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Transportation of Chemical Materials by Chemical Tankers

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This paper provides an overview of the development of the chemical trade and tankers, explains the importance of double hull tankers with the aspect of environmental impact and includes the chemical tanker safety rules and the transportation of chemical materials.

Key Words: Transportation, Chemicals, Tankers.

INTRODUCTION

Shipping is a vital part of the supply chain in the chemicals sector and the greatest advantages made in the last 25 years. Marine chemical transportation is constantly growing in regard of the number of chemicals and the total volume of goods transported. Today, the number of different substances and compounds is quoted in thousands.

Although chemicals are shipped in relatively small amounts, the chemical tanker has been basically developed for the last 40 years. The chemical carrier usually carries a variety of different products, all with different properties and in many cases, presenting a multitude of difficulties and dangers.

Due to the several chemical tanker incident was occured such as collusion, chemical spills, *etc*, single-hull chemical tankers have been increasingly losing their values, on the other hand, many modern double hull construction have been gaining importance in the chemical transportation trade.

Reducing the risk of pollution from chemical tankers, maritime society has also introduced several new actions to improve maritime safety and this was increased understanding of the environment impact of chemicals on the marine environment.

Many of these chemicals are dangerous to the environment and even though the risk of a chemical accident is considered small due to very high standards regarding safety. In this context the common characteristics of chemical tankers, transportation of chemical materials and International Maritime Organization (IMO) safety rules are explained.

Chemical tankers

Bulk liquid chemicals are transported by dedicated chemical tankers or by chemical/oil product tankers. These ships were of necessity more complex than the original first-generation chemical tankers. The chemical trade was becoming more complex during the 1960s. The number of substances being transported at sea was increasing rapidly and the products were technically more complicated. At the same time a growing number of 'parcel tankers' were making their appearance on the chemical transportation trade. These were tankers designed to carry a range a number of different chemical products. By the mid-1960s the chemical tanker had developed into a ship that was different from any other other tanker types. The cargoes carried by chemical tankers were probably potentially the most dangerous substances afloat, to the ships, their crews and to the marine environment. The range of products carried in the first chemical tankers was relatively limited and the products were not transported technically. The carrying only one chemical into the tanker is the most disadvantages issue for the ship owner.

Since the chemical tankers are more complicated than the other tanker types. As the trade developed these ships became more refined and chemical tanker able to carry many different cargoes for a number of different customers and consequently has to be very versatile. For the next decade, tankers used in the carriage of chemicals were nearly all conversions, with the addition of tank linings, cofferdams and other features[1].

Chemical tankers make difference with using cofferdams, double bottoms and similar devices than conventional crude oil tankers. To ensure that incompatible cargoes do not come into contact with each other, tanks are usually separated by a cofferdam which means a space between the two tank walls.

Most chemical tankers have their tanks separated from the outer frame of the ship by a double bottom or double skin. If the ship is damaged in a collision or a grounding this space should protect the cargo tanks from damage and also protect any pollution that may cause on the environment.

The tanks of a chemical tanker are constructed of special materials which designed to carry certain products. The early chemical tankers generally had tanks made of stainless steel which resists corrosion from many products and could be cleaned easily. On the other hand, stainless steel is unsuitable for many chemicals and so different coatings were designed. Nowadays typical coatings are using such as epoxy, phenolic resins, zinc silicate, polyurethane and rubber. As a result of most chemical tankers, especially parcel tankers, will have tanks lined with a number of different coatings (as well as some made of stainless steel) to enable it to carry as wide a range of products as possible.

A wide range of ordinary items are in fact derived from complex chemical processes and are often derived from the by-products of the production of energy. Many of the changes in everyday life that have taken place during the last 50 years as a resulted of the developments in the chemical industry. Since chemical shipments started to grow substantially, with more demanding products, the specialized ships are developed.

Chemical carriers are highly sophisticated ships with the most complex vessels and they are able to carry up to 60 different types of chemicals, each according to its own carriage conditions, with its own piping and pumping system. The cargoes they carry often present tremendous challenges and difficulties from a safety point of view and many chemicals are also a far greater pollution threat than crude oil.

Most of the chemical transportations are done by chemical parcel tankers. Chemical parcel tankers are versatile vessels designed to carry a wide range of liquid cargoes. Externally, they appear similar to petroleum product tankers, but typically can carry 10 to 60 separate cargo tanks to simultaneously accommodate multiple cargoes or parcels.They range in total cargo capacity from *ca.* 3,000 to 40,000 tons, although most are well under 40,000 tons. Chemical parcel tankers, like gas carriers, are governed by international construction standards. They may have cargo tanks lined with stainless steel or specialized coatings, such as epoxy, zinc silicate, or polyurethane, to ensure compatibility with a range of chemicals. The tankers have double bottoms or hulls and maintain spaces between tank walls to prevent incompatible cargoes from coming into contact with each other.

Even if chemical tankers do take safety aspects into consideration, there are a number of other ships in the same sea area, as well as a number of ships crossing their paths and meeting each other in narrow sounds or in dense traffic areas. On the other hand, efficient routing and scheduling of multi-parcel chemical tankers to reduce logistics expenditure which is important for both chemical and shipping industry.

In addition to having more tanks gives greater flexibility and the pipe work associated with the tanks is also extremely complicated during the loading and unloading operations. All procedures involving the cargo have to be carried out with great care and precision, in order to avoid cargo contamination and also to ensure that cargoes owned by different shippers should be kept separately. Piping, monitoring and control equipment are also very complex.

Ship construction also has to be of the highest possible standard. Tank cleaning is crucially important to cargo purity, so traditional stiffening inside the tanks is minimized and the tanks can be cleaned more easily. The chemical cargo tanks have to be designed and constructed in such a way that stresses are avoided as far as possible. Although these can lead to fatigue cracks or damage to the tank coating, the design itself has to take into account the type of cargoes which are to be carried. For example; some cargoes are more than twice as dense as sea water while others have to be carried at high temperatures to stop them solidifying. Welding and other constructional features must be the highest possible quality.Both of these factors can affect the structure.

The tanker types can be identified and depending on their size as shown in Table-1. that is named Tanker types. Liquid bulk carrier includes oil tankers, chemical tankers, LG tanker, tanker barge and other tankers. Handy size is the most common use of chemical tankers[2].

TABLE-1
TANKER TYPES

Tanker size	Deadweight range in ton	Typical deadweight value in ton	Characteristics
Handy	30,000-45,000		Products tankers, in general,in entitled to carry also IMO Type 2 or 3 chemical products
Panamax	55,000-70,000	60,000	70.000 dwt is the maximum size tanker able to transit the Panama Canal
Aframax	75,000-120,000	110,000	Afra stands for Average Freight Rate Assessment'
Suezmax	120,000-200,000	150,000	Tankers generally identified asthose capable of transporting one million barrel cargoes
Very Large Crude Carriers (VLCC)	200,000- 320,000	280,000	Tankers able to transport large volumes of oil including two million barrel cargoes, over relatively long distances.
Ultra Large Crude Carriers (ULCCs)	Above 320,000	400,000	Tankers able to transport very large volumes of oil, up to three million barrel cargoes

Source: http://virtual.vtt.fi/inf/pdf/publications/2006/P595.pdf-Acces date.25.04.2007.

Chemical tanker fleet: As of January 2005, the world tanker tonnage including oil, products, oil/chemical, pure chemical and liquid gas had a share of 41.4 % of the world total Merchant fleet with a capacity of 368.4 million dwt. At the beginning of 2004, the average age of the chemical tanker fleet stood at 17.6 years *vs.* 16.6 years in 2000. 20.9 % of the existing chemical tanker tonnage was built before 1979 (older than 25 years). In international shipbuilding, the tanker tonnage clearly dominated the world order book in 2005. The increase compared to last years cgt figures is 76 % in liquid gas tankers and 44.5 % in chemical tankers[2].

TABLE-2
CHARACTERISTICS OF DIFFERENT TANKER TYPES

Tanker type	Number	Average GT	Average Age	Average L	Average B	Average D
Chemical	1339	3818	17.53	85.21	13.70	5.60
Chemical/Product	1666	12436	11.83	135.38	21.82	8.60
Crude oil	1866	75832	11.56	251.25	42.87	15.29
LNG	177	87505	13.43	268.28	42.00	11.15
LPG	1025	9440	17.04	110.88	17.71	6.59

Source: http://virtual.vtt.fi/inf/pdf/publications/2006/P595.pdf-Acces date.25.04.2007. GT = Gross tonnage

According to the Lloyds Register Fairplay, there were 1,339 tankers in use in 2004 as well as 1,666 chemical/oil tankers. The world tanker tonnage, including oil, products, chemicals, LNG, had a share of 41.3 % of the world total merchant fleet with a capacity of 368.4 million dwt. Chemical/product tankers had an average Gross Tonnage, GT, of 12,436 tons and an average age of 11.83 years. Average length, breadth and draught were 135.4 m, 21.82 m and 8.6 m, respectively as shown in Table-2.

World chemical carrier fleet and trade development: The product and chemical tanker sectors have experienced positive market demand recent years. The legacy of this is currently a large orderbook. In addition, the introduction of new vessel regulations is set to see a large-scale change in the fleets. At the beginning of 2006, IMO specification chemical carrier fleet was estimated at 33.3m dwt. The chemical tanker orderbook is estimated at *ca.* 13.0 m dwt, equivalent to 39 % of the current IMO specification chemical fleet. The aggregate chemical trade has witnessed a sustained period of growth in recent years, with overall imports rising by 21 % between 1999-2004 from 121 mt to 146 mt. Total imports were up by 4 % during 2004 compared to 3 % a year earlier[3].

Overall, the product tanker fleet is forecast to increase from 43 m dwt to 68m dwt by 2015. World seaborne trade is forecast to increase from 649 mt to 1,057mt over the same period as in shown Fig. 1.

The total chemical carrier fleet is forecast to increase from a total of 41 m dwt to 59 m dwt by 2015. Chemical trade is forecast to rise from 151 mt to 215 mt by 2015[3].

Clasification and general characteristics of most chemicals: Grading into the property groups relates only to the respective chemical alone. Chemical tankers carry several different chemicals at the same time and in case of an accident these may mix and the properties of the new compounds may differ from the properties of the original chemicals.

The most common chemical products transported in bulk can be class ified into a number of categories[1]:

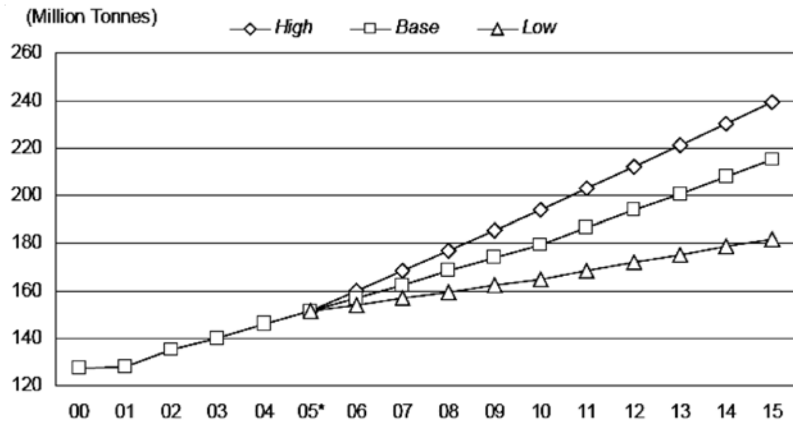

Fig. 1. Overall chemical trade development; Source: www.osclimited.com/releases/Chemical_Carriers_Product_Tankers_to_2015pr.pdf - Access date: 20.03.2007

(i) Heavy chemicals: the substances produced in large quantities such as sulphuric acid, phosphate fertilizer, phosphoric acid, nitric acid and caustics soda, chlorhydric acid and ammonia. **(ii) Molasses and alcohols:** molasses comes from either sugar beet or sugar cane and can be fermented into alcohols such as rum. Many alcohols are produced by the petrochemical industry, but some can also come from the fermentation of starch, such as ethanol. Alcohols of this type, including ethyl, methyl and propyl alcohols and they are used in industrial processes. **(iii) Vegetable oils and chemicals:** edible vegetable oils are derived from soya beans, groundnuts, cottonseed, sunflowers, olives, rape and other seeds. Coconut and palm oil can be used for cooking and also in the production of soap. Some fats are extracted from animals including lard and fish oils. Oils and fats are in general esters of an alcohol (glycerol) and a variety of organic acids. Detergents and inorganics are common commodities which have been traded by sea for many years. **(iv) Petrochemical products:** used in the production of fibre, artificial rubber and plastics and many are carried on liquified gas carriers. Substances carried in chemical tankers include aromatics, such as benzene, which nowadays are derived mainly from oil but can be produced from coal. Other important petrochemicals include xylenes (used in the production of polyester fibres); phenol and styrenes. **(v) Coal tar products:** coal tar is derived from the carbonization of coal. It can be converted into numerous products, oil and coal are both fossil fuels composed of hydrocarbons. The derivatives include benzene, phenol (used for the production of Bakelite, the first 'plastic'), naphthalene and many more. Common products which are derived from coal include nylon, aspirin, antiseptics and herbicides.

Transportation problems of main chemical substances: Since chemical transportation can be effect dangerously during the loading and unloading, the shippers can come across several problems. The chemical substances transportation problems can be listed as follows[2]: **(i) Cargo density:** the specific gravity of chemicals carried at sea varies greatly. Some are lighter than water. Others are twice as dense. Those substances which have especially high density include inorganic acids, caustic soda and some halogenated hydrocarbons. **(ii) High viscosity:** some lubricating oil additives, molasses and other products are very viscous at low temperatures, they are sticky and move very slowly and this causing problems during the cargo-handling and cleaning. **(iii) Low boiling point:** some chemicals vapourize at a relatively low temperature. This can causes contamination problems, since when a liquid turns into a gas it expands, this creating growing pressure. Therefore, to provide either a cooling system or to carry the chemical in specially-designed pressure vessels. **(iv) Reaction to other substances:** some chemicals react to water, to air or to other products. Therefore measures have to be taken to protect them. Apart from the fact that an accident can lead to a dangerous reaction (such as the emission of a poisonous gas) many chemicals can be ruined if they are contaminated by other substances. Methanol, lubricating oil additives and alcohols can be spoiled by even a slight amount of water contamination. Too much oxygen can lead to a rapid deterioration in the quality of some vegetable oils. Other products can change into a different product completely. **(v) Polymerization:** some substances, such as petrochemicals, do not need to come into contact with another chemical before undergoing a chemical change. They are self reactive and liable to polymerization unless protected by an inhibitor. This is a process whereby the molecules of a substance combine to produce a new compound. The process can be accelerated by catalytic factors such as heat, light and the presence of rust, acids or other compounds. Styrene, methyl methacrylate and vinyl acetate monomer are examples. Propylene oxide and butylene oxide are also liable to polymerization process. **(vi) Toxicity:** many chemicals are highly poisonous, either in the form of liquid or vapour or both. The problem is sometimes made worse by the fact that toxicity can be increased when vapours from one substance come into contact with those from another. **(vii) Solidification:** some substances have to be kept at a high temperature, otherwise they solidify or become so viscous that they cannot easily be moved. Examples are some petrochemicals, molasses, waxes and vegetable oils and animal fats. **(viii) Pollution:** while many of the factors listed above present problems for the ship and crew, a considerable number of chemicals are extremely dangerous to marine and other forms of life. Many chemicals are in fact far more poisonous and present a greater threat.

IMO Regulations for the carriage of chemicals by ship: Regarding carriage of chemicals by ship regulation has been defined by International Maritime Organization as follows[4]: (i) Regulations governing the carriage of chemicals by ship are contained in the International Convention for the Safety of Life at Sea (SOLAS) and the International Convention for the Prevention of Marine Pollution from Ships, as modified by the protocol of 1978 relating thereto MARPOL 73/78 (IMO, 2002). (ii) The regulations cover chemicals carried in bulk, on chemical tankers and chemicals carried in packaged form. In this abstract, the relevant codes concerning liquid bulk transportations are the International Code for the Construction of Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code) and the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code). (iii) Carriage of chemicals in bulk is covered by regulations in SOLAS Chapter VII. Carriage of dangerous goods and MARPOL Annex II. Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk. Both Conventions require chemical tankers built after 1 July 1986 to comply with the IBC Code, which gives international standards for the safe transport by sea in bulk of dangerous liquid chemicals. (iv) Regulations concerning chemicals transported in packaged form are MARPOL Annex III. Regulations for the Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form and the International Maritime Dangerous Goods (IMDG) Code. The IMDG Code was developed as a uniform international code for the transport of dangerous goods by sea and covers such matters as packing, container traffic and storage, with particular reference to the segregation of incompatible substances. Amendments to SOLAS chapter VII (Carriage of Dangerous Goods) adopted in May 2002 make the IMDG Code mandatory from 1 January 2004. (IMO, 2005.)

Prescribing the design and construction standards of ships involved in such transport and the equipment will be minimize the risks to the ship, its crew and to the environment, having regard to the nature of the products carried.

Basically, the ship types are related to the hazards of the products covered by the Codes. Each of the products may have one or more hazard properties, which include flammability, toxicity, corrosivity and reactivity. The IBC Code lists chemicals and their hazards and gives the ship type required to carry that product as well as the environmental hazard rating. Chemical tankers constructed before 1 July 1986 should comply with the requirements of the Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (BCH Code).

MARPOL Categories of hazardous chemicals: MARPOL Annex II grades noxious liquid substances carried in bulk into four categories graded

A to D, according to the hazard they present to marine resources, human health or amenities[4]: **Category A:** Noxious liquid substances that, if discharged into the sea from tank cleaning or deballasting operations, would present a major hazard to either marine resources or human health or cause serious harm to amenities or other legitimate uses of the sea and therefore justify the application of stringent antipollution measures. Examples are acetone cyanohydrin, carbon disulphide, cresols, naphthalene and tetraethyl lead. **Category B:** Noxious liquid substances that, if discharged into the sea from tank cleaning or deballasting operations, would present a hazard to either marine resources or human health or cause harm to amenities or other legitimate uses of the sea and therefore justify the application of special anti-pollution measures. Examples are acrylonitrile, carbon tetrachloride, ethylene dichloride and phenol. **Category C:** Noxious liquid substances that, if discharged into the sea from tank cleaning or deballasting operations, would present a minor hazard to either marine resources or human health or cause minor harm to amenities or other legitimate uses of the sea and therefore require special operational conditions. Examples are benzene (benzene and mixtures having 10 % benzene or more), styrene, toluene and xylenes. **Category D:** Noxious liquid substances that, if discharged into the sea from tank cleaning or deballasting operations, would present a recognizable hazard to either marine resources or human health or cause minimal harm to amenities or other legitimate uses of the sea and therefore require some attention in operational conditions. Examples are acetone, phosphoric acid and tallow.

The Annex also listed other liquid substances which are deemed to fall outside Categories A, B, C or D and therefore representing no harm when discharged into the sea from tank cleaning or ballasting operations. These substances include coconut oil, ethyl alcohol, molasses, olive oil and wine.

The hazardous chemicals are listed in the International Bulk Chemical Code (IBC code). Noxious liquid substances that are carried in bulk and are presently categorized as Category A, B, C or D and subject to the provisions of MARPOL Annex II are so indicated in the Pollution Category column of chapters 17 or 18 of the IBC code. Other liquid substances carried in bulk that are identified as falling outside Categories A, B, C and D and indicated as Annex III. in the Pollution Category column of chapters 17 or 18 of the IBC code.

Revised MARPOL Annex II: The revised Annex II Regulations for the control of pollution by noxious liquid substances in bulk was adopted in October 2004. It includes a new four-category categorization system for noxious and liquid substances. The revised annex will enter into force on 1 January 2007. The new categories are as follows[4]: **Category X:** Noxious liquid substances that, if discharged into the sea from tank cleaning or deballasting operations, are deemed to present a major hazard to either marine resources or human health and, therefore, justify the prohibition of discharge into the marine environment. **Category Y:** Noxious liquid substances that, if discharged into the sea from tank cleaning or deballasting operations, are deemed to present a hazard to either marine resources or human health or cause harm to amenities or other legitimate uses of the sea and therefore justify a limitation of the quality and quantity of the discharge into the marine environment. **Category Z:** Noxious liquid substances that, if discharged into the sea from tank cleaning or deballasting operations, are deemed to present a minor hazard to either marine resources or human health and therefore justify less stringent restrictions on the quality and quantity of the discharge into the marine environment. **Other substances:** Substances that have been evaluated and found to fall outside Category X, Y or Z because they are considered to present no harm to marine resources, human health, amenities or other legitimate uses of the sea when discharged into the sea from tank cleaning or deballasting operations.

The discharge of bilge or ballast water or other residues or mixtures containing these substances are not subject to any requirements of MARPOL Annex II. The revised Annex includes also a number of other significant changes. Improvements in ship technology, such as efficient stripping techniques, have made possible significantly lower permitted discharge levels of certain products that have been incorporated into Annex II. For ships constructed on or after 1 January 2007 the maximum permitted residue in the tank and its associated piping left after discharge will be set at a maximum of 75 L for products in categories X, Y and Z compared with previous limits that set a maximum of 100 or 300 L, depending on the product category.

As a result of the hazard evaluation process and the new categorization system, vegetable oils, which were previously categorized as being unrestricted, will now be required to be carried in chemical tankers. The revised Annex includes, under regulation 4 exemptions, a provision for the administration to exempt ships certified to carry individually identified vegetable oils, subject to certain provisions relating to the location of the cargo tanks carrying the identified vegetable oil.

Since accidents such as the Erika (1999) and the Prestige (2002), the demand for safety at sea and protection of the environment has increased and consequently, the interest in identifying high risk areas and ships. Maritime safety is also the objective of the recently implemented automatic identification system (AIS), a mandatory system by which ships automatically transmit and receive information. The data is carried on ordinary maritime VHF radio frequencies and contains static and dynamic information such as the ships identity, destination, cargo *etc.* The intentions of IMO (International Maritime Organization) when implementing AIS as a mandatory carriage requirement was to assist in the efficient navigation of ships protection of the environment and operation of VTS (Vessel Traffic Services)[5].

A procedure by which these intentions can be supported; by giving VTS operators a risk based decision support tool building on AIS technology aiding in the monitoring of ship traffic. The tool could easily be extended to benefit from the upcoming LRIT (Long Range Identification and Tracking) technology, a satellite based system with planned global cover of maritime traffic.

Main differences between single and double hulled tankers: In Pre-MARPOL single hull tankers oil in the cargo tanks is separated from the seawater only by a bottom and a side plate and they have no segregated balast tanks in protective locations (SBT/PL). In 1992, the MARPOL Convention was amended to make the double hull design compulsory for all new tankers (ships ordered after 6 July 1993) of 5000 dwt or more that are conducting international voyages.

The double hull construction incorporates both double bottoms and double sides, which means that the cargo tanks are surrounded with a second internal plate. IMO accepted mid-deck" concept as an alternative design solutions and the Coulombi Egg. A double-hulled ship is built with an additional inner hull. The area between the two hulls can be used for ballast, but not for cargo. The aim of the using double hull is that if the outer hull is pierced, the cargo will still not leak out of the ship. On the other hand, adding an additional layer of steel also increases the size of the tanker. Because of volume and weight concerns, naval architects often decided to use more high-tensile strength (HT) steel in the design of the new double-hulled tankers.

Along with the dimensional differences between single- and double-hulled tankers, operators have found differences between the environments in the cargo tanks. The main difference in the environment is that the cargo tanks in double-hulled tankers are often warmer due to the thermos effect. When the oil is loaded into a tanker, it generally cools over the voyage to the temperature of the surrounding water. This temperature change often only takes a couple of days for a single-hulled tanker; however, for a double-hulled tanker, the outer hull can act as an insulator and it may take 20 to 30 d for the temperature of the cargo to reach sea temperature[6].

Importance of using doublesided structures: Some cargoes will require heating, others cooling, some are so volatile that they must be kept safe under a blanket of inert nitrogen, others react violently with water and so must be handled in ultra-dry conditions. Some cargoes are highly corrosive and require tanks of the highest quality of stainless steel, while others must have tank coatings of a precise specification. Some cargoes must be kept in motion, lest they settle out and others can only be carried in tanks that have never carried cargoes with which they are incompatible. Some cargoes can be tainted by the residue of a previous cargo even after a stainless steel tank has been meticulously cleaned and purged. Some cargoes react violently to others or to exposure to the atmosphere. Many are flammable, explosive or give off noxious vapours, Since safety will always be an important consideration. Many of these chemical cargoes are immensely valuable, demand fantastic standards of cleanliness to maintain their product purity and must be discharged to the last drop, without any remaining on board[7].

New products are being developed all the time by the chemical industry throughout the world and being offered for shipment. Keeping up with the new products is a special responsibility for this sector of the shipping industry that has a modern fleet of double-hulled ships ranging from 3,000 ton acid tankers to 40,000 ton chemical parcel vessels[2].

To plan the prevention of and the preparedness for accidents involving harmful substances, updated information on all aspects of transport is required. This takes into account information on what substances are handled, in what amounts and on what routes these chemicals are transported. The handling of chemicals is a very demanding task and if an accident occurs, information on the amounts and characteristics of the chemicals should be immediately available.

In the case of grounding accidents the double-bottom construction gives additional safety against rock penetration through bottom plates, thus preventing the loss of stability or the outflow of chemical.

It can be seen from the above list that chemicals present many difficulties to the shipowners and crew. A further complication is the fact that most chemicals are transported in relatively small amounts. The ships which carry them are consequently much smaller than crude oil carriers but are expected to carry several different products at the same time.and also these products will have different and usually incompatible properties.

Conclusion

The chemical tanker is basically a development of the last 40 years. The development of the chemical industry have been following the end of World War II led to a demand for ships in which to carry the industry's products.

Although It is a well known fact that the number of large scale oil and chemical spills has declined during the last decades The safety of chemical tankers importance are also introduced by IMO and MARPOL with several new requlations and those need to use in order to improve maritime and environment safety. In order to prevent any chemical transportation incident or accident the requlations need to obey by the all related areas.

Chemical tankers are among the safest ships afloat. One reason for this is the action taken by the industry and governments to adopt and implement stringent regulations regarding both safety and pollution prevention which are IMO requlations are presented in the above.

Even if chemical tankers do take safety aspects into consideration, there are a number of other ships in the same sea area, as well as a number of ships crossing their paths and meeting each other with safely in narrow sounds or in dense traffic areas and this will provide the chemical tanker fleet increased. The product and chemical tanker sectors have experienced positive market demand in recent years. The legacy of this is currently a large orderbook. In addition, the introduction of new vessel regulations is set to see a large-scale change in the fleets.

Since piping, monitoring and control equipment is highly complex, all procedures involving the chemical cargoes have to be carried out with great care and precision, in order to avoid cargo contamination, polymerization, explosion *etc.*

Ship construction also has to be of the highest possible standard. Tank cleaning is crucially important to cargo purity, so traditional stiffening inside the tanks is minimized. Welding and other constructional features must be of the highest possible quality.

Although around 80 % of all incidents and accidents are due to the human factor, new technical means (VTS, AIS, ECDIS, *etc.*) have been established to improve safety, in order to prevent accidents and environmental damage.

The purpose of this Marine Information Note is to draw the attention of the shipping industry and the chemical industry to new International requirements which already effective as of 1 January 2007 with the total revision to MARPOL 73/78 Annex II and the IBC Code.

Furthermore, the hull is protected from damage from cargo loading and offloading equipment. Double hull sided chemical tankers will be decrease the chemical pollution that cause from ship collison, corrision and damage. There are two key advantages identified for the double skin side bulk carrier; the existence of redundancy in case of penetration of the outside shell from a low-to-moderate energy impact and the primary structural members need no longer suffer from corrosive effects by being in direct contact with the cargo. This needs to be taken action by the industry and governments to adopt and implement stringent regulations regarding both safety and pollution prevention.

In order to transport chemical materials with safely, all the related transportation parties need to take account above mentioned criteria and this will be provide the increase of chemical tankers fleet proportion in the general tanker fleet.

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