Dehumidification For Ballast Tank Coatings

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ABSTRACT

Ship ballast tanks present themselves to very corrosive exposures .The paper briefly outlines the nature of corrosion in ballast tanks ,concepts of corrosion and supports application of Protective Coatings as an effective tool for preventing it. Explaining the effect of high humidity while preparing the surface for coating , the need to control the moisture level of the surrounding air to prevent premature coating failure is identified. The paper proposes the use of Dehumidifiers for removing moisture from air while preparing and coating the surface for improved coating performance.

INTRODUCTION

Corrosion Protection in consistently and severely corrosive marine environment often poses a challenge to ship building and maintenance industry. The shipping industry expends considerably on corrosion protection measures to extend the longevity of ships and for increasing the general safety of the vessel.

Fig 1 Ship Maintenance

Steel, the most corrosible of all construction materials, still remains the most economic choice of material for construction of ships and applying protective coatings as the main corrosion prevention system. Though a wide variety of coatings have been developed, the poor coating practices followed often impair the life of coating and thereby that of the ship. The most critical parts of a ship susceptible to corrosion are the boot top / under water areas, ballast tanks and cargo tanks. Considerable financial losses can result from premature damage to the coating systems of these critical parts.

BALLAST TANKS

The outer hull which creates the external shape of a ship forms the ballast tank. The ballast tank, in concert with other tanks internal to the boat, permits the crew to change the ship's buoyancy. The inner water ballast tank surface area of a ship is extremely large. The water ballast tank surface area for a single hull would range from 1.5 million to 1.7 million sq. ft. and that for a double hull from 2.6 million to 3 million sq. ft. The irregular configuration of the ballast tank structure, with welded stiffeners and edges and corners, and its exposure to extremely corrosive environment make it a vulnerable prey to corrosion.

Fig 2.Ballast Tank showing multiple bays

Ballast tanks need careful attention since they form the basic skeleton of a ship and the useful life of a ship is often dependant on the condition of its ballast tanks. The large and complex structure of a ballast tank coupled with frequent wetting and drying in highly corrosive salt water environment makes it one of the biggest maintenance burdens for ship owners and maintenance staff. Maintaining Ballast Tank Coatings of high quality standards helps ship owners not only by the way of cutting down the steel renewal costs over the years, but also maintains the value of the vessel at a higher level .

CORROSION IN BALLAST TANKS

Corrosion occurs with the formation of hydrated ferric oxide (commonly termed as rust) from the electrolytic reaction between iron metal , oxygen and water . The reaction mechanism which is generally accepted involves anodic and cathodic processes. The surface of the iron or steel in contact with water develops localized anodes and cathodes at which these processes takes place. The electrolytic process is schematically illustrated below:

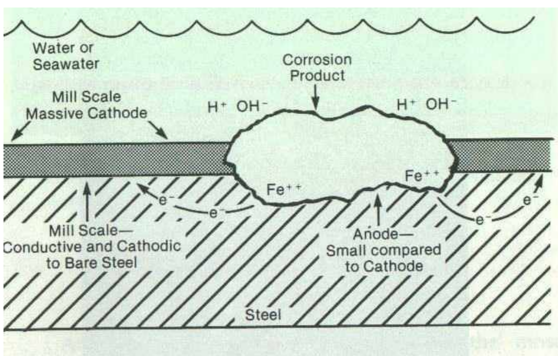

Fig.3 Electrolytic Process of Corrosion

The individual electrode process could be shown as:

At anode : $4\ Fe \rightarrow 4\ Fe^{++} + 8\ e$

At cathode: $4\ H_2O + 2\ O_2 + 8e \rightarrow 8\ OH^-$

The initial product of oxidation is thus ferrous hydroxide

$4\ Fe^{++} + 8\ OH^- \rightarrow 4\ Fe(OH)_2$

In the presence of excess oxygen the ferrous hydroxide is oxidized to hydrated ferric oxide which is rust.

Corrosion in ballast tanks may be either due to the presence of mill scale on the steel surface while ship is under construction or due to pitting of the steel surface.

Mill scale is the layer of oxides of about 60 μm thickness , formed on the surface of steel while it is manufactured . Mill scale , if not properly removed and cleaned ,causes corrosion because of the development of potential difference between the mill scale and bare steel in the presence of an electrolyte ,as sea water .

Pitting is a form of extremely localized attack of corrosion which causes the metal to go into solution more rapidly at that spot than at any other adjacent area. In ballast tanks pitting corrosion mainly occurs due to irregularities in coatings due to improper surface preparation and coating practices . Though pitting may or may not result in the formation of holes in the metal ,it causes major damage to the structural integrity of the tank sometimes resulting in its catastrophic failure.

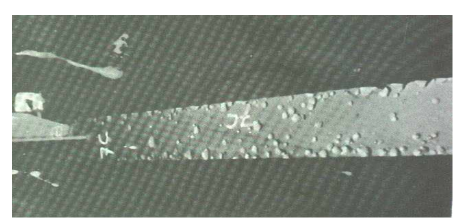

Fig 4.Deep Pitting in a Ballast Tank

ANTI- CORROSIVE PAINT SYSTEMS FOR BALLAST TANKS

Until very recently the measures adopted for protection of ballast tanks from corrosion were inappropriate, many were not even painted. With the introduction of new regulations by International Maritime Organization ,which specify types of protective coatings to be used in ballast tanks at the new building stage and the stricter survey procedures followed by International Association of Classification Societies , for determining the coating condition of ballast tanks in existing ship , the ship operators face the challenge of maintaining their vessels at the specified conditions .

The Marine Coating regulations propose the use of hard coatings preferably in light colors to make inspection easier and effective. Modern systems for ballast tanks normally consist of at least two coats of straight , modified or solvent free epoxies with a total dft of at least 250 micro meters for straight and modified epoxies and 300 to 350 micro meters for solvent free epoxies.

Epoxy based protective coatings have proven to be one of the most effective corrosion protection measure for ballast tanks. But it is often seen that these coatings generally considered to be good performers in corrosive environment, fail much before their specified life. There are several factors which contribute to the short service life of the current coating systems , the most common being poor surface preparation. Uncontrolled environmental conditions during surface preparation leads to surface contamination and moisture condensation on the surface causing the coating to fail prematurely.

Classification Societies have formulated guidelines for application of recognized coating systems for ballast tanks, the emphasis being mainly on the increasing degrees of surface preparation required for increased useful life of the coating.

Surface Preparation

As with any industrial or marine coating project, the key to effective and long lasting protection lies in proper preparation of the surface to be coated. The objective of Surface Preparation is to create proper adhesion of a coat over the substrate. Adhesion is the key to coating effectiveness and it determines whether the coating is just a thin sheet of material lying on the substrate or it becomes the actual part of the substrate. Adhesion is even more critical for the coatings applied inside a ballast tank, where the environment is hot and humid (e.g. 35 C and RH > 90 %) , since condensation on the tank walls hinders the bonding of the paint layer with the surface.

Fig. 5 Corrosion in Ballast Tanks

High humidity causes condensation on the metal surface resulting in blooming or flash rust, between the time the surface is blasted visually clean and when the coating is applied, leading to premature coating failure. In the case of ballast tanks ,because of the wet environment the dew points ar relatively high especially if the ship is in water.

The practical logistics of coating operation also prevent the immediate coating of the surface after cleaning. While the surface is waiting for the coating , small reductions in surface temperature and the presence of high humidity in the surrounding air inside ballast tank result in condensation, which causes immediate corrosion.

Under these circumstances ,the internal ballast tank maintenance is considered as one of the Fleet's significant maintenance burdens. After determining the common patterns and causes of corrosion inside ship ballast , researchers in the field identified the major cause for short service life as improper control of environmental conditions inside the tank. The new Navy protocols developed by Ocean City Research for the U.S. Naval Sea Systems Command specify installation of environmental controls inside the tank during all coating application activities as the key element for improving the coating performance.

DEHUMIDIFICATION – An Aid To Proper Surface Preparation

Any surface after it is blasted and prepared for coating is subjected to environmental factors , until the first coat is applied .Prevalence of high humidity causes the formation of rust bloom on the metal surface , coating over which would lead to blistering and de-lamination. The term "Hold the Blast" is commonly used and referred to the prevention of rust bloom from forming between the blasting and coating cycles. Proper environmental controls with Dehumidifiers helps in 'holding the blast ' during the blast- coat cycle.

A dehumidifier removes enough moisture from the air , so that the air dew point is lowered sufficiently than the surface temperature of the metal. This helps to prevent condensation of moisture on the metal surface thereby eliminating the occurrence of flash rust and mitigating the chances of premature failure of coatings.

The high humidity also results in condensation over coated surfaces and often results in inter-coat de-lamination where multi- coat systems are used . Dehumidification, while eliminating the above problems improves the curing of the paint by saving both on time and quality of finish obtained.

An adequately designed Dehumidification system would be required , inside a ballast tank during blasting and coating operations , to ensure that :

i. the air relative humidity inside the tank is maintained at the level as specified by the Coating manufacturer, for optimum performance of the coating.

ii. the air dew point is maintained at least 5^{O} F (3 ^{O} C) below the surface temperature to prevent condensation and flash – rust , the common reason for premature coating failures. All specifications including NACE ,SSPC, EIL etc. call for a differential of at least 5^{O} F , between the surface temperature and air dew point with surface temperature being higher.

iii. The environmental conditions conducive for coating are extended and coating is completed within the schedule.

iv. Prevents any condensation between coats thereby reducing the possibility of inter- coat de- lamination and improving curing properties .

DEHUMIDIFICATION SYSTEMS FOR BALLAST TANK COATING

The effect of psychometric variables as surface temperature of steel , air dew point and air temperature inside the tank and the air temperature , air dew point and projected rate of change in the ambient conditions outside the tank are analyzed and the proper level of moisture that must be achieved and maintained inside the tank to prevent condensation of moisture on the metal surface is determined.

For determining the dehumidification of ballast tank the following factors are needed / considered:

- Tank and Ship Factors which include size and configuration of the ballast tank and location and space available for equipment

- Weather Factors which include ambient temperature range of air and of ship surfaces during application and curing and moisture in air or absolute humidity

- Required end conditions.

Types of Dehumidification

There are basically two types of systems suitable to dehumidify atmospheric air in enclosed spaces.

i. Refrigerant system which chills the air below the dew point , causing moisture to condense with in the unit,
thereby reducing the temperature and absolute humidity of the air.

ii. Dessicant system which uses a dessicant which adsorbs moisture from the air passing over them.

A dessicant based dehumidifier performs absolutely well in all seasons and if engineered with chillers it could be made to control the increase in temperature especially in hot climates . This would improve the productivity of the workers inside by making the work space more comfortable.

A dehumidification system is specified by the following parameters :

i. Volume of air flow
ii. Moisture removal capacity
iii. Air Velocity through the dehumidifier
iv. Initial and final temperature
v. Power Requirements

Application considerations :
The complete procedure for dehumidification application , from selection to installation , the steps of which are summarized as below:

A. Requirement for dehumidification is ascertained based on following factors :

   a. Dew point, R.H., or temperature is specified in the paint manufacturers data sheet.
   b. Dehumidification is required for controlling the RH or temperature to the specified limits
   c. Dehumidification is required to extend a conducive weather so as to control the down time.

B. Hire the services of a Dehumidification Agency .

C. Based on volume of tank , air changes per hour and surface temperature expected and required , the Agency determines the CFM and provides the appropriate equipment for completion of the job.

D. The layout of the Dehumidification system including placement of equipment and inlet and out let ducting.

E. The operating schedule , the starting and stopping times based on task or specific requirements, is determined.

F. The adequacy of the system is determined by 4 methods viz., checking proper unit function , measuring RH and temperature , measuring air flows and assessing coating failure.

Dehumidification is used 24 hours per day until all the blasting and lining application is complete. Dehumidifiers are applied to the surface preparation operations in the following uncomplicated manner.

Air is taken from the outside environment dried and fed to the interior of the structure where coating is to be carried out. The dry air performs three primary functions :

Prevents condensation and high relative humidity at the surface
Prevents the build up of hazardous vapors inside closed areas to be blasted, during the operations
Provides ventilation air for the personnel at site

The dry, fresh air continuously purges the area or surface and is exhausted to the atmosphere.

BENEFITS OF DEHUMIDIFICATION

Dehumidification would not only extend the useful service life of a coating , but also reduces the normal downtime for ballast tank repair work (which can be as high as 90 days) considerably .

By ignoring this small but very important precaution , i.e. by coating with out dehumidification the ship owners lead themselves to a lot of trouble . But if they take care of this basic requirement they gain in many areas including :

i. No excessive downtime of the ship due to premature failure of coating.
ii. Down time for coating can be accurately programmed and considerably reduced
iii. Less coat per year for maintenance.
iv. Extended life of the ballast tank and thereby the ship.

The major reason for the development of on – board maintenance techniques is the high out- of service hours required for dry dock maintenance , which is worsened in case of adverse weather . By extending the climate conducive for blasting, coating and curing dehumidification enables crew to work day and night and helps in controlling the down time of the vessel. Dehumidification enabled ship yard maintenance would offer itself as a better alternative to the difficult job of on- board maintenance where availability of power , labor , equipment and fresh water are all limited .