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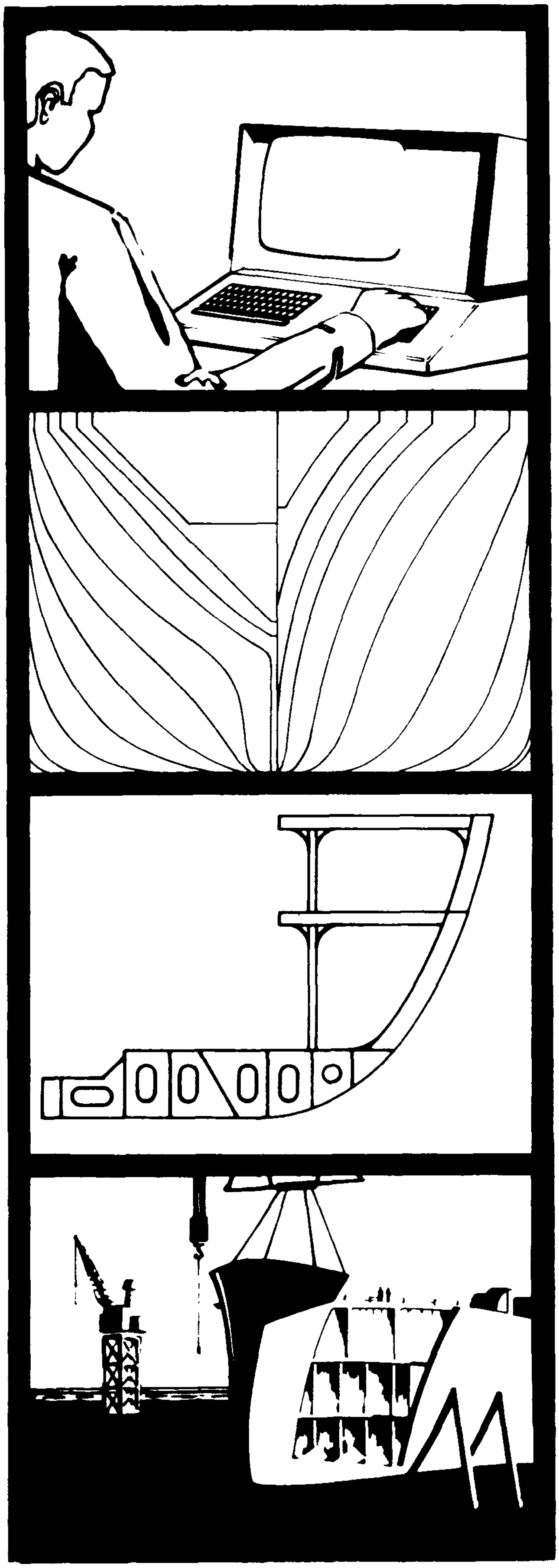

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EVALUATION OF ALTERNATIVE GENERIC COATINGS IN DIFFERENT SHIP AREAS

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ABSTRACT

The information contained within this presentation was obtained from a research project performed under the National Shipbuilding Research Program. The project was a cooperative cost shared effort between the Maritime Administration, Avondale Shipyards, Inc, and Offshore Power Systems, a wholly owned Westinghouse subsidiary. The overall objective of the program was to improve productivity and, therefore, reduce shipbuilding costs to meet the lower construction differential subsidy rate goals of the Merchant Marine Act of 1970.

The information contained within this presentation was obtained from a research project performed under the National Shipbuilding Research Program. The project was a cooperative cost shared effort between the Maritime Administration, Avondale Shipyards, Inc. and Offshore Power Systems, a wholly owned Westinghouse subsidiary. The overall objective of the program was to improve productivity and, therefore, reduce shipbuilding costs to meet the lower Construction Differential Subsidy rate goals of the Merchant Marine Act of 1970.

Toward this end, the following results were achieved to improve the paint system selection process:

- Establishment of a computer program of paint service histories which demonstrates that valid conclusions can be reached as to which generic paint type is best for a specified area of this ship.
- Support by laboratory testing of performance trends of the computer program analysis.
- Demonstration by laboratory testing that careful evaluation of paint suppliers is necessary.
- Indications that careful selection of laboratory test methods and evaluation parameters, to duplicate service conditions, can serve as a screening method for candidate paint(s).
- Identification of craft interference and premature area release for painting prior to compartment completion. That is, poor paint planning and scheduling is the major cause of inordinately high ship painting costs.

As most practitioners of the marine coatings profession can attest to, the selection of a coating system for new ship construction is often thought of as a "crystal ball" art form. Today there are numerous different generic paint types in the marine market place, each of which is advertised as the epitome of excellence. The shipowner is often misled into selecting exotic paint systems with high initial cost on the premise that the higher the initial cost, the more extended the performance without maintenance. This selection method does not always hold true. The system application may require extensive controls beyond the state-of-the-art capabilities of the prospective builder. The end result is an expensive system applied under other than ideal conditions leading to inferior performance.

Likewise, the selection of a low initial cost, short life system may lead to major maintenance and upkeep costs. In neither case is the system cost effective. Therefore, the shipowner is left in a quandary. He has no reference source document to help him select the correct paint system for the intended use or service condition.

If the principles identified within this talk are assimilated by the marine industry, millions of dollars in improved ship paint performance will be realized. Marine Industries will benefit in three ways:

- Less dollars expended at guarantee survey time due to improved paint performance (fewer failures).
- Reduction in the probability of a catastrophic paint failure during vessel construction.
- Increased operational efficiency of ships in service.

As originally envisioned, the project was broken into six tasks. The first three tasks concerned the establishment of evaluation criteria. The remaining tasks concerned the compilation of data and the analysis of results. The paragraphs which follow discuss the sequence of events leading to, and the rationale behind, the selection of evaluation criteria and final systems analysis.

To establish evaluation criteria, questionnaires were sent to major U. S. Shipyards, major marine coatings suppliers and ship owner/operators. The most disappointing responses were received from the owner/operator group. Out of the ninety-five polled, only one provided substantial information.

As a result of the surveys, questionnaire responses and literature reviews, the "Ships/Paints Coatings Performance'Service Histories Questionnaire" was formulated.

As can be seen from the slide, the form is simple, straight forward with little room for interpretation, readily adaptable to rapid keypunch. This form incorporates the following information:

- Ship types representative of the different service conditions
- Types of coatings used
- Inspection criteria and frequency
- Means of documentation

The major effort expended in this project was toward the systematic collection of historical paint performance data. The final report contains the following number of case histories:

Underwater Bottom	282 histories
Underwater Bottom Flats	70 histories
Underwater Bottom Sides	70 histories
Boottop	217 histories
Freeboard	134 histories
Decks	54 histories
Superstructure	36 histories
Cargo Holds & Spaces	17 histories
Product Tanks	156 histories
Ballast Tanks	36 histories
TOTAL	1,072 histories

The numbers of histories are impressive but incomplete to perform a true comparative performance analysis. However, some trends can be noted. With an enlarged data deck for reference, more definitive conclusions can be made. The inspection data was processed into an analysis deck which was then used to provide detailed information on specific service histories. Each service history has a separate, distinct control number. This number does not appear in the final report. It is'printed on the right hand tear-off margin. The code number is unique in that it identifies the source of data and a numerical sequence. Close scrutinization between this code number and the rating of a given service history can result in the rejection of some supplied data.

For example, a biased source may desire to make a given generic material appear to possess better than true, actual performance characteristics. Close examination of the service history, by a knowledgeable individual, can normally detect favoritism; e.g., all extremely good reports with no failures. The philosophy used throughout this study was "When in doubt, do not use the information". With a larger data base, this judgment can be made statistically by determination of a variance from the true mean.

The compiled data is presented in tabular form, and the columns of the report from left to right are explained as follows:

TYPE OF SHIP - Self explanatory. Even though exact ship sizes are not given, a general idea can be gained. Small craft and barges are identified.

TRADE ROUTE - Self explanatory.

AREA/SYSTEM - The first print gives a description as to which performance area of the ship is being evaluated. Each ship is divided into eight different areas. Listed under the area is the generic paint system used to include number of coats.

SURFACE PREPARATION - The codes used are the Steel Structures Painting Council Surface Preparation Standards or a description of the process.

SYSTEM AGE - This is the actual age of the system being rated. It could be the same as the ship's age if the evaluation was completed during the initial survey period, or it could be the time since the last overhaul if the system was applied at that time. Old, intact material could be a part of the system if retained after the completion of the overhaul surface preparation.

FILM THICKNESS - Actual average film thickness of each coat of paint.

SHIP'S AGE - Age of the ship counted from initial delivery of the ship from the shipyard to the owner.

PERFORMANCE EVALUATION - This section is broken into five parts for underwater bottom evaluations and three parts for all others.

% CORROSION - This is the actual percent of corrosion (rust) of the surface expressed as a %. The rating takes into consideration the entire surface area and does not attempt to define extreme localized failures.

% COATINGS FAILURE - By definition this is a measure of the system's inability to perform its intended purpose. This could be a fouling failure, corrosion failure, cosmetic failure or a system failure; i.e., a delamination between coats of paint. This number is always the larger of the numbers which express % fouling, corrosion or other failure.

% FOULING - Measure of the amount of surface area fouled. For example, a ship may have 100% fouling between the waterline and six feet below the waterline. The remainder of the hull may be free of all fouling. The system would not be considered as 100% fouled but at some percent which takes into consideration the entire hull surface area. Since this particular phenomenon is common to underwater bottoms, an attempt was made to rectify the situation by dividing the underwater bottom into two additional subareas, namely underwater bottom-flats and underwater bottom-sides.

TYPE FOULING - Self explanatory. This is important because some types of fouling have more of an influence over ship performance to include increased fuel consumption. Shell has a maximum influence; slime has minimum influence.

The data bank can be sorted into three different catagories:

- Type of ship
- Trade Route
- Functional Performance Area

The histories are then automatically ranked and placed in order of performance, the best performances being listed first.

From the data contained within the data bank, a comparative analysis can be performed on the relative performance of different generic paint systems within a given functional area. As an example, the underwater bottom area to include flats and sides was used as a model. In general, underwater bottom systems are replaced at one, two, or three year time intervals but rarely extend beyond two years. Therefore, the age of the system drops out as a variable. It is interesting to note at this point, that a similar number of data points fell within each failure grouping regardless of the exact age of underwater systems as long as the maximum interval was held at three years. The variable, trade route, was not considered because the sampling was taken on a world wide basis. Therefore, performance is being compared on a world wide basis.

Based on the available histories, the following types of antifouling finish coats were considered for evaluation and comparison. Please note that this is not a comparison of all the available types of antifouling:

- Antifouling, Chlorinated Rubber, Copper
- Antifouling, Epoxy, Copper
- Antifouling, Vinyl, Copper
- Antifouling, Other
- Antifouling, Copper/Organometalic
- Antifouling, Resin Soap, Copper

The "Ships Paints Performance - Service Histories Questionnaire" includes ten different percent rating possibilities. For the purpose of this analysis, these ten ratings were combined into three groupings. This grouping helps to factor out possible variations in ratings by different individuals. The three groupings are:

O-10% - Satisfactory
11-25% - Marginal
26-100% - Unsatisfactory

Unsatisfactory systems should be replaced at the earliest convenience due to increased fuel consumption leading to poor economics of operation. Of the systems evaluated, the following results were obtained.

This analysis indicates that on a world wide basis, Copper, Epoxy Antifouling paint systems are the best and Chlorinated Ribbers are the worst. If sufficient histories were available, trade route and/or type of ship could be considered as variables.

Another analysis was performed on the exterior freeboard area. The data bank contained thirty histories of solvent based, (alkyl) inorganic zinc with polyamide topcoats and thirteen histories of a solvent based (alkyl) inorganic zinc topcoated with a chlorinated rubber. Of the thirty inorganic zinc/polyamide epoxy histories, twenty-eight were rated in the satisfactory performance bracket (O-10% failure), one in marginal bracket (15-25% failure), and one in the unsatisfactory bracket (50-100% failure). Stated differently, the inorganic/polyamide epoxy systems performed satisfactorily 93% of the time. The inorganic zinc/chlorinated rubber system only performed satisfactorily 62% of the time, or eight out of thirteen histories. No positive conclusion can be drawn from these small samples. However, trends are indicated. The wide difference indicates a need for further study.

Another part of this study was a limited test program to verify or support actual case histories. The exterior freeboard was selected as a representative area. This area was chosen because of the availability of the test environment and the potential of collecting adequate numbers of historical data. Solvent based (alkyl) inorganic zinc was selected as the primer because of the extensive use of this material in American Shipbuilding. Five different, well known, commonly used generic topcoats were selected.

It is interesting to note here that on the average, the (alkyl) inorganic zinc, topcoated with a polyamide epoxy, outperformed the same inorganic zinc topcoated with chlorinated rubber. This author does not advocate that inorganic zinc topcoated with polyamides are superior to inorganic zincs topcoated with chlorinated rubber. Sufficient data is not available. But the similarity between actual performance and test data does exist and reinforces the indication for further study.

In addition to indicating performance trends, the laboratory-tests demonstrated that not all paint suppliers are equally capable of formulating and manufacturing all generic types of paint. Some excel in epoxies while others excel in chlorinated rubbers.

Properly designed test programs can screen proposed candidate paints and identify potentially poor performers. The cost of such a test program may seem expensive (approximately $5,000) until it is remembered just how much it costs to replace tank coatings which have failed onboard ship (in the six figure range). It must be stressed that test programs must be properly designed and controlled. Placing steel plates painted with different materials in the steel storage yard, and then checking them at irregular intervals, is not a test program. Service environment, service conditions, type of ship, area of the ship, application methods, etc. must all be taken into consideration. Careful selection of test methods will result in the determination of the best coating systems to meet these variables.

Based on the results achieved and conclusions reached by the project, the following recommendations are offered:

1. Increase the data base of performance histories.
2. Establish a computer software program for life cycle cost evaluation.
3. Establish computer software program for evaluating production parameters for various shipyard operating conditions.
4. Combine life cycle cost data and producibility rankings into a common report for specific cases.
5. Design test programs for various severe ship service areas:
   a. Tanks, Ballast, Fuel and Cargo
   b. Underwater Bottom
   c. Boottop (one test presently in existence)
   d. Decks
   e. Cargo Spaces
6. Initiate studies of planned painting operations.

Additional copies of this report can be obtained from the National Shipbuilding Research and Documentation Center:

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