sea. About 2 million tons of oil each year are recovered using the LOT method.

4. INERT GAS

The presence of flammable vapors in the cargo tanks of tankers has led to the development of a system whereby inert gas is used as a smothering medium on top of the crude oil. Inerting is essential if crude oil washing is to be conducted during the discharge of a cargo. This is the time at which the gas/air mixture proportions can rapidly change, one condition producing a super-rich mixture and another a blend which is potentially highly explosive.

IMO regulations specify that all tankers above 40,000 dwt with high capacity crude oil washing facitlities are required to be fitted with an inert gas system.

A. Inert Gas Production

Inert gas is produced either from the washed flue gas of a boiler or by a special gas generator. Sometimes, when hazardous cargoes that react with air are carried, it is necessary to blanket them with an inert gas, i.e. nitrogen or other nonreactive gas, to prevent reactions of the chemical which could cause serious damage.

Inert gas produced from boiler flue gas should never contain more than 5% oxygen. With good boiler combustion control, 3% or less can be achieved. However, both these levels are below the requirement to support combustion (see Fire and Explosion Hazards in Safety - Chapter X). The generated flue gas is passed through a water scrubbing device where corrosive constitutents such as sulfur are removed. It is then cooled to an acceptable temperature by a seawater spray.

The gas, when suitably treated, is passed under pressure through an on-deck water seal, which acts as a non-return valve to the tanks where it displaces the atmosphere and provides an inert blanket over the cargo.

The actual constituents of flue gas vary, but an average composition for a controlled discharge will be approximately as follows:

Oxygen	3% - 5%
Nitrogen	80% - 81%
Carbon Dioxide	14% - 15%
Other trace gases (approximately)	1%

Certain undesirable constituents, such as the oxides of carbon and sulfur, will be present in the inerting gas if poor quality fuel is used and the gas is not passed through the gas scrubbing unit.

The gas must be supplied to the tanks at a rate which will continuously hold the free oxygen content of the atmosphere below the level required to support combustion which is about 11.5%. With flue gas as the inerting medium, the oxygen concentration should be reduced below 11.5%. If the oxygen concentration in the tanks is maintained at 5% or less, sufficient safety margin is maintained and there will be little, if any, likelihood of a fire or explosion occurring.

As stated above, when petroleum vapors are mixed with air in certain proportions, an explosive blend can be produced which can cause very serious damage if ignited. The percentages required to cause a flammable mixture are approximately 1% to 10% hydrocarbon gas, the balance being air. Below 1% gas, the mixture is too lean, while above 10% the mixture is too rich. The exact proportions required are shown on the graph (Figure 11) which follows.

B. The Flammable-Explosive Mixture Graph

During tank cleaning of crude oil residues with water, the hydrocarbon vapor concentration in a tank very often falls to a level which is well within the flammable range. If the balance of this atmosphere is air (containing oxygen), the mixture would be explosive. By introducing scrubbed flue gas into the tank in such proportions as to reduce the oxygen content to below 5%, the atmosphere is rendered safe, even if the hydrocarbons are within the 1-10% range.

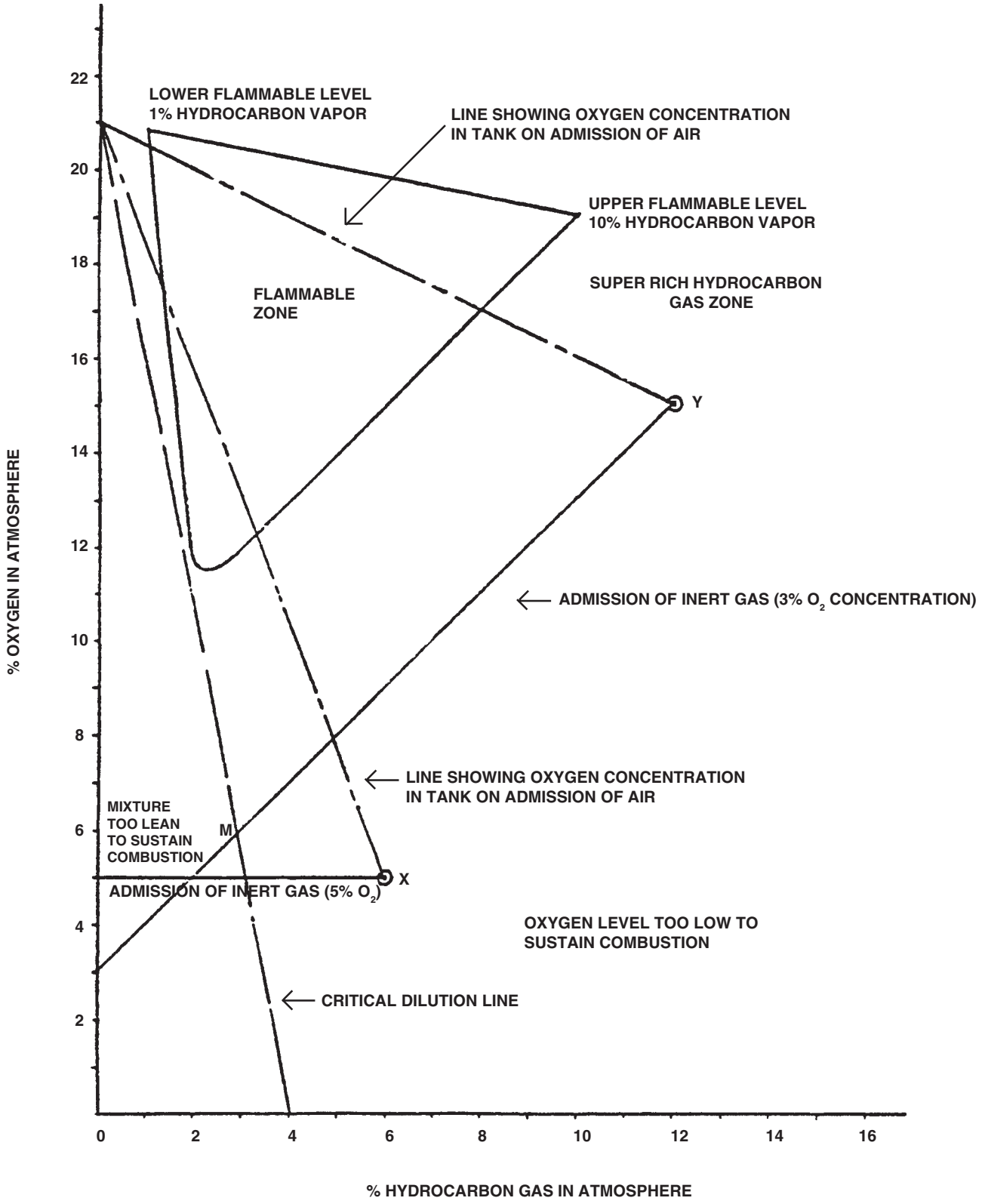
After completion of tank washing, the remainder of the hydrocarbon vapors released during the cleaning process should be displaced by admission of an excess of inert gas. This will ensure that when air is ultimately introduced to the tank to facilitate entry for inspection, a dangerous hydrocarbon vapor-air mixture will not be created.

Shown on the flammable-explosive mixture graph in Figure 11 is the Critical Dilution line. Below this level the admission of any normal atmosphere will not create an explosive mixture. For safety, the hydrocarbon content should be purged to 2% concentration, although a level of 4% can be maintained when oxygen has been completely displaced.

Taking the points X and Y as shown on the graph, it can be seen that if air is introduced to gas free the tank at either concentration, the flammable concentration level will be passed through. To avoid this dangerous condition in the case of point X (6% hydrocarbon, 5% oxygen), inert gas should be first admitted until the hydrocarbon level is about 2% concentration. The addition of air then will not cause the flammable limits to be broached. In case Y (12% hydrocarbon, 15% oxygen), inert gas containing 3% oxygen will reduce the tank's hazardous atmosphere along the line Y-Z until the Critical Dilution line is cut at M when it will be safe to introduce atmospheric air.

Figure 11

FLAMMABLE-EXPLOSIVE MIXTURE GRAPH



C. Crude Oil Grades

Petroleum products are divided into 3 groups depending on their volatile properties.

Class A petroleum is highly volatile and is dangerous due to the fact that it can easily create an over-rich mixture in a storage tank. This could, on admission of atmospheric air, create a flammable-explosive mixture. During loading or discharge of Class A products this probability is a particular problem, and inerting should be maintained throughout these operations.

Class B petroleum gives off only moderate amounts of vapor and is not considered as dangerous as Class A. Nevertheless, Class B materials should be treated with caution especially if heat has been applied to them, since their volatile properites will be greatly increased.

Class C petroleums generally give off little vapor unless heated to above their flash point.

D. The Inert Gas System

A typical boiler flue gas inerting system is shown in Figure 12, together with a deck seal, Figure 13, that has been designed to meet the IMO requirements.

The flue gas inerting system consists of the following main components:

- Trunking fitted with remote controlled regulating valves to convey the gas to the processing unit at the correct rate.
- The filters and scrubbing unit which remove the impurities such as soot particles and carbon monoxide.
- Seawater pumps and lines to provide cooling and scrubbing water.
- Large fans to convey the cooled gas to the tanks through the deck supply lines. The fans also can be used to supply atmospheric air to the tanks via a cross-over valve to accomplish gas freeing.
- An on-deck water seal backed up with vacuum/pressure breakers to prohibit the blow-back of gases from the tanks into the machinery spaces.
- Control panels, situated in the engine room, cargo control room and bridge together with oxygen analyzing equipment, safety devices and alarms. Inerting gas must be fully purged from a tank before personnel are allowed to enter. If the inerting gas has not been fully purged, the lack of oxygen will cause death in a very short time.

  For diesel vessels, where good quality stack gas it not available, there is an inert gas generator. It consists of one unit that:

- Burns fuel directly under combustion controls to minimize oxygen and carbon monoxide.
- Cools and scrubs the combustion gases.
- Conveys the inert gas (or atmospheric air via crossover) to deck water seal and systems.

The advantage of an inert gas generator is consistant good quality gas regardless of vessel operating mode.

Figure 12

A TYPICAL ARRANGEMENT FOR A FLUE GAS INERTING SYSTEM

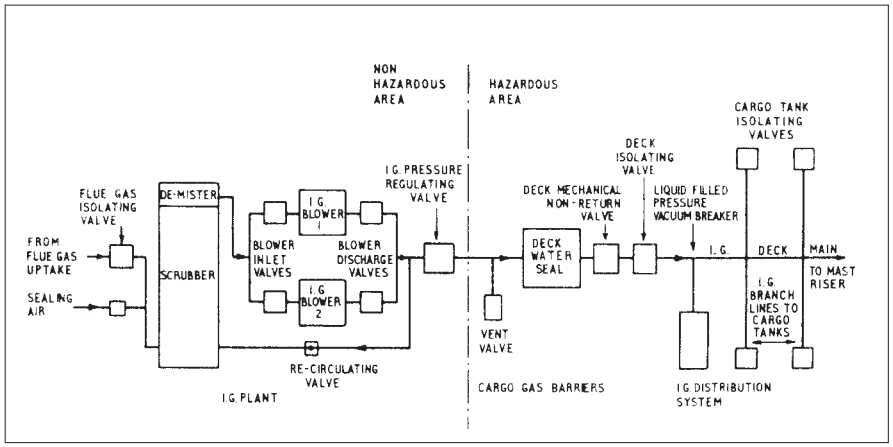
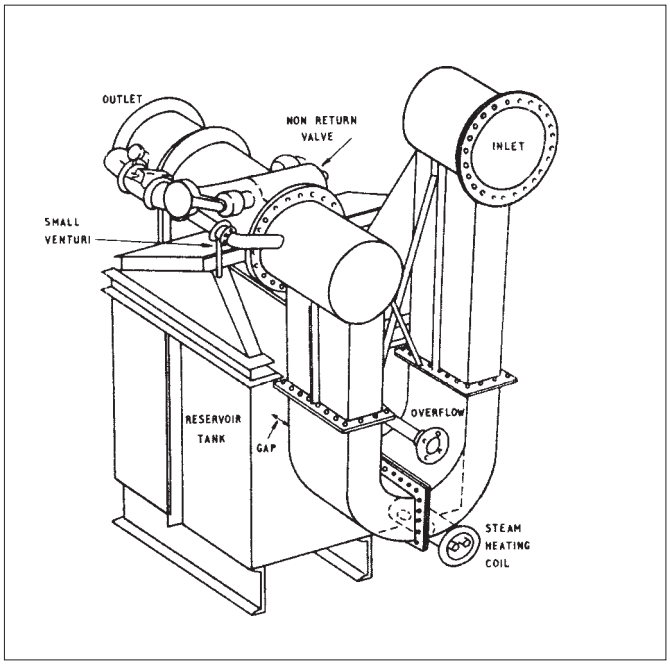


Figure 13

INERT GAS SYSTEM DECK SEAL



CHAPTER X

SAFETY

1. ENTRY INTO CARGO TANKS AND ENCLOSED SPACES

Cargo tanks which have contained a volatile oil are very likely to contain toxic vapors and/or explosive mixtures. Furthermore, tanks which are cathodically protected and have been ballasted can have reserves of hydrogen gas present which should be dispersed by ventilation before entering. Oxygen deficiency can occur in tanks due to corrosion resulting from seawater ballast residues remaining in the tank. Oxygen also may be depleted by the presence of sulfides in seawater which tend to oxidize to sulfates. Sulfides are toxic and, like ammonia, are produced by bacteria (in the seawater), reducing sulfates and nitrogen compounds. Water containing compounds such as hydrogen sulfide can be taken on board when ballasting, especially when the vessel is in estuarial waters.

High concentrations of hydrogen sulfide (up to 7,000 ppm), have been found in gas streams leaving ullage ports above crude tanks. The threshold limit value (TLV) of hydrogen sulfide is currently 10 ppm. American Conference of Governmental Industrial Hygienists has proposed lowering the TLV to 5 ppm.

The normal quantity of oxygen in the atmosphere is 21%. A lower oxygen content than this will initially cause drowsiness leading to loss of consciousness which could result in a fall, injury or death. Thus, a tank apparently safe because it has been isolated and closed, may be dangerous due to lack of oxygen and, possibly, the existence of toxic vapors generated by the presence of bacteria. Further, the oxygen can be displaced by other gases or vapors generated from a cargo or the inert gas from an inerting system.

Fresh flue gases contain typically about 200 ppm of mixed nitrogen oxides. After standing for one or two days, the level drops to 10-20 ppm. The TLV of nitric oxide is 25 ppm and nitrogen dioxide 3 ppm.

Pump rooms can be a special hazard, as they are the working areas most closely associated with the cargo. Pump room bilges can be contaminated by leakage from pump glands and pipeline flanges. Volatile vapors given off from products such as benzene or crude oils have the potential to be toxic and can displace the oxygen of the atmosphere making the compartment dangerous to enter without proper ventilation. Cofferdams similarly can be affected by cargo leakage, possibly via defective weld seams. Both pump rooms and cofferdams, if isolated for long periods, can be deficient in oxygen due to corrosion end products resulting from the reaction of seawater ingress.

Chemical tankers are a particularly dangerous type of vessel due to the vast range of flammable, corrosive or toxic cargoes they may carry. Some toxic substances can be absorbed through the skin and can travel with the blood to affect vital organs. Great care must be taken when cleaning vessel systems which have carried several different chemicals to ensure that they are compatible with the cleaning chemicals and that they will not react with each other in pipelines or slop tanks. When the presence of a toxic, corrosive or flammable substance is suspected, it must be tested and rendered innocuous before human contact is made.

The general precautions to take when dealing with dangerous substances are to inert and then gas free or ventilate thoroughly. Ventilation to the bottom of the tank to be entered is to be continued for the duration of the tank inspection procedure. Before entering a cargo space or pump room, it is good practice to drain any liquids away from the tank tops or bilges in order that dangerous vapors cannot be derived from their presence. Valves and pipelines should not be opened, as contamination can occur from liquid or vapor remaining in the line. Similarly, cargo pumps should always be flushed through and isolated before they are opened for inspection.

After the discharge of certain chemicals, it may be necessary to flush the lines and pumps with a solvent to ensure that they are clean and will not cause injury to personnel when opened for inspection. Protective clothing, including goggles, gloves and shoes should always be worn when in the proximity of chemical cargoes. Respirators should be used when necessary. The guidelines for safe working practice outlined in the booklets “Tanker Safety Code” and “Tanker Safety Guide” and the corresponding IMO recommendations should always be closely followed when cleaning hazardous cargoes from the tanks of ships.

2. GAS FREEING

Gas freeing is done to ensure that enclosed spaces or tanks may be entered safely or in order to make certain that they are not dangerous for carrying out hot work (welding or burning) inside these compartments.

In port, an authorized chemist will issue a gas free certificate after conducting certain tests to prove that any gas present is in a concentration below the lower flammable limit and the threshold limit value. As well as being free of gas, a tank must not contain oil, scale or sludge residues, and any explosive or other toxic hazards must be eliminated before a certificate can be issued. If a tank is to be gas freed for hot work, it is important to ensure that adjacent tanks are also gas free. In this way, the heat transferred will not be responsible for igniting any flammable gases. Adequate ventilation is essential during the entire time that men are working in tanks that have carried hazardous cargoes.

3. FIRE AND EXPLOSION HAZARDS

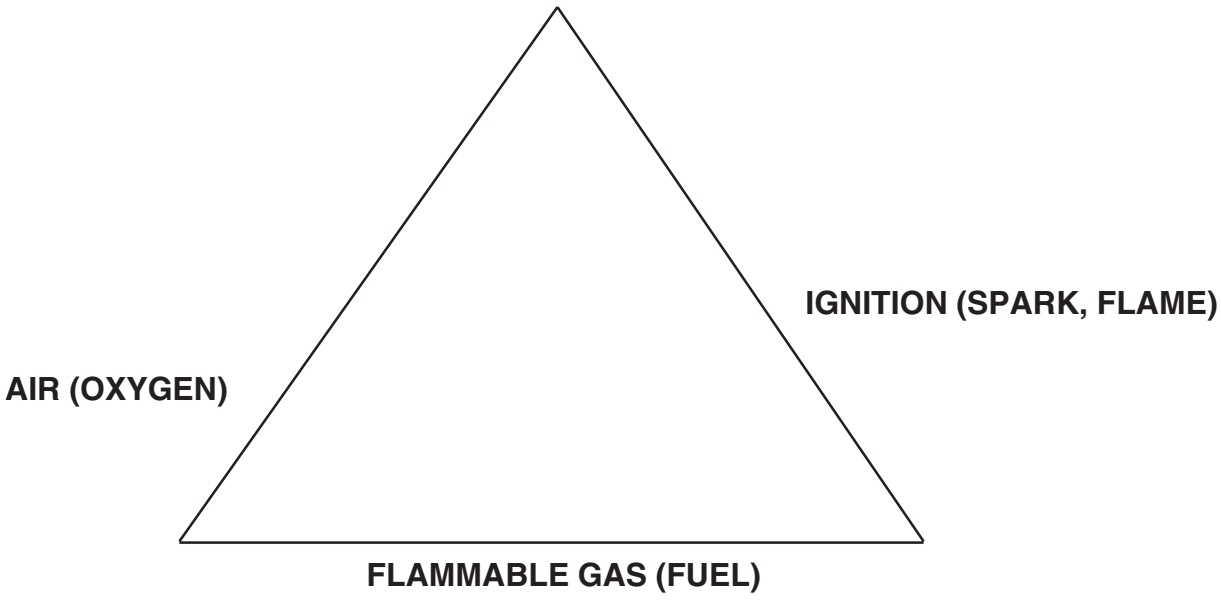
Safety aboard all classes of tankers is of the utmost importance. Most of the risks are eliminated by the designer of the ship and adherence to international, national and company safety regulations. In order to preserve safe working conditions, care must be taken not only by the vessel's crew, but by all people (including shore workers) operating the ship. In order to exercise proper care, it is essential that all personnel are well versed in the behavior, characteristics and properties of the liquid cargoes they are handling under the various physical conditions likely to be met. Fires and explosions are likely to occur when the following conditions are encountered:

- Hydrocarbon or other flammable gas is present in proportion of 1% to 10% in air.
- Oxygen is present in sufficient quantity to support combustion of flammable gases (generally about 11.5%).
- There is an ignition source - usually the flame from a welding oxy-acetylene torch or an electrically or mechanically induced spark.

The above three conditions are quite often represented diagrammatically in the form of a triangle, as shown in Figure 14, below.

Figure 14

THE "FIRE" OR COMBUSTION SUPPORT TRIANGLE



If any one of the sides of the triangle above is removed, the triangle will collapse and combustion will not be possible. It is the aim of all control methods to eliminate one or more of the sides of the triangle to ensure positive elimination of the hazard. The elimination is usually achieved in the following ways:

- When discharging or loading a cargo it is usual to inert the tank, thereby eliminating oxygen.
- The hydrocarbon gas accumulation in a tank or compartment is eliminated by gas freeing and testing the atmosphere regularly.
- To eliminate all ignition sources is not easy. Although tanker operation regulations generally stipulate that matches and/or cigarette lighters are not to be carried on deck, and any lamp or other electric appliance must be spark-proofed, these precautions are only part of a satisfactory program. Further to the above, the following recommendations are usually in force at all times when a tanker is in service:

  a. Smoking is permitted only in those places sanctioned by the Master (usually in areas aft of the funnel).

  b. Use of aluminum or other light metal objects on deck or in tanks where dangerous flammable gases could accumulate is strictly prohibited.

  c. Handle all metal tools and other equipment in enclosed areas carefully to prevent sparks.

  d. Never operate portable radios on deck that are not properly spark-proofed.

  e. Never operate any electrical equipment that is not properly grounded.

When cleaning a tank that has carried a volatile oil, it is quite likely that the atmosphere will pass in and out of the explosive range as the gas is released by the hot or cold cleaning water as it impinges on the oil film and scale sediments. These can absorb and retain quantities of liquid which are released as a vapor. This can increase a lean atmospheric mixture of hydrocarbons into the flammable range which can be ignited in the presence of a spark. Sparks can be generated by static electricity from the high velocity droplets of water from a tank washing operation. These water particles will electrically discharge an instant before contact with the tank bulkhead.

If flammable vapor has been released at this location and it is in a concentration between the upper and lower explosive limits, ignition can take place. This in turn will cause a chain reaction of rapidly expanding fires which will quickly cause an explosion. Similarly, if a rich mixture is diluted by the addition of air, it too can drop the hydrocarbon concentration into the critical flammable range, creating the same highly dangerous explosive atmosphere described above.

4. DETECTION AND MEASUREMENT OF VAPORS AND GASES

A. The Oxygen Analyzer

The instrument used for detecting the presence and concentration of oxygen in an enclosed compartment is known as the oxygen analyzer. Fortunately, oxygen has one physical property which distinguishes it from most other common gases - paramagnetism. This means that it will act exactly as a magnet should and place itself parallel to the lines of force in any magnetic field. This characteristic of oxygen ensures that in the presence of oxygen, a magnetic field intensifies and it will vary with the quantity of oxygen.

Most other gases are to some degree repelled by a magnetic field (diamagnetic). Using the above property, instruments can be manufactured which will accurately measure the oxygen concentration of any atmosphere. These instruments generally take an inert gas as a neutral reference point in a magnetic field. The introduction of oxygen will cause a change in the magnetic flux value. This flux change, which is directly proportional to the concentration of oxygen present, is measured by a coil and photocells. It is magnified and transmitted to a scale calibrated in % oxygen. Against a reference of pure nitrogen to atmospheric air, a range 0-21% is utilized. Sometimes false readings are obtained when another gas with paramagnetic properties is present. The common examples of such gases are chlorine dioxide, which forms acid in moisture, such as your lungs; nitrous oxide (laughing gas) and nitrogen dioxide.

B. Explosimeters

These meters generally take the form of a Wheatstone Bridge circuit, whose power is supplied by an enclosed battery. When the bridge resistances are balanced, no current flows through the meter. The explosimeter has one resistance constructed of a hot filament (usually platinum) in a combustion chamber. A sample is drawn into the combustion chamber where it will burn in the presence of the hot filament. A rise in temperature of the filament will cause its electrical resistance to increase and will, therefore, unbalance the bridge causing a current to flow which is detected and measured on a meter. The scale of the meter generally is marked in ppm of hydrocarbons and represented as a percentage of the lower explosion limit.

Care must be taken when using the explosimeter, as it is possible that the reading can be affected by the presence of an inert gas or by a very low concentration of oxygen being present in the sample. An explosimeter is primarily an instrument for the detection of combustible hydrocarbon gases and should not be used to detect other types of vapors or gases; however, it does give guidance as to the safety of a space for entry by personnel. Before its use for this condition, the spaces should be thoroughly ventilated and the remaining atmosphere monitored carefully. Any reading above zero will indicate a hazardous condition.

C. Toxic Vapor Stain Tubes

These detectors are used individually for tanks which have contained compounds or liquids for which there is no specific metering device. They take the form of glass tubes packed with chemical granules which will change color on contact with a particular gas or vapor. The tubes have a scale showing the length of the stain produced by the gas as it is pumped through the tube. The length of the stain is in direct proportion to the concentration of the gas present.

For each type of chemical vapor to be tested, a different stain tube is provided. To conduct a vapor stain test, the tube is fitted into the discharge side of an analyzer. The suction tube is lowered into the space to be tested and the tank atmosphere is then pumped through the tube in order that the toxic gas concentration can be measured.

The chemicals in the glass vials are protected by supplying them sealed, and the tube neck is broken immediately before use.

5. THE IMPORTANCE OF EARTHING OR GROUNDING OF TANK CLEANING EQUIPMENT

During the water washing operation, very large static electricity charges can be built up in a tank. It is therefore of the utmost importance that all equipment used in the process be positively earthed or grounded.

All portable tank cleaning equipment must be tested for electrical continuity before it is commissioned. Any component, especially a reinforced hose, that is not proved to be satisfactory in this respect, should not be used. Electrical continuity of all components must be verified on each and every occasion that they are used. The earthing wire must, on all occasions, be proved to run continuously from the tank cleaning machine to the last coupling. This ensures that during the operation of several machines simultaneously an earthing patch is created which incorporates every component in the circuit.

Tank cleaning hoses should never be disconnected from the hydrant until they have been removed from the tank. All earth connections should be made and broken on deck and never in a confined space where gases may have accumulated.

CHAPTER XI

THE DISCHARGE OF TOXIC CHEMICALS, OILS AND FATS

1. TOXIC CHEMICAL CARGOES

When toxic chemical cargoes are carried, it is essential that personnel understand the characteristics and properties of these substances and take proper precautions to avoid direct contact. Some chemicals must never come into contact with the skin as they can be absorbed into the blood stream and damage vital body organs (e.g. phenol). Some affect the nervous system when inhaled (e.g. tetra ethyl lead) and others will burn severely if swallowed (e.g. acids).

The proper protective clothing, including gloves, goggles and shoes, must be worn at all times by operators who come within the proximity of toxic materials. Clothing such as this includes complete suits of plastic with attached hoods, breathing apparatus and, of course, goggles.

All toxic substances will produce injury of one type or another when in contact with a vulnerable part of the body. The usual ways in which chemicals are taken into the body are swallowing, absorption through the skin and breathing. Any person who is doused with a chemical or oil should immediately shower and completely change their clothing including shoes and socks.

A common way to assess the safety of a potentially contaminated atmosphere is to compare measured airborne concentrations of a chemical to an occupational exposure limit (OEL). Many countries and organizations publish these levels. Two examples are the Federal Republic of Germany Maximum Concentration Values in the workplace (MAK) and the American Conference of Governmental Industrial Hygienists Threshold Limit Values (TLV's).

These exposure limits represent the amount of airborne chemical to which personnel may be exposed without adverse effects. These values are based on the average exposure over an 8 hour time period.

Exposure to gaseous concentrations below the OEL for a complete working day is considered safe, but exposure to concentrations which exceed the OEL may be hazardous. The OEL is measured in ppm and both TLV and MAK values are constantly under review as new data and information on the various substances are discovered.

It must be said that some hydrocarbon liquid cargoes which normally appear to be innocuous can in reality be very dangerous. Among these are some crude oils that contain hydrogen sulfide, cashew nut oil, and benzene. It is therefore most important that any liquid cargo which has to be cleaned from a tank must first have its properties and characteristics thoroughly investigated in order that the correct procedures are adopted, and any danger to personnel is obviated by careful planning and precautionary measures. The TLV for hydrogen sulfide (H_2S) in sour crude is 10 ppm. Special instruments are necessary to detect this concentration, although the characteristic telltale pungent rotten egg aroma may well provide a good indication of its presence. Higher concentrations can seriously affect the olfactory nervous system (sense of smell) and may not, in severe cases, be detected without the use of instruments. The TLV for benzene is 0.5 ppm and like the hydrogen sulfide in sour crude is extremely toxic. Other hydrocarbons such as paraffin and gasoline (petrol) are much less toxic and have a TLV of about 300 ppm.

2. LEADED PRODUCTS

From time to time it is necessary to clean cargo oil tanks which have carried leaded products. Although it is well known that strong alkaline cleaners will substantially dissolve and remove cargo products such as lead, they will never completely remove traces of this toxic substance.

In fact, experts in leaded cargoes emphatically recommend against using a tank which has carried a lead-bearing product for anything else.

In other words, once the tanks carry lead products, they should be kept in that service, due to the contaminated surfaces. There is no known cleaner which could assure a lead-free condition.

3. NON-DRYING OILS

To ensure that the simplest and easiest tank cleaning procedures are adopted, it is of paramount importance that all of the liquid cargo is discharged, and that as far as possible, there are no large solidified lumps of waxy residue remaining in the tank. To achieve this, several practical conditions must be obtained.

Many vegetable, fish or animal oil cargoes must be carried in a heated condition to ensure that they are sufficiently mobile for pumping to shoreside tanks. Any instructions regarding the carriage and discharge temperatures of the cargo must be strictly followed. Also, it must be remembered that overheating a cargo can, in many instances, be as detrimental as allowing it to cool and solidify. When very low seawater temperatures at discharge ports are encountered, it is quite common to observe solidified layers of cargo product underneath the cargo heating coils. If this condition is found to exist, the product must be physically agitated with the heating coils in use. The solidified lumps will melt and they can be pumped away along with the rest of the cargo.

It is important that tank heating is maintained for the duration of the cargo discharge.

Keeping the product mobile during discharge is important, but it should always be kept flowing in the correct direction - that is towards the suction. It is therefore crucial that the ship be trimmed so that the product will flow continuously to the discharge point ensuring that the cargo pumps maintain a positive suction at all times. The cleaning of non-drying oils from a tank need not be done immediately after discharge such as is necessary for drying or semi-drying oils.

The contents of deep tanks and the residues of certain oils are sometimes pumped out by using portable pumps. Very often the pump is lowered into the tank and at other times it is placed on deck. It is important that the suction lines for these pumps are made of a flexible, noncollapsible material and contain a non-return valve. This will aid in maintaining a positive pump suction up to the practical limit (less than 7 meters).

4. DRYING OILS AND SEMI-DRYING OILS

The degree to which an oil will dry in the presence of oxygen is governed by the concentration of the glycerides contained in the oil, particularly the linoleic acids. The affinity of oils for iodine is used as a method of grading them into drying, semi-drying, or non-drying types. The oils with the greatest affinity (i.e., highest iodine number) to iodine are the fastest drying oils. The lowest iodine values are characteristic of non-drying oils. The process by which an oil dries is called oxidation. The film of oil upon the cargo tank sides absorbs oxygen from the atmosphere, hardens and adheres to any surface it contacts. This process occurs with both natural oils and man-made products in which natural oils are mixed with synthetic resins to produce epoxy resins, chlorinated rubber, etc., These properties are utilized in the production of binders in paints and varnishes. After a drying oil has been discharged, it should be cleaned from the tank immediately before it oxidizes and sets hard. This will involve the use of the tank washing equipment and COLD sea or fresh water. (Hot water causes the drying oils to harden.)

If a drying oil is not cleaned from a tank immediately, it will absorb oxygen from the atmosphere and pass from the liquid state into a gummy, adherent mass. Further oxidation of the oil will cause it to become solidified, and in this form, it turns into a varnish or lacquer film on the tank sides. The addition of heat will cause the drying process to accelerate. This fact must be remembered if a drying oil has been stored in a tank adjacent to a tank which has contained a cargo requiring heating.

If a drying oil, for one reason or another, has been allowed to harden, the only way to remove it from the tank is by using chemicals. This involves recirculating Drew LAC™ liquid alkaline cleaner or DREW™ ABD alkaline-based degreaser in a 5% concentrated solution at a minimum temperature of 70° C (158° F).

However, if the tank has been coated with a zinc-rich organic type paint, this method should not be adopted, because this coating is very sensitive to pH values outside the 5.5 to 11.0 range. Some types of epoxy resin coatings should not be exposed to cleaning temperatures above 45° C (113° F), and care in this respect should always be taken.

5. TYPES OF OILS

DRYING OILS

China Wood Oil
Candle Nut Oil
Hempseed Oil
Linseed Oil
Menhaden Oil
Mustardseed Oil
Otticea Oil
Perilla Oil
Poppyseed Oil
Rubberseed Oil
Safflower Oil
Soya Bean Oil
Tall Oil
Tung Oil
Walnut Oil

SEMI-DRYING OILS

Babassu Oil
Cod Oil
Codliver Oil
Cottonseed Oil
Croton Oil
Herring Oil
Jap Fish Oil
Maize Oil
Sardine Oil
Sesame Oil
Shark Oil
Sunflowerseed Oil
Whale Oil
Wheat Oil

NON-DRYING OILS

Almond Oil
Arachis Oil (Groundnut)
Camphor Oil
Canaga Oil
Carapa Oil
Chashew Nut Oil
Castor Oil
Coconut Oil
Cohune Oil
Curi Curi Oil
Geranium Oil
Lard Oil (Animal)
Neatsfoot Oil
Olive Oil
Palm Oil
Pine Oil
Rapeseed Oil (Colza)
Rice Oil
Seal Oil
Sperm Oil
Tacum Oil
Tallow Oil
Tea Seed Oil

WATER SOLUBLE PRODUCTS

Molasses
Sodium Sulfonate Petroleum
Potassium Sulfonate Petroleum

APPENDIX A

THE RECOMMENDATIONS FOR CLEANING WITH DREW™ABD, LAC™ AND EDGE® CLEANERS

Below is a table showing the quantities of DREW ABD alkaline-based degreaser, EDGE heavy duty cleaner and LAC liquid alkaline cleaner to be used for cleaning non-drying and drying oils as used in the direct injection (once through), recirculation and rock-and-roll methods.

The cleaning cross-reference table should always be referred to for cleaning instructions. A good general idea can be obtained from these charts. Before using DREW ABD degreaser, EDGE or LAC cleaners for tank cleaning, always check that the selected product is compatible with the tank coating (paint) and the material of the tank heating coils. LAC cleaner and DREW ABD alkaline-based degreaser will attack, to some degree, most nonferrous metals, especially aluminum. EDGE cleaner is less aggressive than LAC cleaner, but it is always prudent to ensure that safe limits are maintained. (See CHAPTER V on TANK COATINGS.)

A. Non-Drying Oils

OIL	MACHINE WASHING					
	DIRECT INJECTION		RECIRCULATION		ROCK-AND-ROLL	
	% DREW ABD degreaser LAC or EDGE cleaners	TEMP	% DREW ABD degreaser LAC or EDGE cleaners	TEMP	% DREW ABD degreaser LAC or EDGE cleaners	TEMP
Almond Oil	0.2	50°C	0.4	Ambient	0.4	Ambient
Camphor Oil	0.2	60°C	0.4	60°C	0.4	60°C
Carapa Oil	0.2	60°C	0.5	60°C	0.4	60°C
Cashew Nut Oil	0.2	60°C	0.5	60°C	0.4	60°C
Castor Oil	0.2	Ambient	0.4	Ambient	0.8	Ambient
Coconut Oil	0.2	60°C	0.4	60°C	0.8	60°C
Cohune Oil	0.2	60°C	0.4	60°C	0.4	60°C
Curi-Curi Oil	0.2	60°C	0.4	60°C	0.4	60°C
Geranium Oil	0.2	60°C	0.4	60°C	0.4	60°C
Hemp Oil	0.2	60°C	0.4	60°C	0.4	60°C
Lard Oil (animal)	0.2	50°C	0.4	50°C	0.4	Ambient
Neatsfoot Oil	0.2	60°C	0.4	60°C	0.4	60°C
Olive Oil	0.2	50°C	0.4	50°C	0.4	50°C
Palm Kernel Oil	0.2	60°C	0.4	60°C	0.4	60°C
Pine Oil	0.2	60°C	0.4	60°C	0.4	60°C
Rapeseed Oil (colza)	0.2	60°C	0.4	60°C	0.4	60°C
Sperm Body Oil	0.2	60°C	0.4	60°C	0.4	60°C
Sperm Head Oil	0.2	60°C	0.4	60°C	0.4	60°C
Tallow Oil	0.2	60°C	0.4	60°C	0.4	60°C
Teaseed Oil	0.2	60°C	0.4	60°C	0.4	60°C
Tacum Oil	0.2	60°C	0.4	60°C	0.4	60°C

B. Semi-Drying Oils

OIL	MACHINE WASHING					
	DIRECT INJECTION		RECIRCULATION		ROCK-AND-ROLL	
	% DREW™ ABD degreaser EDGE® or LAC™ cleaners	TEMP	% DREW ABD degreaser EDGE or LAC cleaners	TEMP	% DREW ABD degreaser EDGE or LAC cleaners	TEMP
Babassu Oil	0.3	60°C	0.6	50-60°C	0.6	60°C
Cod Oil	0.3	60°C	0.6	50-60°C	0.6	Ambient
Cottonseed Oil	0.3	60°C	0.6	50-60°C	0.6	60°C
Croton Oil	0.3	60°C	0.6	50-60°C	0.6	60°C
Herring Oil	0.3	60°C	0.6	50-60°C	0.6	60°C
Maize Oil	0.3	60°C	0.6	50-60°C	0.6	60°C
Sardine Oil	0.3	60°C	0.6	50-60°C	0.6	Ambient
Sesame Oil	0.3	60°C	0.6	50-60°C	0.6	60°C
Shark Oil	0.3	60°C	0.6	50-60°C	0.6	50°C
Sunflower Seed Oil	0.3	60°C	0.6	50-60°C	0.6	60°C
Whale Oil	0.3	60°C	0.6	50-60°C	0.6	60°C
Wheat Oil	0.3	60°C	0.6	50-60°C	0.6	60°C

NOTE: Precleaning Semi-Drying oils with cold water is essential before cleaning commences.

C. Drying Oils

OIL	MACHINE WASHING					
	DIRECT INJECTION		RECIRCULATION		ROCK-AND-ROLL	
	% DREW ABD degreaser EDGE or LAC cleaners	TEMP	% DREW ABD degreaser EDGE or LAC cleaners	TEMP	% DREW ABD degreaser EDGE or LAC cleaners	TEMP
Chinawood Oil	0.4	60°C	0.8	60°C	0.8	60°C
Candle Nut Oil	0.4	60°C	0.8	60°C	0.8	60°C
Hempseed Oil	0.4	60°C	0.8	60°C	0.8	40°C
Linseed Oil	0.4	60°C	0.8	60°C	0.8	40°C
Menhaden Oil	0.4	60°C	0.8	60°C	0.8	40°C
Mustardseed Oil	0.4	60°C	0.8	60°C	0.8	60°C
Otticea Oil	0.4	60°C	0.8	60°C	0.8	40°C
Perilla Oil	0.4	60°C	0.8	60°C	0.8	Ambient
Safflower Oil	0.4	60°C	0.8	60°C	0.8	40°C
Soya Bean Oil	0.4	60°C	0.8	60°C	0.8	Ambient
Tall Oil	0.4	60°C	0.8	60°C	0.8	40°C
Tung Oil	0.4	60°C	0.8	60°C	0.8	40°C
Walnut Oil	0.4	60°C	0.8	60°C	0.8	40°C

NOTE: Precleaning with cold water is essential when removing semi-drying and drying oils and fats. DREW ABD alkkaline-based degreaser, LAC liquid alkaline cleaner and EDGE heavy duty cleaner are outstanding cleaning products for removing residues of animal and vegetable oils and fats from cargo tank surfaces. They can be used to clean away residues left by many types of liquid cargoes and also for removing odors produced by various types of cargoes. The following general suggestions are for the application of DREW ABD degreaser, LAC cleaner and EDGE cleaner in the most commonly used washing procedures.

PRELIMINARY CONSIDERATIONS FOR ANY CLEANING METHOD

1. Tanks should be stripped completely at the recommended cargo pumping temperatures.

2. To avoid delays, all equipment for the cleaning method to be used should be onboard and in a condition ready for use before cleaning is begun.

3. Tanks containing drying oils should be cleaned with cold water immediately after discharge to prevent formation of a hard tenacious residue. Adequate ventilation should be provided and other standard procedures should be observed, to allow personnel to enter tanks as soon as possible after unloading.

MACHINE WASHING

1. **Direct Injection Method** (the once through or total loss method).

   a. Introduce DREW™ ABD alkaline-based degreaser, LAC™ liquid alkaline cleaner or EDGE® heavy duty cleaner directly into the tank wash water line by means of an eductor or small metering pump. Adjust the feed rate to give the correct solution strength. (See previous charts)

   b. The tank should be stripped continuously while washing.

   c. Rinse the tank with ambient temperature water, immediately after cleaning with DREW ABD degreaser, LAC cleaner or EDGE cleaner.

   d. If necessary, spot clean manually to remove any patches of soil material that remain after cleaning.

2. **Recirculation Method**

   a. While filling the recirculation tank with water, add the amount of DREW ABD, LAC or EDGE cleaners required for correct solution strength.

      This can be worked out using the charts prior to these instructions.

   b. Except for the fact that tanks being washed are stripped back to the recirculation tank, the procedure is similar to that for once through washing.

ROCK-AND-ROLL METHOD

   a. Fill the tanks to be cleaned with water to the required level, at the same time adding enough DREW ABD degreaser, LAC cleaner or EDGE cleaner to give correct solution strength.

   b. If a warm or hot cleaning solution is required, apply full heat on the heating coils until proper temperature is reached, first checking that the heating coil material is compatible with the DREW ABD degreaser, LAC cleaner or EDGE cleaner. EDGE cleaner is chemically much less aggressive than LAC cleaner and should not affect deleteriously surfaces which a similar concentration of LAC cleaner would harm.

   c. After 24 hours or more if required, strip and rinse the tank.

SPOT CLEANING (MANUAL)

1. Prepare a 3% solution of EDGE cleaner or a 1% solution of LAC cleaner/DREW ABD degreaser, using 30 cc of EDGE cleaner per liter of water or 10 cc of LAC cleaner/DREW ABD degreaser per liter of water. (About 4 ounces of EDGE cleaner per U.S. gallon of water or 1-1/4 ounces of LAC cleaner/DREW ABD degreaser per U.S. gallon of water.)

2. Scrub the area to be cleaned with brush or broom using generous amounts of the cleaning solution. Protective clothing including goggles and face masks to prevent liquid from spattering into the eyes must be used.

3. Flush the surfaces with clean water.

It must, of course, be understood that the details of the cleaning methods including temperatures and quantities of cleaner may be subject to change due to varying conditions, all of which obviously cannot be discussed in this manual. Therefore, the above is a guide and not an exact procedure to follow at every occasion.

CAUTION

It should also be noted that many animal and vegetable oils absorb the oxygen from the atmosphere. This is specifically so after a tank which has been carrying such an oil has been emptied. The residue remaining upon the tank sides can rapidly absorb the oxygen content of the tank rendering it dangerous to enter. At least 18% concentration of oxygen in air is required to support human life.

Certain cargoes such as cashew nut oil, are particularly hazardous and entrance to any tank carrying such a cargo should never be contemplated. The cargo carrying instructions should always be referred to before entering any tank which has carried any type of liquid.

Following are two graphs (Figures 15 and 16) specifically designed to show the DREW™ ABD degreaser/LAC™ liquid alkaline cleaner/EDGE® heavy duty cleaner dosages in gallons and liters per minute against water pressure in pounds per square inch and kilograms per square centimeter for various diameter tank cleaning nozzle tips. The dosages are specifically for the direct injection cleaning method.

The curves show feed rates in liters/minute to give 0.1% solution. Multiply by the appropriate concentration factor to get feed rates for stronger solutions.

Example: From the graph, locate the point for a 3/8" nozzle tip and water pressure of 10 kg/cm^2. Dosage for 0.1% solution is 0.375 liters/minute.

To get 0.2% strength, multiply 0.375 by 2. This gives 0.75 liters per minute.

Figure 15

DREW™ ABD alkaline-based degreaser, LAC™ liquid alkaline cleaner and EDGE® heavy duty cleaner Dosages

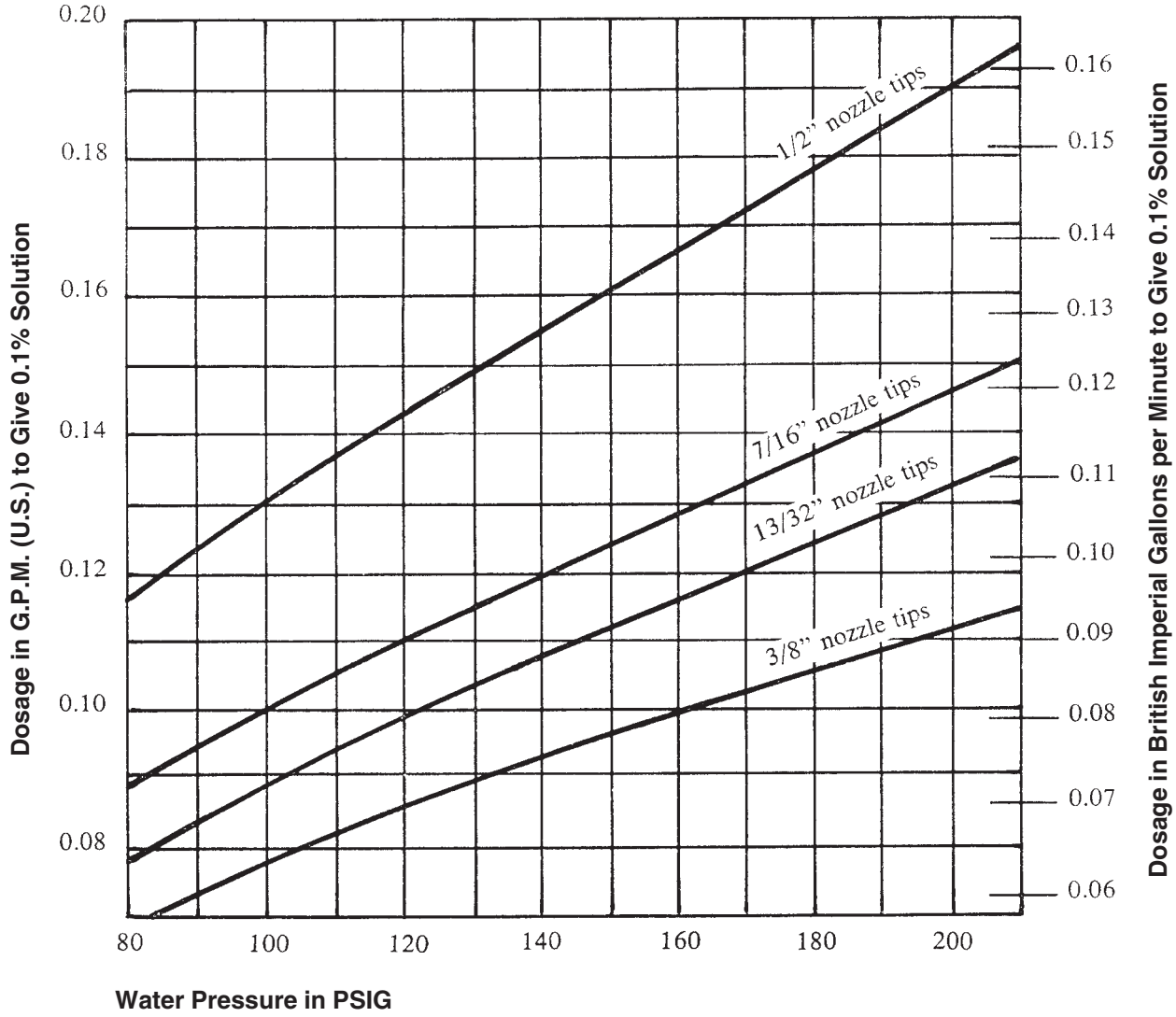
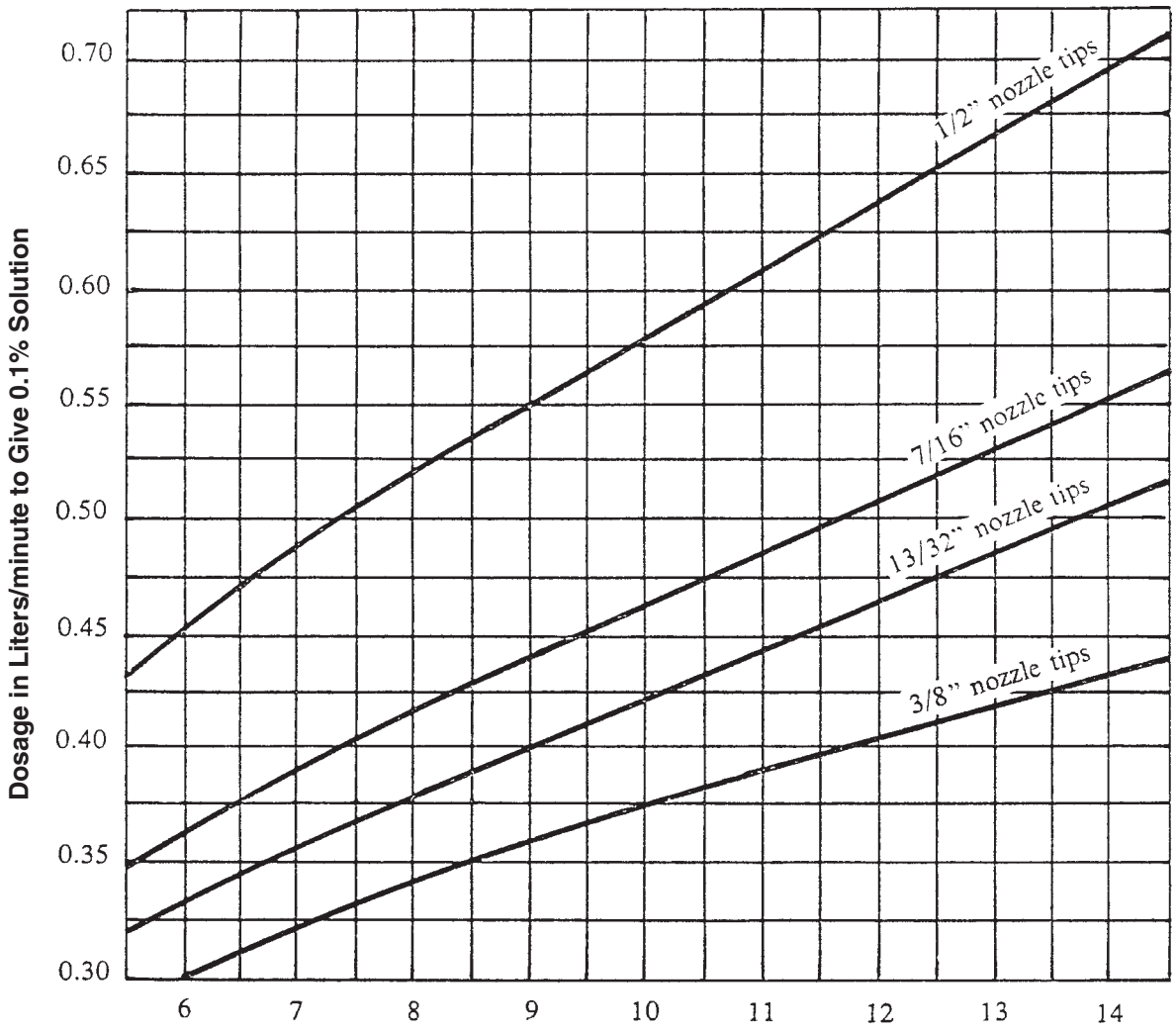


Figure 16

DREW™ ABD alkaline-based degreaser, LAC™ liquid alkaline cleaner and EDGE® heavy duty cleaner Dosages



APPENDIX B

SHIP STRUCTURAL DIAGRAMS

Figure 17 - Transverse Section of a Tanker

Figure 18 - Tank Vessel Internal Structure

Figure 17

TRANSVERSE SECTION OF A TANKER

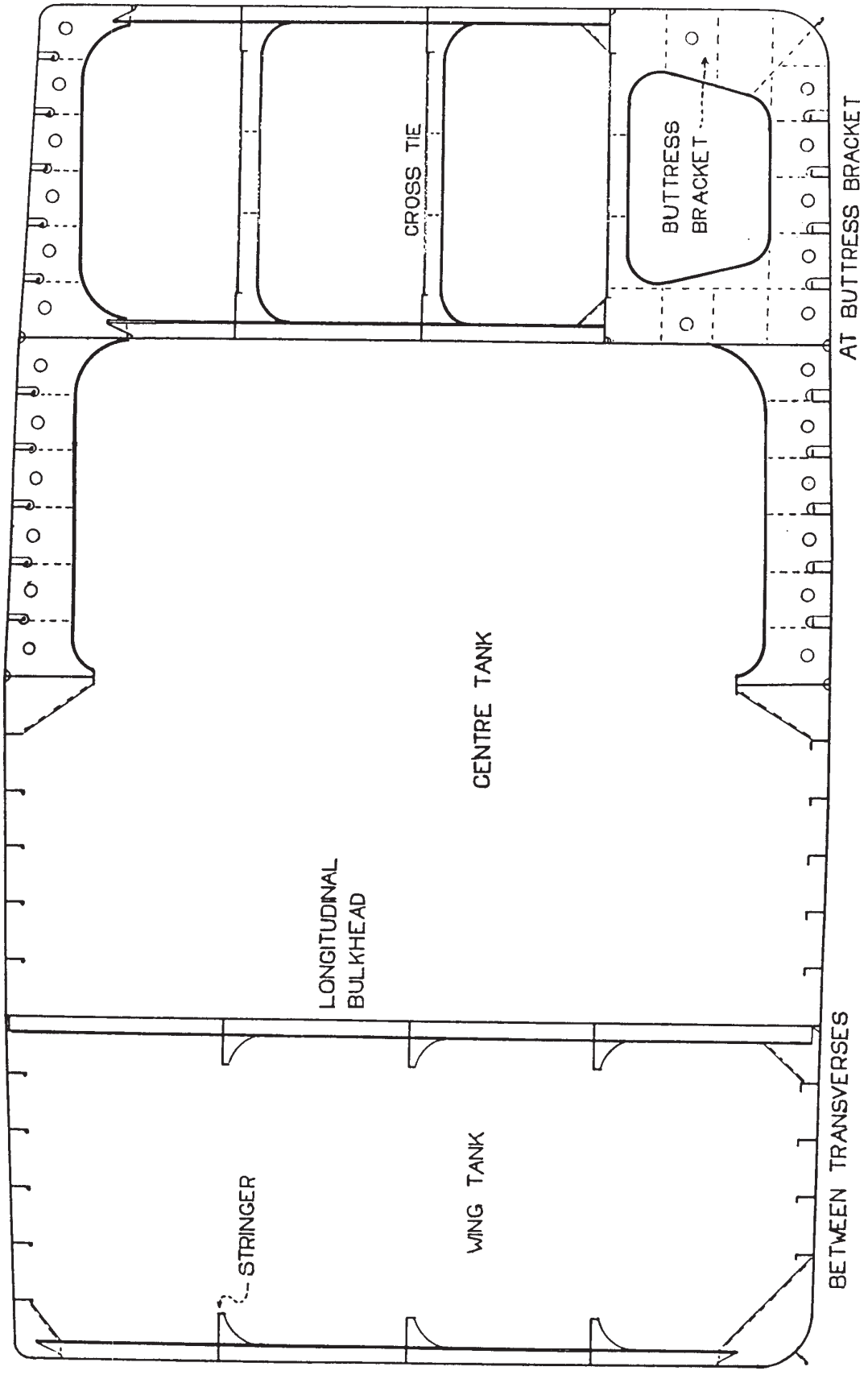
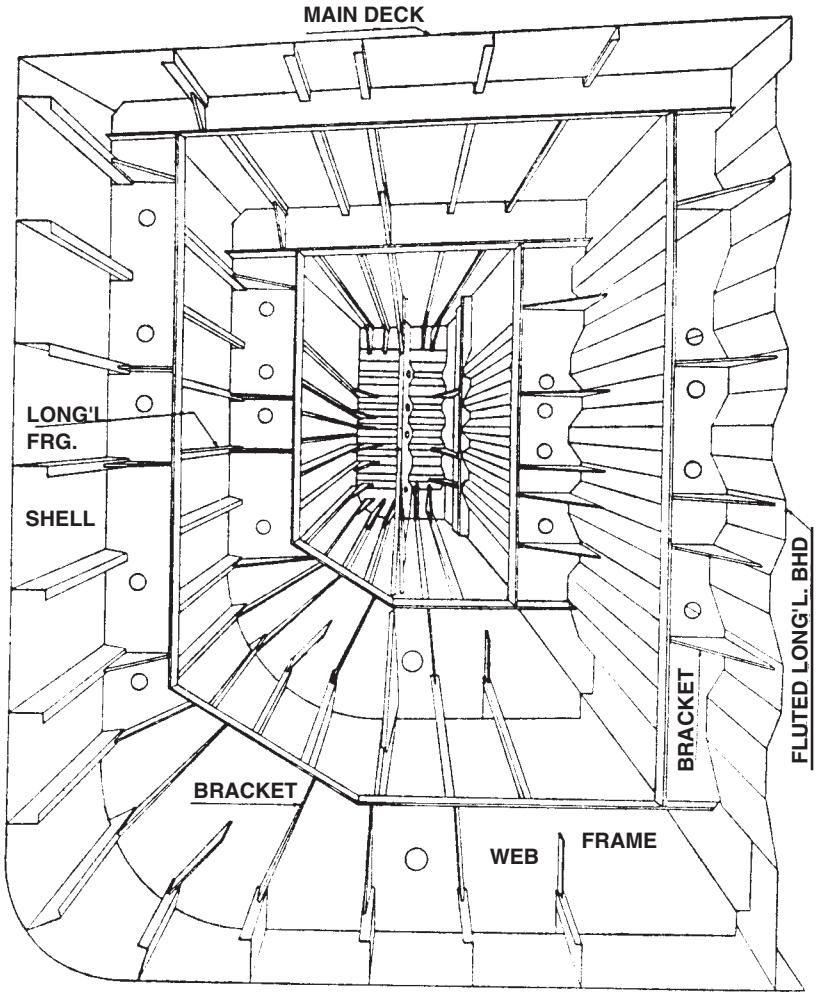


Figure 18

TANK VESSEL INTERNAL STRUCTURE



Introduction to Steel Shipbuilding, Elijah Baker III, 1943, 1953, used with permission of McGraw-Hill Book Company, Inc.

APPENDIX C

A GUIDE TO CRUDE OIL SPECIFICATIONS WORLDWIDE

A GUIDE TO CRUDE OIL SPECIFICATIONS WORLDWIDE

COUNTRY	CRUDE OIL NAME	GRADE OF OIL	SULPHUR WT %	POUR POINT °C	REID VAPOUR PRESSURE kg/cm²	VISCOSITY KvcST 40°C	A.P.I. NO. at 16 °C	MINIMUM VOYAGE TEMP (°C) PASSAGE	MINIMUM VOYAGE TEMP (°C) DISCHARGE
ALGERIA	ASKARENE	L	0.14	2	0.56	2.3	41.7	NH	NH
	HASSI MESSAOUD	L	0.14	-50	0.60	2.0	43.0	NH	NH
	OHANET N8S	L	0.09	-25	0.54	2.6	44.0	NH	NH
ANGOLA	N. ZOMBO	L	0.13	27	0.17	20.0	33.0	40	44
AUSTRALIA	GIPPSLAND MIX	L	0.09	16	0.27	2.0	44.0	27	32
	KING FISH	L	0.10	14	0.25	2.0	47.0	25	30
BRAZIL	BAHIA	L	0.10	38	0.20	16.6	35.8	48	54
	BARINAS	L	1.70	13	0.22		26.1	25	30
CHILE	DANIEL	L	0.01	0	0.60	1.8	43.0	NH	NH
COLUMBIA	ORITO	L	0.76	-46	0.37	4.9	33.8	NH	NH
	CASABE	L	0.06	-26	0.41	2.0	44.0	NH	NH
	RIO ZULIA	L	0.36	27	0.45	4.7	40.0	40	45
	TIBU	L	1.00	-9	0.23	10.8	32.0	NH	NH
EGYPT	BELAYIM	M	3.04	5	0.30	83.0	21.0	16	21
	BELAYIM MARINE	L	1.81	16	0.27	11.5	31.0	27	32
	EL MORGAN KAREEM	L	1.81	7	0.33	9.2	32.3	18	24
	BAKR	M	4.60	7	0.17	140	20.0	24	29
	RAMADAN	L	2.00	10	0.26	12.0	31.7	24	29
GABON	GRONDIN	L	0.13	16	0.15	31.6	31.8	27	32
GREAT BRITAIN	BRENT	L	0.26	-3	0.59	3.72	38.2	NH	NH
	NINIAN	L	0.41	7	0.37	6.94	35.1	18	24
	MURCHISON	L	0.28	-1	0.72	3.5	38.8	NH	NH
	FORTIES	L	0.30	-3	0.48	4.0	36.6	NH	NH
INDONESIA	BADAK	L	0.10	-18	0.04	1482.	35.0	55	60
	BEKAPAI	L	0.10	-32	0.06	326	41.1	30	35
	TARKAN	H	0.20		0.04	1432.	11.2		
IRAN	AGHA JARI	L	1.36	-15	0.28	5.2	34.2	NH	NH
	AHWAZ ASMARI	L	1.60	-26	0.20	4.9	34.5	NH	NH
	CYRUS	M	3.55	-18	0.30	237	18.4	46	52
	DARIUS	L	2.75	-18	0.39	5.2	34.0	NH	NH
	IRANIAN HEAVY	L	1.64	-12	0.45	8.8	31.6	NH	NH
	IRANIAN LIGHT	L	1.35	-21	0.48	5.6	34.8	NH	NH
	SASSAN	L	1.90	-9	0.27	6.9	34.0	NH	NH
IRAQ	AIN ZALAH	L	1.90	-15	0.46	5.2	31.0	NH	NH
	BASRAH	L	1.92	-18	0.52	6.1	35.0	NH	NH
	KIRKUK	L	1.95	-29	0.30	4.3	36.0	NH	NH

A GUIDE TO CRUDE OIL SPECIFICATIONS WORLDWIDE

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COUNTRY	CRUDE OIL NAME	GRADE OF OIL	SULPHUR WT %	POUR POINT °C	REID VAPOUR PRESSURE kg/cm²	VISCOSITY KvcST 40°C	A.P.I. NO. at 16 °C	MINIMUM VOYAGE TEMP (°C) PASSAGE	DISCHARGE
KUWAIT	EOCENE (neutral zone)	M	5.01	-34	0.23	148	18.2	NH	NH
	KUWAIT	L	2.58	-29	0.55	8.6	31.4	NH	NH
	RATAWI (neutral zone)	L	4.13	-34	0.31	33.5	24.9	NH	NH
LIBYA	AMAL	L	0.24	18	0.26	13.0	36.0	29	35
	BEDA	L	0.23	2	0.42	2.4	40.0	NH	NH
	DHARA	L	0.35	2	0.41	2.8	40.0	NH	NH
	ES SIDER	L	0.46	0	0.38	4.9	37.0	NH	NH
	KOTLA	L	0.45	7	0.36	5.2	34.0	18	24
	SARIR	L	0.16	21	0.23	9.8	37.2	32	38
	ZUEITINA	L	0.19	0	0.27	2.6	41.0	NH	NH
MEXICO	PANUCO	H	5.40	2	0.03	9,800	12.8	60	66
	REFORMA	H	2.80	21	0.03	790	16.8	30	35
MOROCCO	CUETA	L	0.22	-32	0.39	5.2	35.0	NH	NH
	HARICHA	L	0.20	-21	0.40	2.8	40.0	NH	NH
NIGERIA	FORCADOS	L	0.28	-26	0.29	6.9	28.8	NH	NH
	NIGERIAN BLEND	L	0.15	-4	0.36	3.4	35.0	NH	NH
	NIGERIAN LT	L	0.13	16	0.22	3.4	36.0	27	32
	NIGERIAN MED	L	0.26	-34	0.27	9.2	27.0	NH	NH
NORWAY	EKOFIS K	L	0.13	-16	0.52	3.5	44.0	NH	NH
NEUTRAL ZONE	KHAFJI	L	3.02	-23	0.53	20	28.0	NH	NH
OMAN	FAHUD	L	1.24	-32	0.25	7.1	33.4	NH	NH
QATAR	DUKHAN	L	1.20	-23	0.60	2.6	42.2	NH	NH
	QATAR MARINE	L	1.51	-21	0.42	3.5	37.5	NH	NH
SARAWAK	SERIA	L	0.09	18	0.2 0	2.3	36.9	29	35
SAUDI ARABIA	ARABIAN LT (Berri)	L	1.71	-26	0.31	4.9	34.5	NH	NH
	ARABIAN MED (Khurais)	L	2.65	-15	0.27	9.0	30.3	NH	NH
	ARABIAN HEAVY (Sanfaniyah)	L	2.86	-34	0.56	17.5	28.6	NH	NH
SUMATRA	DURI	M	0.18	2	0.02	113	23.0	27	32
	MINAS	L	0.10	35	0.16	17.4	35.0	49	55

A GUIDE TO CRUDE OIL SPECIFICATIONS WORLDWIDE

COUNTRY	CRUDE OIL NAME	GRADE OF OIL	SULPHUR WT %	POUR POINT °C	REID VAPOUR PRESSURE kg/cm²	VISCOSITY KvcST 40°C	A.P.I. NO. at 16 °C	MINIMUM VOYAGE TEMP (°C) PASSAGE	DISCHARGE
TUNISIA	EDJEHE	L	0.11	-40	0.17	5.1	35.0	NH	NH
	ZARZAITINE	L	0.07	-18	0.46	3.1	41.9	NH	NH
UAE	FATEH	L	1.49	12	0.32	5.8	32.0	NH	NH
	MURBAN	L	0.84	12	0.3	3.1	39.0	NH	NH
	UMM SHAIF	L	1.35	-15	0.42	3.5	37.0	NH	NH
	ZAKUM	L	0.94	-12	0.4	2.8	39.8	NH	NH
USA	CARPENTERIA	L	1.31	-4	0.34	11.6	28.5	NH	NH
	COASTAL HEAVY	L	0.24	-46	0.16	6.3	30.4	NH	NH
	DELTA OSTRICA	L	0.35	-46	0.25	9.6	30.8	NH	NH
	DRIFT RIVER MIX	L	0.11	-21	0.38	3.8	36.9	NH	NH
	FEDERATED PL	L	0.14	-9	0.56	2.6	40.9	NH	NH
	FELLA/SUNNILAND	L	3.62	-34	0.42	16.6	25.8	NH	NH
	HAWKINS	L	2.46	-46	0.38	35.0	22.5	NH	NH
	H.E.Y.	L	3.70	-23	0.22	44.6	22.5	NH	NH
	LACONCHITA	L	1.56	-9	0.32	20.3	26.4	NH	NH
	McCOMB	L	1.00	-4	0.06	2.8	41.5	NH	NH
	MIXED SWEET	L	0.14	-23	0.25	3.1	37.6	NH	NH
	NIKISKI	L	0.12	-21	0.53	3.8	36.0	NH	NH
	REFUGIO LT	L	0.13	-62	0.28	2.6	35.0	NH	NH
	REFUGIO HY	L	0.26	-62	0.06	9.1	24.0	NH	NH
	SOUTH LA	L	0.22	-15	0.22	4.4	36.0	NH	NH
	S.W. TEX	L	0.62	-29	0.31	4.4	37.6	NH	NH
	SWEDEN	L	0.07	-4	0.31	2.3	42.9	NH	NH
	W.C. TEXAS	L	0.45	-15	0.32	3.8	37.8	NH	NH
	W. TEX SOUR	L	1.63	-9	0.38	6.3	33.4	NH	NH
	WILLAMAR	L	0.49	-18	0.05	11.9	30.6	NH	NH
VENEZUELA	BACHAQUERO	M	2.21	-21	0.15	264	17.2	57	62
	CENTRO	L	1.42	-12	0.25	8.3	31.5	NH	NH
	NIPA	L	0.85	-29	0.38	9.6	30.8	NH	NH
	LAGUNILLAS	M	1.93	-21	0.14	250	22.0	27	32
	LEONA	L	1.39	-46	0.24	26.7	29.8	NH	NH
	FALCON	L	0.35	21	0.49	4.7	25.0	32	38
	PILON	H	2.19	-4	0.03	1607	14.0	55	60
	SANTA ROSA	L	0.04	10	0.31	1.6	49.3	21	27
	TIA JUANA LT	L	1.11	-34	0.34	9.4	32.0	NH	NH
	TIA JUANA M	L	1.64	-40	0.25	37.6	24.5	NH	NH
	TIA JUANA HY	M	2.11	-37	0.12	1916	18.4	27	32
	ZULIA	L	1.6	-10	0.24	7.9	31.5	NH	NH

CODE: NH = No Heat
H = Heavy
M = Medium
L = Light

NB Mimimum Carrying Temperature: - As indicated it is of practical value but any instructions given by owners, charterers, receivers or suppliers will supercede these figures.

APPENDIX D

TANK CLEANING PRODUCT CROSS-REFERENCE TABLE AND CLEANING INSTRUCTION GUIDE

The table which follows is included as a guide to the cleaning of the tanks of a vessel from any one of the 87 listed products to any one of the other products included in the table.

It is intended that the recommendations listed in this table be incorporated into the procedures outlined in the following sections of the TANK CLEANING MANUAL:

CHAPTER VII - THE METHODS OF USING CHEMICALS FOR CLEANING PURPOSES

DETERMINING THE NUMBER OF TANK CLEANING MACHINE DROPS FOR EACH CLEANING JOB, PAGES 28-29

CHAPTER VIII - THE CALCULATION OF CHEMICAL QUANTITIES AND CLEANING TIMES

CLEANING TIME CALCULATION, PAGE 31
QUANTITY OF CHEMICAL REQUIRED PAGES 31-33

HOW TO USE THE CROSS-REFERENCE TABLE

The "Tank Cleaning Guide" which precedes the Cross-Reference Table lists the letter codes (A through Y) used in the table and the cleaning steps recommended for each of these lettered procedures.

Along the left-hand side of the cross-reference table are listed alphabetically 87 products which may be carried. Each has an assigned number. The numbers are repeated along the right-hand side as well.

Along the top and bottom of the table are numbers which refer to these same product names.

To determine the best cleaning procedure to use when going from one product cargo to another, locate the name and number of the product currently in the tank along the left or right side of the table. Then locate the number of the next product to be carried along the top or bottom of the table. Follow along the horizontal row and vertical column of the two products to the point of intersection. The letter printed at this point refers to the letter of the recommended cleaning procedure in the "Tank Cleaning Guide".

For example, if the current cargo is fuel oil and the future cargo is molasses, locate fuel oil (number 30) and molasses (number 49). Since the current cargo is fuel oil, use number 30 along the left or right side of the table. The future cargo, number 49, should be found along the top or bottom of the table. Look across the page at number 30 and down the page at 49. The spot where the two rows cross is indicated by the letter "L". Finally, find cleaning procedure "L" in the Tank Cleaning Guide and follow the recommended cleaning steps.

NOTE: TC#4™ tank cleaner is our recommended tank cleaner. If TC#4 tank cleaner is not available in the quantities required, it may be substituted by using the following other Drew products:

DREW™ TC SEA tank cleaner

DREW™ ABD alkaline-based degreaser, LAC™ liquid alkaline cleaner or EDGE® heavy duty cleaner should be used whenever the residues of animal, vegetable or fuel oils and fats are to be cleaned from tank surfaces. DREW ABD degreaser or LAC cleaner will only be required at times when these sediments have been permitted to partially harden on the surfaces and have become sticky and tenacious.

TANK CLEANING GUIDE

A =
- Drain tank, pumps and lines
- Gas free by air and/or steam
- Dry

B =
- Tank clean with cold water for 1-1/2 - 2-1/2 hours
- Steam out (if required)
- Drain tank, pumps and lines
- Dry

C =
- Tank clean with warm fresh or seawater (40-55°C) (104°-131°F)
- Steam out (if necessary)
- Drain tank, pumps and lines
- Dry

D =
- Tank clean with hot seawater for 1-2 hours (60-80°C) (140°-176°F)
- Flush and steam out if required
- Drain tank, pumps and lines
- Dry

E =
- Tank clean with cold seawater for 1-1/2 - 2-1/2 hours
- Tank clean with hot seawater or fresh water for 1-1/2 - 2-1/2 hours (60-80°C) (140°-176°F)
- Flush out with fresh water if required
- Steam out
- Drain tank, pumps and lines
- Dry

NOTE: For those products which do not require chemicals for cleaning, consideration can be given to the use of DREW™ ABD degreaser, LAC™ or EDGE® cleaners for deodorizing purposes and supplied accordingly for the cleanings listed above.

F =
- Tank clean with cold seawater for 1 - 1-1/2 hours
- Tank clean with hot (60-80° C) (140°-176° F) seawater and 0.1-0.5% TC#4™ or DREW TC SEA cleaner for 1 - 2-1/2 hours
- Tank clean with hot fresh or seawater (60-80° C) (140°- 176° F) for 1 hour
- Steam out when necessary
- Drain tank, pumps and lines
- Dry

G =
- Tank clean with cold seawater for 1-2 hours
- Tank clean with hot seawater (60-80° C) (140°-176° F) for 1-2 hours with 0.1-0.5% TC#4 cleaner or DREW TC SEA cleaner for zinc silicate coated tanks. For all other tanks a 0.2-0.8% solution of DREW ABD degreaser, LAC or EDGE cleaners can be used. (See Appendix A)
- Steam out as required
- Tank clean with fresh water for 1/2 hour
- Drain tank, pumps and lines
- Dry

H =
- Tank clean with cold seawater for 1-1/2 - 2-1/2 hours
- Tank clean with warm water (45-55° C) (113°-131° F) and 0.1-0.5% TC#4 cleaner or DREW TC SEA cleaner 1 - 2 hours
- Steam out when necessary
- Tank clean with fresh water for 1/2 - 1 hour
- If hydrocarbon-free is required, rinse with .2% DREW NBD degreaser
- Drain tank, pumps and lines
- Dry

I =
- Tank clean with hot seawater (80° C) (176° F) for 1-2 hours
- Tank clean with hot seawater (80° C) (176°F) and 0.1-0.5% TC#4 cleaner or DREW TC SEA cleaner for 1-1/2 - 2-1/2 hours. (Where coating permits, 0.2-0.8% DREW ABD degreaser, LAC or EDGE cleaners may be used. See Appendix A)
- Tank clean with hot seawater (80° C) (176° F) for 1 hour
- Flush with fresh water
- Drain tank, pumps and lines
- Dry

J =
- Tank clean with hot seawater (80°C) (176°F) for 1-2 hours
- Tank clean with hot seawater (80°C) (176°F) and 0.1-0.5% TC#4™ cleaner or DREW™ TC SEA cleaner for 2-1/2 - 3-1/2 hours
- Tank clean with hot fresh water for 1-2 hours
- Steam out or flush with 0.2% solution of DREW ABD degreaser, LAC™ or EDGE® cleaners where coating permits. See Appendix A.
- Tank clean with hot fresh water and steam out or rinse with hot distilled water
- Drain tank, pumps and lines
- Dry

K =
- Tank wash with hot seawater (80°C) (176°F) for 2-3 hours
- Rinse with distilled water
- Dry

L =
- Tank clean with cold seawater (high wax) for 2 hours
- Tank clean with hot (80° C) (176° F) seawater and 0.1-0.5% TC#4 cleaner or DREW TC SEA cleaner until contamination has been removed
- Spot clean as required
- Steam out tank if necessary
- Tank clean with hot (80° C) (176° F) seawater for 1/2 - 1 hour
- Drain tank, pumps and lines
- Dry

M =
- Tank clean with warm (40-55° C) (104°-131° F) fresh water for 1-2 hours
- Drain tank, pumps and lines
- Dry

N =
- Tank clean with hot (80° C) (176° F) seawater for 1-2 hours
- Tank clean with hot (80° C) (176° F) seawater and 0.1-0.5% TC#4 cleaner or DREW TC SEA cleaner for 1/2 - 1 hour
- Steam out
- Tank clean with hot fresh water
- Drain tank, pumps and lines
- Dry

O =
- To ease the cleaning process, any tank designated to carry latex should be coated with paraffin wax before loading
- Tank clean with hot water (80°C) (176°F) and 0.1% of TC#4 cleaner or DREW TC SEA cleaner for 1/2 - 1 hour
- Tank clean with hot water (80° C) (176° F) and 0.2-0.8% DREW ABD degreaser, LAC or EDGE cleaners for 2-3 hours. See Appendix A.
- Manually remove from the tank any latex sediments
- Tank clean with hot water (80° C) (176° F) and 0.1-0.5% TC#4 or DREW TC SEA cleaner for 1-2 hours to remove the paraffin wax.
- Tank clean with hot seawater for 1-2 hours
- Steam out tank
- Drain tank, pumps and lines
- Dry

P =
- Tank clean with hot (80° C) (176° F) seawater for 1-1/2 - 2-1/2 hours
- Steam out tank
- Tank clean with hot water (80° C) (176° F) and 0.1-0.5% TC#4 cleaner or DREW TC SEA cleaner for 2 hours
- Steam out tank
- Tank clean with hot (80° C) (176° F) seawater for 1/2 - 1 hour
- Drain tank, pumps and lines
- Dry

R = - Flood tanks with hot seawater (60°C-80°C) (140°-176°F) and 0.5 to 1% solution of TC#4™ cleaner or DREW™ TC SEA cleaner and allow solution to rock and roll for 6-18 hours
- Empty tank
- Tank clean with hot seawater (80° C) (176° F) for 2 hours
- Steam out tank
- Drain tank, pumps and lines
- Dry

S = - Immediately after cargo is discharged, strip tank completely and fill with cold water
- Tank clean with cold seawater after emptying tank 1-2 hours
- Tank clean with cold seawater and 0.1-0.5% TC#4 cleaner or DREW TC SEA cleaner for 1-2 hours
- Tank clean with 0.1% DREW ABD degreaser, LAC™ or EDGE® cleaners. See Appendix A.
- Rinse with fresh water
- Drain tank, pumps and lines
- Dry

T = - Tank clean with cold seawater for 1-2 hours
- Tank clean with hot seawater (80° C) (176° F) and 0.1-0.5% TC#4 cleaner or DREW TC SEA cleaner for 1-1/2 - 2-1/2 hours
- Tank clean with seawater and 0.1% DREW ABD degreaser, LAC or EDGE cleaners for 1 hour. See Appendix A.
- Tank clean with seawater for 1 hour
- Drain tank, pumps and lines
- Dry

V = - Tank clean with cold seawater for 1-2 hours
- Tank clean with hot seawater (80° C) (176° F) and 0.1-0.5% TC#4 cleaner or DREW TC SEA cleaner for 1-1/2 - 2 hours
- Tank clean with warm (40-55° C) (104°-131° F) seawater for 1/2 hour
- Tank clean with 5%-10% solution of acetic acid until lead content of tank is within recommended limits
- Tank clean with cold seawater and 0.1% DREW ABD cleaner, LAC or EDGE cleaners for 1/2 - 1 hour. See Appendix A.
- Tank clean with cold seawater for 1/2 hour
- Drain tank, pumps and lines
- Dry

NOTE: Tanks which have previously carried leaded fuel are not normally accepted by health authorities to carry edible oils or fats.

W = - These products are not to be carried immediately after the subject cargo.

Y = - Tank cleaning usually not required

FROM	TO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
(FOR GAS FREE CERTIFICATE)		B	I	B	N	V	T	J	I	C	E	E	I	L	F	I	B	E	I	G	P	L	F	J	C	A	C	M	G	I	L	
1 ACETONE			B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	1
2 ACID OIL		I		I	I	I	I	I	I	I	I	I	I	C	I	I	I	I	I	I	I	C	I	I	I	I	I	I	I	C		2
3 ACRYLIC ACID		B	B		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	3
4 AROMATIC EXTRACTS		N	N	N		N	N	N	N	N	N	N	N	C	N	N	N	N	N	N	N	C	N	N	N	N	N	N	N	N	C	4
5 AVIATION GASOLINE (LEADED)		V	V	V	V		B	B	V	V	V	V	V	Y	V	V	V	V	V	V	V	Y	V	B	V	V	V	V	V	V	B	5
6 AVIATION GASOLINE (UNLEADED)		T	T	T	T	T		B	T	T	T	T	T	Y	T	T	T	T	T	T	T	Y	T	B	T	T	T	T	T	T	B	6
7 AVIATION OIL		J	J	J	J	J	J		J	J	J	J	J	Y	J	J	J	J	J	J	J	Y	J	J	J	J	J	J	J	J	B	7
8 ALMOND OIL		I	I	I	I	I	I	I		I	I	I	I	C	I	I	I	I	I	I	I	C	I	I	I	I	I	I	I	I	C	8
9 BENZENE		C	C	C	C	C	C	C	C		C	C	C	A	C	C	C	C	C	C	C	A	C	C	C	C	C	C	C	C	B	9
10 BUTYL ACETATE		E	E	D	E	E	E	E	E	E		E	E	A	D	D	E	E	D	D	D	A	E	D	E	E	E	E	D	E	B	10
11 BUTYL ALCOHOL		E	E	D	E	E	E	E	E	E	E		E	A	D	D	E	E	D	D	D	A	E	D	E	E	E	E	D	E	B	11
12 CAMPHOR OIL		I	I	I	I	I	I	I	I	I	I	I		C	I	I	I	I	I	I	I	C	I	I	I	I	I	I	I	I	C	12
13 CARBON BLACK FEEDSTOCK		W	L	W	W	L	L	L	W	W	W	W	W		W	L	W	L	L	L	L	L	W	W	W	W	W	W	L	L	L	13
14 CARBON TETRA CHLORIDE		F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F	F	A	F	B	F	F	F	F	F	F	B	14
15 CASHEWNUT OIL		I	I	I	I	I	I	I	I	I	I	I	I	C	I		I	I	I	I	I	C	I	I	I	I	I	I	I	I	C	15
16 CARBINOL		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A		A	A	A	A	A	A	B	A	A	A	A	A	A	B	16
17 CAUSTIC SODA SOLUTION		E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E		E	E	E	E	B	E	E	E	E	E	E	E	E	17
18 COCONUT OIL		I	I	I	I	I	I	I	I	I	I	I	I	C	I	I	I	I		I	I	C	I	I	I	I	I	I	I	I	C	18
19 CODLIVER OIL		G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G		G	B	G	B	G	G	G	G	G	G	B	19
20 CREOSOTE		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P	P	P	P	P	P	P	P	P	P	20
21 CRUDE OIL		W	L	W	W	L	L	L	W	W	W	W	L	W	W	L	W	L	L	L	L		W	L	W	W	W	W	L	L	L	21
22 CUMENE		F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	Y		F	F	F	F	F	F	F	F	22
23 DIESEL OIL		H	J	F	F	C	C	C	J	F	H	H	J	F	F	J	H	C	J	J	J	Y	J		J	H	F	F	J	J	B	23
24 DIETHYLENE GLYCOL (ANTIFREEZE)		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C		C	C	C	C	C	C	24
25 ETHANOL		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A		A	A	A	A	A	25
26 ETHYL BENZENE		C	C	C	C	C	C	C	A	B	C	C	A	C	C	A	C	C	A	A	A	B	B	B	C	C		C	C	C	B	26
27 ETHYLENE DIAMINE		M	M	M	M	M	M	M	M	M	M	M	M	C	M	M	M	M	M	M	M	C	M	C	M	M	M		M	M	C	27
28 FISH OILS		G	G	G	G	G	G	G	G	G	G	G	G	B	G	G	G	G	G	G	G	B	G	B	G	G	G	G		G	B	28
29 FATTY ACIDS/ALCOHOLS		I	I	I	I	I	I	I	I	I	I	I	I	C	I	I	I	I	I	I	I	C	I	C	I	I	I	I	I		C	29
30 FUEL OILS		W	L	W	W	L	L	L	L	W	W	W	L	L	W	L	W	L	L	L	L		W	L	W	W	W	W	L	L		30
31 FURFURAL		T	T	T	T	T	T	T	T	T	T	T	B	T	T	T	T	T	T	T	T	B	T	T	T	T	T	T	T	T	B	31
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	

FROM	TO	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	
(FOR GAS FREE CERTIFICATE)		T	J	J	C	I	G	C	C	D	F	V	J	I	O	G	J	A	F	K	P	J	B	F	I	J	D	G	
1 ACETONE		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	1
2 ACID OIL		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	2
3 ACRYLIC ACID		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	3
4 AROMATIC EXTRACTS		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	4
5 AVIATION GASOLINE (LEADED)		V	B	B	V	V	V	V	V	V	V	V	B	B	V	V	V	B	V	V	V	V	B	V	V	V	V	V	5
6 AVIATION GASOLINE (UNLEADED)		T	B	B	T	T	T	T	T	T	T	B	B	T	T	T	B	T	T	T	T	B	T	T	T	T	T	T	6
7 AVIATION OIL		J	D	J	J	J	J	J	J	J	J	J	J	J	J	J	D	J	J	J	J	D	J	J	J	J	J	J	7
8 ALMOND OIL		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	8
9 BENZENE		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	9
10 BUTYL ACETATE		E	D	D	E	D	D	E	E	E	E	D	D	E	D	D	E	E	E	D	D	E	D	E	D	E	E	D	10
11 BUTYL ALCOHOL		E	D	D	E	D	D	E	E	E	E	D	D	E	D	D	E	E	E	D	D	E	D	E	D	E	E	D	11
12 CAMPHOR OIL		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	12
13 CARBON BLACK FEEDSTOCK		W	L	W	L	L	L	W	W	W	W	L	L	W	L	L	L	W	W	L	W	L	L	L	L	W	W	W	13
14 CARBON TETRA CHLORIDE		F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	A	F	F	F	F	F	F	F	F	F	14
15 CASHEWNUT OIL		E	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	15
16 CARBINOL		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	16
17 CAUSTIC SODA SOLUTION		E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	17
18 COCONUT OIL		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	18
19 CODLIVER OIL		G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	19
20 CREOSOTE		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	20
21 CRUDE OIL		W	L	W	L	L	L	W	W	W	W	L	L	W	L	L	L	W	W	L	W	L	L	L	L	L	W	W	21
22 CUMENE		F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	22
23 DIESEL OIL		F	B	B	H	J	J	F	H	H	F	C	C	J	F	J	C	H	F	J	F	C	C	F	J	F	F	F	23
24 DIETHYLENE GLYCOL (ANTIFREEZE)		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	24
25 ETHANOL		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	25
26 ETHYL BENZENE		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	26
27 ETHYLENE DIAMINE		M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	27
28 FISH OILS		G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	28
29 FATTY ACIDS/ALCOHOLS		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	29
30 FUEL OILS		W	L	W	L	L	L	W	W	W	W	L	L	L	L	L	L	W	W	L	W	L	L	L	L	W	W	W	30
31 FURFURAL			T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	31
		31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	

	FROM	TO	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	
	(FOR GAS FREE CERTIFICATE)		J	G	I	R	G	G	F	I	F	G	I	S	E	O	I	I	E	H	C	C	G	G	D	I	I	G	I	C	C	C	
1	ACETONE		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	1
2	ACID OIL		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	2
3	ACRYLIC ACID		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	3
4	AROMATIC EXTRACTS		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	4
5	AVIATION GASOLINE (LEADED)		B	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	5
6	AVIATION GASOLINE (UNLEADED)		B	T	T	T	T	T	T	T	B	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	6
7	AVIATION OIL		D	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	7
8	ALMOND OIL		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	8
9	BENZENE		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	9
10	BUTYL ACETATE		E	E	E	E	D	D	E	D	E	D	D	E	E	E	E	D	D	E	E	E	D	D	E	E	E	D	E	E	E	E	10
11	BUTYL ALCOHOL		E	E	E	E	D	D	E	D	E	D	D	E	E	E	E	D	D	E	E	E	D	D	E	E	E	D	E	E	E	E	11
12	CAMPHOR OIL		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	12
13	CARBON BLACK FEEDSTOCK		L	L	W	L	L	L	W	L	W	L	L	W	W	L	L	L	W	W	W	W	W	L	W	W	W	W	W	W	W	W	13
14	CARBON TETRA CHLORIDE		F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	14
15	CASHEWNUT OIL		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	15
16	CARBINOL		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	16
17	CAUSTIC SODA SOLUTION		E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	17
18	COCONUT OIL		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	18
19	CODLIVER OIL		G	G	G	G	G	G	G	G	G	G	B	G	G	G	G	G	G	G	G	G	G	G	G	G	G	B	G	G	G	G	19
20	CREOSOTE		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	20
21	CRUDE OIL		L	L	L	L	W	W	W	L	W	L	L	W	W	L	L	L	W	W	W	W	W	L	W	W	W	W	W	W	W	W	21
22	CUMENE		F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	22
23	DIESEL OIL		C	J	F	C	J	J	F	J	C	J	J	F	F	F	J	J	F	F	F	F	J	F	F	J	F	J	C	J	F	F	23
24	DIETHYLENE GLYCOL (ANTIFREEZE)		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	24
25	ETHANOL		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	25
26	ETHYL BENZENE		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	B	B	C	C	C	C	C	C	C	B	B	26
27	ETHYLENE DIAMINE		M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	27
28	FISH OILS		G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	B	G	G	G	G	28
29	FATTY ACIDS/ALCOHOLS		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	29
30	FUEL OILS		L	L	W	L	L	L	W	L	W	L	L	W	W	L	L	L	W	W	W	W	W	L	W	L	W	W	W	W	W	W	30
31	FURFURAL		T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	31
			58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	

FROM	TO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
32 GASOIL		H	J	F	F	C	C	C	J	F	H	H	J	F	F	J	H	C	J	J	C	Y	F	C	H	H	F	F	J	J	B	32
33 GASOLINE		T	J	T	T	B	B	B	J	T	T	T	J	B	T	J	T	T	J	J	T	Y	T	B	T	T	T	T	J	J	B	33
34 GLYCERINE		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	B	C	C	C	C	C	C	C	C	B	34
35 GREASE		I	I	I	I	I	I	I	I	I	I	I	I	C	I	I	I	I	I	I	I	C	I	I	I	I	I	I	I	I	C	35
36 GROUNDNUT OIL		G	B	G	G	G	G	G	B	G	G	G	B	B	G	B	G	G	B	B	G	B	G	B	G	G	G	G	B	B	B	36
37 HEPTANE		B	B	B	A	A	A	A	B	B	B	B	B	Y	C	B	B	A	B	B	A	Y	A	A	B	B	B	B	B	B	B	37
38 HEXANE		B	B	B	A	A	A	A	B	B	B	B	B	Y	C	B	B	A	B	B	A	Y	A	A	B	B	B	B	B	B	B	38
39 ISOBUTYL ALCOHOL		D	D	D	D	D	D	D	D	D	D	D	D	B	D	D	D	D	D	D	D	A	D	D	D	D	D	D	D	D	B	39
40 ISOPAR		F	F	F	D	D	D	D	F	F	F	F	F	B	C	F	F	D	F	F	D	Y	D	D	F	F	F	F	F	F	B	40
41 JETFUEL		H	V	F	F	C	C	C	V	F	H	H	V	B	V	V	H	C	V	V	C	B	F	C	H	H	F	F	V	V	B	41
42 KEROSENE		H	J	F	F	C	C	C	J	F	H	H	J	B	F	J	H	C	J	J	C	B	F	C	H	H	F	F	J	J	B	42
43 LARD		I	I	I	I	I	I	I	I	I	I	I	I	C	I	I	I	I	I	I	I	C	I	I	I	I	I	I	I	I	C	43
44 LATEX		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	44
45 LINSEED OIL		G	B	G	G	G	G	G	B	G	G	G	B	B	G	B	G	G	B	B	G	B	G	B	G	G	G	G	B	B	B	45
46 LUBRICATING OILS		J	J	J	J	J	J	D	J	J	J	J	J	Y	J	J	J	J	J	J	J	Y	J	J	J	J	J	J	J	J	B	46
47 METHANOL		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	47
48 METHYLENE CHLORIDE		F	F	F	F	F	F	F	F	F	F	F	F	B	A	F	F	F	F	F	F	B	F	F	F	F	F	F	F	F	B	48
49 MOLASSES		K	D	K	K	D	D	D	D	K	K	K	D	B	D	D	K	D	D	D	D	B	D	D	K	K	K	K	D	D	B	49
50 NAPHTHALENE		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	50
51 NAPHTHENIC DISTILLATE		J	J	J	J	J	J	D	J	J	J	J	J	B	J	J	J	J	J	J	J	Y	J	J	J	J	J	J	J	J	B	51
52 NAPHTHENIC ACID		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	52
53 OLEFINES		F	F	F	I	D	D	D	F	F	F	F	F	B	F	F	F	D	D	F	D	Y	D	D	F	F	F	F	F	F	B	53
54 PALM OIL		I	I	I	I	I	I	I	I	I	I	I	I	C	I	I	I	I	I	I	I	C	I	I	I	I	I	I	I	I	C	54
55 PARAFFINS		J	J	J	J	J	J	J	J	J	J	J	J	C	J	J	J	J	J	J	J	C	J	J	J	J	J	J	J	J	C	55
56 PHENOL		D	D	D	D	D	D	D	D	D	D	D	D	B	D	D	D	D	D	D	D	B	D	D	D	D	D	D	D	D	B	56
57 PINE OIL		G	G	G	G	G	G	G	G	G	G	G	G	B	G	G	G	G	G	G	G	B	G	G	G	G	G	G	G	G	B	57
58 PRIME OIL		J	J	J	J	J	J	D	J	J	J	J	J	B	J	J	J	J	J	J	J	Y	J	J	J	J	J	J	J	J	B	58
59 RAPESEED OIL		G	B	G	G	G	G	G	B	G	G	G	B	B	G	B	G	G	B	B	G	B	G	B	G	G	G	G	B	B	B	59
60 RESIN OIL		W	W	I	W	W	W	W	W	I	I	I	W	B	I	W	W	W	W	W	I	Y	I	B	W	W	I	W	W	W	B	60
61 RESIN SOLUTION		R	R	R	R	R	R	R	R	R	R	R	R	B	R	R	R	R	R	R	R	Y	R	R	R	R	R	R	R	R	B	61
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	

FROM	TO	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	
32 GASOIL		F		C	H	J	J	F	H	H	F	C	C	J	F	J	C	H	F	J	F	C	C	F	J	F	F	F	32
33 GASOLINE		T	B		T	J	J	T	T	T	T	B	B	J	T	J	B	T	T	T	T	B	T	T	J	T	T	T	33
34 GLYCERINE		C	C	C		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	34
35 GREASE		I	I	I	I		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	35
36 GROUNDNUT OIL		G	G	G	G	B		G	G	G	G	G	G	B	G	B	G	G	G	G	G	G	G	G	B	G	G	G	36
37 HEPTANE		B	A	A	B	B	B		A	B	A	A	A	B	A	B	A	B	C	B	A	A	B	A	B	A	A	A	37
38 HEXANE		B	A	A	B	B	B	A		B	A	A	A	B	A	B	A	B	C	B	A	A	B	A	B	A	A	A	38
39 ISOBUTYL ALCOHOL		D	D	D	D	D	D	D	D		D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	39
40 ISOPAR		F	D	D	F	F	F	D	D	F		D	D	F	F	F	D	F	C	F	D	D	F	D	F	D	F	D	40
41 JETFUEL		F	C	C	H	V	V	F	H	H	F		C	V	F	V	C	H	V	V	F	C	C	F	V	F	F	F	41
42 KEROSENE		F	C	C	H	J	J	F	H	H	F	C		J	F	J	C	H	F	J	F	C	C	F	J	F	F	F	42
43 LARD		I	I	I	I	I	I	I	I	I	I	I	I		I	I	I	I	I	I	I	I	I	I	I	I	I	I	43
44 LATEX		O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O	O	O	O	O	O	O	O	O	O	44
45 LINSEED OIL		G	G	G	G	B	B	G	G	G	G	G	G	B	G		G	G	G	G	G	G	G	G	B	G	G	G	45
46 LUBRICATING OILS		J	D	J	J	J	J	J	J	J	J	J	J	J	J	J		J	J	J	J	D	J	J	J	J	J	J	46
47 METHANOL		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A		A	A	A	A	A	A	A	A	A	A	47
48 METHYLENE CHLORIDE		F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F		F	F	F	F	F	F	F	F	F	48
49 MOLASSES		K	D	D	K	D	D	K	K	K	K	D	D	D	D	D	D	K	K		D	D	D	K	D	D	D	D	49
50 NAPHTHALENE		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P		P	P	P	P	P	P	P	50
51 NAPHTHENIC DISTILLATE		J	D	J	J	J	J	J	J	J	J	J	J	J	J	J	D	J	J	J	J		J	J	J	J	J	J	51
52 NAPHTHENIC ACID		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B		B	B	B	B	B	52
53 OLEFINES		F	D	D	F	F	F	I	I	F	I	D	D	F	F	F	D	F	F	F	D	F	D		F	D	F	D	53
54 PALM OIL		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I	I	54
55 PARAFFINS		J	D	J	J	J	J	J	J	J	J	J	J	J	J	J	D	J	J	J	J	D	J	J	J		J	J	55
56 PHENOL		D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D		D	56
57 PINE OIL		G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G		57
58 PRIME OIL		J	D	J	J	J	J	J	J	J	J	J	J	J	J	J	D	J	J	J	J	D	J	J	J	J	J	J	58
59 RAPESEED OIL		G	G	G	G	B	B	G	G	G	G	G	G	B	G	B	G	G	G	G	G	G	G	G	B	G	G	G	59
60 RESIN OIL		I	I	I	W	W	W	W	W	I	W	I	I	W	W	W	W	W	W	W	I	W	W	W	W	W	I	W	60
61 RESIN SOLUTION		R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	61
		31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	

	FROM	TO	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	
32	GASOIL		C	J	F	C	J	J	F	J	C	J	J	F	F	F	J	J	F	F	F	F	J	F	F	J	F	J	C	J	F	F	32
33	GASOLINE		B	J	T	T	J	J	T	J	B	J	J	T	T	T	J	J	T	T	T	T	J	T	T	J	T	J	B	T	T	T	33
34	GLYCERINE		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	34
35	GREASE		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	35
36	GROUNDNUT OIL		G	B	G	G	B	B	G	B	G	B	B	G	G	G	B	B	G	G	G	G	B	G	G	B	G	B	G	G	G	G	36
37	HEPTANE		A	B	A	A	B	B	A	B	A	B	B	B	B	A	B	B	B	A	B	B	B	A	B	B	B	B	A	B	B	B	37
38	HEXANE		A	B	A	A	B	B	A	B	A	B	B	B	B	A	B	B	B	A	B	B	B	A	B	B	B	B	A	B	B	B	38
39	ISOBUTYL ALCOHOL		D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	39
40	ISOPAR		D	F	D	D	F	F	D	F	D	F	F	F	F	F	F	F	F	F	F	F	F	D	F	F	F	F	D	F	F	F	40
41	JETFUEL		C	V	F	C	V	V	F	V	C	V	V	F	F	F	V	V	F	F	F	F	V	F	F	V	F	V	C	V	F	F	41
42	KEROSENE		C	J	F	C	J	J	F	J	C	J	J	F	F	F	J	J	F	F	F	F	J	F	F	J	F	J	C	J	F	F	42
43	LARD		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	43
44	LATEX		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	44
45	LINSEED OIL		G	G	G	G	B	B	G	B	G	B	B	G	G	G	B	B	G	G	G	G	B	G	G	B	G	B	G	G	G	G	45
46	LUBRICATING OILS		D	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	46
47	METHANOL		A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	47
48	METHYLENE CHLORIDE		F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	48
49	MOLASSES		D	D	D	K	D	D	K	D	D	D	D	K	D	D	D	D	D	K	K	K	K	D	K	D	K	D	D	K	K	K	49
50	NAPHTHALENE		P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	50
51	NAPHTHENIC DISTILLATE		D	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	51
52	NAPHTHENIC ACID		B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	52
53	OLEFINES		D	F	D	D	F	F	I	F	D	F	F	F	F	F	F	F	F	F	F	F	F	D	F	F	F	F	I	F	F	F	53
54	PALM OIL		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	54
55	PARAFFINS		D	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	55
56	PHENOL		D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	56
57	PINE OIL		G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	57
58	PRIME OIL			J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	J	58
59	RAPESEED OIL		G		G	G	B	B	G	B	G	B	B	G	G	G	B	B	G	G	G	G	B	G	G	B	G	B	G	G	G	G	59
60	RESIN OIL		W	W		I	W	W	W	W	I	W	W	I	W	W	W	W	W	W	I	I	W	W	W	W	W	W	W	I	I	60
61	RESIN SOLUTION		R	R	R		R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	61
			58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	

FROM	TO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
62 SAFFLOWER OIL		G	B	G	G	G	G	G	B	G	G	G	B	B	G	B	G	G	B	B	G	B	G	B	G	G	G	G	B	B	B	62
63 SESAME OIL		G	B	G	G	G	G	G	G	G	G	G	B	B	G	B	G	G	B	B	G	B	G	B	G	G	G	G	B	B	B	63
64 SHELLSOL		F	F	F	D	D	D	D	F	F	F	F	F	B	F	F	F	D	F	D	F	Y	D	D	F	F	F	F	F	F	B	64
65 SOAPSTOCK		I	I	I	I	I	I	I	I	I	I	I	I	C	I	I	I	I	I	I	I	C	I	I	I	I	I	I	I	I	C	65
66 SOLVENT NAPTHA		F	F	F	D	D	D	D	F	F	F	F	F	B	F	F	F	D	F	F	D	Y	D	D	F	F	F	F	F	F	B	66
67 SOYBEAN		G	G	G	G	G	G	G	G	G	G	G	G	B	G	G	G	G	G	G	G	B	G	B	G	G	G	G	G	G	B	67
68 SPERM OIL		I	I	I	I	I	I	I	I	I	I	I	I	C	I	I	I	I	I	C	I	C	I	I	I	I	I	I	C	I	C	68
69 STYRENE MONOMER		S	S	S	S	S	S	S	S	S	S	S	S	B	S	S	S	S	S	S	S	B	S	S	S	S	S	S	S	S	B	69
70 SURFONIC		E	E	E	E	E	E	E	E	E	E	E	E	B	E	E	E	E	E	E	E	B	E	E	E	E	E	E	E	E	B	70
71 SYNTHETIC LATEX		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	71
72 TALL OIL		I	I	I	I	I	I	I	I	I	I	I	I	C	I	I	I	I	I	C	I	C	I	I	I	I	I	I	C	I	C	72
73 TALLOW		I	I	I	I	I	I	I	I	I	I	I	I	C	I	I	I	I	I	C	I	C	I	I	I	I	I	I	C	I	C	73
74 TEEPOL		E	E	E	E	E	E	E	E	E	E	E	E	B	E	E	E	E	E	E	E	B	E	E	E	E	E	E	E	E	B	74
75 TEXANOL		H	H	H	H	H	H	H	H	H	H	H	H	B	H	H	H	H	H	H	H	B	H	H	H	H	H	H	H	H	B	75
76 TOLUENE		C	C	C	C	C	C	C	C	B	C	C	C	C	C	C	C	C	C	C	C	B	B	C	C	C	B	C	C	C	B	76
77 TOLUOL		C	C	C	C	C	C	C	C	B	C	C	C	C	C	C	C	C	C	C	C	B	B	C	C	C	B	C	C	C	B	77
78 TUNG OIL		G	G	G	G	G	G	G	G	G	G	G	G	B	G	G	G	G	G	G	G	B	G	B	G	G	G	G	G	G	B	78
79 TURPENTINE		G	G	G	G	G	G	G	G	G	G	G	G	B	G	G	G	G	G	G	G	B	G	B	G	G	G	G	G	G	B	79
80 VERSENE		D	D	D	D	D	D	D	D	D	D	D	D	B	D	D	D	D	D	D	D	B	D	D	D	D	D	D	D	D	B	80
81 VEGETABLE OILS		I	I	I	I	I	I	I	I	I	I	I	I	C	I	I	I	I	I	C	I	C	I	I	I	I	I	I	C	I	C	81
82 VORANOL		I	I	I	I	I	I	I	I	I	I	I	I	C	I	I	I	I	I	I	I	C	I	I	I	I	I	I	C	I	I	82
83 WHALE OIL		G	G	G	G	G	G	G	G	G	G	G	G	B	G	G	G	G	G	G	G	B	G	G	G	G	G	G	G	G	B	83
84 WHITE SPIRIT		I	F	F	F	E	E	E	I	I	F	F	I	B	I	I	F	E	I	I	E	B	E	E	F	F	I	F	I	I	B	84
85 WINE		C	C	C	C	C	C	C	C	C	C	C	C		C	C	C	C	C	C	C	Y	C	B	C	C	C	C	C	C	B	85
86 XYLENE		C	C	C	C	C	C	C	C	B	C	C	C	C	C	C	C	C	C	C	B	Y	C	B	C	C	C	C	C	C	B	86
87 XYLOL		C	C	C	C	C	C	C	C	B	C	C	C	C	C	C	C	C	C	C	B	Y	C	B	C	C	C	C	C	C	B	87
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	

FROM	TO	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	
62	SAFFLOWER OIL	G	G	G	G	B	B	G	G	G	G	G	G	B	G	B	G	G	G	G	G	G	G	G	B	G	G	G	62
63	SESAME OIL	G	G	G	G	B	B	G	G	G	G	G	G	G	G	B	G	G	G	G	G	G	G	G	B	G	G	G	63
64	SHELLSOL	F	D	D	F	F	F	D	D	F	D	D	D	F	F	F	D	F	F	F	D	D	F	D	F	D	F	D	64
65	SOAPSTOCK	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	65
66	SOLVENT NAPTHA	F	D	D	F	F	F	D	D	F	D	D	D	F	F	F	D	F	F	F	D	D	F	D	F	D	F	D	66
67	SOYBEAN	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	67
68	SPERM OIL	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	68
69	STYRENE MONOMER	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	69
70	SURFONIC	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	70
71	SYNTHETIC LATEX	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	71
72	TALL OIL	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	72
73	TALLOW	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	73
74	TEEPOL	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	74
75	TEXANOL	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	75
76	TOLUENE	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	76
77	TOLUOL	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	77
78	TUNG OIL	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	78
79	TURPENTINE	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	79
80	VERSENE	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	80
81	VEGETABLE OILS	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	81
82	VORANOL	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	82
83	WHALE OIL	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	83
84	WHITE SPIRIT	F	E	E	F	I	I	F	F	F	F	E	E	I	E	I	E	F	F	I	I	E	E	F	I	E	I	E	84
85	WINE	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	85
86	XYLENE	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	86
87	XYLOL	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	87
		31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	

FROM	TO	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	
62 SAFFLOWER OIL		G	B	G	G		B	G	B	G	B	B	G	G	G	B	B	G	G	G	G	B	G	G	B	G	B	G	G	G	G	62
63 SESAME OIL		G	B	G	G	B		G	B	G	B	B	G	B	G	B	B	G	G	G	G	B	G	G	B	G	B	G	G	G	G	63
64 SHELLSOL		D	F	D	D	F	F		F	D	F	F	F	F	F	F	F	F	F	F	F	F	D	F	F	F	F	D	F	F	F	64
65 SOAPSTOCK		I	I	I	I	I	I	I		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	65
66 SOLVENT NAPTHA		D	F	D	D	F	F	D	F		F	F	F	F	F	F	F	F	F	F	F	F	D	F	F	F	F	D	F	F	F	66
67 SOYBEAN		G	G	G	G	G	G	G	G	G		G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	67
68 SPERM OIL		I	I	I	I	I	I	I	I	I	I		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	68
69 STYRENE MONOMER		S	S	S	S	S	S	S	S	S	S	S		S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	69
70 SURFONIC		E	E	E	E	E	E	E	E	E	E	E	E		E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	70
71 SYNTHETIC LATEX		O	O	O	O	O	O	O	O	O	O	O	O	O		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	71
72 TALL OIL		I	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	72
73 TALLOW		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I	I	I	I	I	I	I	I	I	I	I	I	I	73
74 TEEPOL		E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E		E	E	E	E	E	E	E	E	E	E	E	E	E	74
75 TEXANOLH		H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H		H	H	H	H	H	H	H	H	H	H	H	H	75
76 TOLUENE		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C		C	C	C	C	C	C	C	C	C	C	C	76
77 TOLUOL		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C		C	C	C	C	C	C	C	C	C	C	77
78 TUNG OIL		G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G		G	G	G	G	G	G	G	G	G	78
79 TURPENTINE		G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G		G	G	G	G	G	G	G	G	79
80 VERSENE		D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D		D	D	D	D	D	D	D	80
81 VEGETABLE OILS		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I	I	I	I	I	81
82 VORANOL		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I		I	I	I	I	I	82
83 WHALE OIL		G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G		G	G	G	G	83
84 WHITE SPIRIT		E	I	E	I	I	I	I	I	E	I	I	F	I	E	I	I	I	F	F	F	F	E	I	F	F	I		F	F	F	84
85 WINE		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C		C	C	85
86 XYLENE		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	B	B	C	C	C	C	C	C	C	C		C	86
87 XYLOL		C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	B	B	C	C	C	C	C	C	C	C			87
		58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	

APPENDIX E

SQUARE ROOT TABLE

NUMBER (Deadweight tonnage - dwt)	SQUARE ROOT ($\sqrt{\ }$) (Approximate)
1,000	32
2,000	45
3,000	55
4,000	63
5,000	71
6,000	78
7,000	84
8,000	90
9,000	95
10,000	100
11,000	105
12,000	110
14,000	118
16,000	127
18,000	134
20,000	141
25,000	158
30,000	173
35,000	187
40,000	200
45,000	212
50,000	224
60,000	250
70,000	265
80,000	283
90,000	300
100,000	316
120,000	346
150,000	387

APPENDIX F

GLOSSARY OF TERMS

A

ABSORPTION OILS (scrubbing oil; wash oil)

Generally refer to a moderately high boiling oil distilled from petroleum (i.e., a gas oil) or coal tar, and used for separating desired gases or vapors by dissolving them from some mixture.

Thus, the vapors of natural gasoline are separated from certain natural gases by passage up a tower through which a stream of an absorption oil is passed. Benzene, toluene, and xylene are recovered from coal gas by a similar procedure.

ACID

Any chemical compound containing hydrogen, capable of being replaced by positive elements or radicals to form salts. Acids and acid solutions turn litmus paper red. They have a pH value from less than 7.0 (neutral) down to 0.0 (extremely acid).

ACID VALUE

The number of grams of potassium hydroxide neutralized by the free acids present in one gram of oil.

ACIDIC

An acid solution with a pH below 7.0 (neutral).

ADHESIVENESS

The condition in which a soil or deposit clings to a surface and cannot be easily removed by normal water flow, flushing, or mechanical means.

ALKALI

Any compound having marked basic properties. Alkalis and alkaline solutions turn litmus paper blue. They have a pH value above 7.0 (neutral) up to 14.0 (extremely alkaline). These include the oxides and hydroxides of barium, calcium, magnesium, and sodium. Hydroxides are strong alkalis.

ALKALINE

An alkali solution with a pH above 7.0 (neutral).

AMBIENT TEMPERATURE

Normal atmospheric temperatures up to the range of 38°C (100°F).

AMORPHOUS

A material whose structure is irregular and formless.

API GRAVITY SCALE

A standard scale agreed between the American Petroleum Institute, the U.S. Bureau of Standards and the Bureau of Mines in 1921 for measuring the specific gravity of oil expressed in terms of degrees. There is a direct relation between API degrees, specific gravity and the weight of oils. The lower the API degree, the higher the specific gravity and weight of oil, as shown in the table on the following page.

A.P.I Gravity 60°F	Specific Gravity 60/60°F	Pounds Per US Gal @60°F	A.P.I. Gravity 60°F	Specific Gravity 60/60°F	Pounds Per US Gal @60°F	A.P.I. Gravity 60°F	Specific Gravity 60/60°F	Pounds Per US Gal @60°F
0	1.0760	8.962	18	.9465	7.882	35	.8498	7.076
1	1.0679	8.895	19	.9402	7.830	36	.8448	7.034
2	1.0599	8.828	20	.9340	7.778	37	.8398	6.993
3	1.0520	8.762	21	.9279	7.727	38	.8348	6.951
4	1.0443	8.698	22	.9218	7.676	39	.8299	6.910
5	1.0366	8.634	23	.9159	7.627	40	.8251	6.870
6	1.0291	8.571	24	.9100	7.578	41	.8203	6.830
7	1.0217	8.509	25	.9042	7.529	42	.8155	6.790
8	1.0143	8.480	26	.8984	7.481	43	.8109	6.752
9	1.0071	8.388	27	.8927	7.434	44	.8061	6.713
10	1.0000	8.328	28	.8871	7.387	45	.8017	6.675
11	0.9930	8.270	29	.8826	7.341	46	.7972	6.637
12	.9861	8.212	30	.8762	7.296	47	.7927	6.600
13	.9792	8.155	31	.8708	7.251	48	.7883	6.563
14	.9725	8.099	32	.8654	7.206	49	.7839	6.526
15	.9659	8.044	33	.8602	7.163	50	.7796	6.493
16	.9593	7.999	34	.8550	7.119			
17	.9529	7.935						

AUSTENITIC

A form of steel particularly susceptible to chloride ion attack, especially during hydrochloric acid cleaning processes. Non-magnetic steel. Also called stainless steel.

AUTOIGNITION TEMPERATURE

The temperature at which flammable vapors given off by a substance spontaneously ignite, without the application of a spark or flame.

AVIATION GASOLINE

A fuel especially suited for aircraft use, in that it has volatility, high octane rating, and good stability. The main components are toluene and various highly branched hydrocarbons produced by alkylation, along with other petroleum hydrocarbons and some tetraethyl lead to produce the required high octane number and volatility.

B

BACK FLUSHING

The forceful flushing of a system in which the flow is counter- current to the normal operation flow path.

BIODEGRADABLE

That which is capable of being decomposed by biological agents, especially bacteria.

BLIND SPOTS

Areas of the tank not reached by the tank washing machine water jets.

BLOWN OILS

Oxidized oils; base oils; thickened oils; polymerized oils. Vegetable and animal oils which have been heated and agitated by a current of air or oxygen. They are partially oxidized, deodorized and polymerized by the treatment, and are increased in density, viscosity and drying power. Important blown oils are castor, linseed, rape, whale and fish oils.

BOILING POINT

The temperature at which a liquid boils freely, normally quoted for standard atmospheric pressure (760 mm Hg). Can be raised by increasing, lowered by decreasing pressure.

BURNING

Liquid petroleum does not burn, petroleum vapor burns. Danger increases according to how quickly the product vaporizes. The lower the temperature at which a petroleum evaporates, the more dangerous it is.

C

CALORIE

The amount of heat necessary to raise one gram of water one degree centigrade at constant pressure of one standard atmosphere.

There are various calories depending upon the interval chosen.

Sometimes the unit is written as the gram-calorie or the kilogram calorie, the meaning of which is evident. The calorie may be defined in terms of its mechanical equivalent.

1 watt = 1 joule/sec.

CATALYTIC AGENT

A substance which by its presence alters the velocity of a reaction and may be recovered unaltered in nature at the end of the reaction.

CAUSTIC

When used alone, the term usually alludes to caustic soda, sodium hydroxide.

CENTISTOKE

One one-hundredth of a stoke.

A stoke is the kinematic unit of viscosity; it is equal to the viscosity in poises divided by the density of the fluid in grams per cubic centimeter, both measured at the same temperature.

CHELANT

A chemical compound which has the capability to attach itself to or hold metal ions in a soluble state.

CHELATION

The chemical reaction in which the treating material called a “chelant” holds a metal ion in solution.

CLEAN CARGO

Any product carried in commerce which by its physical or chemical characteristics would not contaminate a following cargo and which can be easily removed by water flushing.

CLEANER (solvent-based)

A blend of surface-active agents, emulisifiers and dispersants in a solvent solution used to remove soils from a surface.

CLEANER (water-based)

A blend of surface-active agents, emulisifiers and detergents and dispersants in a water solution used to remove soils from a surface.

COLLOID

A solution in which the solute is not as individual molecules, but in clusters of molecules. With some colloids there is a risk of the solute settling out due to various causes. Colloids, unlike ordinary molecules, will not diffuse through membranes.

COMPOUND

A substance in which two or more elements are chemically combined, as opposed to a mixture in which elements or compounds are only mechanically intermingled. A homogenous combination of elements in fixed proportion.

CORROSION

The conversion of iron, steel and other alloys and metals into oxides due to the action of air and water or both. The minor components present in the air or water are important factors in the rate of corrosion and the kind of corrosion products. A minor component such as carbon dioxide in air and water can cause serious corrosion, but contaminants introduced by all types of air and water pollution usually accelerate corrosion.

Salts, as in seawater, are serious causes of corrosion.

Sulfur in fuel is also an important source of corrosion, so that removal treatments are common.

CRYSTALLINE

A material formed in such a manner that its structure is arranged in a regular, repeated and interlocked pattern.

D

DEGREASER

A solvent-based or an alkaline water-based cleaner especially effective on heavy petroleum deposits.

DEMULSIFIER

A chemical surface active agent which breaks an emulsion, forcing droplets of the dispersed liquid or semi-solid to combine into larger drops which separate into a phase distinct from the original mixture.

DENSITY

The mass of a substance per unit volume at a standard temperature and pressure. In the metric system, measured in grams per cubic centimeter, when it is equal to specific gravity.

DEPOSIT

An accumulation of unwanted materials in a system.

DETERGENT

A synthetic cleansing agent resembling soap in its ability to emulsify oil and hold dirt, and containing surfactants which do not precipitate in hard water.

DIRTY CARGO

Any product carried in commerce which by its physical or chemical characteristics would contaminate a following cargo unless it is chemically cleaned.

DISPERSING AGENTS

Any materials added to a suspending medium to promote and maintain the separation of the individual, extremely fine particles of solids or liquids which are usually of colloidal size.

DROPS

During tank cleaning with a portable tank cleaning-type machine, the cleaning cycles are commenced at the top of the tank and periodically moved down in stages or “drops” at regular intervals of tank depth.

DRYING-TYPE OILS

Organic liquids which tend to dry to a hard solid upon exposure to air in a relatively short time. Equipment containing these products should be cleaned immediately after discharge.

E

EMULSIFIER

A chemical surface active agent which produces a dispersion of one liquid or semi-solid in another in extremely small droplet size and renders the resultant mixture stable for relatively long periods of time.

EMULSION

A substantially permanent mixture of two or more liquids which do not normally dissolve in each other but which are held in suspension, one in the other. The suspension is usually stabilized by small amounts of additional substances known as emulsifiers. These modify the surface tension of the droplets to keep them from coalescing. Typical emulsions are milk, mayonnaise and such pharmaceutical preparations as cod-liver oil emulsion. Typical emulsifiers are egg yolk, casein and certain other proteins; soap; and surface active agents such as the quaternary ammonium compounds, sulfonated oils, and polyhydric alcohol esters and ethers.

Specific kinds of soaps include those from tallow, grease, fish oil and resin acids.

EPOXY RESINS

Thermosetting resins based on the reactivity of the epoxide group.

The reactive epoxies can form a tight cross-linked polymer network, and are characterized by toughness, good adhesion, corrosion and chemical resistance, and good dielectric properties. Since their curing is by condensation, no extraneous or volatile product has to be taken care of, so that large castings can be made without bubbles or voids.

EROSION

The physical process by which a solid material, usually a metal, is worn away by the abrasive contact with a solid, liquid or gas.

EVAPORATION

The change of a liquid into a vapor, not necessarily by boiling. Usually such vapors are called gases.

F

FANS

Either steam, water or air driven devices to facilitate quick ventilation of the tanks. The fans fit into the tank cleaning openings.

FAT

A natural organic compound which solidifies at or below 20°C, but otherwise similar to natural oils.

FIRE POINT

The temperature at which a liquid continues to burn when ignited.
This is always higher than the flash point.

FLAMMABLE

Liquids or mixtures of liquids or liquids containing solids in solution or in suspension which give off a flammable vapor at temperatures of not more that 65.5°C (150°F) closed cup test or not more than 65.6°C (150.1°F) open cup test.

FLAMMABLE LIMITS

It is possible to have a mixture containing so much or so little petroleum vapor that it cannot ignite. Mixtures which have reached these limits respectively have reached their Upper Flammable Limit or Lower Flammable Limit. (Also known as the Upper or Lower Explosion Limit - UFL, UEL, LFL, LEL.)

FLAMMABLE RANGE

Between the UFL and LFL a range of mixtures exists which are flammable - The Flammable or Explosion Range. Most substances when heated expand; evaporation causes very rapid expansion. Burning vapor causes heating and even more rapid expansion. If this expansion is confined, the pressure will increase - the result is an explosion.

FLASH POINT

The lowest temperature at which a combustible liquid will give off a flammable vapor which can be ignited and will burn momentarily. For the purposes of the official shipping regulations, the flash point is determined by the Tagliabue open-cup method, usually abbreviated TOC.

FLUID

Any substance in liquid form.

FLUSHING

Washing a surface with a forceful flow of a liquid, usually water, to remove loosened material or residual cleaning solutions in precleaning or after cleaning operations.

FREE FLOW

A system in which pipelines are not used in the onboard oil pumping process. Instead, sluice gates are fitted into the bulkheads. This is normally found only on very large tankers.

FREEZING POINT

For a pure substance the freezing point or melting point is the temperature at which the liquid and solid are in equilibrium with one another; i.e., at a higher temperature the solid will melt and at a lower temperature the liquid will solidify.

For a mixture the freezing point or melting point varies with the composition, but is still the temperature at which the liquid mixture is in equilibrium with the solid material that separates from it on cooling. This latter is usually one pure component of the mixture, but may be a solid solution or a mixture.

FRESH WATER

Any shoreside water which is not seawater, brackish water or condensate (distilled water).

G

GAS

Any substance in the gaseous state.

GAS-FREEING

The process of eliminating a hazardous or explosive atmosphere from an enclosed area by ventilation, washing, or chemical cleaning.

GEL

A colloid which has set into a jelly-like substance.

H

HEAT OF COMBUSTION

The heat of combustion of a substance is the amount of heat evolved by the combustion of 1 gram molecular weight of the substance.

HIDDEN AREAS

Surfaces which are concealed from the direct flow of a cleaning solution and as such do not receive the forceful cleaning effect desired. These areas often have to be spot cleaned.

HOT WORK

Welding or metal cutting using gas, plasma or electric arc equipment.

HUMIDITY - ABSOLUTE

Mass of water vapor present in unit volume of the atmosphere, usually measured as grams per cubic meter. It may also be expressed in terms of the actual pressure of the water vapor present.

HYDROGEN ION CONCENTRATION

The concentration of hydrogen ions in solution when the concentration is expressed as gram-ionic weights per liter.

A convenient form of expressing hydrogen ion concentration is in terms of the negative logarithm of this concentration. The negative logarithm of the hydrogen ion concentration is called pH.

Water at 25°C (77°F) has a concentration of H+ ion of 10^{-7} and of OH^- ion of 10^{-7} per litre. Thus the pH of pure water is 7.

I

IGNITION TEMPERATURE

The lowest temperature at which combustion (with fire) can occur spontaneously without any heat supply from outside.

INDICATOR

A chemical substance which shows by its color or visibility the acidity, alkalinity, or neutrality of a solution.

INERTING

The act of expelling or displacing oxygen-containing corrosive or explosive atmosphere from an area by injection or blanketing with a nonreactive gas such as nitrogen or washed combustion exhaust.

IODINE NUMBER

The percentage of iodine that will be absorbed by a chemically unsaturated substance (vegetable oils, rubber, etc.) in a given time under arbitrary conditions. A measure of unsaturation.

ION

An ion is an atom or group of atoms that is not electrically neutral but instead carries a positive or negative electrical charge. Positive ions are formed when neutral atoms or molecules lose valence electrons; negative ions are those which have gained electrons, or, as in the case of a dissociated water molecule, have lost a proton.

L

LOAD-ON-TOP (LOT)

This term refers to the process of demulsifying and settling a cleaning slop to separate the oil and water phases. After separation, the oil-free water phase is discharged overboard and the oil phase is saved and combined with the new cargo of oil.

M

MAK VALUE

Maximum allowable concentration. Expressed in ppm (parts per million). This is a concentration of a certain substance in the air, which is the maximum allowable exposure for working, for a normal person, without danger.

MACHINE CYCLE

The time taken for the complete planetary movement through a 360° arc of the cleaning machine.

MECHANICAL HOISTS

Air driven winches attached to shear legs that can be situated over tank cleaning openings or tank lids to lift out the buckets of sludge from tank bottoms.

MIXTURE

A heterogeneous combination of elements and/or compounds in unfixed proportion.

MUCKING

The physical removal of loose debris or deposits after primary cleaning operations.

N

NAPHTHA

A general name for mixtures of certain aromatic hydrocarbons.

NEAT

Full strength application of a cleaner.

NEUTRALIZATION

The chemical process in which a solution is brought to a pH of 7 by the addition of a counteracting solution.

NON-DRYING OILS

Organic liquids which remain fluid on exposure to air.

NON-FERROUS METAL

A metal or alloy which has no iron content.

NON-VOLATILE

Some petroleum products do not readily evaporate. Those with flash points above 60°C (140°F) are classed as nonvolatile. Gas oil and diesel oil are two examples.

NTP

Normal temperature and pressure - a temperature of 0°C and a pressure of 760 mm Hg, sometimes called standard temperature and pressure (STP).

O

OLEIC ACID

An unsaturated fatty acid present in vegetable oils and fats.

ONCE-THROUGH CLEANING

Cleaning surfaces with a chemical solution in which there is no recirculation or reuse of the solvents.

OXIDATION

A chemical reaction that increases the oxygen content of a substance or compound.

OXIDE

A chemical compound produced by the reaction of oxygen with metal; example: Iron Oxide.

P

ppm

The abbreviation for “parts per million” which means one part per one million parts.

PASSIVATION

A process of treating a freshly cleaned metal surface to form a protective film or molecular layer which inhibits the rapid rerusting of the surfaces. For stainless steel tanks a layer of chromium oxide is formed by treating the surface with a dilute solution of nitric acid.

PERCENTAGE BY VOLUME

A method of determining a solution’s strength with respect to the volume of the most important constituent. Example: 5% (by volume) acid solution is 5 parts concentrated liquid acid with 95 parts water, giving 100 parts solution.

PERCENTAGE BY WEIGHT

A method of determining a strength of a mixture with respect to the weight of the most important constituent. Example: 5% (by weight) SAF-ACID descaling compound solution is 5 parts by weight dry acid with 95 parts by weight water giving 100 parts solution.

NOTE: One gallon (U.S.) of fresh water equals 8.3 pounds or one liter equals 1000 grams (1 kilogram).

PETROL

Hydrocarbon fuel as used for ignition-type internal combustion engines. In the U.S.A. this is called gasoline or gas.

pH

A means of expressing the degree of acidity or basicity of a solution. Thus, at standard temperature a neutral solution such as pure distilled water has a pH of 7, a tenth-normal solution of hydrochloric acid (approximately 3.65 g HCl/liter) has a pH near 1 and a normal solution of a strong alkali such as sodium hydroxide has a pH of nearly 14.

pH is defined as the logarithm of the reciprocal of the hydrogen ion concentration in gram equivalents per liter of solution.

$$pH = \log \frac{1}{(H+)}$$

POLYMERIZATION

The bonding of any two or more substances (monomers) to form a polymer. Any chemical reaction that produces a bonding.

POUR POINT

The temperature at which a liquid solidifies or congeals and can no longer be poured.

PRECIPITATE

An insoluble substance which may be formed in a solution as the result of chemical reaction. The precipitate normally settles on the bottom.

PRECLEANING

The preparation of a surface for a cleaning operation by the removal of loose debris or soils by flushing or mechanical means.

R

RECIRCULATION CLEANING

Cleaning a system with chemical solution which is returned repeatedly to the area to be treated until the job is completed or the strength of the solution is depleted.

REID VAPOR PRESSURE

Reid Vapor Pressure (RVP) is a method of measuring the tendency of liquids to give off flammable vapors.

A small amount of the flammable liquid is placed in a closed container and heated to 37.78°C (100°F). The resulting pressures are then measured. Flammable liquids are those which give off flammable vapors at or below 26.7°C (80°F). Flammable liquids can therefore be classified as follows:

Grade A - having an RVP of 14 lbs/sq in. (1 kg/cm^2) or more (light naphthas, etc.)

Grade B - having an RVP under 14 lbs/sq in. (1 kg/cm^2) but over 8-1/2 lbs/sq in. (0.6 kg/cm^2) (gasolines, etc.)

Grade C - having an RVP of 8-1/2 lbs/sq in. (0.6 kg/cm^2) or less and a flash point of 80°F (26.7°C) or below (crudes, cut-back, asphalts, etc.)

RING MAIN

A pipeline system that makes a complete circuit in a ring formation, passing through the wing tanks of the vessel, crossover lines through the center tanks, to the other side of the main.

ROCK AND ROLL CLEANING

The process of cleaning a shipboard tank with a chemical solution with the only agitation being that of the ship's motion in transit.

RUST

The product of a chemical reaction involving iron, water and oxygen (air).

S

SACRIFICIAL METAL

A pure metal or alloy, generally non-ferrous in structure, which will oxidize or be attacked in the normal operation of protecting the overall system from corrosion. These materials are highly susceptible to attack by strong acids or alkalis and as such should be removed from the system during a cleaning operation.

SAPONIFICATION

The chemical reaction or process in which an ester is heated with aqueous alkali, such as sodium hydroxide, in order to form an alcohol and the sodium salt of the acid corresponding to the ester. The process is most frequently carried out on fats, which are glyceryl esters of fatty acids. The sodium salts formed in this case are soaps, which leads to the use of the term saponification.

SAPONIFICATION NUMBER

The number of milligrams of potassium hydroxide required to saponify 1 gram of a sample of an ester (glyceride; fat) or mixture.

SAYBOLT SECOND UNIVERSAL (SSU)

The method of expressing viscosity in the Saybolt Universal System.

SAYBOLT VISCOSITY UNIVERSAL (SVU)

The time in seconds (SVU) it takes for 60 ml of a sample flowing through a calibrated Universal orifice in a Saybolt viscometer under specified conditions. The design and dimensions of the Saybolt viscometer are subject to very rigid specifications.

SCALE

A crystalline chemical solid which has formed at the point in the system at which it is found. Usually scale materials occur from chemical reactions and precipitation of solids from solutions or the reaction of an aggressive solution or gas in contact with a metal.

SLOPS

Spent cleaning solutions and soils.

SLUDGE

A mixture of amorphous and/or loose “scale-like” particles which is carried by fluid flow and accumulates at one or more points in a system due to lack of sufficient flow velocity.

SOLUBLE OILS

These oils are known as emulsifying oils, since they are normally bright, clear oils which, when mixed with water, produce milky emulsions. In some soluble oils the emulsion is so fine that instead of milky solutions in water, amber colored transparent solutions are formed. Typical examples are sodium and potassium petroleum sulfonates.

SOLVENT

A fluid chemical which dissolves or solubilizes another material.

SPECIFIC GRAVITY

The ratio of the density of a substance at a given temperature, compared with the density of water at its maximum 4°C (39°F). Thus a specific gravity (SG) of 3.0 means a substance is three times as dense as water (and thus weighs three times as much as the same volume of water). The SG of oils is usually stated for a temperature of 15°C (59°F).

SPOT CLEANING

The secondary cleaning of specific soiled areas with the neat application of a solvent followed by water flushing and/or wiping to produce a deposit-free surface.

SPUR MAIN

A system of pipelines, usually 3 or 4 in number, that run from the after pump room straight up through the center tanks and supply block tanks only.

STAGING

Temporary scaffolding erected in a tank to facilitate a cleaning job for a work crew.

STAINLESS STEEL

An alloy of iron with 12-20% chromium, and sometimes nickel, which reacts with oxygen in the air to form a chromium oxide, rendering the steel resistant to corrosion by many substances. Such stainless steel is called passivated.

STRIPPING

The act of removing excess liquids, solids or gases from a system prior to cleaning.

SURFACE-ACTIVE AGENT

A soluble compound that reduces the surface tension of liquids, or reduces the interfacial tension between two liquids or a liquid and a solid. It therefore increases its wetting ability. These agents are also known as surfactants.

SURFACE TENSION

The surface of a liquid is usually in tension, behaving somewhat like a stretched rubber membrane; the reason why droplets do not spread on solid surfaces.

SUSPENSION

Very small, solid or liquid particles floating in a second liquid.

T

TLV VALUE

Threshold limit value. The average concentration of airborne chemical to which the normal person can be exposed without injury for 8 hours per day, 5 days per week, for an unlimited period.

U

UPPER EXPLOSION LIMIT

This is the highest concentration, measured in percent by volume of a gas in air, at which it can ignite. Sometimes also referred to as upper flammable limit (UFL). Above the UFL a gas/air mixture is said to be too rich to burn. There is also a lower explosion limit.

V

VAPOR

A substance in a gaseous state. Vapor can be liquified by increasing the pressure without changing the temperature. (If a change of temperature is also needed, it is a gas not a vapor.)

VAPOR PRESSURE

All liquids and some solids give off vapor. In an enclosed space, this vapor eventually attains a maximum pressure, depending only on the nature of the substance and on its temperature. At this point, the vapor is said to be saturated. The vapor pressure increases with temperature.

VARNISH

This term refers to the baked-on, polymerized products of a combustion process.

VENTILATION

The provision of adequate air flow into or out of a confined space containing equipment being cleaned.

VENTING

The act of providing free flow of air or other gases into or out of the equipment being cleaned.

VISCOSITY

The resistance of a fluid to internal motion; the more viscous a fluid, the less easily it is poured or pumped. Viscosity can usually be reduced by raising the temperature of the fluid. All fluids possess a definite resistance to change of their form. This property, a sort of internal friction, is called viscosity. It is expressed in dyne-seconds per cm^2 or poises.

For practical purposes viscosity is determined by noting the number of seconds for a given quantity of a liquid (60 cc) to flow through a standard orifice at a particular temperature. The Saybolt Universal Viscometer is generally used for this purpose. The viscosity of any oil will decrease as its temperature increases. Kinematic viscosity is the ratio of viscosity to density.

The unit of kinematic viscosity is the stoke.

VOLATILE

Readily vaporizable at a relatively low temperature.

W

WAXY CARGO

Any petroleum product containing a significant quantity of paraffin as one of its constituents.

APPENDIX G

TANK CLEANING QUESTIONNAIRE

TANK CLEANING QUESTIONNAIRE

- Name of vessel _____
- Name and address of owner/operator _____
- Who is to be billed? _____
- Vessel particulars: Gross tons _____ Net tons _____ d.w.t. _____
- Vessel age: _____ years
- Number of tanks to be cleaned _____

  Centers Size _____ Size _____

  Wings Size _____ Size _____

  Double bottoms Size_____ Size _____
- Number of slop tanks _____ Size _____
- Number of permanent ballast tanks _____ Size _____
- Date of arrival _____ Location _____
- Time allotted for cleaning _____ days
- Location of cleaning: At sea _____ In transit _____
- In transit to where? _____
- At discharge port _____ At tank cleaning station _____
- Supervisor required? ☐ No ☐ Yes Date: from _____ to _____
- Cleaning required for: Upgrading to grain _____ Gas-freeing _____

  Cleaning cargo _____ Hot Work _____

  Tank coating _____ Other _____
- Present cargo (give details) _____

_____

- History of immediate two past cargoes: _____

_____

_____

- Are tanks coated? ☐ No ☐ Yes Type of coating _____

  When coated? _____ Present Condition _____
- Cleaning machines: Number _____ Type _____ Condition _____
- Auxiliary cleaning equipment available: Hoses _____ Reels _____

  Saddle _____ Clamps & rigging materials _____ Buckets _____

  Scoops _____ Bucket hoists _____
- How many machines can be worked simultaneously? _____
- Highest temperature attainable while underway: _____° C _____° F
- Highest working pressure _____ kg/cm^2 _____ psig

- Number of crewmen available for underway cleaning _____
- Loading port (new cargo) _____
- Pumping system: Ring main _____ Spur main _____ Direct main _____
- Is tank washing line common with deck service or fire line? _____
- Number of stripping pumps (eductors) _____ Capacity _____
- Date of last major cleaning _____ For what reason _____

_____

- Inert gas system available? ☐ No ☐ Yes Type _____
- Are tanks fitted with heating coils? ☐ No ☐ Yes

  Type _____ Max Temp. _____°C _____°F
- Diagram of ship layout (Attach drawing showing tanks, cofferdams, pumproom position, etc.)
- Is air pressure available on deck? ☐ No ☐ Yes
- Is a permanent chemical tank fitted? ☐ No ☐ Yes
- At which port will chemicals be required? _____
- Is a system available to wash by pre-mixed chemical solution, i.e. from:

  Chemical tank _____ Can solution be heated? ☐ No ☐ Yes

  Slop tank _____ Can solution be heated? ☐ No ☐ Yes

  Cofferdam _____ Can solution be heated? ☐ No ☐ Yes
- Describe ventilation facilities: _____

  _____

  _____
- Have Drew Marine Chemicals been used for tank cleaning before? ☐ No ☐ Yes

  Type _____ Results _____

_____

- Have competitive tank cleaning chemicals been used before?

  ☐ No ☐ Yes Whose?

_____

  Results _____
- Remarks _____

_____

_____

_____

_____

_____

_____

Signed _____ Date _____

REFERENCES

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