

## AN ANALYSIS OF BUILDING REQUIREMENTS FOR OIL TANKERS IN ORDER TO PREVENT MARITIME ACCIDENTS

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### ABSTRACT

One of the major components of tankers' architecture is represented by the hull's design. A tanker having a simple exterior structure between cargo and the ocean is not safe enough when it comes to protecting the cargo which is valuable or the environment from pollution in case of collision or grounding. Most of the new tankers have a double hull with a supplementary space inserted between the cargo tanks and the ship's hull. There have been also some hybrid designs such as those with double laterals and a double bottom combining characteristics of the single hull ships with characteristics or those which have a double hull. In this paper we intend to present the advantages of the double hull projects such as easier ballasting operations in case of emergency, a reduction in the use of salt water for ballasting cargo tanks which led to a decrease of the corrosion phenomenon, a higher protection of the environment, faster cargo discharge operations, more efficient cargo tanks' washing operations and especially an increased protection in case of collisions and groundings having a lower impact over the safety of the ship, cargo and marine environment.

The main disadvantages of such a project are the high costs involved in building such a tanker, higher operation expenses (higher canal and port taxes), more difficult operations in ventilating the ballast tanks, the necessity for constantly monitoring and maintaining the ballast tanks, an increased surface, which led to more surfaces to maintain, a higher risk of explosion in the doubled tanks if the vapours' detection system would not be efficient and ballast tanks' washing becoming more difficult for double hulled ships. Over all, we are going to show how double hulled tankers are considered to be more secure in case of grounding especially if the soil is not too rocky. Still, the safety benefits are less clear for larger ships in case of a high speed impact. This is why our paper intends to show that in spite of such restrictions, the safety benefits do exist for double hulls even if less clear in case of an impact at high speed.

**Keywords:** *building requirements, oil tankers, double hulled, single hulled, accidents.*

### 1. INTRODUCTION

The inert gas system of an oil tanker is one of the most important components of the ship, and this is why special attention is paid when designing such a system. The fuel itself is quite difficult to be burnt but its vapours are flammable were they combined with air in dangerous concentrations. The purpose of such a system is to create a proper atmosphere inside the tanks in which vapours would not ignite. As the inert gas is led into a mixture of hydrocarbon and air vapours, it raises the minimum flammable limit or results in the lowest concentrations at which the vapours can ignite. It also lowers the maximum flammable limit or the maximum concentration at which the vapours can burn. When the total oxygen concentration in the tank attains 11%, the limits of the maximum and minimum flammability converge and the flammable variation disappears. Inert gas systems produce air with an oxygen concentration of less than 5% volume. As a tank is pumped out, it is filled with inert gas and maintained safe until the next cargo is loaded. However, there is an exception when it has to go into the tank. Proper ventilation of a tank is made by hydrocarbons vapour discharge with inert gas until the hydrocarbon concentration in the tank goes below 1%. Therefore, the air replaces the inert gas and the concentration cannot increase above the lowest flammable limit and becomes safe.

### 2. LOADING / UNLOADING OPERATIONS

The cargo flows from the tank to the shore station via the maritime loading equipment attached to the cargo collector attached to the tank. Operations on board tankers should obey a number of international practices and laws. Goods can be loaded and unloaded on board an oil tanker in different ways. One of the practices is to moor the ship to the quay and then connect her with a cargo hose or marine loading equipment in order to load cargo. Another method involves mooring the oil tanker to the offshore buoys connecting an underwater cargo hose. Another way to load liquid cargo is the ship-to-ship transfer. When using this method, two ships meet abeam in the offshore and oil is transferred from one tank to another via a flexible hose. Berthing to a buoy is also used when the ship is too large to enter port.

#### 2.1. Loading

When describing loading, first of all we need to talk about the process of pumping cargo into the ship's tanks. As the oil enters the tank, the vapours from the tank must be evacuated which is why loading operations need to be very precise and properly conducted. Depending on the local legislation, vapours may be discharged into the atmosphere or discharged back into the pumping station by using the vapour recovery line. It is also normal for the ship to unload ballast water during loading in order to maintain proper balance.

#### 2.2. Discharging

The oil unloading process from the tank is similar to loading with some key differences. The first step is to obey the same procedures before transfer. When the unloading begins, the pumps on the ship will be the ones used to transfer product at shore. Similar with loading, the transfer starts at low pressure to make sure that the equipment is working properly and that all connections are secure. Then she touches her constant pressure and is maintained throughout the operation. During pumping, levels in the tank are carefully monitored and key points such as connections to the freight and cargo collector pump room are constantly monitored.

### 2.3. *Washing the tanks*

Cargo tanks should be washed from time to time for various reasons. One reason, and probably the main one, is changing the type of cargo transported in the tank. Also when the tanks are to be inspected, they should not only be washed but also ventilated. On most tankers there is a system especially necessary for the washing process. This system helps to circulate part of the cargo through a fixed tanks washing system in order to remove wax and other deposits. Tanks carrying less viscous cargo may also be washed with water.

After a tank is washed, it also needs to be properly ventilated in order to be ready for the next cargo. Ventilation is carried out by pumping the inert gas into the tank until the hydrocarbons have been sufficiently evacuated. Then the tank is ventilated by the introduction of fresh air. Ventilation leads the oxygen concentration in the tank up to 20.8% O<sub>2</sub>. This process makes it possible to have an atmosphere in the tank which shall never ignite.

## 3. CONSTRUCTION REQUIREMENTS FOR OIL TANKERS

Based on the analytical comparison of single and double hulled design using the statistical data methodology, the authorities concluded that in the case of an accident involving collision or grounding, a properly designed double-hulled tanker would significantly reduce oil leakage compared to single-hulled ships. Similar analytical results were obtained for barges navigating the ocean. Therefore, the authorities decided for the whole fleet of petroleum carriers to switch to double hull which would also increase protection of the environment.

Despite the potential benefits of the double hull, not all double-hulled vessels designed or built after 1990 provided environmental protection and safe operation which they expected when the double hull was adopted. These potential problems clearly demonstrate that the national and international schemes of the projects originally developed for single hulls are not suitable for double hulls' projects. Using performance-based design criteria takes into account variations in the performance of the different double hull projects and ensures flexibility in the development of possible superior projects.

Ship owners and oil tanker operators reported significant differences between single-hulled and

double-hulled tankers with regard to operational safety, inspection and maintenance, and handling of cargo. Except for some concerns about access and ventilation in ballast spaces and on stability, industry representatives generally think that double-hulled tankers can be operated safely with greater attention than those attributed to those with a single hull. The impact of the double hull obligation on the international tankers industry on the one hand, led to the exclusion of simple tankers and, on the other, to their withdrawal from international trade 30 years after construction.

With the adoption of these international trends, many of the tankers involved in international trade have been phased out before the date of withdrawal from the market. In other words, their hope for life was not affected by the double-hull legislation. However, economic factors influencing the lifetime of tankers have changed partially due to the requirements for the Double hull. The costs of a double-hull tanker are estimated to be from 9 to 17 per cent higher than those for single-hulled tanks, and the cost of operating and maintenance ranges from 5 to 13 per cent higher as well. In recent years, there has been a question of reducing maritime pollution and shipwreck loss following accidents due to collision or groundings. Damage resulting from the accident of the Exxon Valdez vessel has determined the US to promulgate the Oil Pollution Act (OPA-90).

In 1992, MARPOL was amended to make it obligatory for standard tankers of 5,000 TDW and larger built after July 6, 1993 to be equipped with a hull or an alternative design approved by the IMO (Regulation 19 of Annex I to the MARPOL). The same requirement, which applies to new tankers, has already been applied to ships existing under a program that began in 1995 (under the old 13G regulation (now Regulation 20 of Annex I to MARPOL). All oil tankers should have been modified or put out of use when they reached a certain age (up to 30 years of age). This measure has been adopted to eliminate the overworking of shipyards because the capacity of a shipyard is limited and it is not possible to modify all of the existing ships simultaneously without causing a disturbance to world trade and industry. The double hull requirements were adopted in 1992 following the incidents produced over the years. IMO Member States have proposed to speed up the removal of single-hull oil tankers. Thus, in April 2001, the IMO adopted a new program to remove these types of ships, a program that entered into force on 1 September 2003. In December 2003, other changes were made, further accelerating the program for the removal of single-hull vessels. The new amendments have been applied since the date of 5 April 2005.

## 4. COMPARISON BETWEEN SINGLE HULL SHIPS AND DOUBLE HULL SHIPS

A double-hulled ship may be defined as a ship designed to carry bulk oil products whose storage spaces are separated from the outside environment by a Double hull both on the laterals and on the bottom of the ship, space that is dedicated for storage of ballast water. The risks of an accident or grounding near the coast, where vessels are assumed to use low speed due to the heavy

traffic or restricted areas are low. Oil spillages are unlikely to occur. However, in the event of such an incident, the double hull reduces the risk of spillages.

For example, in 1997, the Nissos Amorgos ship, a single hull tanker grounded in the bay of Venezuela. Following this incident a water hole occurred, so significant leakage of petroleum products resulted. In the same area another oil tanker, Olympic Sponsor, a double-hull ship, following a similar incident suffered an exterior rift, the inner part remaining intact. So there was no pollution.

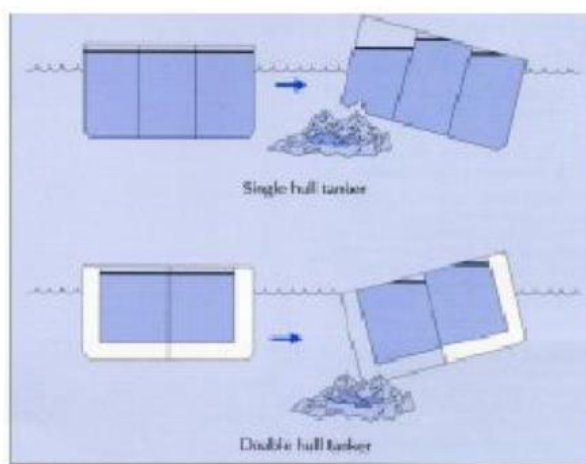


Fig. 1 Single hull ship compared to double hull ship



Fig. 2 Section inside a double hulled ship

At the time when it was first proposed to build double-hulled ships, many questions appeared about the risks that may arise. The most important areas of interest were: maintenance, operation, construction, saving, design, stability, ventilation and access in cargo tanks or ballast tanks. Proper maintenance is the responsibility of the ship owner. One of the most important causes of cracking in the ship's hull is represented by undetectable corrosion. Also if the integrity of the protective layer of the ballast tanks is not properly maintained, for example, it can lead to leakage, pollution, and even fires. For double-hulled vessels maintenance of ballast tanks is perhaps more important because they cover a larger surface area of the vessel compared to single hull vessels. According to the structure, ballast tanks are

more accessible to the inspections if the ship has a double hull compared to single hulled vessels because for the first type of ship the width of the ballast tanks is 2 to 3.5 m.

When it comes to the operation of these vessels, compared to single hull vessels, those with a double hull have two disadvantages in terms of stability. A disadvantage is given by lifting the centre of gravity by adding the double bottom, so the stability reserve is reduced. The second disadvantage is given by the existence of free surfaces both in cargo tanks and in ballast tanks, which occupy a large surface in the case of double-hulled vessels at the time of loading or unloading cargo. Free surfaces cause the loss of stability of the ship and the appearance of a transversal tilt angle, especially if the ship was not designed with longitudinal bulkheads in cargo tanks. The operational procedures necessary to maintain stability in such cases may restrict the operating procedures.

The greatest danger in the operation of double-hulled vessels is that of potential leakage of cargo in the ballast tanks. Leakage occurs due to fractures occurring in the walls between cargo tanks and ballast tanks due to local tensions, constructive defects or corrosion. Another danger is due to sediment deposits in the ballast tanks, especially in the double bottom tanks. The piping system for ballast tanks is separate from that for cargo tanks in the case of double - hull vessels, thus avoiding contamination of ballast water with transported products. In the case of single-hulled vessels, the same piping system was used for both cargo tanks and ballast tanks and there was a possibility of contamination of the ballast water. In the shipbuilding process, the most important aspect is that of ballast tanks. The interior of these compartments may be affected the most by corrosion due to salt water. Due to the fact that in double-tankers the surface of these tanks is larger they are more affected by this problem. Although protective layers are a mandatory requirement of the classification societies, the ship owner is the one who decides the type and the number of layers and makes sure that they are properly applied. Closed areas of ballast tanks, side or bottom, are much more restrictive when working inside them compared to single-tanks.

The three-dimensional shape of rigid blocks used in the construction of double hulls is less susceptible to deformations than the two-dimensional components most commonly used in the construction of single-hull vessels. However, the number of cross joints used under construction is increased, most of them being used in critical areas, areas which are subjected to higher levels of stress. In the case of rescue operations, we can encounter the following situations: In case a double-hull tank goes aground, resulting in a break in the exterior surface, statistics show that the inner wall in most situations does not suffer cracks. In the case of a single hulled oil tanker breaking the plank will cause drainage of the cargo causing a decrease in weight of the ship, which will help the ship to re-float easier.

Damage to an L-shaped ballast tank on double bottom ships will produce flooding of one of the edges subjecting the ship to a transverse list, so the ship does not rest on the ground that sustains it, continuing to float.

This can be corrected by balancing a tank on the opposite board. For the Prestige, one of the boards was flooded, and a tank on the opposite board was ballasted to put the ship on straight keel. This made the ship's body to be overloaded by 68% higher than the limit for which it was designed. The difference between the reaction mode and the design of double - hulled and simple hulled ships in case of an accident depends largely on weather conditions at the moment, as well as the availability and training of rescuers, but according to statistics, it will take longer for double-hulled vessels to be re-floated, compared to those with single-hull.

Shipbuilders constantly use their accumulated experience in designing ships over the years, and each new ship becomes a development of a previous successful project. This is due to the complex interactions between the variables that affect the structure of a ship during her life at sea. Thus, the variables that can affect the structure are: thickness of planking, tensile areas, stiffness and correct transmission of loads; the quality of the construction is affected by local imperfections, steel quality and welding; distribution of cargo weight; the static and dynamic forces of the waves resulting from the roll and pitch; engine vibrations; corrosion and internal distribution of voltage zones between primary, secondary and tertiary structures.

Double-hull vessels can operate under stress conditions at a 30% higher level than single-hull vessels, due to the uniform distribution of cargo and ballast water along the ship. Cross-stability was not considered to be a problem for single-hull vessels. This type of ship had longitudinal walls along the cargo tanks to provide a longitudinal resistance. The distance between these walls could be chosen in such a way as to ensure an equal capacity between the compartments.

In the case of double-hulled vessels, these longitudinal walls are not required, because the inner hull provides a long enough longitudinal resistance. Thus, cargo tanks have a larger capacity, but also the effect of free surfaces is greater, resulting in a decrease in transverse stability. When it is combined with the effect of the double bottom, which raises the centre of gravity of the ship, it results in a substantial reduction of stability. This phenomenon can occur during the simultaneous loading of cargo and ballast water. This requires higher attention to the distribution of freight on a double-hulled ship compared to a single-hulled ship. In the case of double-hulled vessels, increased attention is also needed for ventilation, cargo leakage check, corrosion and sediment deposit in ballast tanks due to their cellular nature. Right from the beginning, starting with the design and then during construction enough ventilation holes must be ensured.

## 5. CONCLUSIONS

Although tankers are very efficient in the transport of petroleum products to destination from all over the world, this kind of ships are criticized for the accidents in which they can be involved. The main reason for these criticisms is represented by the devastating consequences that may result from oil spills, fires or even explosions.

Finding solutions in this regard has therefore become imperative. Thus, one of the solutions to reduce the environmental impact of accidents on tankers, was the replacement in the design and construction of this type of vessels of the double sheath simple cover. This solution presents both advantages and disadvantages.

Despite the potential benefits of the double hulled, which are presented in the paper, not all the tankers designed and built after 1990 provide protection to the environment, because double hulls do not guarantee that there will be no oil spills. Another disadvantage is that this new structure does not ensure the safety functions that were expected.

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