Vessel and Fleet Technical Management

Marine Coating

February 2008

By Markus Brinkmann

MSc Marine Engineering and Management

Content

1.0 Introduction

In recent years the regulations and international requirements which ship operators have to comply with have significantly increased. These regulations cover all aspects of maritime operations and affect the conventional methods of managing fleets. However, recent developments have forced the ship management and operation sector to recognise the economical and ecological benefits of paint coats.

This chapter provides a general overview on preventions against corrosion on ships and demonstrates how the management and operations of a ship have to adjust according to the given guidelines and regulations.

2. Ships benefit through marine coatings

The benefit of coatings for a cargo ship is the prevention from corrosion and infestation. In operational terms, it is a way of increasing the life span of the metal structure as well as maintaining its profitability in terms of speed and fuel consumption.

There are different coating systems on a ship due to the nature of the various surfaces on the ship. The main surfaces on the ship are known as the outer hull, cargo hold, and deck area. The outer hull is the outside of the ship that requires a paint coat that can protect the ship from continued contact with salt water and fresh water. The cargo hold is where a variety of goods are stored and therefore requires a different paint coat due to the nature of cargo. The deck includes the main work area of the ship as well as the crew living quarter. This surface area has to be constantly improved and monitored to ensure safe loading and unloading of the cargo.

A ship that is well maintained has the advantage of a longer life span due to the continues strength of the metal. Rust infested metal does not only create damage to the affected area but it also weakens the strength of the metal. However, it is possible to replace the corroded metal but not the structural damage in the mainframe of the ship, which is why corrosion has to be dealt with almost immediately.

Another advantage of a superior paint coat is the operation of the ship. The surface of the hull defines the speed and therefore the fuel consumption of the vessel. As the fowling of the hull service increases, the performance declines accordingly. This can reduce the speed to more than 10% of its original performance.

Most importantly a continues maintenance of the paint coat reduces cost in the long run due to less repair expenses as well as reduction on time spent in the drydock due to repair work.

3. Survey on ships

Continues surveys have been implemented by Flag States, Classification Organisation and Charterers. These different inspections take place on regular intervals when the ship is in the port or drydock.

The survey intervals change according to the task of the ship (Tanker, Bulker or Container) as well as to the age of the ship.

The survey is carried out by a skilled engineer using a hammer and torch. The engineer uses the hammer to identify weaknesses in the metal. Additionally, gauging the steels thickness may be required depending on the survey or recommendation from the engineer.

The ship should be examined according to the required standard (e.g. ESP) to ensure the condition of the ship. Furthermore, it has to be checked if corrosion over the allowed limits, and if these items must be replaced during the inspection.

All classification societies have developed permissible limits to thickness reductions of the steal and have introduced rules according to which the plating is replaced if the permissible limits are exceeded. In the following example, the permissible reductions have been adopted by the Hellenic Register of Shipping (HRS) included in Table 3.0.

Table 3.0: Permissible wastage due to corrosion t_k (mm)

Structural members and plating bordering with	Compartment /cargo hold region	
	1.5m below the main deck	Elsewhere
Water ballast tanks	3	1.5
Cargo oil tanks	2	1
Dry bulk cargo holds	1	1
Water ballast tanks/Cargo oil tanks	2.5	1.5 ,1.0
Water ballast tanks/dry bulk cargo holds	2	1.5 ,1.0
Water ballast tanks/other compartments	2	1
Cargo oil tanks/other compartments	1	0.5

(Source: Hellenic Register of Shipping, 2001)

4. Corrosion

Corrosion is the breakdown of metal through a chemical reaction with oxygen and water. For example, iron or steal will not corrode through dry air or water which is free from dissolved oxygen, which proves that both oxygen and water are a necessary part to initiate the corrosion process.

Corrosion may rapidly lead to serious problems on the ship when the main structural areas are affected. The corrosion rate however may change according to environmental conditions such as temperature, oxygen content and water velocity (Fig. 4.0).

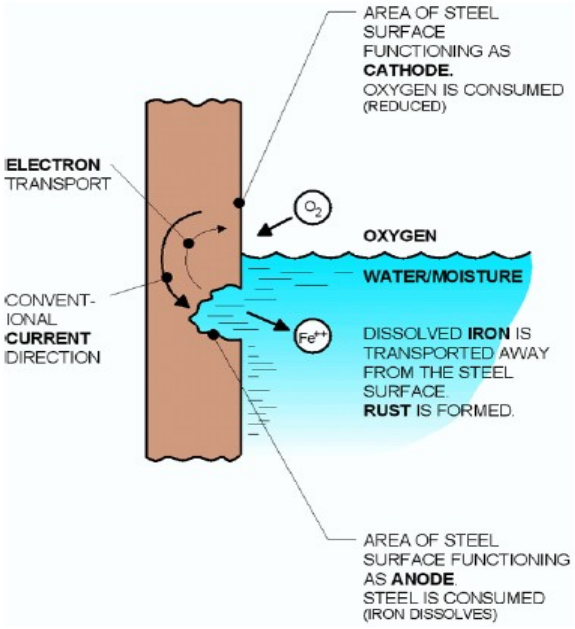


Fig. 4.0: Mechanism of Electrochemical Corrosion (Source: DNV Piraeus, 2003)

4.1 Dry Corrosion

Dry corrosion occurs through the connection between metal and gas/vapour. The main characteristic of dry corrosion is that the reduction of metal and the formation of compound must occur at the same place.

4.2 Wet Corrosion

The wet corrosion is the oxidation and reduction of the metal in a fluid. The oxidation here occurs at different areas of the metal.

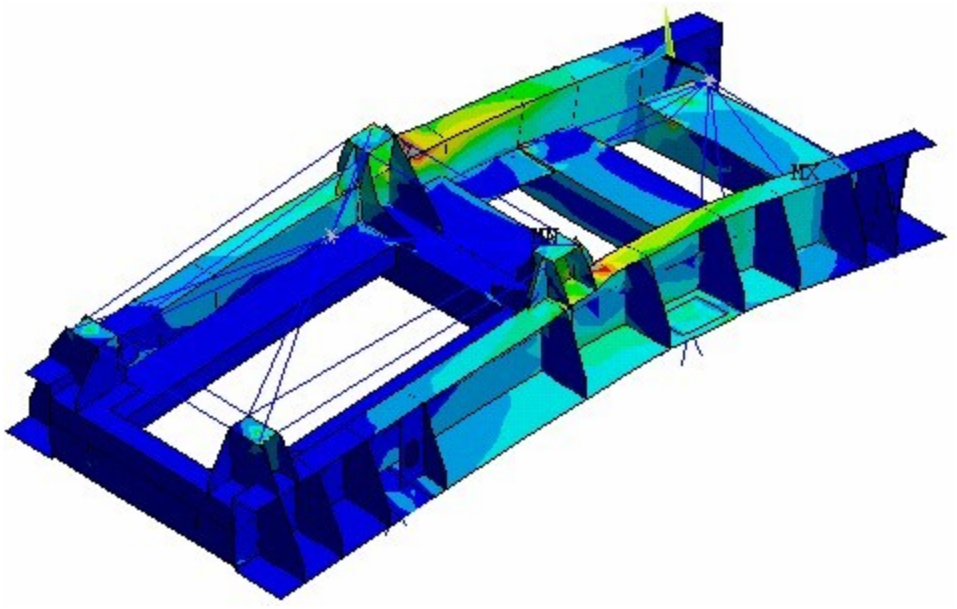
5.0 Stress and Fatigue

The main damages on ships and offshore structures arises from loading/offloading cargo as well as heavy weather that may not necessarily approach the critical stress levels but over time weaken the structure of the ship. This is why it is more appropriate to use high quality steel instead of light aluminium for the ship structure.

For example, some of the main structure of the MV Queen Elizabeth II had to be rebuild earlier than expected due to the use of aluminium instead of steel as the main structure.

In order for ships and offshore structures to prove financially sound investments, the duration of their useful life is usually estimated at 25-50 years. During this length of time, it is estimated that they will be subjected to more than 108 varying and often repetitive loading in different temperatures and weather conditions. The continued loading and unloading, the effect of waves, the environment and their long useful life all contribute to the occurrence of damages that are attributed to fatigue.

The loading and offloading as well as bad weather creates movement in the metal which weakens the paint coat and causes it to brakes. The failure of the paint coat reduces the protection of the metal and enables water as well as moist air to corrode the exposed surfaces. Due to the general ship design it is possible to determine where it is most likely for problems to occur in the paint.



6.0 Paint Coatings

The coating on the metal structure main task is the prevention of corrosion of the metal surface as well as minimisation of infestation by marine organisms.

In order to achieve this protection, the following three paint procedures have to be applied:

***First Procedure**:*
This paint coat is a barrier protection to prevent oxygen, moisture and any corrosive fluid to reach the metal structure. However, the current paint coats can not protect the metal structure fully which is why the typical barrier coatings are two-part epoxies (e.g. epoxy amines) to improve the probability.

Second Procedure:
This coating protects by inhibition which contains special pigments and other chemicals to inhibit the corrosion reactions on the steel surface.

Third Procedures:
This coating contains zinc in powder form. Zinc is more active than steel which means if the zinc comes into contact with water it will corrode instead of steel. Most of the times zinc is contained in the primer or in big objects on the hull surface to protect the steel.

The primer is the first coat applied to the clean metal surface. It is very important to ensures that the surface is sterilised before applying the paint. This preparation supports the coating connection to the metal. Many primers for steel also contains anti-corrosive pigments that actively assist the control of corrosion.

Intermediate coat or undercoat is required in many coating systems and may provide one or all of the following functions; improve chemical resistance, serve as an adhesion coat between the primer and topcoat when the primer and topcoat are not compatible, and increase the thickness of the coating system.

The finishing coat also called the topcoat is formulated to chemically resist water and or other fluids and provide characteristics such as colour, gloss and wear resistance.

7.0 Antifouling Paints

Fouling is the undesirable growth of marine organisms on artificial structures immersed in seawater. The most visible form of such fouling is seaweed, when attached to a ships hull it reduces the performance of ships considerably. Worldwide, the cost of keeping marine fouling minimal is estimated around 1.4 billion US$ per year. [Clare 1995].

The process of fouling can be divided into four stages, as illustrated in (Fig. 7.0).

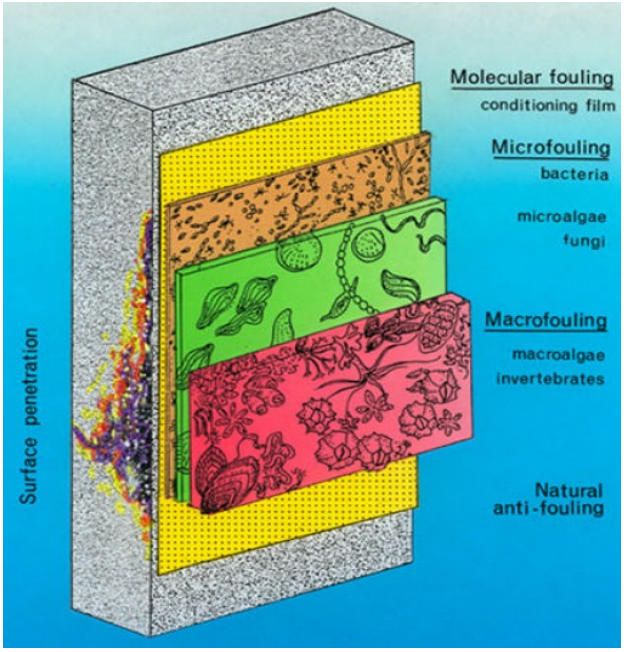


Fig. 10.1: Build-up of marine biofouling
(Source: Davis and Williamson, 1995)

Soluble Matrix paints have a natural product (Rosin) as a binder. This rosin slowly dissolves in seawater. When the coating is immersed in seawater the biocide leaches out of the paint. This release rate however soon falls to a level below which the fouling can be controlled. The lifespan of the paint coat is approximately 12 months.

Insoluble Matrix paints has a binder that is insoluble in seawater. As only biocides are released the paint film is left as a porous skeleton. As the porous layer increases, the rate of biocide release reduces. Eventually no more biocides can be released and anti-fouling performance drops dramatically and the layer becomes clogged with fouling. The lifespan of the paint coat is approximately 24 months.

Self-polishing Anti-fouling were introduced in the 1970s, which made it easier to plan material purchases and the sailing intervals between dry-dockings.

The new technology introduced at a time when fuel prices increased drastically, which made it possible to provide considerable economic benefits to the shipowner. The anti-fouling contain chemically bound organotin which is released following hydrolysis in seawater. Once this is released the remaining polymer backbone is soluble and is released from the surface. Layer after layer of the anti-fouling provides the same performance until the total paint film is polished away. Selective erosion occurs because the turbulence on the surface peaks of the paint is greater. These peaks erode at a faster rate than the general paint film and lead to a polishing of the surface. Roughness is therefore reduced and results in more economic performance.

During the 1980s the environmental protection agencies in the USA and Europe were concerned over the use of tributyltin (TBT) in self-polishing anti-fouling, especially on small craft. Studies had indicated that significant marine life in waters near ports was deformed or extinct. It has been suggested that there may be a ban on the use of TBT. Up to now only Japan has put forward a total restriction on the use of TBT for all vessels. Furthermore, in the North Sea TBT-based anti-fouling coated vessels of less than 25m in length have been banned. It is foreseeable that in the near future a World wide ban on their use TBT will be implemented.

8.0 Repairs in the dry dock

Large surfaces such as the outer hull of the ship and big cargo spaces and ballast tanks can only be coated properly in a drydock because the equipment required as well as the techniques being used.

When a ship is placed in a drydock the hull will be cleaned from salt water and any infestation by marine organisms. Thereafter, it is common to take off the current paint layers until the metal is totally cleaned of all substances. Following this process the undercoat has to be applied immediately to minimise any water particles connecting to the metal surface.

9.0 Repairs while travelling

It is common to repair the ship while sailing on the sea to minimise the effect of minor damages and continue repairs that have not been finished in the drydock.

The repairs are being commenced by the skilled seaman on the ship which are coordinated by the 1st Officer, Foreman and/or Mechanic. The Foreman is responsible for the quality of the finished repairs, which is why he chooses the right paint and mixes the two component paints together if necessary.

10.0 Systems against corrosion

Seawater, ballast water as well as cargo-sweat are significant factors that can contribute to the corrosion of the metal structure. Water, especially salt water (seawater) contains sulphur compounds that can harm exposed metal on the ship.

Seawater is being used to clean cargo holds to reduce costs. For this process the transfer pipes are a common weakness and need intensive cleaning with fresh water afterwards.

The strong temperature changes and continues refilling of the ballast tanks with seawater makes it particularly hard to protect the surface. Due to this situation it is fairly common to use a strong two component paint in the ballast tanks.

Moving parts such as cranes, hatches and doors are the Achilles Heel of the deck. To protect these part continues oiling and waxing is required.

Cargo sweat can only be minimised by ventilating the cargo hold accordingly to calculations of the temperatures of the cargo, air outside and water surrounding the ship. Furthermore, including in this calculation one has to incorporate the current weather (wind and sunshine) as well as the humidity.

11.0 Conclusion

The different systems to prevent corrosion as well as infestation of the surface by marine micro-organism support the functionality of the ship. Though it is necessary to implement all of the systems to reduce costs as well as extend the lifetime of the vessel.

Better and more profound surface protection systems will be developed in the near future to aid vessels as the competition increases and environmental awareness rises.