A SURVEY OF JAPANESE SHIPYARD APPLIED MARINE COATINGS PERFORMANCE

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PROGRAM MANAGEMENT

On May 19, 1986 the program management of the Surface Preparation and Coatings Panel was transferred from Avondale Industries, Inc. (Avondale) to National Steel and Shipbuilding Company (NASSCO). With the transfer the panel number was changed from SP-023-1 to SP-3.

This report is the result of the IHI contract, performed under Avondale's Panel Program Manager Mr. John Peart. The printing and distribution was carried out under the new Panel Program Manager Mr. James Ruecker, NASSCO.

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FOREWORD

This report is the result of one of the numerous projects managed and cost shared by Avondale Shipyards, Inc. under the auspices of the National Shipbuilding Research Program (NSRP) whose principle objective is "increased shipbuilding and productivity". The program was a cooperative effort with the Transportation Department, Maritime Administration Office of Advanced Ship Development.

On behalf of Avondale Shipyards, Inc., Mr. John Peart as the Program Manager was principally responsible for this research tour and resulting observations and conclusions.

Assisting Mr. Peart in-performing the survey and preparation of the final report was Mr. Benjamin S. Fultz of Bechtel National, Inc. The tour was arranged and organized by IHI Marine Technology Inc., Mr. Y. Ichinose President. In addition, acknowledgement is given to the companies, their managers and staff, listed below for their valuable contribution of information.

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EXECUTIVE SUMMARY

In July 1982, an on site inspection of Japanese shipbuilding facilities was performed to study Japan's surface preparation and coatings planning and production methods. The study found that the Japanese approach to planning and construction did, in fact, reduce cost. Another finding was that the Japanese have developed a standard coating system which is designed to facilitate construction. Any variance from this standard system is considered an add-on and results in increased procurement costs for the ship owner. The question then logically arises, "Are the Japanese application methods and coating systems adequate for the intended purpose?" and "Will the systems provide adequate protection for the ships steel during the life of the vessel?" AS will be seen in the body of the report, the Japanese system does provide adequate protection for a ships life cycle with scheduled crew and drydock maintenance. Generally, a ship is designed with a twenty year life cycle. In addition the following specifics should be noted:

- The Japanese standard coating system provides adequate corrosion protection with scheduled maintenance over the life cycle of the ship

- The Japanese thin film, modified inorganic zinc shop primer does not provide undercutting protection for the exterior above the water line coating systems

- Double stripping weld seams and sharp edges on the exterior deck house appears to provide improved performance

- Uncontained, open abrasive blasting has effectively been eliminated from Japanese shipyards

- The Japanese coating systems are designed for shipyard productivity resulting in lower initial cost but requiring increased maintenance during ship operation (No data is available on actual coatings life cycle cost)

- Chlorinated rubber coatings, even though relatively short lived, provide an ideal maintenance coating

- Weldability of the shop primer is film thickness dependent and requires qualification of processes in each shipyard.

Although several coating system performance conclusions are drawn from the survey data, it must be remembered that a limited number of ships were inspected. To be statistically accurate, numerous U.S. and Japanese ships would have to be inspected and documented. However, the data presented is believed to be indicative of coatings system performance.

1.0 BACKGROUND

1.1 Introduction

The basis of Japanese shipbuilding productivity is the Zone Planning Method which, in turn, is based upon the principle of group technology. As opposed to some U.S. shipyards which are driven by steel erection and system completion, Japanese planning aims at interim product completion in the form of hull blocks. Each block includes necessary structural steel plus various degrees of system installation, i.e., electrical, mechanical, structural, coating etc. Stated another way, the Japanese planning technique is not based on individual system completion. The planning block is considered as an end item to be completed prior to being jointed to other items. To accomplish this plan, coating activities must be planned in detail and accomplished as planned in order to have minimum negative impact on other scheduled activities. Surface preparation must therefore be limited to methods which do not create dust and contamination. Open, uncontained, abrasive blasting must be and has been essentially eliminated from Japanese Shipyards.

Initial surface preparation is accomplished using automatic, enclosed blast machines, and secondary surface preparation is limited to power tool cleaning methods. To match the limitations imposed by surface preparation restrictions, the Japanese have developed standard coating systems, fully integrated with the Zone Planning and Zone Painting methods. Coating systems are selected with care in order to be compatible with surface preparation techniques, construction methods and schedules.

1.2 Japanese Surface Preparation and Coatings Methodology

The national Shipbuilding Research Program report “A Descriptive Overview of Japanese Shipbuilding Surface Preparation and Coating Methods” published in September 1982 and written by Mr. John W. Peart and Dr. Gerald Soltz contains a detailed description of Japanese methodology. Summarized in the following discussion are some of the pertinent points of this technology.

The Japanese shipyards place a high priority on the selection of the shop primer (preconstruction primer). The shop primer is precisely formulated to meet defined performance criteria. These include:

- Ease of application
- Quick dry-to-handle times (l–4 minutes)
- Steel protection during construction (3–4 months)
- Acceptable burning speeds with automatic equipment
- Acceptable weld-thru characteristics
- Low toxicity and few polluting agents
- Reasonable cost

Prior to the early seventies, a vinyl butylral wash primer met most of the primer design requirements. As the state of the art progressed, epoxy zinc rich, straight epoxy and then alkyl silicate primers with zinc dust and welding enhancement pigments were developed. The alkyl silicate primers with zinc dust and welding enhancement pigments have now become the mainstay of Japanese shop primers.

To reduce open abrasive blasting, raw steel is processed through a centrifical wheel blast machine and automatic spray application booth. Flat plate and stock shapes are abrasive blasted to a degree equivalent to SSPC SP1O and primed with an average dry film thickness of 0.60 mils of a modified inorganic zinc primer. The raw stock, thus treated, is then routed to the various fabrication shops and built up into pre-erection subassemblies which are then jointed to form building blocks. At various stages of the block construction, the burned, welded and damaged primer is repaired using power tool cleaning (primarily disc grinding with #16 grit disc) and touched-up with an organic zinc rich primer. Intermediate and some finish coats are also applied at the block stage of construction.

The Japanese finish coating systems have also been standardized. There may be some variance between shipyards but the systems are essentially the same. Coal tar epoxy is the dominant ballast tank coating; chlorinated rubber is used extensively on the exterior hull above deep load line, and bleached tar epoxies are used for dry cargo holds. Coal tar epoxy anticorrosive and ablative antifouling systems are now being used on the underwater hull area. Historically chlorinated rubber has been used on both the decks and superstructure. Some newer specifications require an epoxy intermediate coat with aliphatic polyurethane topcoats applied to the superstructure. In summary, it can be stated that the Japanese shipbuilding coatings methodology consists of automatic application of a thin film, modified inorganic zinc shop primer which is maintained during the construction cycle, not removed, and-then topcoated with organic coating systems.

The above described procedure is diametrically opposed to most U.S. methods which either do not use a shop primer or uses one and then completely removes it prior to applying the specified coating system. U.S. coating systems are generally more sophisticated thus requiring application directly over abrasive cleaned steel. These additional surface preparation requirements increase coatings cost. The question then arises – Is the more expensive U.S. method necessary to provide needed corrosion protection over the life cycle of the ship? Stated another way, which of the two methods is most cost effective? Since cost information is not readily available and was out of the scope for this project, a final determination of total life cycle costs could not be calculated and presented; however, some observations and conclusions are presented.

1.3 Project Objectives

To test the hypothesis of the adequacy of the Japanese shipbuilding coatings technology, a research and development project was formulated to survey the performance of Japanese coated ships after various service intervals. The remainder of this report addresses the findings of that survey. Four ships were inspected and two Japanese paint companies were visited. The service intervals of the four ships were 1 year, 6 years, 8 years and 14 years.

2.0 JAPANESE COATING SYSTEMS

Two painting schedules were obtained during the survey. One for the ship with a one year service life and the other for the six year old ship. Table I summarizes the systems used on these two ships. Alternates will be discussed for the other two ships during the performance discussion of each ship. As stated earlier, the surface preparation consists of initial automatic blasting followed by steel fabrication and then secondary surface preparation (power tool cleaning) prior to touch-up and/or final coatings application. The one year ship was primed with a modified inorganic zinc shop primer. With the exception of the deck and deck house, the six year ship was shop primed with a vinyl butylral wash primer. The deck and deck house were primed with an epoxy zinc rich. Shop primers removed by welding, cutting or mechanical damage were not reapplied except in way of erection weld areas on the outside shell, upper deck and outside of deck house. The paint schedules also state that weld beads and sharp edges resulting from gas cutting or welding shall not be ground for paint purposes.

The exterior freeboard and deck for both ships were coated with the standard Japanese chlorinated rubber coating system. The underwater bottom and deck house of each ship was different. The ballast tanks were coated with one coat of coal tar epoxy.

TABLE I
REPRESENTATIVE JAPANESE COATING SYSTEMS

AREA	SHIP	SHOP PRIMER*	TOPCOATS* 2	38	4	5
Underwater Bottom	1 Year	Inorganic Zinc	Coal Tar Epoxy	Vinyl Tar Epoxy	Self Polishing Anti Fouling	2 Coat Self Polishing AF
	6 Year	Wash Primer	Chlorinated Rubber AC	Chlorinated Rubber AC	Chlorinated Rubber AF	Chlorinated Rubber AF
Boottopping	1 Year	Inorganic Zinc	Coal Tar Epoxy	Vinyl Tar Epoxy	Self Polishing Anti Fouling	
	6 Year	Wash Primer	Chlorinated Rubber AC	Chlorinated Rubber AC	Chlorinated Rubber Finish Coat (FC)	
Freeboard	1 Year	Inorganic Zinc	Chlorinated Rubber AC	Chlorinated Rubber AC	Chlorinated Rubber FC	
	6 Year	Wash primer	Chlorinated Rubber AC	Chlorinated Rubber AC	Chlorinated Rubber FC	
Exterior Deck	1 Year	Inorganic Zinc	Chlorinated Rubber Primer	Chlorinated Rubber Primer	Chlorinated Rubber FC	Chlorinated Rubber FC
	6 Year	Epoxy Zinc	Chlorinated Rubber Primer	Chlorinated Rubber Primer	Chlorinated Rubber FC	Chlorinated Rubber FC
Deck House	1 Year	Inorganic Zinc	Epoxy Primer	Epoxy Primer	Polyurethane	Polyurethane
	6 Year	Epoxy Zinc	Chlorinated Rubber Primer	Chlorinated Rubber Primer	Chlorinated Rubber FC	Chlorinated Rubber FC
Water Tight Hatches	1 Year	Inorganic Zinc	Chlorinated Rubber Primer	Chlorinated Rubber Primer	Chlorinated Rubber FC	Chlorinated Rubber FC
	6 Year	Wash Primer	Chlorinated Rubber Primer	Chlorinated Rubber Primer	Chlorinated Rubber FC	Chlorinated Rubber FC

TABLE I (Cont.)
REPRESENTATIVE JAPANESE COATING SYSTEMS

AREA	SHIP	SHOP PRIMER*	TOPCOATS* 2	3	4	5
Deck Machinery	1 Year	Supplier Standard	Chlorinated Rubber Primer	Chlorinated Rubber Primer	Chlorinated Rubber FC	Chlorinated Rubber FC
	6 Year	Supplier Standard	Chlorinated Rubber Primer	Chlorinated Rubber Primer	Chlorinated Rubber FC	Chlorinated Rubber FC
Living and Working Spaces	1 Year	'Inorganic Zinc**	Alkyd Zinc Chromate	Alkyd	Alkyd	
	6 Year	Wash Primer**	Alkyd Zinc Chromate	Alkyd	Alkyd	
Dry Cargo Hold	1 Year	Inorganic Zinc**	Bleached Tar Epoxy			
	6 Year	No Dry Cargo Hold	N/A			
Ballast Tank	1 Year	Inorganic Zinc**	Coal, Tar Epoxy			
	6 Year	Wash Primer**	Coal Tar Epoxy			

* Dry Film Thickness per coat when specified:
Inorganic Zinc - 0.75 mils
Wash Primer - 0.50 to 0.70 mils
Coal Tar Epoxy – 5.0 mils for Underwater Bottom and 7.0 mils for Ballast Tanks
Vinyl Tar Epoxy – 5.0 mils
Chlorinated Rubber AC
Self Polishing AF – 4.0 mils

** Primer not reapplied to weld prior to topcoating.

Code: AC = Anticorrosive
AF = Antifouling
FC = Finish Coat

3.0 SHIP COATING SURVEY RESULTS

3.1 Vessel With One Year Service Life

This ship is a containership which was undergoing the one year guarantee survey drydocking. The builder was IHI Kure, and the ports of call were Japan, Taiwan and the United States.

The coatings failure on the underwater hull and freeboard was primarily limited to mechanical damage resulting from anchor chains and fenders. There was no fouling except in areas where the antifouling (AF) was removed due to mechanical damage. There was no undercutting at the damaged areas. Some inorganic zinc shop primer could be seen at the edges where the coatings were removed. This finding seems to support the suitability of use of inorganic zinc primers as undercoats for immersion service; however, it must be remembered that the film thickness was limited to 0.6 mils and the material is modified with a reduced zinc loading and an organic resin. See Figure 3.1 for overall view of underwater bottom.

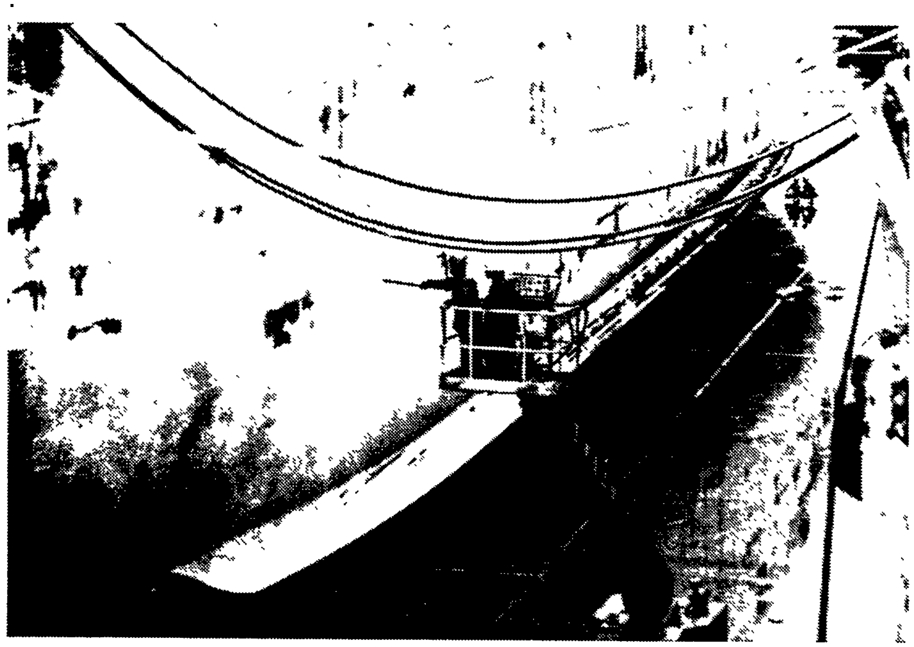

Figure 3.1: View of Foul Free Bottom

The ablative antifouling had polished in some areas to a degree that one or more of the intermediate coats could be seen. This could mean that the system was overpolishing in these areas because of increased water velocity due to hull roughness or due to low initial coatings thickness. The contrasting colors of each coat of AF assists drydocking personnel in identifying areas of reduced thickness which require special attention.

Another point of discussion concerns the purpose of the vinyl tar anticorrosive coat which is applied as a barrier or tie coat between the coal tar epoxy and subsequent AF coats. The vinyl tar is applied prior to the time that the coal tar epoxy fully cures hard. The vinyl tar retains solvent sensitivity so that the AF will partially resolvate and thus adhere to the vinyl tar. The coal tar epoxy does not provide a suitable substrate for the direct application of AF. The vinyl tar seemed to be performing as designed; however, there were some areas where the system was delaminating from the coal tar epoxy anticorrosive. (See Figure 3.2) This delamination was less than 1% of the total surface area. There was one small area of delamination at an overboard discharge outlet which could have been caused by overcoating this area during construction when the area was not properly dried. The delamination pattern followed the outline of probable water path. No blistering was observed around the anode shield area.

The measured average film thicknesses of the total system was 19.5 to 27.5 mils. The specified thickness was 22 mils. Where the various other coats were exposed, the film thicknesses measured approximately 12 mils for the coal tar epoxy, 16 mils for the total system minus the last 2 coats of AF which had worn away, and 22 mils in those areas where only the final coat of AF had been removed.

was only repaired using power tool cleaning techniques. As will be seen later in the discussion, some paint company technical personnel recommend that the underwater bottom be abrasive blast cleaned prior to the application of the coal tar epoxy.

Figure 3.2: Evergiant Damaged Area

The freeboard area coating system (modified inorganic zinc shop primer plus three coats of chlorinated rubber) was providing excellent corrosion protection where the film had not been mechanically damaged; however, in those areas where the film was ruptured, much rust could be seen. (See Figure 3.3). As would be expected, the thin film zinc shop primer was not providing underfilm corrosion protection. (See Figure 3.4) Also as would be expected, the chlorinated rubber topcoat was beginning to chalk.

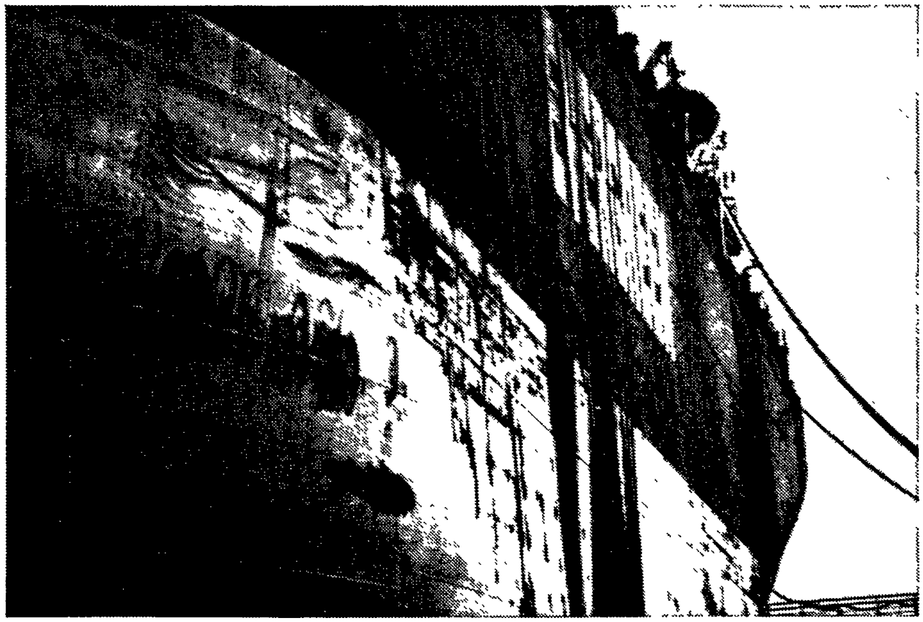

Figure 3.3: Freeboard Damage

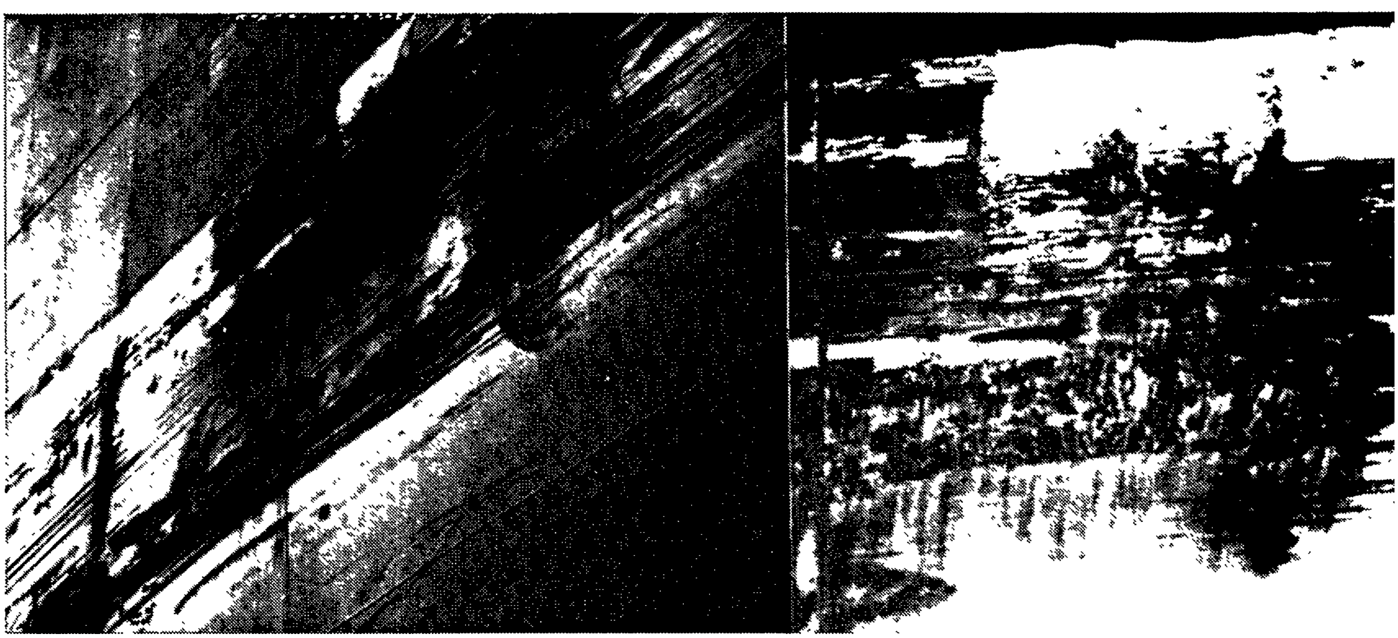

Figure 3.4: Evergiant Freeboard Damage.

The freeboard area of most U.S. ships have a thick film (2-5 mils) inorganic zinc as the freeboard primer. In this particular ship area, the U.S. system provides superior underfilm corrosion protection from undercutting as compared to the Japanese system. As will be seen as this report develops, the Japanese system does provide adequate protection for the life cycle of the ship with possible additional maintenance costs.

The aft water tight hatch covers were in good condition with no coatings breakdown. The measured total film thickness averaged between 8 to 10 mils.

The deck house was in excellent condition to include sharp edges, ventilation opening, attachments and appertenences. The deck house system consisted of an epoxy/polyurethane system. The sharp edges and some erection welds were double hand stripped prior to application of the complete epoxy intermediate coats. The overall deck house looked better than most U.S. ships that had been observed by both inspectors. The excellent condition could possibly be due to the stripping technique used. (See Figure 3.5). Some minor rust bleed was noticed on some isolated vertical weld seams on the aft portion of the deck house. (See Figure 3.6)

The main deck coatings showed some evidence of topcoat embrittlement and underfilm corrosion with some isolated areas with poor adhesion. (See Figure 3.7) The deck also shows some rust breakthrough along weld seams (See Figure 3.8).

The forepeak tank was selected for tank coating inspection. The applied system consisted of one coat of coal tar epoxy applied over shop primer. The weld and damaged areas were repaired with power grinders but no primer was reapplied to repaired areas. Swirl marks from the secondary surface preparation was visible through the coating. The actual measured thickness varied from 18 to 20 mils. The overall condition of the tank coating was good

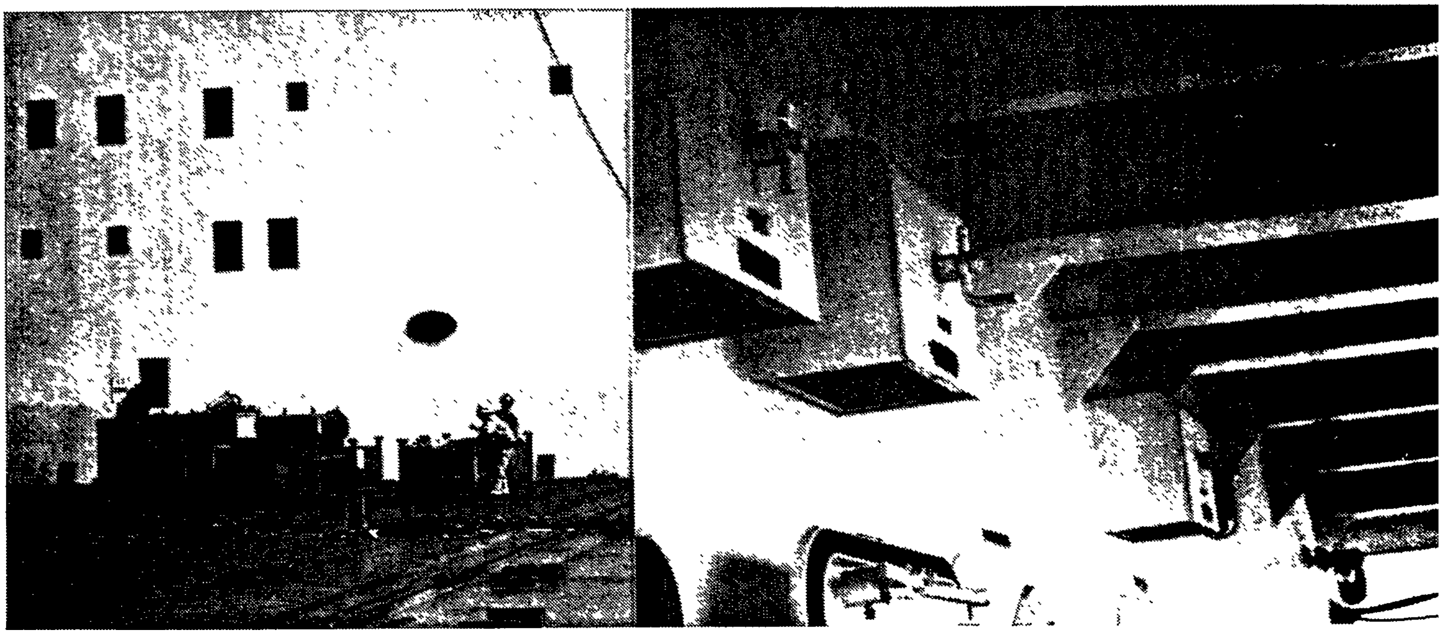

Figure 3.5: Evergiant House

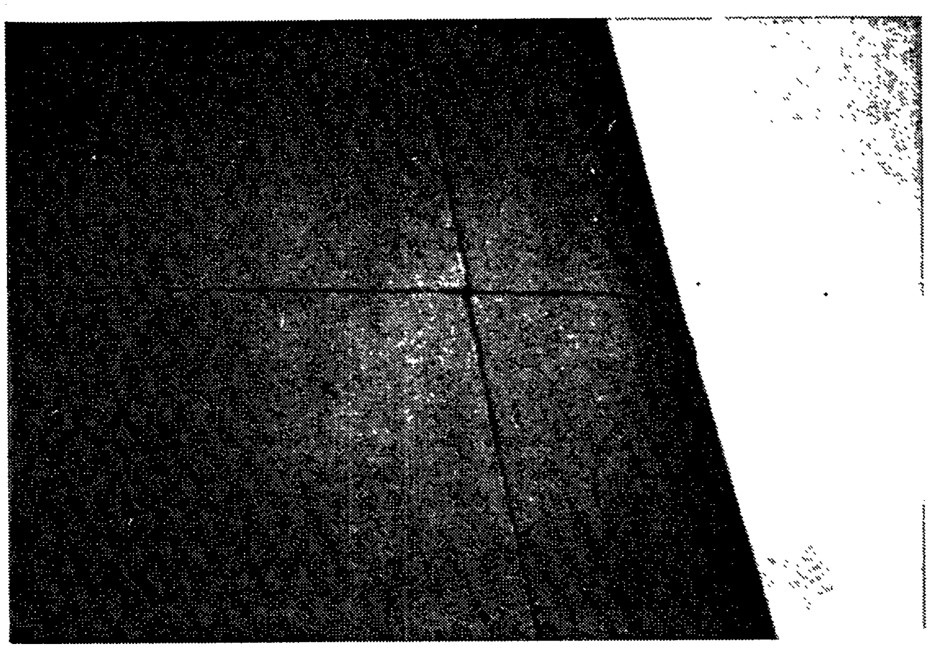

Figure 3.6: Evergiant House

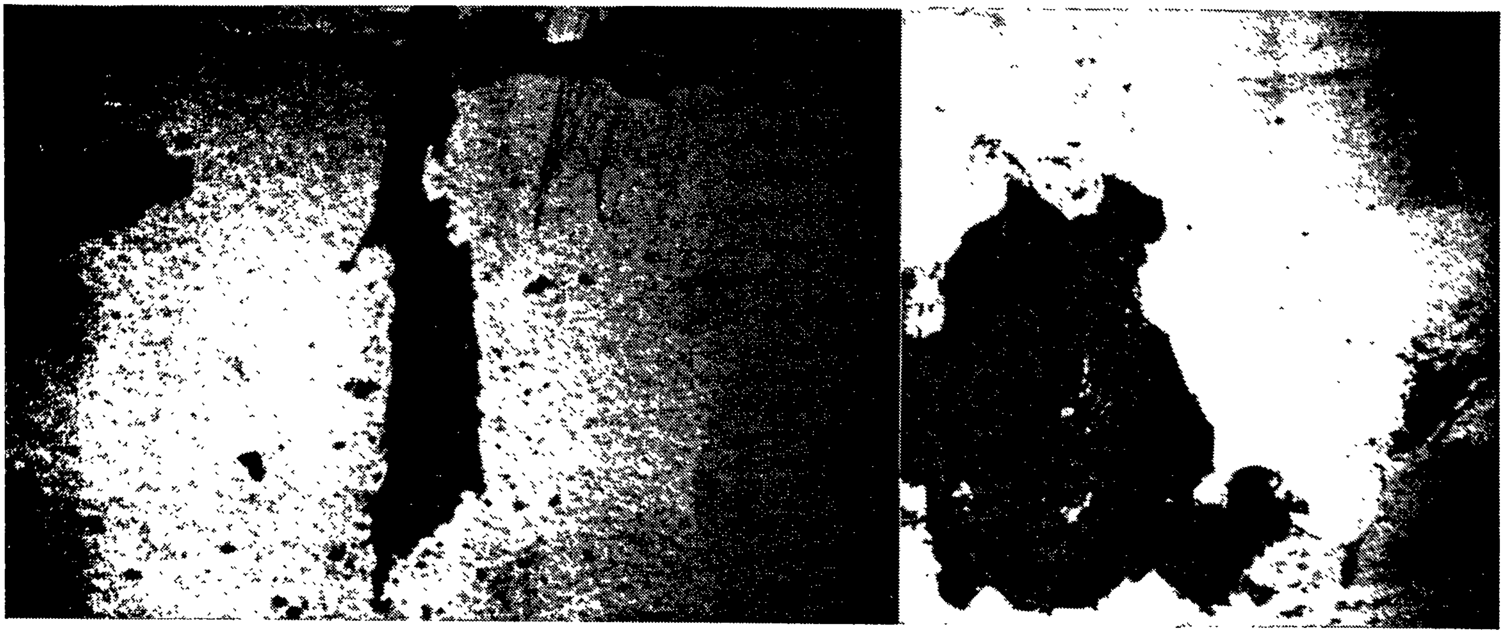

Figure 3.7: Evergiant

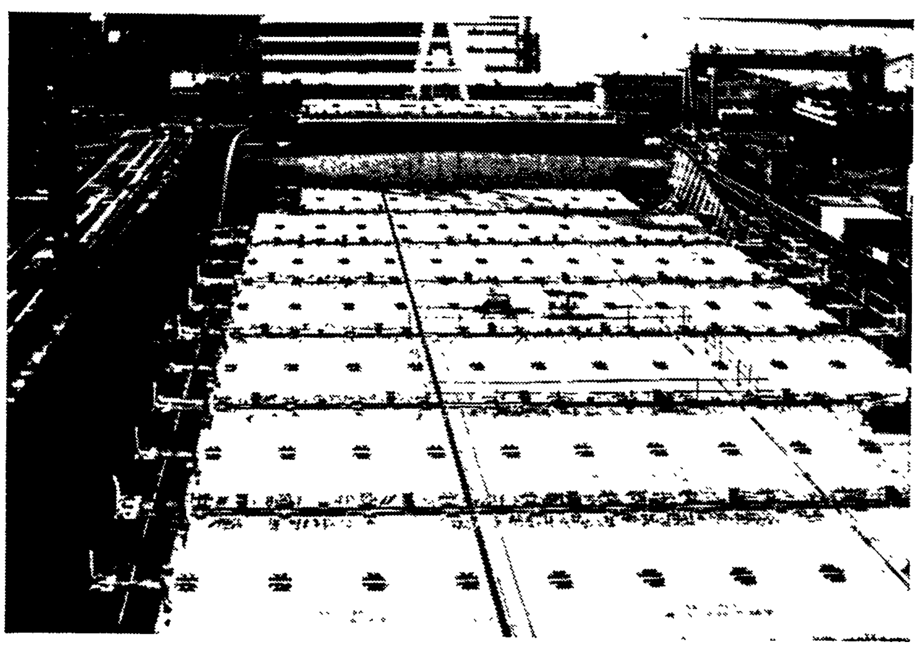

Figure 3.8: Evergiant Hatch Cover

with no blistering but with some minor failure of weld areas. It also appeared that the tank had not been fully pressed up during ballast. (See Figure 3.9) The tank coating was supplemented with one 10 to 15 pound zinc anode in each tank cell. The anodes did not appear to have been activated, therefore, exhibiting little or no consumption. This could be attributed to the anode mounting method which consisted of mechanical fastening of the round anode bar to a round “C” clamp. Rust was observed on the anode rod and the bare area of structural steel immediately around the anode. Additionally, no calcareous deposits were noted on the bare steel which would indicate the lack of electrical continuity between the anode and the steel.

Figure 3.9: Evergiant Tank

The bleached tar epoxy system in the dry cargo holds was in excellent condition. There was some checking of the coating in areas of measured high film build - 13 mils. (See Figure 3.10) The checking did not extend to the steel substrate. The condition of the alkyd system in the Forecastle area was also excellent with no failure.

In summary, the overall condition of the one year old container ship was excellent with the possible exception of the main deck and lack of undercutting protection due to the absence of a thick film inorganic zinc on the freeboard area. The house, superstructure, underwater bottom and tank coatings were supplying superior or adequate protection.

Figure 3.10: Evergiant Cargo Hold

3.2 Vessel With Six Year Service Life

The six year old ship was a large tanker. The ship was built by IHI Aioi. Ports of call are Japan to Europe through the Red Sea. The coating system is shown in Table I. The primer used was a vinyl butyral wash primer except for the exterior main deck and the deck house which were primed with an epoxy zinc rich material. The underwater system was originally a chlorinated rubber type which was replaced by a slow self polishing type.

There was approximately 3% overall failure of the underwater bottom with some isolated #6 medium dense blisters. The sea chests were in good condition. Two years had passed since the last drydocking. Loose fouling was just beginning to form and consisted primarily of crustaceans. The AF system was flaking in some areas. Flakes ranged in size up to 12 inch with most in the 1 inch to 2 inch range. The cathodic protection system was limited to a few anodes in the high corrosion areas such as around the stern.

The bow area had major rusting due to chain damage. The overall freeboard had approximately 20% scattered rust. Again the absence of the inorganic zinc primer was evident because of the amount of undercutting and rust bleed.

The deck and superstructure were in good condition with some breakdown in weld areas. It was also evident that the ships crew had maintained some portions of the superstructure and deck coatings.

The forepeak tank was selected for coating inspection. As opposed to the one year old ship tank coatings, the coatings in this tank were judged overall to be poor. There was extensive corrosion along the bottom edge of the tank top and bottom of the bulkhead where it joins the tank top (See Figure 3.11). One of the tank cells inspected was approximately 10 feet high by 30 feet wide by 20 feet long. This cell was representative of the others inspected. As with the one year ship, the coating system was reinforced with a zinc

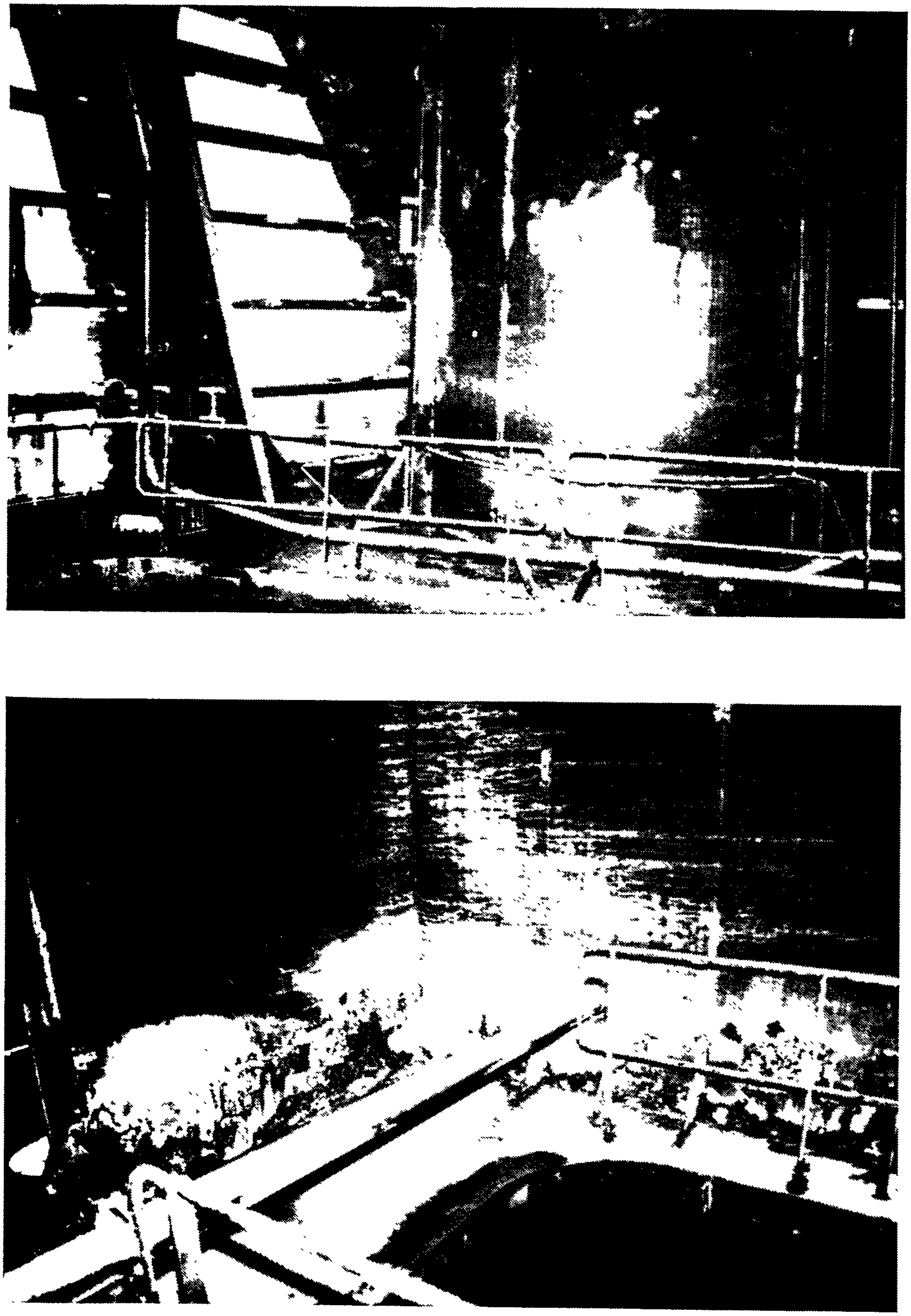

Figure 3.11: Shoii Maru TEAC Tank

Figure 3.11 (Cont.)

sacrificial anode cathodic protection system. The representative tank was fitted with eleven, 20 pound anodes. The attachment technique was the same as discussed for the previous ship. Again very little calcite formation had taken place (See Figure 3.12). The coal tar epoxy had numerous large blisters. One which was approximately 5 inches in diameter contained water but no underfilm rust was evident. The measured coating film thickness ranged from 10 to 13 mils. Some isolated, exfoliation and attendant severe corrosion was also evident on cut plate edges. In these cases the steel had also exfoliated. There was also substantial loss of coatings due to a lack of adhesion. In flat areas the failure seems to start with blisters which rupture and then undercut. The overall coatings failure was 10% to 15%. Some pitting was observed on the bare flat surfaces but not on the verticals. The degree of coating failure was judged to be greater than would have been expected. Previous inspections of coal tar epoxy applied directly over blasted steel revealed very little coatings failure in comparison. The blistering and lack of adhesion could be a result of a compatibility problem with the vinyl butyral wash primer even though no definite conclusions can be made.

In summary, it can be stated that the underwater bottom and the exterior superstructure systems were performing satisfactorily. Decks were in good condition but appear to have been maintained by the crew. The tanks and freeboard required extensive repairs. Discussions with a Japanese paint chemist, which took place later in the project, verified that the systems are performing as forecast. (See para. 4.1) The exterior freeboard will be recoated. Many times, the tanks are not reworked and the cathodic protection system is increased to provide needed protection. U.S. epoxy tank coatings are generally expected to last 6 to 10 years with no cathodic protection. Overall the ship coatings are performing as predicted.

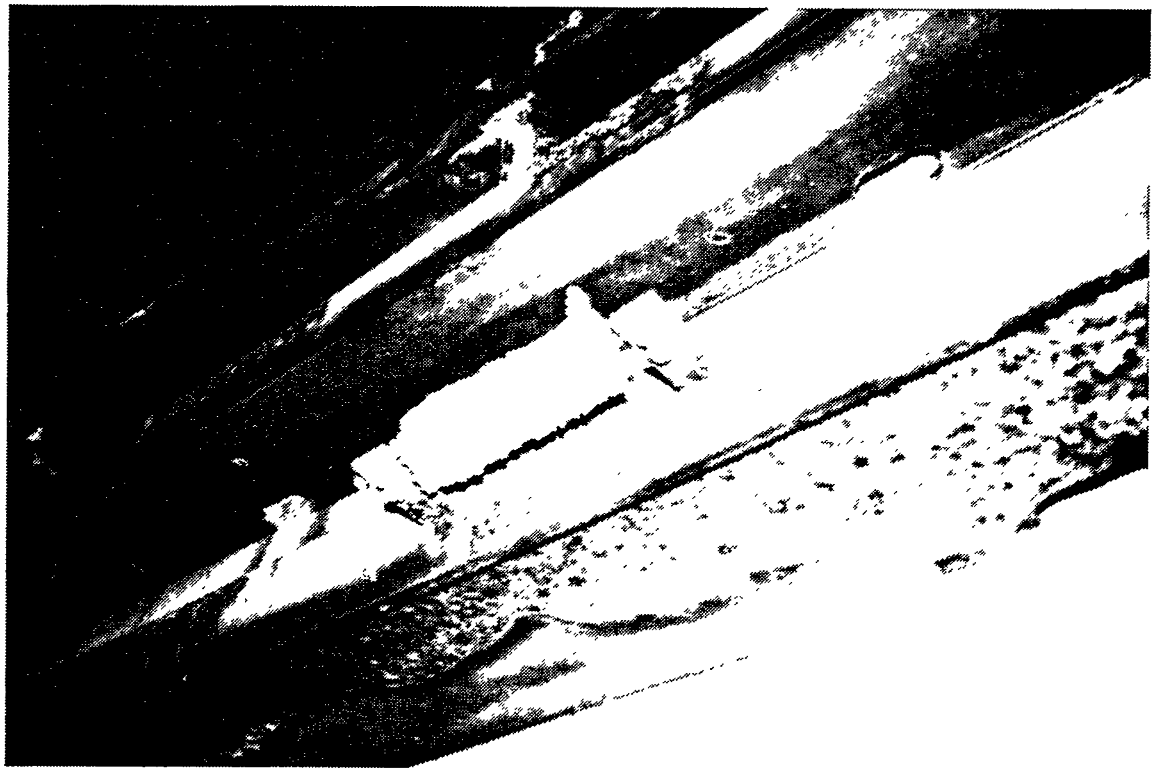

Figure 3.12: Shoii Maru – Anode not Protecting

3.3 Vessel With Eight Year Service Life

The eight year ship was a car carrier. The primer system is unknown but the entire exterior to include the anticorrosive portion of the underwater bottom is coated with chlorinated rubber. When the ship was being pumped up on the drydock late one afternoon, the general condition of the freeboard was noted to be 5 to 6% coatings failure. There was 1% failure on the superstructure. Some areas had totally delaminated. By the time the inspection crew arrived early the next morning, the ship was up, had been totally washed, sweep blasted and spot primed (See Figure 3.13). The surface preparation and coating activity was a quick hit and miss operation. Measured thicknesses of unfailed coated-areas were as high as 30 mils except for deck areas which were as much as 1/16 inch thick. This probably results from the quick sweep blast and application of additional paint.

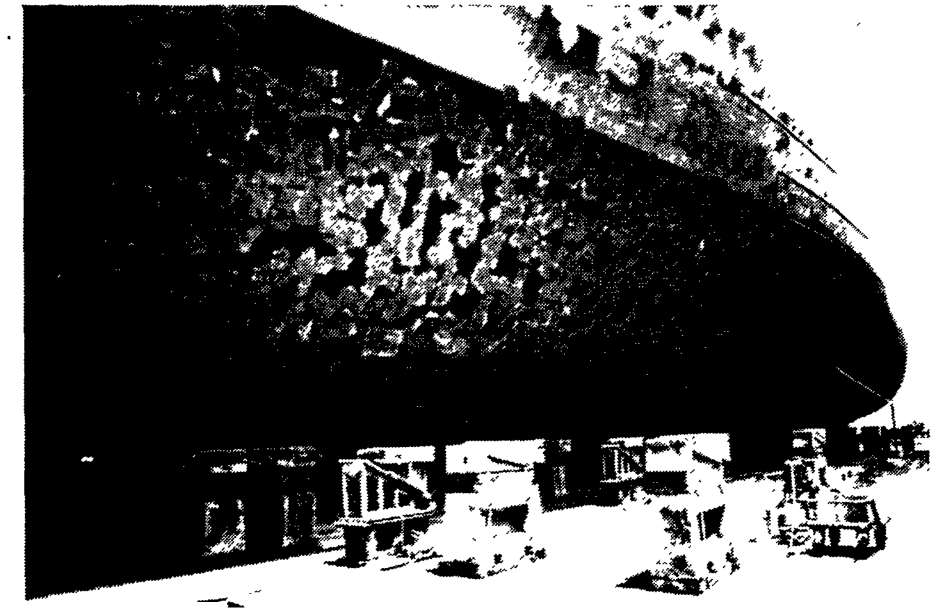

Figure 3.13: Southern Highway Hull

The underwater bottom was not inspected prior to the beginning of surface preparation; however, judging from the amount of touch-up observed the next morning, the bottom probably had at least 50% failure. Figure 3.14 is a close up of the repaired area after spot priming immediately prior to topcoat application. Note that the chlorinated rubber is flaking, appears brittle and is showing signs of delamination. The spot priming and top coats of chlorinated rubber were applied over this condition. The resulting rough condition on the underwater bottom would be unacceptable to some ship owners due to increased fuel consumption.

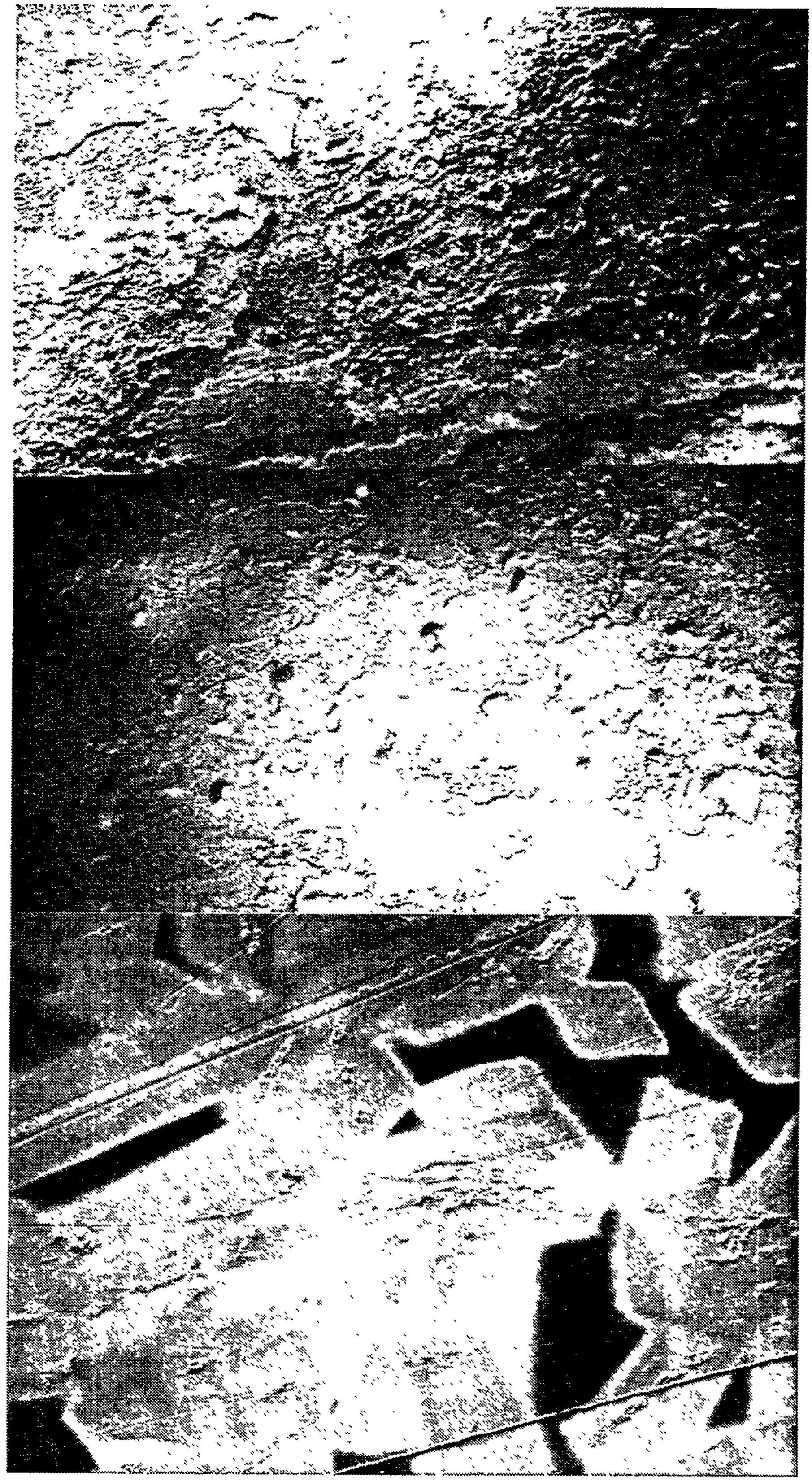

Figure 3.14: Southern Highway

The interior car cargo spaces were in excellent condition. (See Figure 3.15) Here the system was an alkyd.

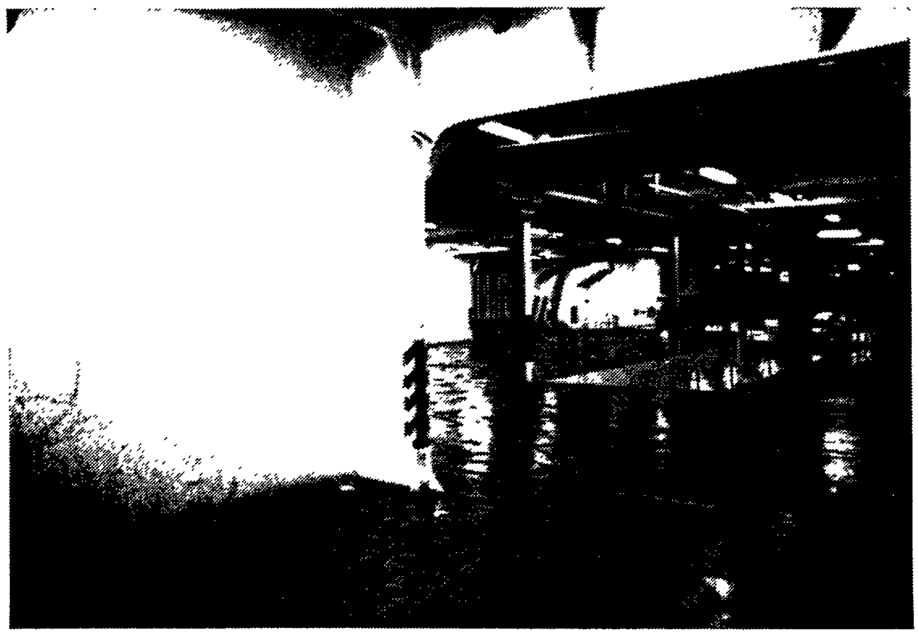

Figure 3.15: Southern Highway Cargo Area

In summary, it can be stated that the overall condition of the ship was satisfactory as concerns corrosion protection with no evidence of major steel reduction. This statement can be supported even though the coating shows major failure by U.S. standards. After completion of the speedy paint job, approximately 24 hour turnaround, the ship looked good and was ready for service. The steel corrosion protective measure consisted of increasing and/or replacing the corrosion barrier.

3.4 Vessel with Fourteen Year Service Life

The last ship surveyed was a break bulk cargo ship which had been in service for 14 years. No maintenance records were available, and it is not known if, nor when, the coating system may have been replaced. No coating schedule was available, but chlorinated rubber appeared to have been used on the exterior exposed to wind and weather. The underwater bottom was not available for inspection.

The ship was originally constructed at IHI Aioi and was inspected at IHI Aioi. As things happen, a new ship of the same type was at dock on the same quay as the surveyed ship. Figure 3.16 provides a good contrast between old and new.

Figure 3.16: Golden Orchid

The freeboard had 50% coatings failure with numerious areas of mechanical damage. Some steel side shell plate was being replaced. Deck coatings, hatch coaming, and hatch covers had failed 100% with rust,scale present. (See Figures 3.17, 3.18 and 3.19) Side of the hatch covers had deep pitting and metal loss. Deck machinery coatings failure ranged from 30 to 50%. Cargo hold coatings were approximately 40% failed. (See Figure 3.20) The repair crew was in the process of applying one coat of silver chlorinated rubber over a power tool cleaned surface on the interior of the cargo space.

Figure 3.17. Golden Orchid

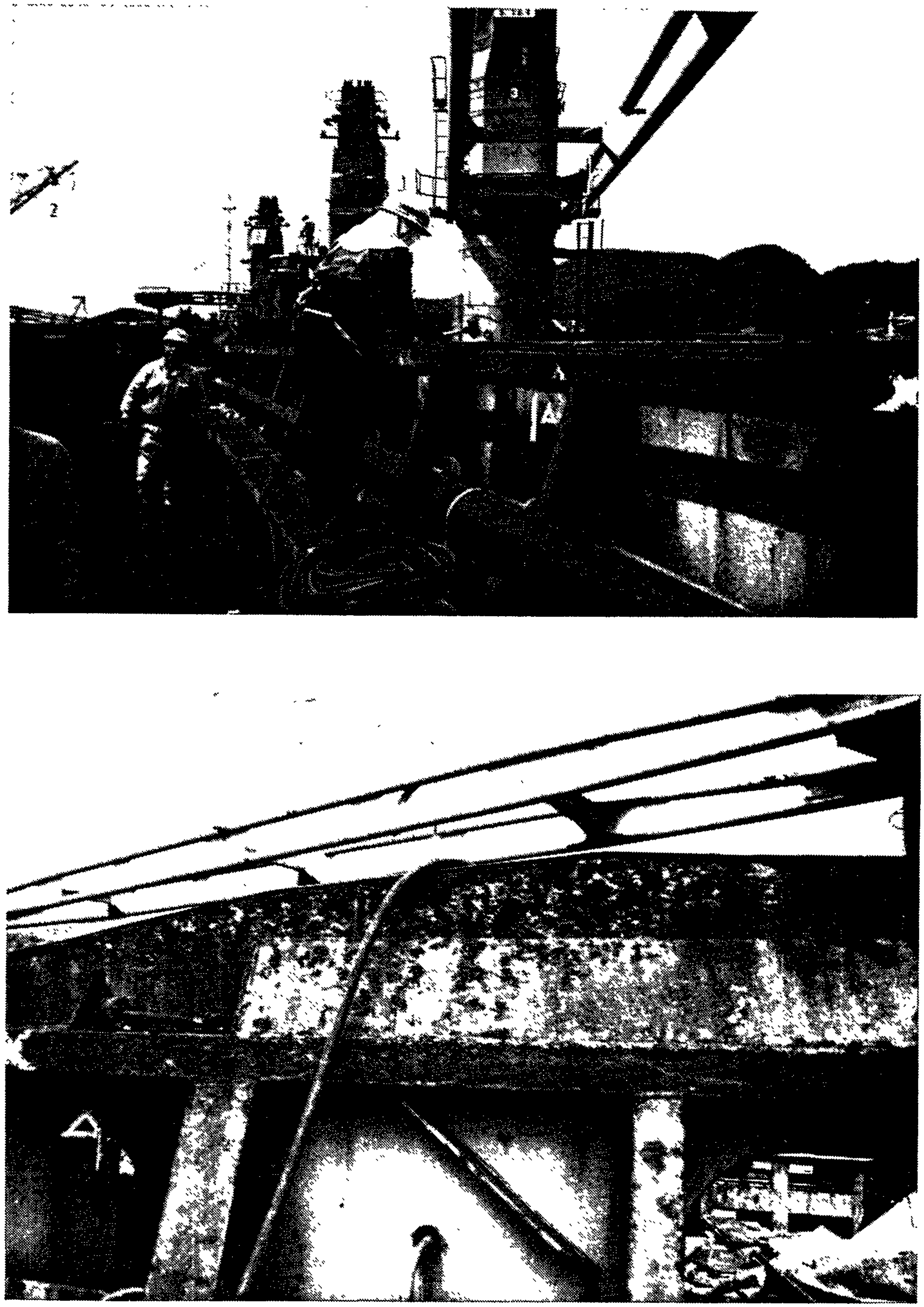

Figure 3.18: Golden Orchid

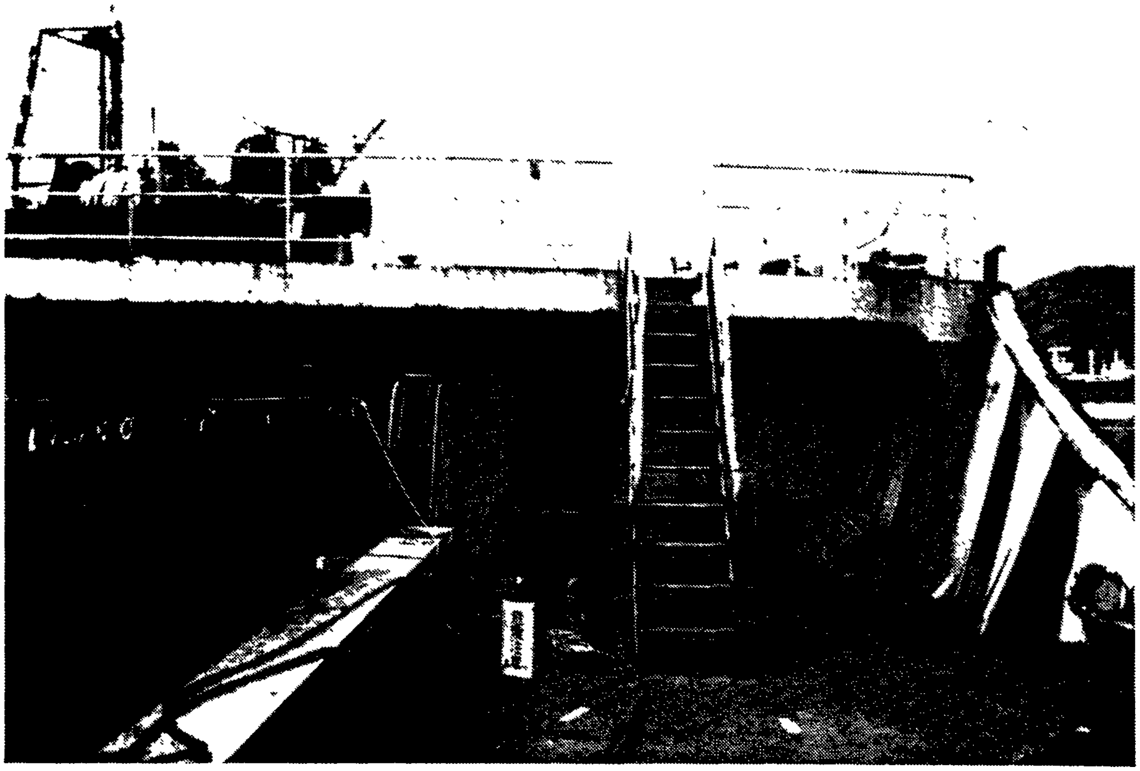

Figure 3.19: Golden Orchid

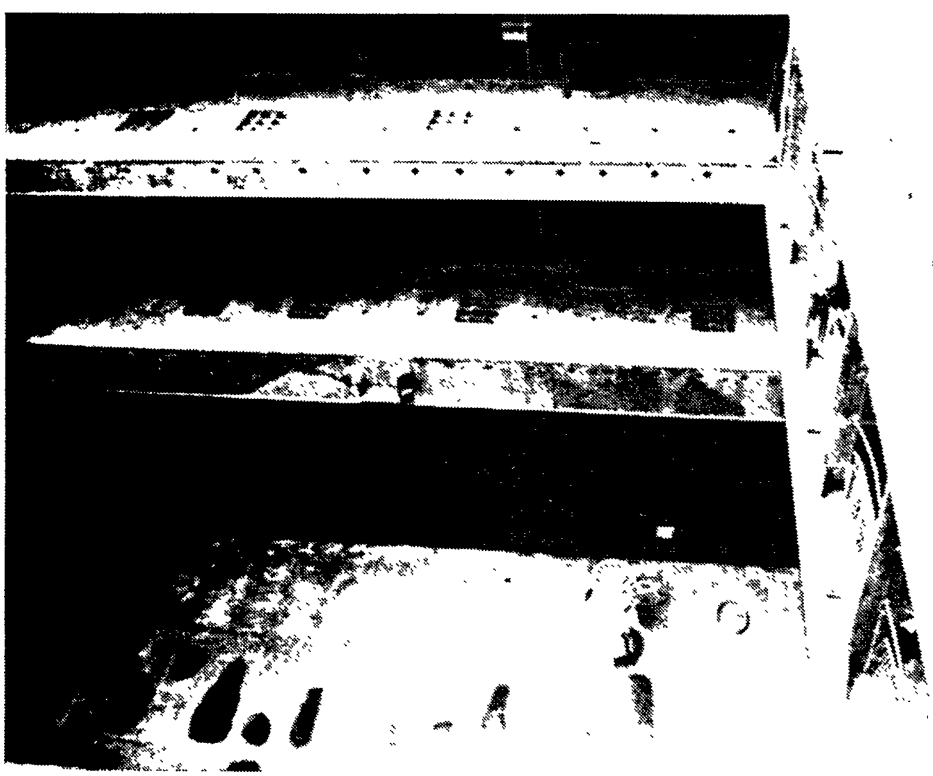

Figure 3.20: Golden Orchid

The interior of the engine room was in excellent condition. The exterior of the superstructure was in good condition and had apparently been painted numerous times. (See Figure 3.21) The measured film thickness ranged from 38 - 40 mils.

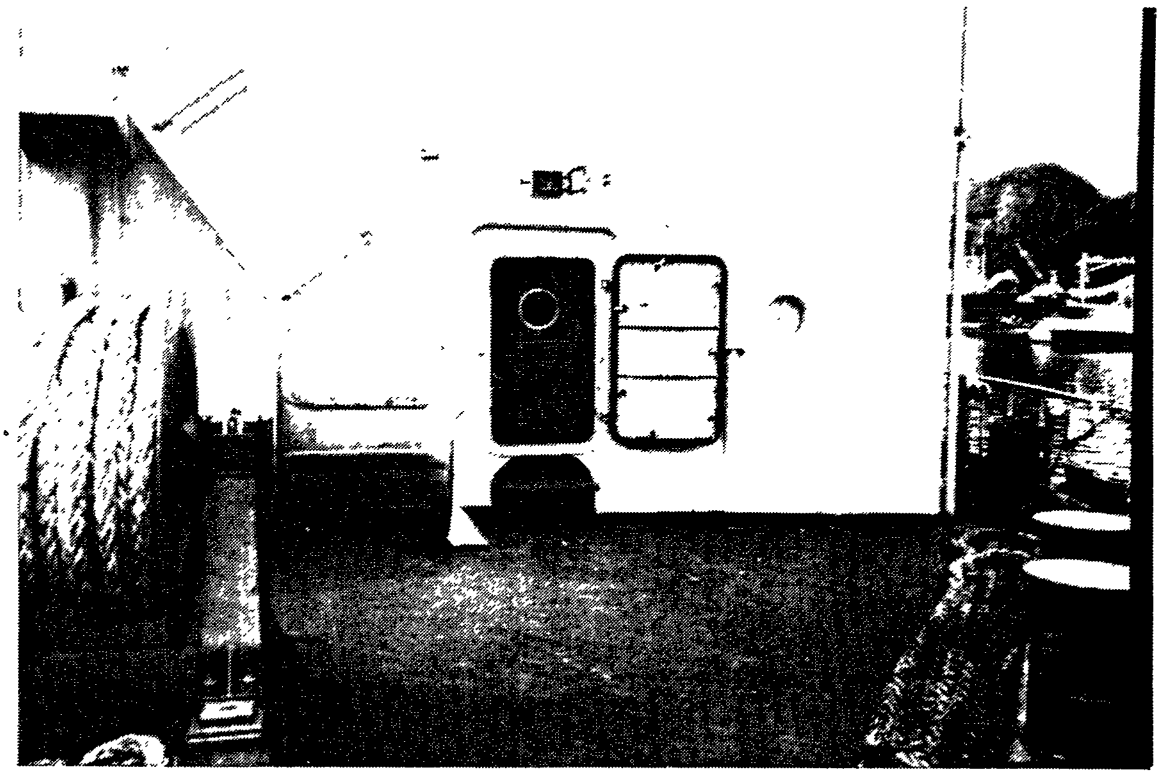

Figure 3.21: Golden Orchid

The side ballast tanks were divided into wet and dry tanks. The dry tanks were coated with a gray epoxy which had 3 to 5% failure. Apparently these tanks were rarely, if ever, used for ballast. Inspection of one of the wet tanks revealed 50% coatings failure. The inspection team was told that two years ago eight 100 pound zinc anodes were added to the tank. The tank was 15 feet long by 15 high on one side and narrowing to 2 feet high on the other side. A heavy calcareous deposit has formed on all bare areas. (See Figure 3.22) Some black iron rust was visible but no pitting or metal loss was

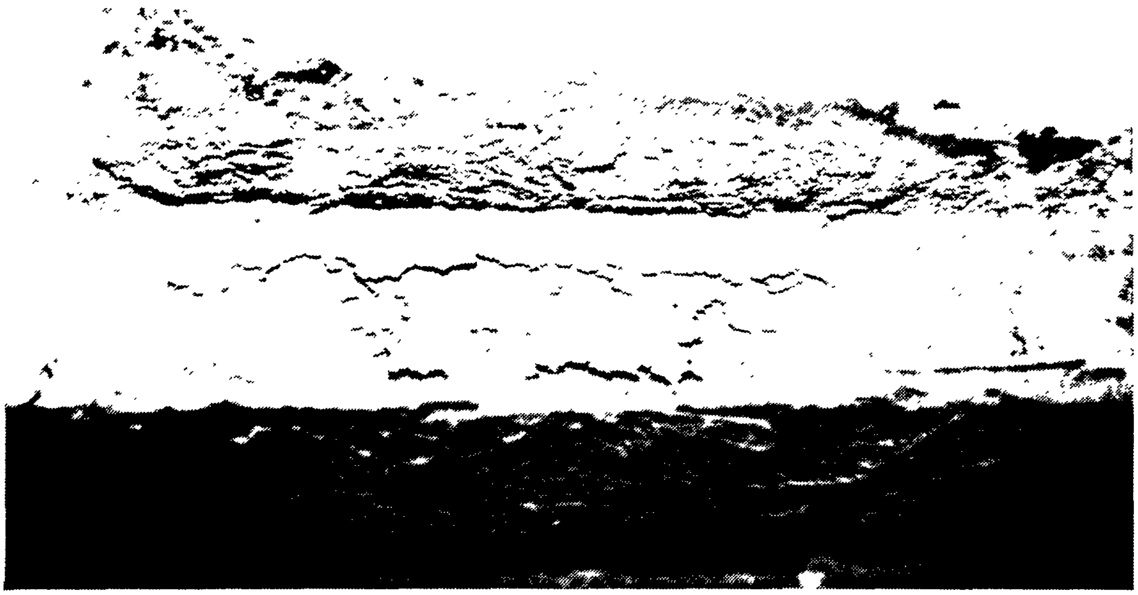

Figure 3.22: Golden Orchid

evident under the calcite coating. (See Figure 3.23) Rust was also present where the tank had not been pressed up. The heavy calcareous deposit with attendent corrosion protection in immersed areas and the lack of protection in the averhead substantiate the finding of the Mar Ad sponsored study entitled "Cathodic Protection/Partial Coatings versus Complete Coatings in Tanks" performed by Mr. Benjamin S. Fultz. The number of anodes used and the ratio of weight to exposed surface area are approximately the same as those used in the referenced study. It should also be noted that the anodes were welded in position thus assuring good electrical conductivity necessary for cathodic Protection.

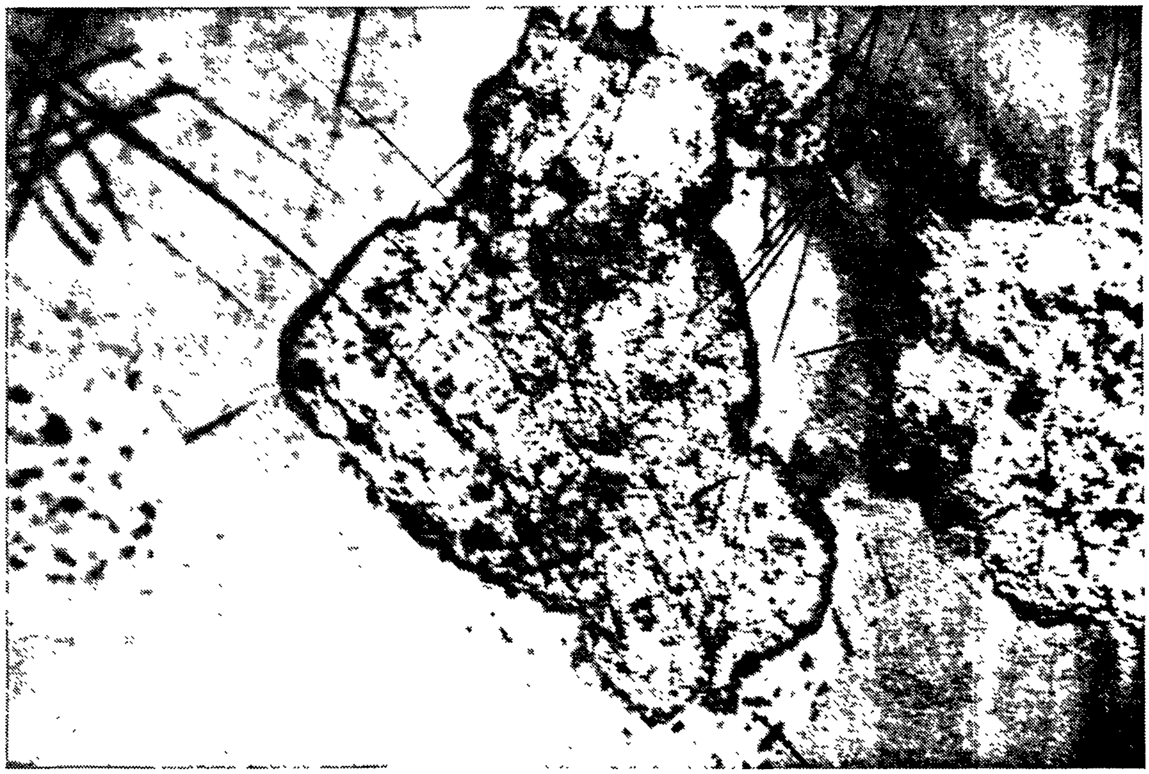

Figure 3.23: Golden Orchid

In summary the fourteen year ship will probably last for the 20 year projected life cycle with some steel replacement but not beyond,

3.5 Comparison of Japanese to United States Coating System

The findings of this survey can be summarized in the following statements:

- As opposed to the U.S. thick film inorganic zinc primers, the Japanese modified thin film zinc shop primers do not provide undercutting protection on those exterior, above the water line coating systems.

At the one year survey period, the exterior deck house coating system looked as good as, or better than, a typical U.S. ship. This could be attributed to the practice of double stripping of welds and sharp edges.

- Japanese choose the coating system to match construction methodology. The number and type of U.S. systems are as numerous and varied as the Naval Architects or Owners who specify the systems.

- Japanese coating systems are less sophisticated but adequate with planned crew and drydock maintenance cycles. U.S. systems are generally more sophisticated, require increased surface preparation, and thus are more expensive but have longer replacement cycles.

- The extensive use of secondary surface preparation by the Japanese precludes the use of sophisticated coating systems.

- Japanese coatings maintenance during the ship's life cycle depends on a finish coat which is easily maintained and recoated with minimum surface preparation. Chlorinated rubber, which is easily redissolved, is an ideal choice for this purpose even though the performance of chlorinated rubbers require shorter replacement cycles.

4. DISCUSSIONS WITH JAPANESE COATINGS COMPANIES

4.1 Nippon Paint Company - Osaka

The survey team met with the chief chemist. The visit consisted of a question and answer discussion period followed by a tour of the research and development center.

When questioned about the design parameters which affected the formulation of the shop primer, the following points were brought out. The primer is formulated to be applied at 0.6 mils dry. At higher millage, cutting and welding speed and quality would be degraded. Sufficient zinc pigment is added to provide anti-corrosion protection only during construction - 3 to 4 months. Higher zinc loading increase zinc fumes during cutting and welding to an unacceptable level. Some welding enhancement pigments and organic resins are also added. Zinc free primers require application at 1.5 to 2.0 mils to provide the same degree of protection. At this thickness, the organic primers were found to cause weld porosity.

When asked about the recoatability of zinc shop primer with a thick film inorganic zinc (3 mil range), the recommendation was to sweep blast the shop primer first.

Discussions of-shipyard procedures for touch-up of the modified inorganic zinc shop primer were divided between adequate and preferred. For underwater bottoms and ballast tanks, an organic epoxy zinc rich primer is the preferred material even though some yards do not replace the primer prior to overcoating. For ballast tanks, the thickness of the primer should be controlled between 0.6 and 1.5 mils dry. If the modified inorganic zinc shop primer is used for touch-up, abrasive blast is the recommended surface preparation method. Thick film inorganic zinc primers are not recommended because of longer cure requirements. If used, the cure should be checked prior to topcoating. An alcohol rub test for cure was recommended.

Amine cured epoxy is the preferred recommendation for fresh water tanks, and polyamide cured epoxies are recommended for salt water immersion areas to include the underwater bottom.

Two types of coal tar epoxies are used in Japan. One for winter and one for the other seasons. The winter grade is recommended when the temperature falls below 41°F. In U.S. yards, epoxy materials cannot be used below 50°F. The maximum recommended overcoat time for coal tar epoxy is five days. Zinc anodes are recommended in ballast tanks to supplement the coal tar epoxy system.

Bleached tar epoxy materials are recommended for container holds. The acceptable film thickness is 6 mils dry with the preferred being 8 mils dry. Bleached tar is not recommended for contact with petroleum products or immersion but can be used in some operating areas such as the engine room. One weak point of the material is yellowing with age.

The following forecasted coating system ages are used to develop maintenance plans:

Coal Tar Epoxy (Immersion)	- 10 years
Epoxy (Immersion)	- 3 to 4 years (much blistering)
Bleached Tar Epoxy	- 6 to 7 years
‘Chlorinated Rubber	– 4 years (due to loss of plasticizer)

Attempts are being made to extend the planned drydocking interval to 4 or 5 years. Antifouling coatings are available to provide 5 years minimum fouling service but the limiting factor is mechanical damage of the coating. This point was borne out by this survey. The vinyl tar tiecoat which is necessary to promote adhesion between the coal tar epoxy and the ablative antifouling coating is one of the weak points. This coating is relatively soft and easily damaged. New anticorrosive coatings are being developed which should solve this problem.

A tour of the research and development center was most informative. The center is equipped with very sophisticated test equipment to include scanning electron microscopes, chromatographs, spectrophotometers, specialized test cabinets, etc.

4.2 Chugoku Marine Paints - Hiroshima

The meeting at Chugoku opened with a discussion of shop primers. The points concerning film thickness, zinc pigment loading, corrosion protection, machine cutting and welding were reiterated during the discussion.

It was found that primer weld through qualification does not have universal Japanese regulatory approval. Just as in the U.S., each shipyard must qualify the type of primer, film thickness and welding process. The approval is based on radiography and break strengths. The exact procedures could not be identified but the final approval is granted by various regulatory bodies such as Det Norske Veritas and Lloyd's Register of Shipping.

Chogoku also recommended that coal tar epoxy be roughened prior to topcoating or repair if left exposed for longer than one week. Damaged areas of coal tar epoxy should be disc sanded to a feather edge 6 to 8 inches into sound coating when making repairs.

Zinc rich epoxy primers are recommended for touch-up of the shop primer prior to overcoating for immersion areas. Abrasive sweep blasting of shop primer is recommended prior to the application of a full coat of inorganic zinc.

The coal tar epoxy is polyamide cured with a recommended thickness in the ballast tanks of 8 to 10 mils. This is approximately the same as the shipyard requirement which is 7 mils. Pure epoxies and bleached tar epoxies are not recommended for ballast tanks.

The shop primer should be removed in product tanks which require coating. For chemical carriers approximately 70% should be removed and for critical service (strong acids) 100% removal is recommended. The preferred product tank coating is an amine adduct cured epoxy applied in 2 to 3 coats. Heat (forced) cure is recommended for severe cargoes.

Alkyd and oil based paints are recommended over the modified zinc shop primer on interior, dry areas only. An epoxy ester barrier coat is recommended for other applications.

Chlorinated rubbers are recommended for most exterior applications with the epoxy/polyurethane system being preferred for deck houses. The predicted life of chlorinated rubber systems was four years.

4.3 Summary of Paint Company Technical Discussion

Several generalizations can be made based on discussions with the paint company technical personnel.

- Coating systems are designed with shipyard productivity requirements in mind.

- Shop primers are precisely formulated to provide adequate in process protection without having a detrimental effect on automatic welding and burning

- Coating systems are designed for maintainability

- Chlorinated rubber coatings have a forecasted life of four years which corresponds to drydocking cycles. Recoat every second drydocking is recommended

- Just as in the U.S., there is a difference between best and acceptable shipyard coating processes.