

CHAPTER 12

PAINTING OF VESSELS FOR SALT WATER SERVICE

by

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I. INTRODUCTION

The transition of shipbuilding from wood to ferrous materials subject to corrosive attack by the environment made it necessary to provide suitable methods to protect these materials. Coating systems comprised of dense barrier coats or containing inhibitive pigments can effectively protect against corrosion. Finish coats are applied to improve appearance and to protect primers against external influences so they retain anticorrosive properties.

This chapter describes present day practices for application, coating materials and surface preparation for all surfaces on a ship subject to corrosion. New construction will be discussed separately from maintenance and repair because modern construction procedures have made construction coating procedures quite different from those in maintenance and repair. Protection problems vary among ship types such as tankers, freighters, bulk carriers and small work boats. Specialized problems often arise in a particular service, but answers will usually be evident if fundamental principles of marine corrosion and its prevention through the use of coatings are understood and followed.

This discussion is limited to commercial vessels. Naval vessels are considered a special case and are covered in a separate chapter. Even though surface preparation, coating materials and application are generally the same, service requirements for naval vessels are different from those of commercial operators. Navy criteria for testing and approving coating materials and systems are often a guide for selection of items by the marine community, and Naval approvals of proprietary systems often lead to acceptance of the systems by commercial operators.

II. GENERAL DISCUSSION

Coating applicators and equipment manufacturers must follow government regulations covering application and use of coating materials. For instance, the effects of surface preparation on air and water pollution is of considerable concern. Rules and regulations to control pollution add costs and other burdens for the shipyards.

Coating systems that minimize maintenance and the frequency of drydocking are cost-effective. The cost of

drydocking a supertanker runs into hundreds of thousands of dollars, not including the revenue lost while the ship is out of service. Thus effective corrosion control and anti-fouling measures during construction are of utmost importance to the ship owner/operator. Also, strong consideration should be given to repairability of coatings and coating systems. When a ship is being constructed, areas to be coated are usually accessible, and sufficient time can be spent on preparation and application. While in drydock, however, conditions for work can be marginal. When coating systems are selected, therefore, the overall cost effectiveness should be studied, including cost of maintenance, repair, and out-of-service costs.

Surface preparation and coating application traditionally are the last scheduled and least considered operations of construction. Coating during the modular stage of construction has partially relieved some problems, but has created others. Final coating is still dependent on the work schedules of other crafts involved, whether it is new construction or maintenance and repair. As a result, efficient planning and operation must be maintained if costs are to be limited.

A. THE PROBLEM

When a vessel is built, consideration is given to how to protect metal surfaces against the environment. Coatings are the primary method to protect surfaces. The type of coating applied, surface preparation and film thicknesses will, to a degree, depend on expected service conditions, such as salt water immersion, fouling, atmospheric exposure, etc. Often, cargo tanks should be coated to protect the steel from corrosion and the cargo from contamination.

Destruction of a coating film and subsequent protection breakdown is caused by steel rusting beneath the coating. Rusting occurs because of a reaction of the steel substrate with water and oxygen that diffuse through the film.

In a rural environment, good protection can be obtained by minimizing diffusion with a highly impervious film that functions as a barrier coating. In more aggressive marine environments the rate of corrosion is greater, partly due to the presence of soluble gases and salts. Those gases and salts ionize and diffuse through the film. Corrosion is accelerated by chemical attack on steel and elec-

trolytic action. The need for a high performance coating system in these circumstances is paramount.

The underwater area of a ship can be one of the most critical areas for protection. Because it can be observed only while the vessel is in drydock or through a perfunctory inspection by divers, coating systems and other methods of corrosion control, such as cathodic protection, become increasingly important. Hull roughness, which is caused by corrosion, breakdown of the coating system and fouling can cause a loss in speed. To compensate for speed loss an increase in power and fuel consumption is required.

Never in the history of the maritime industry has vessel "downtime" been so expensive. Drydock charges range from \$10,000 to \$30,000 and more per day, depending on the vessel's size. This, plus costs for yard labor and materials to prepare a dirty and fouled hull for coating, tends to make ship owners delay the chore until the very last minute. Many owners wait until seasonal slowdown or the deadline for its classification survey to minimize lost income while the vessel is out of service.

Balanced precariously against the high cost of maintaining a vessel is the even higher cost of delaying maintenance for too long.

Most vessel operators know that between 10 and 20 percent more power is required to maintain speed because of fouling (underwater marine growth on the hull and propeller) or because of hull roughness caused by pitting from corrosion. The increased cost of petroleum fuels and their potential scarcity, the need for extra power to stay on schedule, or additional voyage time from running at reduced speed to conserve fuel can quickly exceed the cost of recoating.

A VLCC (Very Large Crude Carrier) operating at a reduced speed of 13 knots can consume more than \$700,000 in extra (wasted) fuel during a 30-month drydock cycle because of drag caused by fouling. A typical 250,000 deadweight ton (dwt) tanker, with its hull freshly coated and smooth, will run at 13 knots with an output of approximately 14,500 shaft horsepower (shp). A year later, 16,000 shp will be required; by the end of two years 20,000 shp is required, and by 30 months the required shp will have gone over 21,000 — an increase of almost 30 percent. Operated at full power to hold schedules, the same tanker will start running close to 17 knots, drop to 16 knots after one year, 15 knots after two years and finally, struggle along after 30 months at 14.5 knots — with its engines developing full shp. Drastic increases in fuel consumption require vessel operators either to shorten the drydock cycle or to resort to interim hull maintenance, such as underwater cleaning to reduce hull drag caused by fouling.

In addition to the general difficulties presented by ships' operational schedules, marine coatings must have many specific resistances. Even though areas on ships differ greatly, the following conditions are among those that cause the most trouble:

1. Presence of salt water, an excellent electrolyte for the promotion of corrosion.

2. Alternate immersion, such as alternate exposure to the air, sunlight and salt water, causing premature failure of coating materials.
3. Abrasion damage from rubbing against piers, tugs, loading barges, or the bottom when operating in shallow waters, etc.
4. Fumes from stack gases and port environments.
5. Pollution of waters in harbors and docking areas that may attack coatings.
6. Air pollution caused by industrial smogs.
7. Wide range of temperature, humidity and other conditions during application and service.
8. Cargo splash and spillage.

B. ECONOMICS

The economics of painting ships in service is complicated by the uniqueness of the services they perform and their size. A ship is only serving its function when moving cargo from one point to another. Each day a vessel spends tied at a shipyard represents a financial loss to the owners. Depending on prevailing cargo rates and the ship size, this loss can total thousands of dollars a day.

When calculating the cost of repairing corrosion damage, it is first necessary to multiply the extra days in dock by daily charges and losses. Losses due to corrosion are usually represented by work, such as renewing welds, replacing steel, renewing piping, repairing equipment, installing new gear, etc.

Large sums of money involved in ship repairs make it apparent that controlling corrosion, can reduce costs. Any effective corrosion preventive measures that can be applied when the vessel is built, or installed at regular visits to a shipyard necessitated by regulatory bodies (such as American Bureau of Shipping's Survey Requirements), should prove economical. Section 45 "Surveys after Construction" of the "Rules for Building and Classing Steel Vessels"⁽²⁾ of the American Bureau of Shipping shows there are definite intervals during the life of a ship when it must undergo inspection for corrosion damage. Some special surveys normally take a ship out of service for several days. This is an opportune time to consider corrosion prevention.

High dollar value for a ship's availability requires a ship owner to study the total economics of corrosion protection with performance requirements and cost of installation compared with dollar returns. For high grade coatings there is usually a higher grade surface preparation required, which normally translates into time.

The optimum time for coatings and other corrosion preventive measures is during construction. All areas of the vessel are more accessible at that time (Figures 1 and 2). During construction, conditions are more suitable for surface preparation and coating than at any other time during a ship's service life. Maintenance planning should begin during design and be incorporated into construction. At this time a vessel owner should establish a tentative hull preservation and maintenance program.

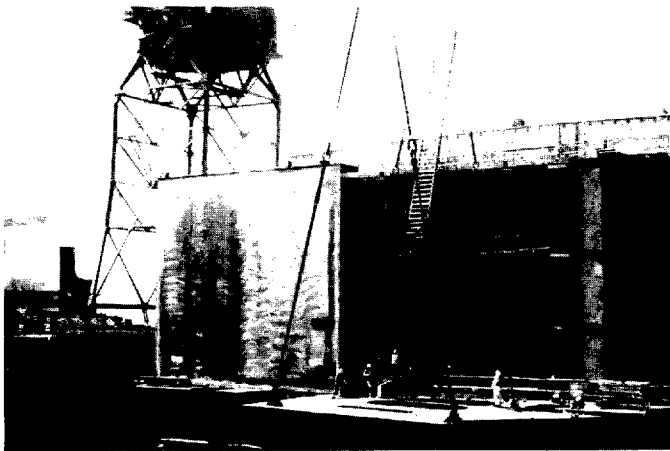


FIGURE 1

Unit Construction of Ship.

Courtesy: Bethlehem Steel Corp.

C. SURFACE PREPARATION

The effective life of any coating system depends on the condition of the surface to which it is applied. The surface preparation required may vary depending on the severity of service to which it will be subjected and the type of coatings applied.

In an environment with any degree of aggressiveness, the higher the degree of surface preparation the longer the expected coating life.

Surface preparation is so important and diversified that it is examined in several chapters of this volume. Standards for surface preparation have been developed by several organizations. The most widely used, particularly in the marine industry, are the Steel Structures Painting Council (SSPC) Specifications, which describe requirements for surface preparation from hand cleaning to abrasive blasting. Abrasive blasting specifications have been supplemented by pictorial standards, such as the Swedish Standards. Other pictorial standards are found in a publication offered by the Society of Naval Architects and Marine Engineers⁽³⁾. The National Association of Corrosion Engineers also has standards for abrasive blasted steel.

Abrasive blasting is the primary method used by shipyards for surface preparation. Blasting results in the required degree of surface cleanliness and surface profile with the greatest economy on large areas. For small areas, power or hand tool cleaning is generally accepted and is the most economically feasible.

In repair yards, high pressure water jetting is used for removing fouling and loose paint from underwater hulls and for cleaning heavily scaled surfaces.

Environmental regulations have an impact on surface preparation. Open air blasting is being scrutinized because of dust and health hazards associated with abrasives containing free silica or similar material.

Closed cycle blasting machines have been developed for cleaning hulls and decks. Water blasting is being utilized

on a larger scale by repair yards, but problems with pollution arise because of regulations against foreign matter being dumped into the water. The cost of surface preparation is increasing rapidly, partly due to these restrictions and regulations.

1. Abrasive Blasting

Automatic blasting is an airless blasting technique (Figure 3) using a rotating wheel to throw abrasives at a surface at a high speed with great force. Abrasives normally used, steel shot and/or grit, are recycled. The initial cost of abrasives is high, but recycling reduces the quantity per square foot of blasted surface, which makes their use viable and economic. The efficiency and effectiveness of this type of blasting is well documented. It is used by most new construction yards for preparing plates and shapes prior to assembly. Mill scale, rust scale and rust are primary contaminants that must be removed.

Most new construction yards using this method for initial cleaning of plates and shapes apply a primer immediately after blasting, usually a pre-construction or after-blasting primer. This maintains the condition of the blasted surface during fabrication of units prior to application of specified coating systems.

Portable closed-cycle blasting machines for cleaning hulls and decks are available (Figures 4, 5 and 6). Their importance increases as regulations against use of open air blasting become more prevalent.

Small parts can be cleaned very efficiently and economically in closed cycle blasting cabinets by one person. These cabinets are available in a variety of sizes and capacities.

2. Nozzle Type Blasting

This method (Figure 7) utilizes air to impart kinetic energy to the abrasive particles and is the

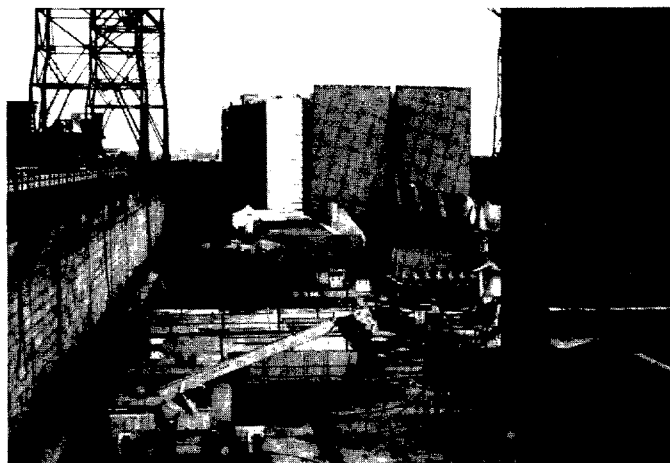


FIGURE 2

Unit Construction of Ships.

Courtesy: Bethlehem Steel Corp.

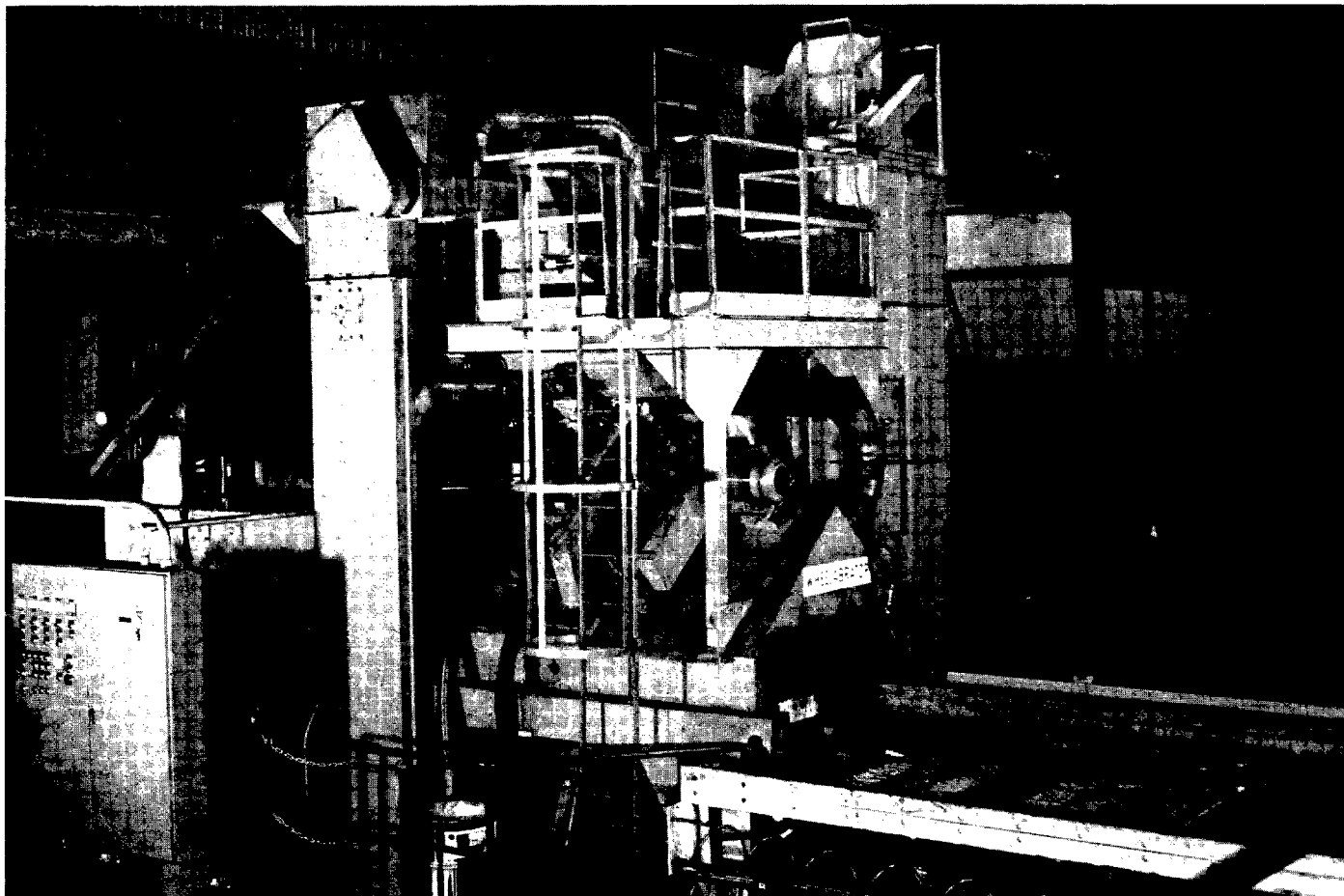


FIGURE 3
A Typical "Pre-Fabrication" Structural Steel Cleaning Machine.
Courtesy: Wheelabrator-Frye Co.

most common and widely used method of cleaning in shipyards. Because of the large surfaces to be cleaned, it is the fastest and most economical method for field cleaning. In new construction yards, initial coatings are applied in the modular stage. Except for yards that have large facilities for centrifugally blasting modular units, nozzle blast cleaning is used. Most of this is done in an enclosed area where conditions can be controlled (Figure 8). Buildings in a number of yards have installed recycling systems, using steel grit, which falls through grated floors and is reclaimed just as in the closed cycle blasting machines.

Other yards use mineral abrasives for blasting in blast and paint facilities. There is normally no recycling of these abrasives; therefore, vacuum systems and/or manual disposal is required.

What is a viable and cost effective method for one yard may not be for another because of capital outlay, space allocation, climatic conditions, etc.

Nozzle blasting is used to meet surface

preparation requirements in tanks and on ships requiring recoating in drydock and to make other shipyard repairs.

3. High Pressure Water Cleaning

High pressure water cleaning has been extensively used as a cleaning method for existing paint systems to remove haunches (barnacle roots), weed growth, loose paint flakes etc. The pressure required for this work does not usually exceed 137.9 to 206.8 bar (2000 to 3000 lb/in²). High pressure water cleaning can be used, however, to provide a white metal finish with pressure up to 689.5 bar (10,000 lb/in²). A suitable mechanism injects fine grit of 300/400 mesh to create a slurry. This system can also be used to dose the blasting water with suitable chemical inhibitors that passivates the cleaned steel surface until coating can commence or to "feed in" detergent to enhance chemical cleaning.

High pressure water blasting minimizes health hazards, material costs and the need to remove blasting media. One advantage is the complete removal of all residual salts from pitted



FIGURE 4
Portable Ship Deck Cleaning System.
Official U.S. Navy Photograph

steel. Failure to remove contaminants, such as chlorides and sulphates, is one of the main factors that cause premature breakdown of paint systems.

Water blasting can be a relatively cheap and effective method for the removal of:

- a. exhausted anti-fouling composition;
- b. loosely adherent paint, rust and marine fouling;
- c. included residual salts;
- d. calcareous deposits caused by cathodic protection.

4. Hand and Power Tool Cleaning

To supplement abrasive blast cleaning for small areas and areas where abrasive cleaning cannot be used, hand and power tool cleaning are used. Power tool cleaning is the most widely used method in commercial shipyards. Most yards use air-powered abrasive tools because of certain ad-

vantages over electric tools. Some of the advantages are:

- a. More power per pound; air-powered abrasive tools are lighter, smaller and easier to handle than electric tools;
- b. No overheating;
- c. Low maintenance requirements.

Basic types of hand power tools used in the shipbuilding industry are abrasive wheels of various sizes and shapes, scalers and chisels.

For description of types, maintenance and use of hand tools, see the Steel Structures Painting Council Manual, Volume 1, and the "Catalog of Existing Small Tools for Surface Preparation and Support Equipment for Blasters and Painters", prepared under a research project sponsored by the National Shipbuilding Research Program⁽⁹⁾.

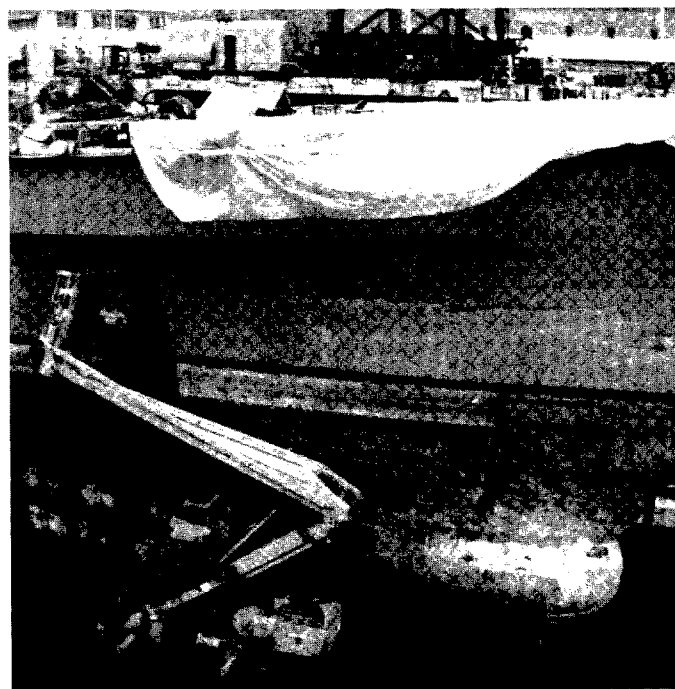


FIGURE 6
Portable Ship Hull-Side Cleaning System.
Official U.S. Navy Photograph

D. SURFACE TREATMENT

There are times when surface treatments are used on steel and other metals. When steel is cleaned using water, such as in hydroblasting, wet abrasive blasting or chemical cleaning, it must be inhibited to prevent flash rusting. Inhibitors are introduced at the time of cleaning or are an integral step in a sequence, such as in a chemical cleaning. Inhibitors must be compatible with the coating. Volume 1 of the Steel Structures Painting Manual provides much information on chemical surface treatments. A washcoat primer (Navy Formula 117, Military Specifica-



FIGURE 5
Portable Ship Hull-Bottom Cleaning System.
Official U.S. Navy Photograph