SEPT
1982

A DESCRIPTIVE OVERVIEW

OF

JAPANESE SHIPBUILDING SURFACE PREPARATION

AND

COATING METHODS

U.S. DEPARTMENT OF TRANSPORTATION
MARITIME ADMINISTRATION

IN COOPERATION WITH
AVONDALE SHIPYARDS: NEW ORLEANS, LOUISIANA

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(Text preparation services by Laurey Sledd)

This work is dedicated to the memory of Nils A. Wirstrom:

a marine coating supplier who was a respected professionaL

FOREWORD

FOREWORD

The National Shipbuilding Research Program (NSRP), whose principal objective is "increased shipbuilding and productivity," has stimulated a broad range of research projects. These projects, in turn, have kept that goal in clear view of the industry.

Recently, an objective of the National Shipbuilding Research Program has been to seek international communications, liaison and research. Logically, because Japan has won the reputation for outstanding productivity, "outreach" researchers have focused their attention on her facilities and technology.

In July 1981, an on site inspection of Japanese shipbuilding facilities was performed to study Japan's surface preparation and coating planning and methods. In addition, coating material manufacturers and application subcontractors' facilities were visited. This report summarizes the information gathered from the field survey.

Mr. John Peart of Avondale Shipyards was principally responsible for this research tour and its resulting observations and conclusions. Accompanying him was Dr. Gerald Soltz, a specialist in corrosion control and effective surface preparation and coating methodology.

The ease with which their field survey was planned, scheduled and coordinated with IHI Marine Technology, Inc. indicates the strong international character of technology in today's world. Some business publications have even suggested that "technology" will come to function as a "universal language" of the late 20th Century. Whether or not this prediction becomes a reality, certainly our keen interest in Japanese shipbuilding technology rests directly on its potential for increased productivity and applicability in U.S. yards.

This book results from one of the many projects managed and cost shared by Avondale Shipyards Inc. in conjunction with the National Shipbuilding Research Program. The program is a cooperative effort between the Maritime Adminstration's Office of Advanced Ship Development and the U.S. shipbuilding industry. The objective, described by the Ship Production Committee of the Society of Naval Architects and Marine Engineers (SNAME), emphasizes productivity. The program is conducted under the auspices of SNAME Surface Preparation and Coating Committee 023-1, Mr. C. J. Starkenburg, Avondale Shipyards, Inc. Chairman.

Special appreciation must be expressed to M. Kuriki, Y. Ichinose, H. Kurose, Y. Okayama and Mr. I. Kawai of IHI and Mr. O. Shiota, Chugoku Marine Paints, Ltd. , whose guidance made both the trip and the gathering of the information possible. Appreciation is also expressed to Mr. William F. Kirkpatrick and Mr. Ralph Neilsen of Ogden Marine Inc., whoo made the Sumitomo-Oppama visit possible and to Mr. William A. Guerry, whose insight on Japanese coating methodology and personal introductions were invaluable.

We also wish to acknowledge the companies, their managers and staffs, listed below for their valuable contribution of information.

Mr. Y. Ikehata:	Nippon Kokan Kabushiki Kaisha - Shimizu
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Mr. T. Yamamoto:	IHI - Tokyo

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Section One

SCOPE

SCOPE

1.1 BACKGROUND

The obvious world leadership of the Japanese shipbuilding industry is demonstrated by the Marine Engineering Log's comparison of Japanese, U.S. and World Ship Production for 1974. See table 1-1. [1]

TABLE 1-1

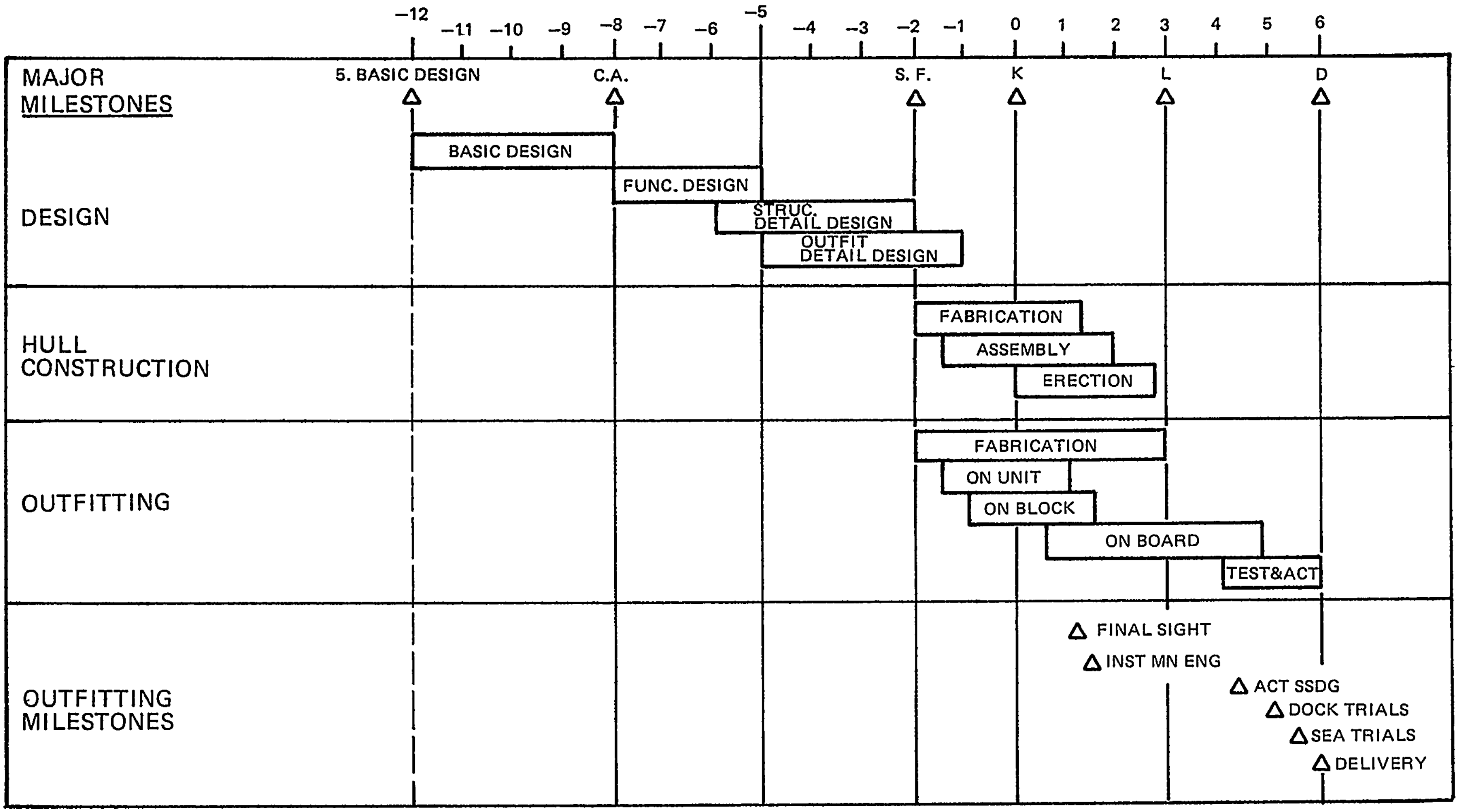
WORLD SHIP PRODUCTION

Builder	Total Ships	Total D.W.T.
World Wide	2,614	211,186,465
Japan	848	98,106,735
USA	101	5,757,460

That Japan's production superiority is characterized by short delivery times is shown in figure 1.1 [2, 3] by the milestone schedule for Mitsuibulk carrier. Traditionalists have rationalized these hugh differences in productivity times as the results of Japanese work ethics, labor costs, superior facilities and other methodological considerations. However, subsequent research by the National Shipbuilding Research Program (NSRP) investigators has not substantiated this explanation.

One of the first efforts to discover the real reasons for short delivery times was initiated by SNAME Outfitting and Production Aides Panel SP-2, Louis P. Chirillo, Chairman. This was a study of Japanese Outfitting Methods [4]. This comparative methodology study sought to identify the logic and principles of the Japanese system which could be applied to improve outfit procedures in the U.S. shipbuilding industry.

Achieving short delivery times and high ship productivity requires that production start before design and material efforts are completed. Figure 1.2 [4] illustrates this principle.



NOTES: TYPICAL WITH MINOR ADJUSTMENTS FOR A NON-STANDARD CARGO, BULK, CONTAINER, OR RO/RO SHIP.

Figure 1.1 TYPICAL JAPANESE MILESTONE SCHEDULE FOR COMMERCIAL CONSTRUCTION [2] [3]

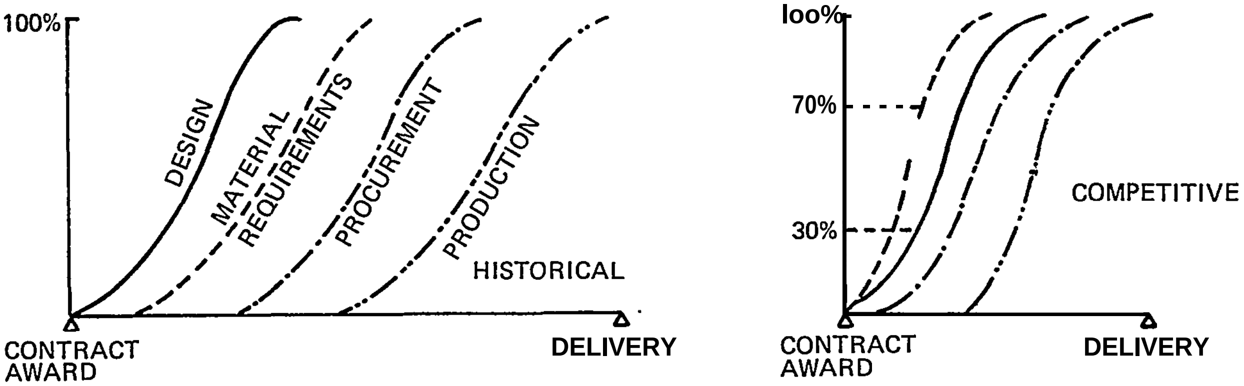


Figure 1.2 DELIVERY TIMES:OVERLAP OF OUTFIT DESIGN, MATERIAL DEFINITION, PROCUREMENT AND PRODUCTION WHICH HAS BEEN ACHIEVED BY THE MOST COMPETITIVE SHIPBUILDERS. WHEN ONLY 30% OF A DESIGN IS COMPLETED, 70% OF ITS REQUIRED MATERIAL IS DEFINED [4]

Japanese shipbuilders efficiently integrate their efforts by applying the logical principle that design and material identification are aspects of planning. Achieving such efficiency requires that the design, material identification and procurement, and production functions be perfectly integrated.

In the U. S., most shipyards now use the block-by-block approach to hull construction and, to some degree, pre-outfitting. However, in the past, pre-outfitting suffered from most of the same constraints as conventional outfitting because the work was planned and implemented by functional ship systems such as cargo, oil, and ballast propulsion.

In contrast, Japan's zone outfitting approach addresses everything within a limited 3-dimensional space or zone, freeing outfitting as much as possible from dependence on hull construction and from arbitrary control by the ships' systems. To achieve these ends, zone outfitting addresses an interim product: a hull block to which subassemblies of outfitting materials (without respect to systems) has been joined prior to transport to the erection site. This approach permits and encourages most of the outfitting work to be accomplished earlier and in shops where it is safer and cleaner and allows tools and materials to be delivered to work sites quickly and economically. Figure 1.3 summarizes the goals and benefits of zone outfitting. [4]

Zone outfitting permits the division of a production process by classes of problems so that common solutions can be applied regardless of product configurations or ships' systems. This is the basic principle of Group Technology (GT): a method for applying mass production techniques to a variety of products in varying quantities. [5]

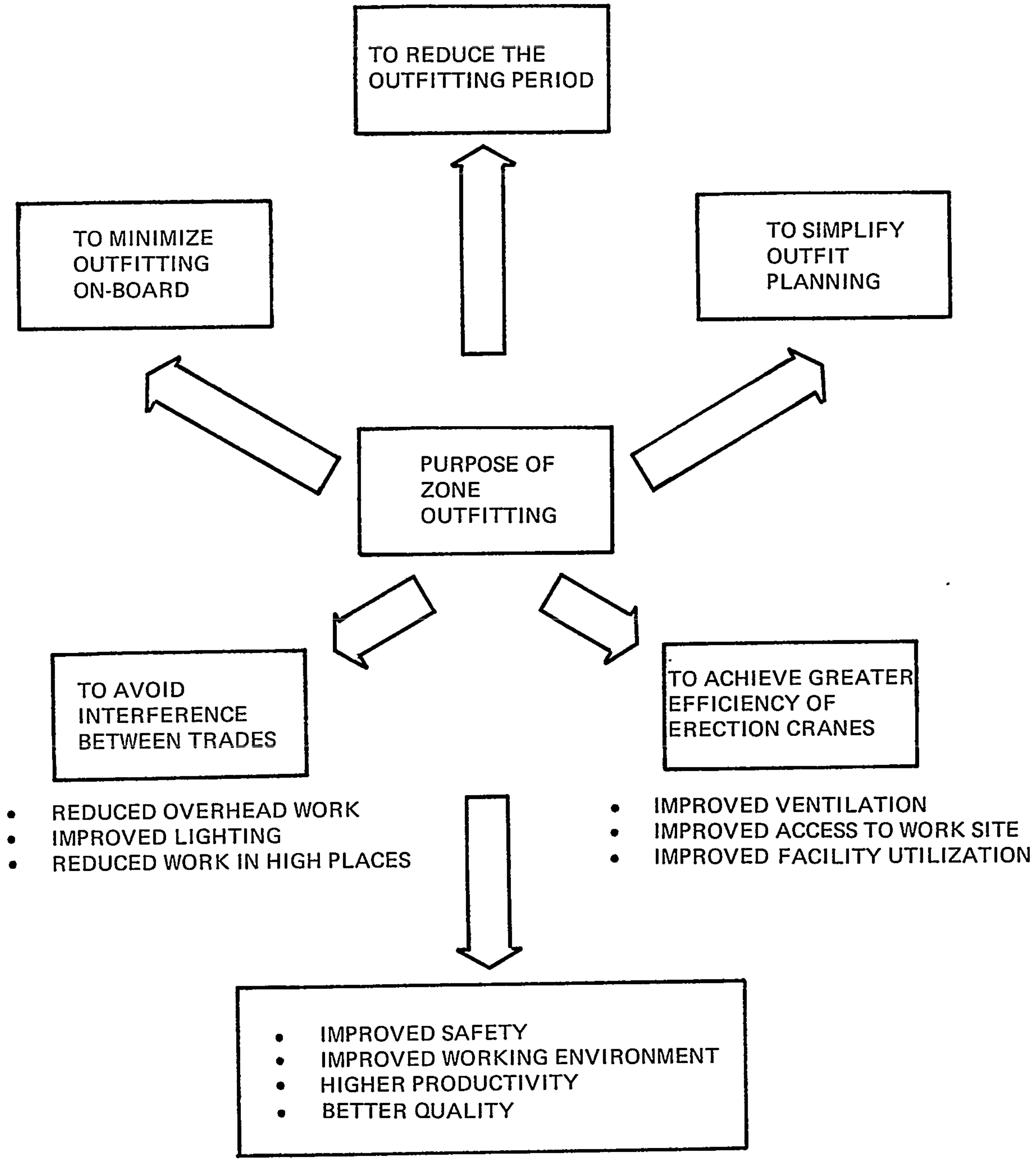


Figure 1.3 GOALS AND BENEFITS OF ZONE OUTFITTING [4]

Further investigation of the application of the logic of GT to Japanese shipbuilding methods by SNAME Outfitting and Production Aides Panel SP-2 resulted in the publications of Product Work Breakdown Structure (PWBS). [6] PWBS features classifications to permit grouping of products by similarities in production problems without regard for end-use systems. Logically, the PWBS first divides the shipbuilding process into three basic types of work: hull construction, outfitting, and painting. Each imposes inherently different problems. Regardless of difference in functional systems, zones/area/stage classifications of comparable work packages for different size ships of the same type change very little. Even for different type ships, such classifications remain essentially the same for related zones to bows, sterns, engine rooms and superstructures. Figure 1.4 schematically depicts this system. [6]

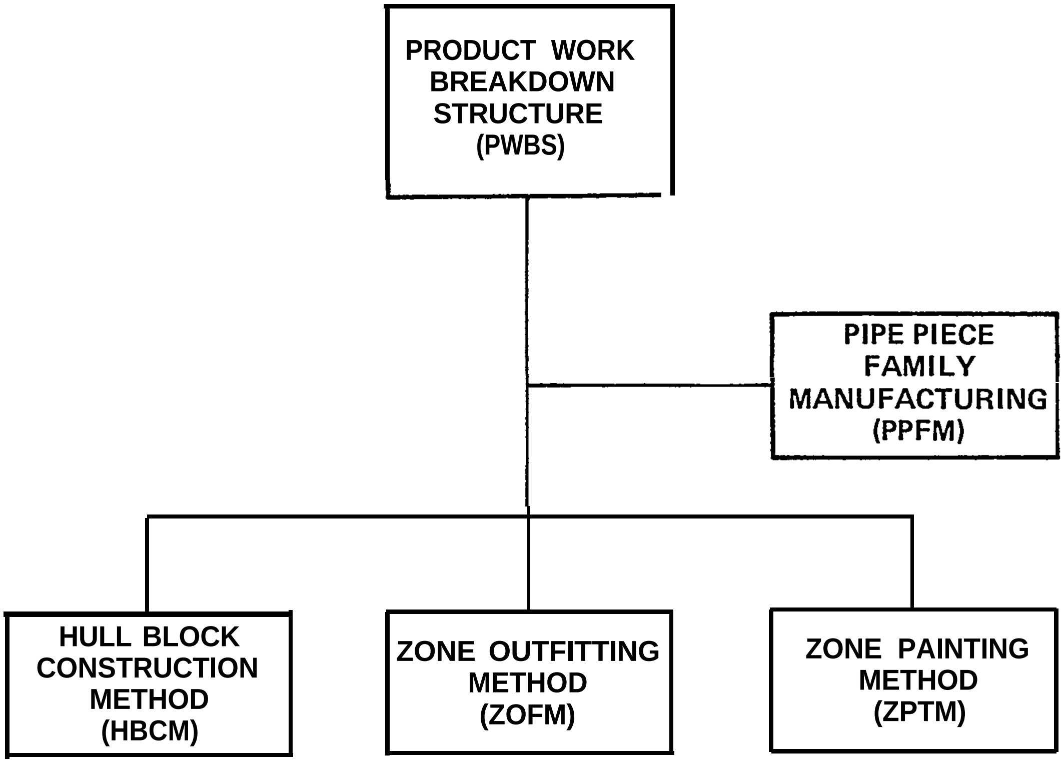


Figure 1.4 **PRODUCT WORK BREAKDOWN STRUCTURE (PWBS).** **In shipbuilding PWBS features three basic methods. Each addresses a distinct type of work. As all are zone/problem-area/stage oriented, they can be readily integrated. Also, they facilitate real and virtual flow processes in accordance with the principles of Group Technology. A fourth supporting method which is problem-area/stage oriented facilitates the application of Group Technology for fabricating parts such as pipe pieces.**

SNAME Panel 023-1 Surface Preparation and Coating, Mr. C. J. Starkenburg, Chairman, realizing the importance of the Zone Painting Method (ZPTM) in the Japanese Shipbuilding scheme, initiated a program to identify the differences between Japan and the U.S. shipyards' surface preparation and coating application and planning methods, quality standards, and materials. An additional objective is to provide procedures for integrating applicable cost effective Japanese surface preparation and coating methods applicable to U.S. shipyards. The project is subcontracted to IHI Marine Technology, Ishikawajima-Harima Heavy Industries Co., Ltd. (IHI) Japan and Chugoku Marine Paint, Ltd. The project report entitled Zone Painting Method should be published by the end of 1982.

1.2 OBJECTIVES

To provide finer definition of program objectives and method of information transfer, a visit to IHI Japan was arranged and selected shipyards and Marine Painting Contractors were visited. More generally, **the project aimed to look at the ability of Japanese shipbuilding industry to maintain high productivity and still provide a protective coating system of respectable quality .**

1.3 ORGANIZATIONS VISITED

Visits to shipyards and organizations, with the exception of the Sumitomo-Oppama visit, were arranged by IHI and all were made in a ten day period in July of 1981.

Shipyards:

- IHI-Kure Shipyard
- IHI-Tokyo Shipyard
- Sumitomo Heavy Industries, Ltd. -- Oppama Shipyard
- Kanasashi Shipbuilding Co., Ltd. -- Toyohashi Works

Paint Contractors

- Nakatagumi Co., Ltd. -- Nagasaki
- Nikami Marine Eng., Co. Ltd. -- Nippon Kokan Kabushiki Kaisha (NKK) -- Shimizu Shipyard

Other

- IHI International -- Tokyo
- Chugoku Marine Paints, Ltd. -- Hiroshima Factory
- Chugoku Marine Paints, Ltd. -- Kyushu Factory

IHI-Kure and Tokyo are older yards which have been modernized, Sumitomo and Kanasashi, being new yards. Kanasashi was being built during the Arab oil embargo of 1973. The subsequent Japanese reduction in shipbuilding capacity resulted in the yard not being completed as originally planned.

Section Two

JAPANESE WORK SYSTEMS

2.0 JAPANESE WORK SYSTEMS

2.1 GENERAL

Japanese work systems have been described very simply as SYSTEMS THAT WORK. Interviews and on-site observations conducted during this project indicated a number of factors that help make the Japanese systems work successfully.

2.1.1 Rational Approach (Detail Planning)

We are certainly not AGAINST efficiency but the term seems overused whenever Japanese production is discussed. Sometimes, it becomes a catch all term that is not totally reliable. While efficiency is just fine as a general goal, it is also possible to work with great EFFICIENCY on something that shouldn't be done at all! If this happens there won't be any productivity gain! This is not the case in the Japanese approach to work. Rather, their system can best be summarized simply as the application of logic to the business of shipbuilding.

For example, Ishikawajima-Harima Heavy Industries Co. Ltd. (IHI-KURE) puts an emphasis on the word "rational" in explaining their approach to shipbuilding. They explain that, **"the fabrication systems are established rationally according to the lines and shapes of the products from the supply of materials to completion... ."** Elsewhere in the same company publication is the statement that **"The block construction method that is incorporated with a conveyor system further ensures overall rational operation."**

What this Japanese company means by "rational" is "WELL PLANNED!"

Throughout the Japanese shipbuilding industry, the PLANNING PHASE PREDOMINATES! It is more wide-ranging, more methodical, more comprehensive, and worked out in more detail than is usual in the U.S.

2.2 ZPTM PLANNING

2.2.1 General

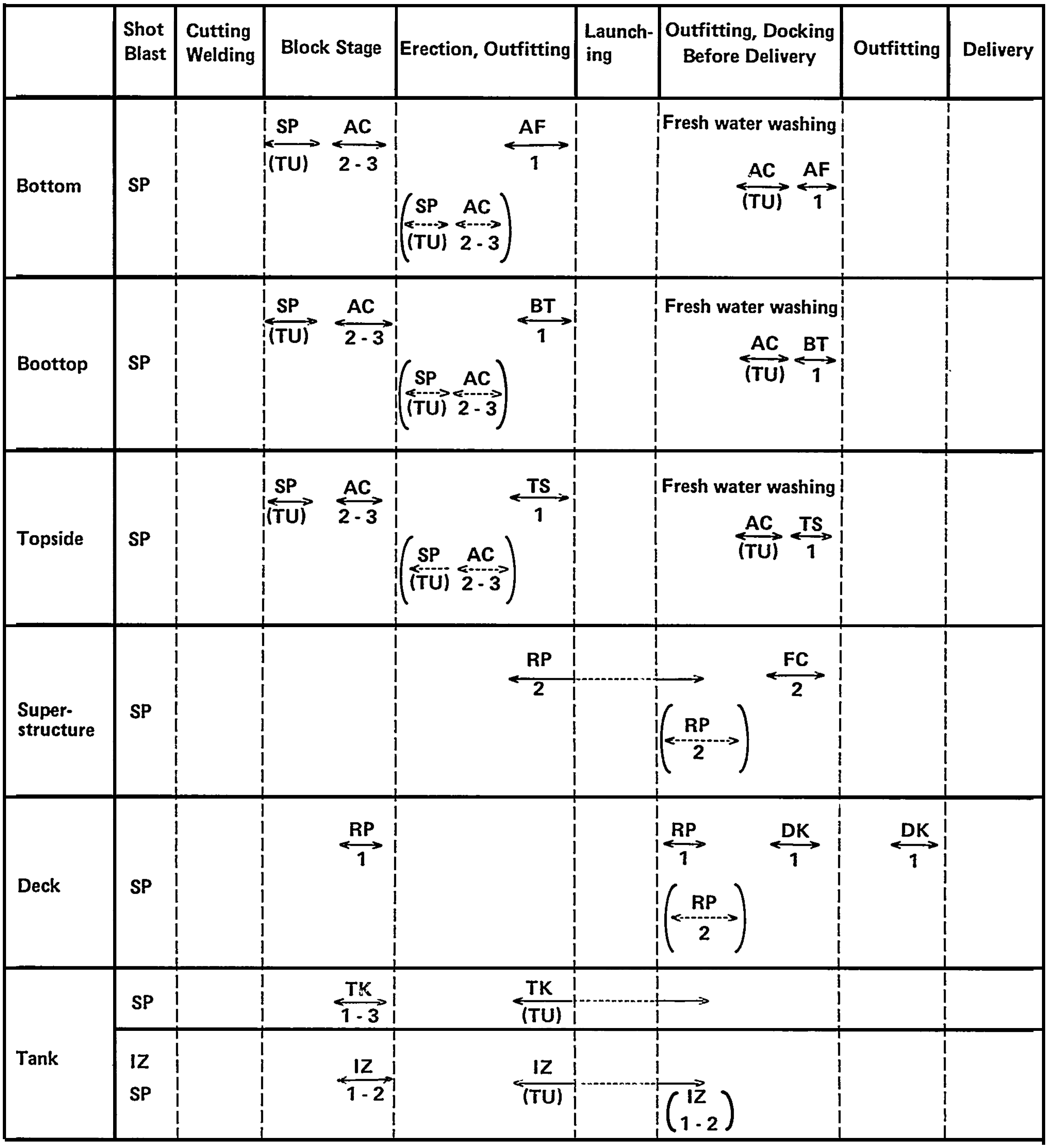
This section will provide brief introduction of the planning processes required to effectively implement the Zone Painting Method as practiced by Japanese Shipbuilders. The Zone Painting Method project report will define the planning aspects in detail.

Japan's introduction of the hull construction (HBCM) and zone outfitting initiated the development of the ZPTM, which has improved the surface preparation and coating productivity. These developed processes are conceptualized according to principles of Produce Work Breakdown Structure (PWBS) discussed in section one. These principles as applied in the HBCM not only enable the outfitting processes (ZOFM) to be grouped in work packages but also allow the painting processes (ZPTM) to be so grouped and integrated with them. These groupings are made according to zone, area, and stage of the product being fabricated, removing the painting process from the historical "catch as catch can" scheduling approach to a carefully planned and integrated one.

The three processes (HBCM, ZOFM, ZPTM) progress sequentially. Therefore, each activity must be coordinated into one integrated master schedule, the driving force behind effective ship production. Expressed more emphatically, schedules control production rather that the reverse.

The painting process varies somewhat, depending on shipyard facilities, period of construction, type and size of ship, and so forth. Figure 2.1 depicts the standard painting process used by the Japanese zone construction method. Its emphasis on block coating and careful integration with the other construction processes results in shorter construction periods, increased production, and better surface preparation and coating control.

The most obvious deviation from U.S. shipyard painting methods, depicted in figure 2.1, is the fact that all plate and structurals are shop primed and no abrasive blasting is performed subsequently. All secondary touch-up surface



Note: SP: Shop primer, AC: Anti-corrosive paint, AF: Anti-fouling paint,
BT: Boottop paint, TS: Topside paint, FC: Finish paint,
RP: Rust preventive paint TK: Tank paint, IZ: Inorganic zinc paint,
TU: Touch-up, (<---------->): Other processes

Numbers: number of coats: e.g. $\overset{AC}{\underset{2-3}{\longleftrightarrow}}$ means 2 or 3 coats of antifoulant

Figure 2.1 STANDARD NEW CONSTRUCTION PAINTING PROCESS preparation performed at the block and erection stages consists of power tool cleaning.

2.2.2 Plan Development

Surface preparation and coating, treated as equal in importance and integrated with the hull construction and zone outfitting planning processes, are addressed in every phase of the ship construction sequence:

- Pre-contract negotiations
- Engineering definition
- Integrated scheduling
- Materials Control (paint quantity and need dates)
- Test
- Drydock
- Cost Control

This is illustrated in Figure 2.2, which schematically depicts paint planning and engineering documentation flow. Painting is referenced at some twenty milestone points. In the figure, milestones are listed horizontally and the function and cognizant group, vertically. Of special interest in the schematic is the degree of planning detail and the extend to which it is accomplished prior to the start of construction. This is characteristic of the zone construction method.

2.2.3 Schedules

Three typical schedules, figures 2.3, 2.4, and 2.5, demonstrate the degree of planning detail and the close integration of the coating process with the hull construction and zone outfitting processes accomplished by the Japanese planners. Full definition of schedule content such as nomenclature, derivation of data, and unit magnitudes has yet to be fully provided by IHI. These schedules will be discussed in greater detail in the Zone Painting Method report.

Figure 2.3, Master Coating Schedule and Manhour Plan, is much less detailed than the actual IHI equivalent which is, in fact, a combination of 2.3 and

2.4, (Block Stage Coating Schedule). The milestones appear horizontally on all the schedules. The month is divided into three periods of ten days based on a five day work week. This division makes the development of the paint shop’s two week painting schedule easier. The estimated manhours, paint quantity, painted area and a calculated efficiency for evey ten days are plotted graphically as shown in figure 2.3.

The painting efficiency varies from block to block due to block configuration and stage to stage (unit, block and berth). The estimated efficiency is based on actual historical manhours/square meter data accumulated from painting blocks with similar configurations and problem areas. This data is always being refined as additional data is accumulated as each ship is painted.

As work progresses, paint quantity, area painted and manhour data are collected for each ten day period (two calendar weeks), and the efficieny is calculated. Then, data is plotted and compared to the estimated data in the Master Coating Schedule and Manhour Plan, (figure 2.3).

If there is sufficient variation from the estimated norm, an immediate investigation is made to determine the cause and the corrective action required. If the deviation can be explained by identifying a new problem area not associated with past blocks upon which the estimate was based, the data base is updated to reflect this condition. This results in more accurate estimates on future contracts and closer production control. By using these planning procedures, close control on painting progress and cost is maintained.

The Block Coating Schedule (figure 2.4) is generated at the Master Construction Schedule Meeting. Engineering drafts the schedule, coordinating it with managers of assembly, erection, and hull machinery and electrical outfitting. The data presented in the schedule cannot be fully interpreted as presented. Additional information such as the ship's block breakdown plan and more detailed instruction on its use is required. A discussion of this material will not be attempted in this introductory overview but will be addressed in the Zone Painting Method report. Some block identifying nomenclature is presented as an aide to understanding figure 2.4.

The blocks are numbered aft to forward:

D: a double bottom hull block. e.g. D9
G: the shell portion of a double bottom hull block. i.e. D9-G
S: shell block (next level up.) e.g., D-O-G-S
Exponential S or P: designates starboard or port respectively.
e.g., D-9-G-S^P
DL: a lower deck block (next level up.) e.g. L-9-DL
DU: an upper deck block (next level up.) e.g. L-9-DU
T: transfer cofferdam. e.g. T 8
HC: Cargo hold. e.g. HC3

The coating schedule after launch, figure 2.5, is made in a similar manner as the Block Stage Coating Schedule except Quality Control Department is included and Hull Construction Department is excluded unless specifically required in the coordination. These schedules are presented to the shop foremen, who are responsible for the detailed planning on a biweekly and/or weekly basis.

2.3 SHIPYARD FACILITIES: TECHNICAL BASE

Shipyard facilities are obviously an important factor *in* overall ship building productivity. The shipbuilding facilities observed in Japan reflected CAREFUL PLANNING IN THE COORDINATED USE of machines, automatic and computer linked devices, and heavy equipment that were OFTEN EXCELLENT--but ALWAYS ADEQUATE--when measured against the best current state-of-the-art facilities.

Japanese facilities varied in sophistication from Sumitomo-Oppama, a new yard, to IHI-Tokyo, an old yard with very limited room. Sumitomo-Oppama used highly efficient, numerically controlled plasma arc cutting and employed many automatic welding techniques in its steel fabrication shop. In contrast, IHI-Tokyo depended more on Electro Print Marking (EPM) and relied on semi-automatic cutting techniques. More use of semi-automatic and manual welding was noted, also. That the less modern IHI-Tokyo facility achieves such high production efficiency and competitive posture reemphasizes the importance of logic and planning to Japanese productivity.

See figures 2.6 and 2.7 for descriptions of these two yards.

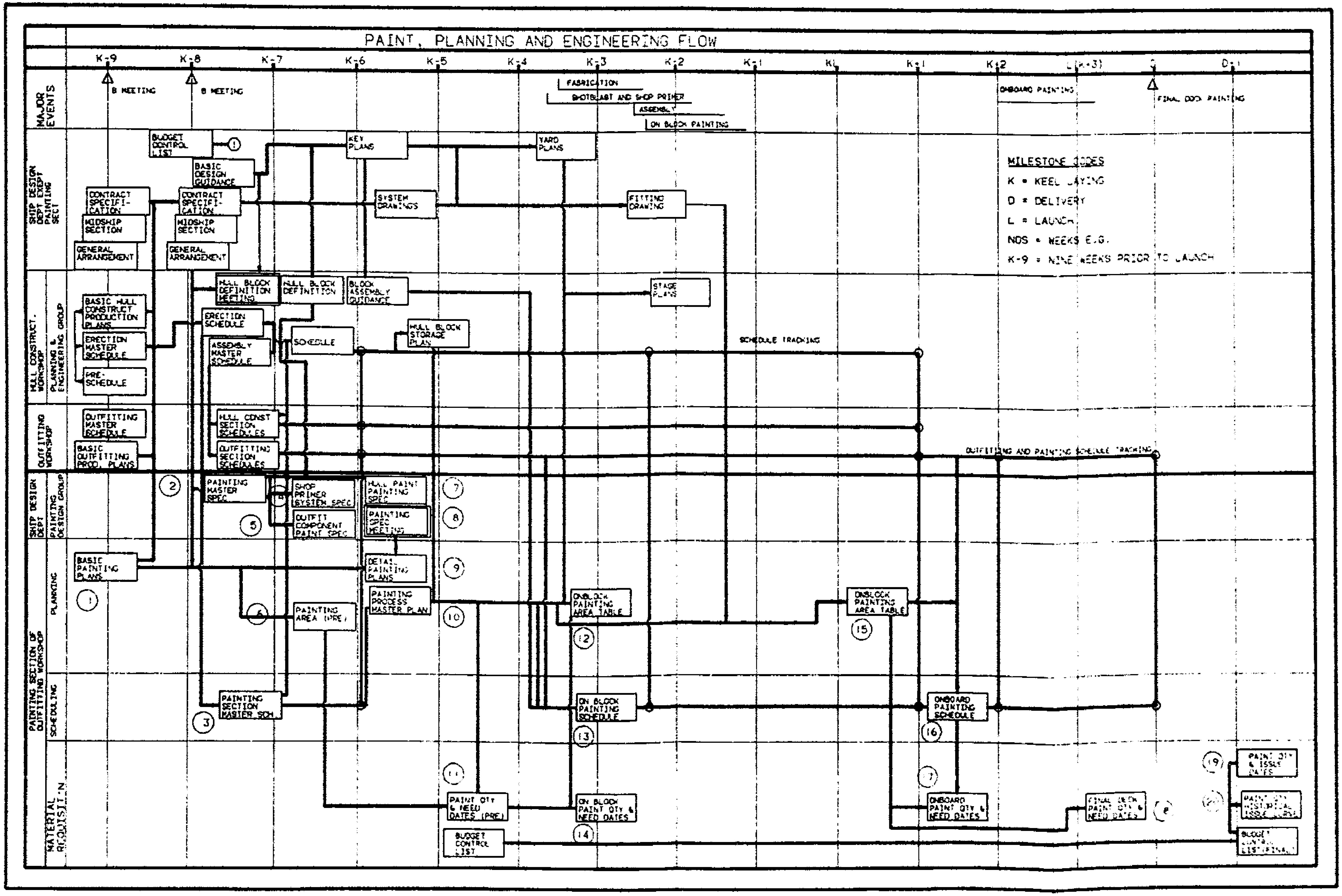

PAINT, PLANNING AND ENGINEERING FLOW
K-9
K-8
K-7
K-6
K-5
K-4
K-3
K-2
K-1
KL
K+1
K+2
L(K+3)
D
D+1
MAJOR EVENTS
B MEETING
B MEETING
FABRICATION
SHOTBLAST AND SHOP PRIMER
ASSEMBLY
ON BLOCK PAINTING
ONBOARD PAINTING
FINAL DOCK PAINTING
SHIP DESIGN DEPT EXEPT PAINTING SECT
BUDGET CONTROL LIST
1
BASIC DESIGN GUIDANCE
KEY PLANS
YARD PLANS
CONTRACT SPECIFI-CATION
MIDSHIP SECTION
GENERAL ARRANGEMENT
CONTRACT SPECIFI-CATION
MIDSHIP SECTION
GENERAL ARRANGEMENT
SYSTEM DRAWINGS
FITTING DRAWING
MILESTONE CODES
K = KEEL LAYING
D = DELIVERY
L = LAUNCH
NOS = WEEKS E.G.
K-9 = NINE WEEKS PRIOR TO LAUNCH
HULL CONSTRUCT. WORKSHOP
PLANNING & ENGINEERING GROUP
BASIC HULL CONSTRUCT PRODUCTION PLANS
ERECTION MASTER SCHEDULE
PRE-SCHEDULE
HULL BLOCK DEFINITION MEETING
HULL BLOCK DEFINITION
BLOCK ASSEMBLY GUIDANCE
STAGE PLANS
ERECTION SCHEDULE
ASSEMBLY MASTER SCHEDULE
SCHEDULE
HULL BLOCK STORAGE PLAN
SCHEDULE TRACKING
OUTFITTING WORKSHOP
OUTFITTING MASTER SCHEDULE
BASIC OUTFITTING PROD. PLANS
HULL CONST SECTION SCHEDULES
OUTFITTING SECTION SCHEDULES
OUTFITTING AND PAINTING SCHEDULE TRACKING
SHIP DESIGN DEPT
PAINTING DESIGN GROUP
2
PAINTING MASTER SPEC
4
SHOP PRIMER SYSTEM SPEC
HULL PAINT PAINTING SPEC
7
5
OUTFIT COMPONENT PAINT SPEC
PAINTING SPEC MEETING
8
PAINTING SECTION OF OUTFITTING WORKSHOP
PLANNING
BASIC PAINTING PLANS
1
DETAIL PAINTING PLANS
9
6
PAINTING AREA (PRE)
PAINTING PROCESS MASTER PLAN
10
ONBLOCK PAINTING AREA TABLE
12
ONBLOCK PAINTING AREA TABLE
15
SCHEDULING
PAINTING SECTION MASTER SCH.
3
ON BLOCK PAINTING SCHEDULE
13
ONBOARD PAINTING SCHEDULE
16
MATERIAL REQUISITI'N
11
PAINT QTY & NEED DATES (PRE)
BUDGET CONTROL LIST
ON BLOCK PAINT QTY & NEED DATES
14
17
ONBOARD PAINT QTY & NEED DATES
FINAL DECK PAINT QTY & NEED DATES
18
19
PAINT QTY & ISSUE DATES
20
PAINT QTY HISTORICAL ISSUE CURVE
BUDGET CONTROL LIST (FINAL)

FIGURE 2.2

Ship No.

MASTER COATING SCHEDULE AND MANHOUR PLAN

Prepared as of

Owner's Name

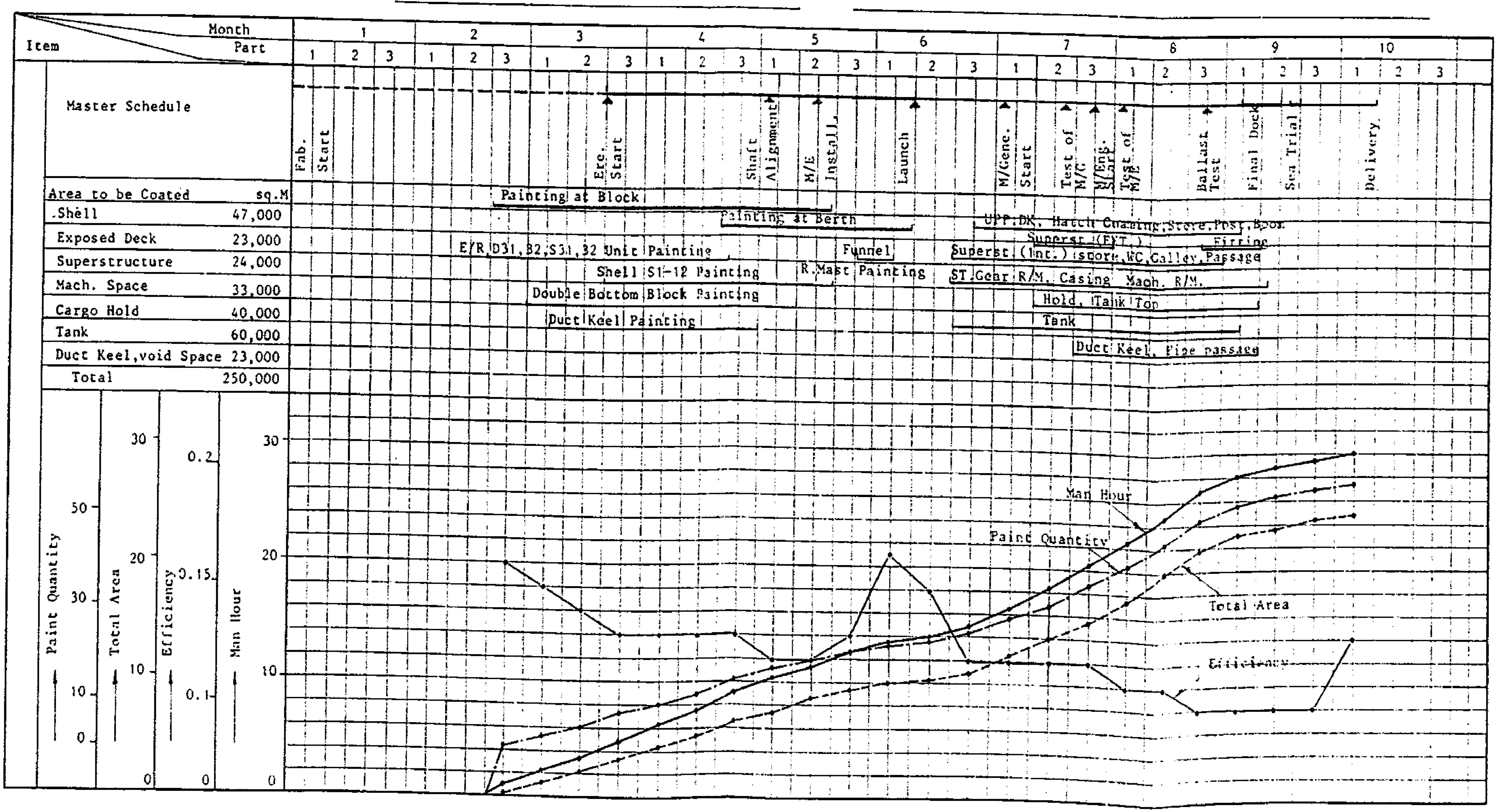


Figure 2.3

Ship No.

BLOCK STAGE COATING SCHEDULE

Prepared as of

Owner's Name

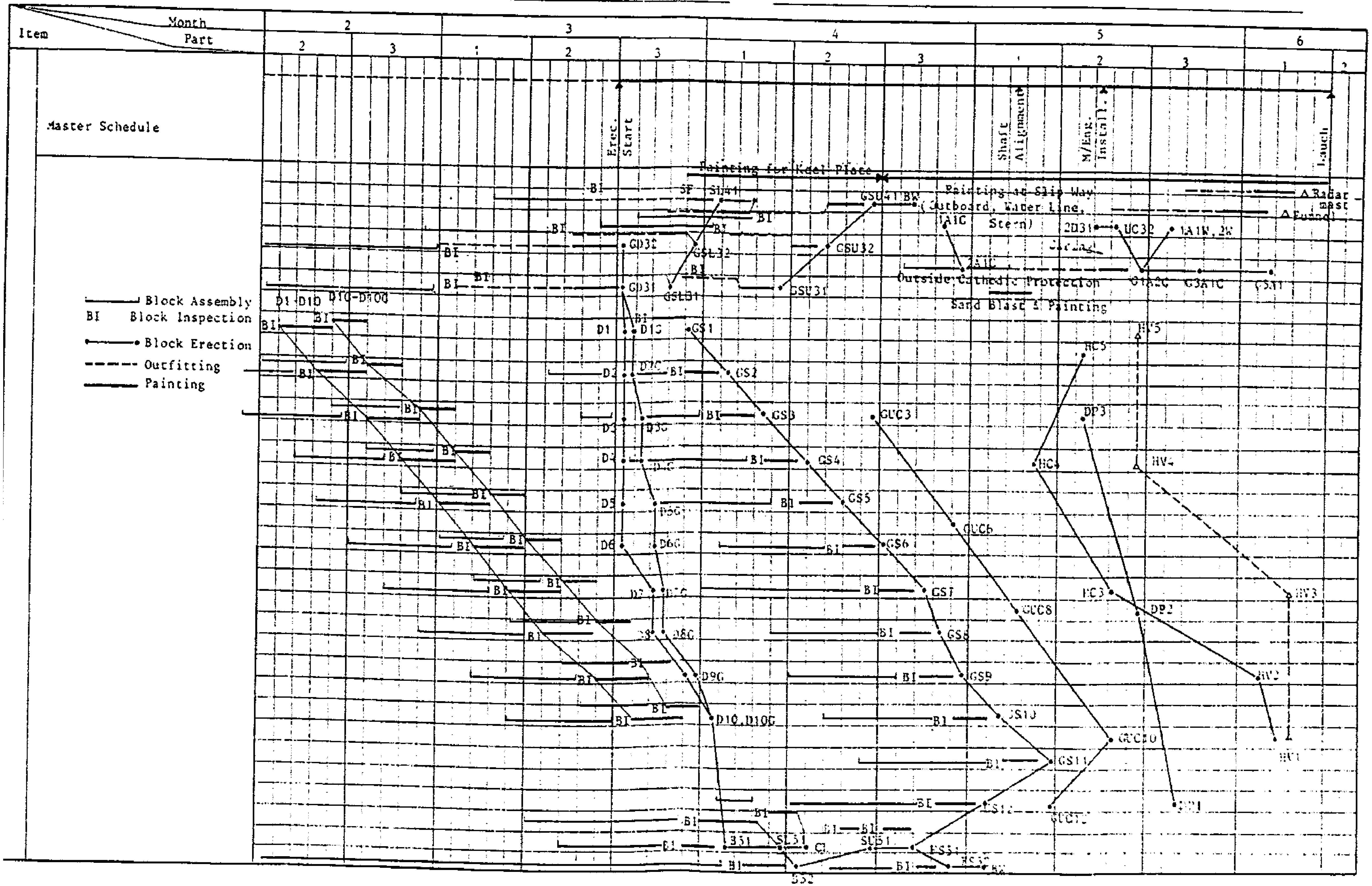


Figure 2.4

Ship No.

COATING SCHEDULE AFTER LAUNCHING

Prepared as of

Owner's Name

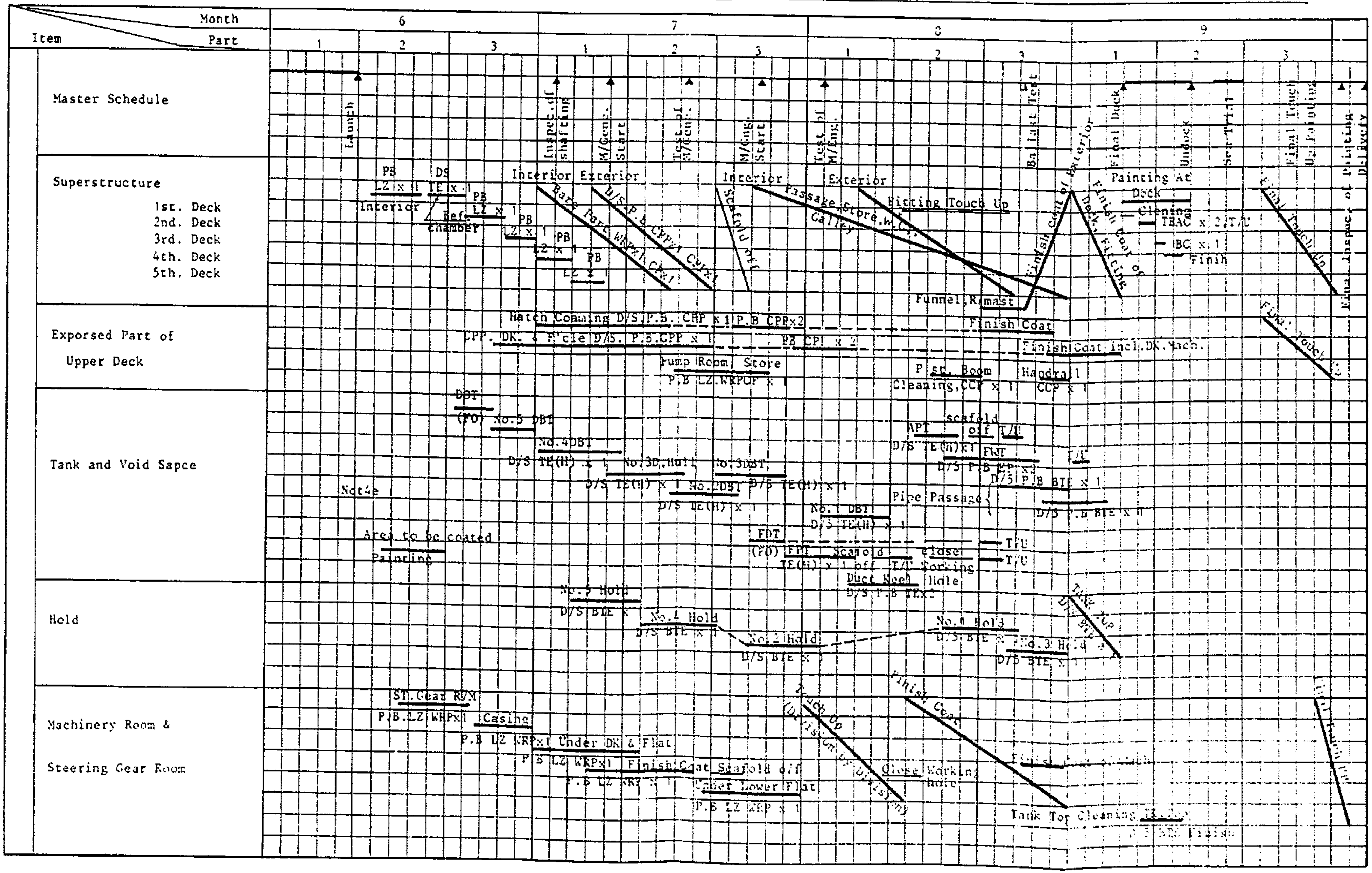


Figure 2.5

ACITY AND FACILITIES

:	538,000m^2 (133 acres)
ling dock:	
ype:	Dual entrance
apacity:	500,000 dwt
ength:	560m (1,840 ft)
readth:	80m (263 ft)
epth:	12.6m (42 ft)
uxiliary cilities:	2 sets of 300-ton goliath cranes 200-ton jib crane 2 sets of 30-ton hammer head cranes 30-ton jib crane 3-ton movable jib crane Tunnel to the bottom of dock

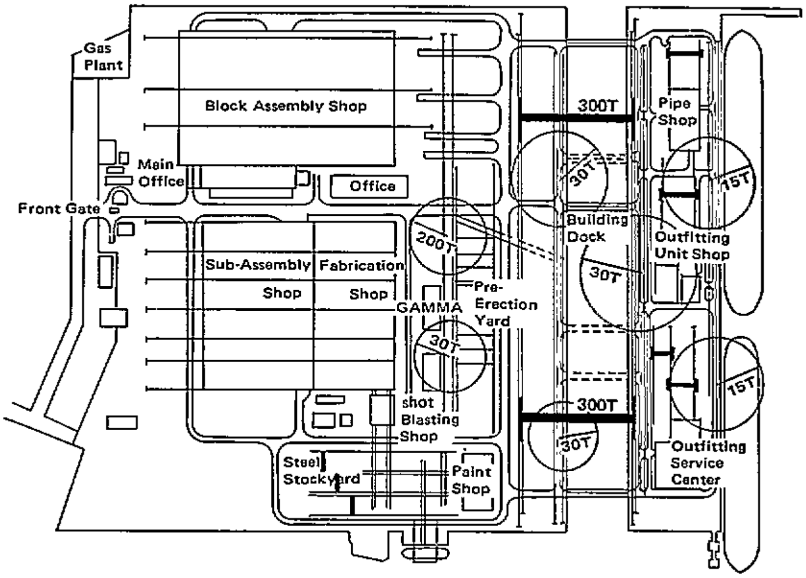


Figure 2.6 SUMITOMO - OPPAMA

SCOPE OF TOKYO SHIPYARD

S & BERTH	LENGTH	WIDTH	DEPTH	CRANE
dock	138m (453 ft)	19.5m (64 ft)	7.27m (24 ft)	10T x 1 6T x 1
dock	180m (591 ft)	24.0m (79 ft)	7.27m (24 ft)	10T x 1
	175m (574 ft)	25.0m (82 ft)	–	85T x 1, 45T x 3 5T x 1

rea of premises:

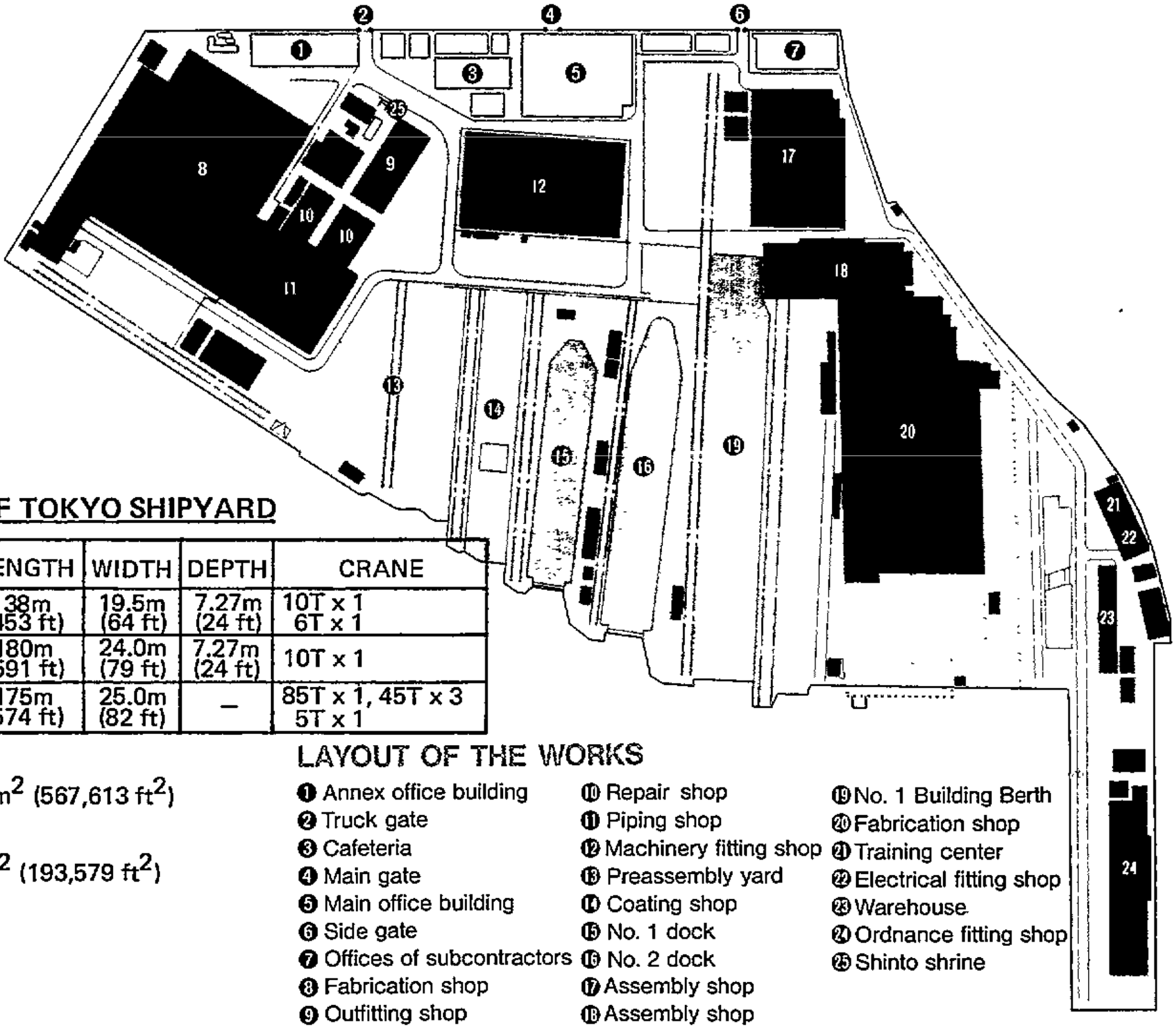
Approx. 173,000m^2 (567,613 ft^2)

rea of buildings:

Approx. 59,000m^2 (193,579 ft^2)

employees:

Approx. 1,900



LAYOUT OF THE WORKS

- ① Annex office building
- ② Truck gate
- ③ Cafeteria
- ④ Main gate
- ⑤ Main office building
- ⑥ Side gate
- ⑦ Offices of subcontractors
- ⑧ Fabrication shop
- ⑨ Outfitting shop
- ⑩ Repair shop
- ⑪ Piping shop
- ⑫ Machinery fitting shop
- ⑬ Preassembly yard
- ⑭ Coating shop
- ⑮ No. 1 dock
- ⑯ No. 2 dock
- ⑰ Assembly shop
- ⑱ Assembly shop
- ⑲ No. 1 Building Berth
- ⑳ Fabrication shop
- ㉑ Training center
- ㉒ Electrical fitting shop
- ㉓ Warehouse
- ㉔ Ordnance fitting shop
- ㉕ Shinto shrine

Figure 2.7 IHI - TOKYO

2.4 ROLE OF SUBCONTRACTORS

The impact of surface preparation and coating on the cost of a ship is well recognized and appreciated by the Japanese shipbuilder. In fact, it is given equal importance as hull construction and outfitting and is addressed logically in every phase of the construction sequence. Moreover, the production problems associated with surf ace preparation coating are considered so specialized that much of the in-house work is subcontracted. These specialty subcontractors are given both production responsibility and prestige.

For instance, IHI-Kure estimates that it employs 600 people in work related to surface preparation and coating responsibility. This figure includes engineering, supervision, management, quality control, production liaison and similar functions in addition to workers who actuallY carry out designated job operations. Of this number, however, 300, or 50 percent, are SUBCONTRACTED PERSONNEL rather than direct hired-i n-the-yard employees!

Moreover, where “in sittu” surface preparation of tanks is required after erection, as in the case of product carrier cargo tanks, subcontractors do it at the outfitting dock after launch, or the ship is moved to the subcontractor’s facilities’.

Mikami Marine Engineering Co., Ltd. and Nakatagumi, Co., Ltd. two major Japanese coating subcontractors, offer <u>specialized expertise</u> in their area which they can continually build upon and refine for higher productivity. Of the 70 product carriers that the Japanese shipbuilding industry projected for 1981, approximately 30 were to be coated at Nakatagumi facilities. Subcontractor capabilities are further discussed in section 3.7.2., Cargo Tanks.

2.5 INTRA- I NDUSTRY RELATIONSHIPS

In Japanese industry, consortium-type business relationships are recognized and are valid for shipbuilding. Therefore, different yards have preferred propulsion and electrical equipment and marine coating suppliers.

The business bond between Japanese yards and coating suppliers is characterized by TRUST. These “trusting” business relationships, these guarantees of products, are no mere exercises of good manners but, rather, are a serious fact of business in Japan. Yards trust paint companies to provide quality materials and inspection standards. When questioned, a shipyard manager stated, “WE DO NOT HAVE TO TEST A PAINT COMPANY‘S COATING MATERIAL TO SEE IF IT LIVES UP TO ITS SPECIFICATIONS.”

This “consortia-like” behavior may indicate that these more advanced or “evolutionary” kinds of business organization and ethics may have more impact on Japanese productivity than previously anticipated. For example, a result of this business relationship, Japanese shipyards have greater influence selecting the new construction marine paint systems and suppliers than the owner; the opposite is true in the U.S. In application problems, results are a true concern of the supplier, who is very aware of WHERE and HOW the material is to be applied and how it will react to the application environment.

Demonstrating this concern is the fact that preconstruction primers and top coats have been developed by the paint companies in response to shipyard production requirements. These requirements are prime development criteria for the Japanese coating formulations of the future”. This supplier/shipyard cooperative partner relationship is also extended to include the application subcontractor, resulting in extended guarantees. See Table 2-1.

TABLE 2-1

TYPICAL EXTENDED COATING GUARANTEE

1st yr:	will repair any coating damage beyond 3%
2nd yr:	will repair any damage beyond 5%
3rd yr:	repair damage exceeding 8%
4th yr:	repair coating damage exceeding 10-15%

The supplier assumes more responsibility in the definition of application requirements, inspect ion procedures, documentation, and final product quality. The process' quality is imparted by the applicator and is insured by his supervisor before the job is released to the paint suplier representative for inspection. In this scheme the shipyard and owner inspect at only two points: after final surface preparation and after job completion. (Ref. to Cargo Tank Finish Specification, Inspection, Appendix A, section 6). This integrated relationship makes partners of the three parties in productivity and provides a quality product. Thus, the system which Japan employs offers obvious advantages to shipbuilding productivity.

2.6 JAPANESE MANAGEMENT

A comprehensive discussion of Japanese management techniques must first look at their production system, the cornerstone of Japan's highly productive shipbuilding industry. The Product Work Breakdown Structure (PWBS) [6] employs the logic of group technology, which requires middle managers to be TRAINED TO THINK ANALYTICALLY ABOUT INDUSTRIAL ENGINEERING CONCERNS.

These managers are highly trained shipbuilding engineers who Plan and coordinate various material procurement, fabrication, and assembly tasks required in shipbuilding. Based on interim products, their planning and coordinating efficiently integrates painting, outfitting, and hull construction.

According to Dr. Shinto, past president of IHI, the lack of industrial engineering training of production managers in the U.S. creates an obvious and serious weakness in our shipbuilding industry. Japanese designers and managers are different from those in the U.S. in that they work cooperatively with all of the work groups who plan the detailed work designs. In fact, managers' performance and and abilities are measured and evaluated, in part, according to their success in cooperating with and coordinating work between groups. The smoothness with which the system works, then, provides the yardstick with which a manager's ability is measured.

The manufacturing system depends on the production of many interim products, and each product is a cost center. To estimate the time and manhours needed to complete a certain job, then, the Japanese call upon data accumulated from manufacturing previous interim products which presented similar problem areas. In this way, the time taken to perform a task can be compared to the estimated normal time. If the projected times are exceeded, the reasons for the deviation are identified, analyzed, and corrected. Thus, managers and personnel are accountable for their performance. Moreover, workers understand their importance to the system and its success and are motivated to cooperate with managers to increase production.

2.7 JAPANESE WORKER ATTITUDES

Japanese labor relations can best be described by the following excerpt from a Forbes Magazine article entitled “Tiger by the Tail .’’[7]

THE JAPANE SESYSTEM: MANAGEMENT AND MACARTHUR

> “Am more modern form of labor organization than anything we have in the West′′is how Robert J.Ballon describes the Japanese system of labor management relations. Ballon is a professor of economics at Tokyo’s Sophia University and one of the foremost experts on Japanese labor practices.’’ It’s a common myth,"he says,"that the system grew out of a traditional pattern of Japanese culture.’’ Not at all. it’s a postwar innovation, owing a great deal to General Douglas MacArthur - a system developed on patterns borrowed mainly from U.S. corporations and academics and pragmatically melded with the traditional Japanese social structure.
>
> This melding creates verbal confusion.’’ Most of the English words people apply to Japanese business conditions don’t really mean what they suggest,"Ballon says. There are shareholders in most Japanese companies, but the companies don’t feel accountable to stockholders; the business really belongs to the people who work there, which is partly why Japan has no takeover movement. And the object of the business isn’t usually, or primarily, to make money for the owners but to provide jobs for the workers. There are labor unions. Except for the seaman’s union, however, they are not craft or industrial unions, but enterprise unions, organizations encompassing all the permanent workers of a single company. In Japan, a company consists of labor and management combined, and until MacArthur told them it wasn’t proper, management personnel belonged to the unions along with the workers. And why not? The success of the company is the common interest of everybody who works for it. “If the company goes bankrupt," Ballon explains, “that’s the end of the union.”
>
> “In the West,"says Ballon, a Belgian-born Jesuit priest who has spent the last thirty years in Japan, ″we take some individuals and add them up and somewhere a group comes out.″ In Japan, it’s the work group that gives a man his significance, his identity. It’s an identity he proclaims by the company pin he wears in his lapel’’A Japanese uses the same word to refer to his home and his company, and that's fitting,'EalIon says,"because a Japanese doesn’t work for a living, he considers work a way of life.″
>
> Given the high degree of security Japan’s lifetime employment system provides, how come the Japanese are so thrifty? The whole system is geared to encourage thrift and thus provide low cost capital for industry. For example, in addition to the usual monthly wage payment, there are two semiannual deferred payments, inaccurately called bonuses. They are paid in June and December and, combined, often equal more than six additional monthly payments. For the companies, the plan is a way of encouraging thrift and financing working capital needs without pain. For the employees, it means they tend to live below their means, and that is in part why the Japanese 20 percent annual savings rate is among the highest in the world.
>
> “When you talk about wage,’’ Ballon says, “in Japan also talk about age.’’Mostpeople go to work for a company when they get out of high school or college, move up, more or less in lockstep, with other people hired at the same time, and stay there until they retire at age fifty-five. They don’t have much choice but to stay because if you go anywhere else, you are back to zero in the seniority system.

With this cooperative relationship, described in the above article, the company’s financial success becomes the paramount concern of both management and labor. In the shipbuilding industry, this concern is obvious. It is claimed in Japan that workers always strive to bring a job to completion above specification not because it is an owner’s requirement or directive, but, rather, because the quality of their work must be maintained in order to assure that their PRODUCTION SYSTEM works. Thus, because workers are informed by management about what is needed for productivity, they share an awareness of broad company-wide production goals. Then, when the company is successful, management recognizes and publicly acknowledges the workers’ contributions to its success.

The workers are also taught that attentive observation is critical to material and procedural assessment and is essential to quality control. Through the “Quality Circle” program, they are encouraged to analyze and report their observations to managers in the interest of improving productivity.

Moreover, workers are expected to focus attention upon small work scopes, work routines and/or subsystems. This worker psychology contrasts significantly with Western norms as it is not based on ambitious outreach to extend a worker’s sphere of influence; instead, it is based on EXCELLENT EXECUTION OF MODEST WORK ROUTINES TO THE BETTERMENT OF THE WHOLE. To many, this attitude explains one remarkable strength of the Japanese production system.

2.8. WORKER SAFETY

The basic tenant of the zone construction method is to do as much work as possible at the unit, assembly, and block level and to keep work to be done on berth at a minimum. This system enables the manager to plan safe, comfortable, and convenient jobs for the workers, resulting in higher productivity and quality.

The ZPTM plan adheres to the same principle, creating the following production advantages.

- Improved access to work sites
- Protection from the elements
- Improved ventilation
- Improved lighting
- Reduced overhead work
- Reduced work in high places
- Reduced requirements and better use of facilities
- Reduced craft interference
- Improved worker safety

When on-berth painting is required and scaffolding is necessary, the design provides ample room for worker safety, and safety nets are used. Wherever possible, permanent adjustable scaffolding fixtures are designed to be reusable from ship to ship. Refer to section 3.10, Production Aides.

Japanese unions and management are very conscious of the industrial hygiene requirements for the work areas and are concerned for the health and safety of the workers. For example, tank blasting and coating present threats such as height, fire, and toxicity which are addressed in the coating company literature and in the job specification. To counter these dangers, much attention is given to in process ventilation, humidity, and temperature control of the tanks.

Concern for the toxicity of solvent base paints is shown by the high solids and waterborne coatings which are now being developed and field tested. The shipyards' interests in worker safety and influence on the marine coating market are driving forces behind developments of this kind.

Section Three

SURFACE PREPARATION: TECHNIQUES

3.0 SURFACE PREPARATION: TECHNIQUES

3.1 METHODOLOGY: ZONE PAINT METHOD (ZPTM)

Because the Japanese shipbuilding methodology focuses upon producing interim products and analyzing costs accurately, it realizes the impact of surface preparation on the cost of building a ship. Not only is the direct cost of the labor and materials for surface and coating preparation known; the Japanese are also aware of their impact on hull construction, outfitting, man hours, and delivery schedules. Moreover, their system also takes into consideration that the operations involved are dirty, uncomfortable, and dangerous and, therefore, unattractive to the higher educated, younger generation who might otherwise specialize in this field.

Recognizing all of these effects of surface preparation and coating on overall productivity and cost, a Choguku Marine Paints, Ltd. paint publication concludes that the only way to mitigate this impact is to increase operation efficiency and reduce the manhours required to perform these operations. Shipbuilders, then, treat surface preparation and coating as equally important as hull construction and outfitting. Each phase of ship construction from pre-contract negotiations to final drydocking and delivery addresses surface preparation and coating problems.

Every paint process is carefully analyzed, planned, and closely integrated to the scheduling and manufacturing plan. Painting systems are selected with care in order to be compatible with construction methods and schedules. In most cases, subcontracted specialists take over the responsibility of paint application.

The care taken to select appropriate material is emphasized by the universal use of shop primer and their preference for inorganic zinc as this primer. Its superior corrosion and burn back resistance has reduced secondary preparation costs by 30 to 40 percent according to a Japanese shipbuilding manager. Also emphasizing care taken in material selection is the preference for coal tar epoxy, including the use of the bleached type for engine room applications. This choice of coal tar epoxy was made because it is compatible with power tool cleaning, their choice of secondary surface preparation, when possible.

The ZPTM employed adheres to the basic concepts of the HBCM and ZOFM and is compatible with them. Painting at the part, assembly, and block level is maximized; only erections weld pickup and/or finish coats are applied on berth. All work on interim products is completed as planned, and no unscheduled welding, grinding or other work is permitted on the items later in the production cycle. In this way, little damage of previously applied coating occurs.

The Japanese are as meticulous in carrying out work as they are in planning it, a key contribution to high quality work and overall productivity. In some yards, hand rails, ladders, and other assemblies that could be coating-damaged by handling or traffic are carefully wrapped prior to be being installed to reduce possible damage. The wrapping material is a non-adhesive nylon fabric which is wound and tied around the structures that are to be protected. Refer to figure 3.1.

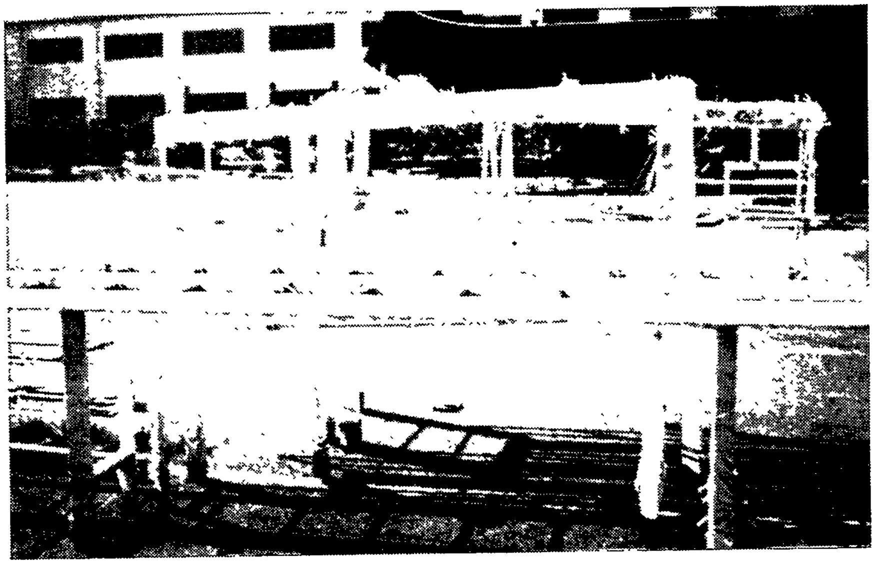


Figure3.1 WRAPPED COATED LADDERS-- KANASASHI

This small procedural detail illustrates Japanese respect for high standards and quality work components in their system. In fact, no effort is spared to avoid damage, material loss and consequent time loss to repair or replacement work. The most ABSOLUTE law in the Japanese manufacturing system in NO REWORK, as reworking has such a negative impact on productivity.

3.2 SURFACE PREPARATION

In primary surface preparation, to remove corrosion products and mill scale from steel, automated steel shot blasting with centrifugal wheels is used. To protect against corrosion during fabrication and erection, a preconstruction primer is applied.

In secondary preparation, to remove weld slag; damaged primer, and rust formed during fabrication when the primed steel is cut, welded, burned or mechanically damaged; power tool cleaning is employed, unless otherwise specified.

Table 3-1 defines the surface roughness obtained from different surface preparation methods.

TABLE 3-1

SURFACE PREPARATION METHOD AND SURFACE ROUGHNESS

Method	Max. Roughness	
Grit blast	100 microns	4 roils
Shot blast	70 microns	2.8 roils
Sand blast	40 microns	1.6 roils
Power brush	5 microns	.2 roils
Disc sander	15 microns	.6 roils
Acid pickling	10	.4 roils

The degree of derusting is the most important aspect of surface preparation. It therefore is necessary to consider formalized cleaning standards for surface preparation.

The major standards are shown below.

a. S1S 055900 (SVENSK STANDARD, Swedish Standards)
b. SSPC-SP (STEEL STRUCTURES PAINTING COUNCIL SURFACE PREPARATION SPECIFICATION, U.S.A.)
c. STANDARD FOR DE-RUSTING OF SHOP-PRIMED STEEL SURFACE (The Japanese Shipbuilding Research Association, JAPAN)

Among these standards, S1S 055900 and SSPC-SP have been widely used. Table 3-2 shows the **comparison of SIS 055900 with** SSPC-SP.

TABLE 3-2

COMPARISON **OF SSPC-SP AND S1S**

SSPC-SP	S1S 055900			
SSPC-SP2	B St 2	C st 2	D St 2	
SSPC-SP3	B St 3	C st 3	D St 3	
SSPC-SP5 *	A Sa 3	B Sa 3	C Sa 3	D Sa 3
SSPC-SP6 *	B Sa 2	C Sa 2	D Sa 2	
SSPC-SP7	B Sa 1	C Sa l	D Sa 1	
SSPC-SP1O *	B Sa 2 1/2			

* sspc-sp5 : White blast cleaning

SSPC-SP6 : Commercial blast cleaning

SSPC-SP1O: Near white blast cleaning

3.3 PRE-PRIMED PLATES AND STRUCTURAL

In some Japanese yards, the initial surface preparation and priming are carried out at the steel mills before delivery to the yard. The ability of the Japanese to order pre-primed plates and structural directly from the mill is a great advantage to yards that do not have the space for blasting and coating facilities or do not want to spend the money that such a facility would require.

For example, IHI-Kure and Sumitomo chose to invest in their own facilities, but IHI-Tokyo has pre-primed plates and structural delivered. The steel mill will pre-prime with any standard primer, according to specifications. Such primers include etching primer (butyral), organic zinc rich, and inorganic zinc.

3.4 AUTOMATED PLATE PRIMING

Automatic blasting and priming facilities are typical of Japanese yards which do not purchase pre-primed plates. First, the plates are normally pre-heated and then shot-blasted with centrifugal wheels with steel grit and/or steel shot, which is recycled. Both sides of the plate are blasted simultaneously. The quality of the blast is an Sa 2.5 with about a 2-mil profile.

After blasting and dust removal, the plate proceeds immediately to an automatic spray machine where both sides are coated simultaneously, usually at a 15 micron (.6 mils) dry film thickness. Then, it is oven dried at about 50 degrees C. (122 F.) for “several minutes. Table 3-3 depicts a typical process specification.

TABLE 3-3

PROCESS SPECIFICATION

grade of shot (diameters used.)	0.8-1.2 mm
impeller motor hp (6 wheels)	50 hp
impeller speed	2000 rpm
feed rate of steel plate	20 FPM
width of steel plate blasted	12′
surface roughness of steel after blasting	40-60 (4) (1.5-2.5 roils)
-- grade of blasting	SSP-SP-lO(SA 2.5) Near White

3.4.1 Airless Spray

In Japanese yards, airless spray is used almost exclusively. Even though airless spraying characteristics of inorganic zinc primer are less than ideal, it is superior to the previous pre-construction primers that were specified. In most Japanese shipyards, airless equipment is used to apply inorganic zinc.

3.4.2 Tapered Rollers

Tapered rollers are used to transport the painted plate until it is dry. This system allows the plate to remain suspended during the paint application and drying phases. The tapered roller, which touches only the plate edges, eliminates the coating damage that non-tapered rollers can cause. See figure 3.2.

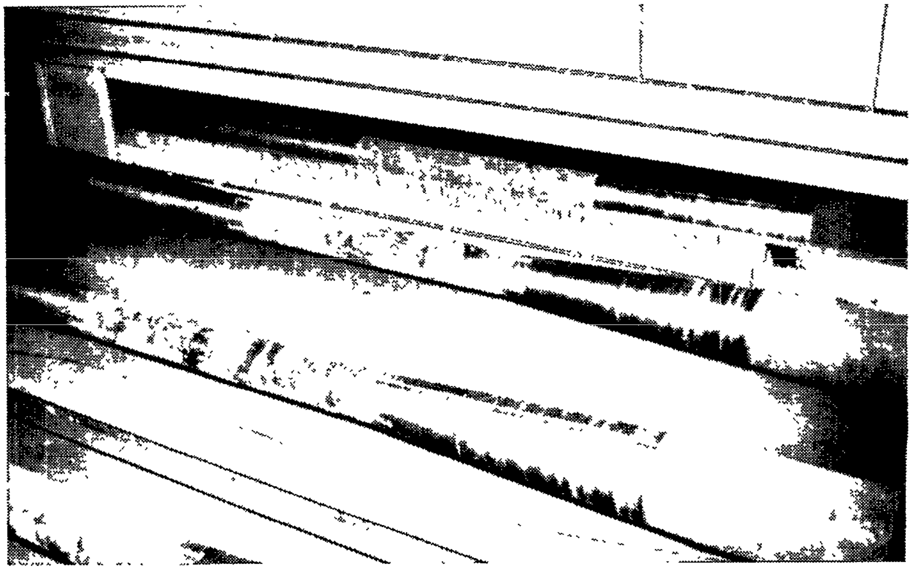


Figure 3.2 TAPERED ROLLERS - - IHI-KURE

3.5 PLATE HANDLING AND BURNING

After the painted plate moves through the drying oven, it is dry to touch but not fully cured. When this stage of coating and initial drying is complete, most yards use a magnetic pick-up crane for lifting the plates to a storage buffer zone in the plate burning area. None of the surveyed yards use numerically controlled (NC) transfer systems that automatically move the plate to the designated burning station.

In general, Japan's yards use NC burning machines for plate cutting much less than U.S. yards. Older Japanese yards rarely use them while new yards like Sumitomo, which is designed to build 6 VLCC, up to 500,000 tons yearly, use them exclusively. Sumitomo uses plasma arc numerically controlled cutting. Even there, however, comparably fewer N.C. burning machines are available than in U.S. yards of similar size. This difference might be explained by the zone planning and scheduling methods in Japan, which preclude accumulating unscheduled items.

Electro Print Marking (EPM) is used a great deal in Japan, even in yards which have some NC burning equipment. To a smaller extent, some optical guide torch systems are used. In general, after the parts are EPM marked, they are cut to shape by semi-automatic track-guided torches. Figure 3.3 shows a close up of an EPM marked plate and figure 3.4 shows an EPM processed plate being cut semi-automatically by a tracked burner.

Figure 3.3 EPM MARKED PLATES
-- IHI-KURE

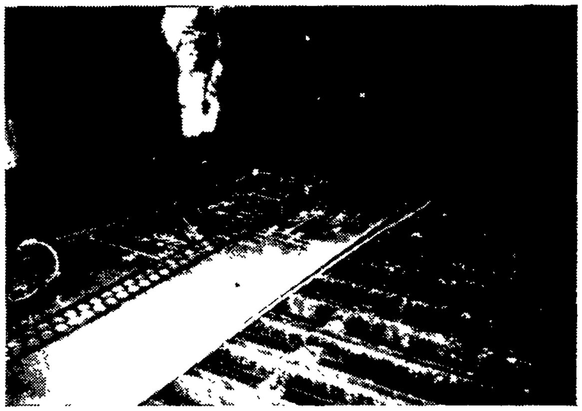


Figure 3.4 EPM PROCESSED PLATE
-- IHI-KURE

3.6 BLOCK FABRICATION/PRE-OUTFITTING

Because further processing of shaped plate parts depends on their size, small parts are forwarded to a knitting area where they are organized into a group (a kit) for a particular assembly or block fabrication. Other parts may be moved directly to assembly fabrication stations. Large plates continue by a roller system or by crane transfer to the panel line, where plate and structural joining is performed.

The panels and fabricated assemblies are then further joined into blocks of twenty to four hundred tons, depending on the size of the ship. For larger vessels, blocks may be joined again into super blocks (sections) in areas adjacent to the graving dock. To transfer these super blocks into the dock for erection, large gantry cranes are used. These blocks are extensively pre-outfitted prior to erection. Also, the block coating plan requires that pre-outfitted parts and assemblies are primed and/or finished coated before installation. See figures 3.5, 3.6, 3.7 and 3.8, actual on-site photos.

3.7 SECONDARY SURFACE PREPARATION AND COATING

3.7.1 General

In the coating process, it is standard in Japan's ZPTM system to combine the shop primer system with block coating. The shop primer is applied after the steel is shot blasted, and the coating is applied at the block stage. Also, power tool cleaning is used and coating systems are selected to be compatible with this grade of required surface preparation, thus increasing the system's productivity.

The standard secondary surface preparation that the block receives prior to coating is as follows.

- Flat surface edges and butt welds are abrasive disc sanded.
- Fillet welds are cleaned with radially wire brushes and/or twisted wire cup brushes powered by a high speed die grinder.

Figures 3.9, 3.10, 3.11, and 3.12 are photos of secondary surface preparation observed in Japanese yards.

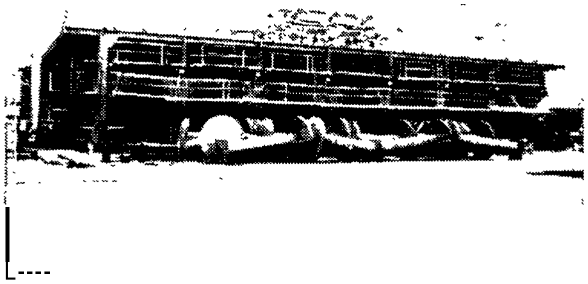


Figure 3.5 PRODUCT CARRIER DECK BLOCK--SUMITOMO

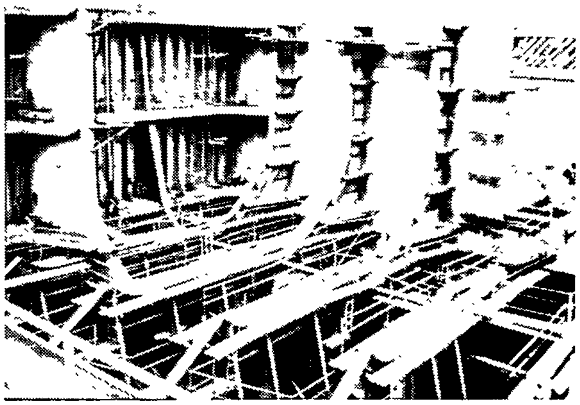


Figure3.6 PRODUCT CARRIER CARGO TANK BEING ERECTED --SUMITOMO

Figure3.7 BALLAST TANK BEING ERECTED--SUMITOMO

Figure3.8 PRODUCT AND BALLAST TANK BLOCK AWAITING ERECTION --SUMITOMO

Figure 3.9 shows a flapper, an abrasive disc machine used by Kanasashi to clean exterior butt welds.

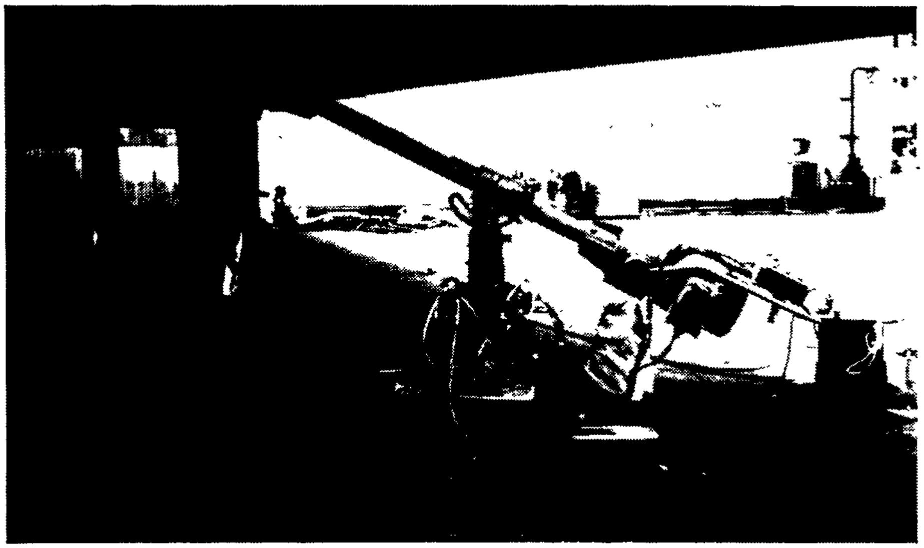


Figure 3.9 FLAPPER WHEEL MACHINE --KANASASH1

Figure 3.10 shows a butt weld at IHI-Tokyo before and after cleaning by disc sanding.

Figure 3.10 BUTT WELD BEFORE AND AFTER DISC SANDING --IHI-TOKYO

Figure 3.11, also taken at Kanasashi, illustrates surface preparation of heat damaged primer by disc sanding.

Figure 3.11 DISC SANDING HEAT DAMAGED PRIMER --KANASASHI

Figure 3.12 shows how Kanasashi cleans a fillet weld by wire cleaning. Notice that the cleaning is not complete; rust remains on the edge of the stiffener.

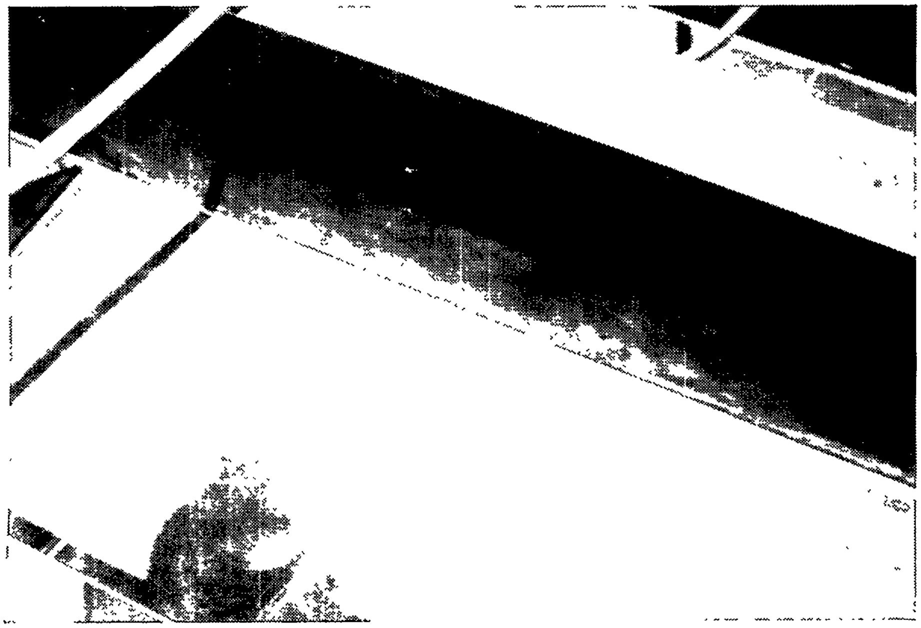


Figure 3.12 FILLET WELD CLEANED BY WIRE BRUSHING -- KANASASHI

Figure 3.13 pictures an upper side block at IHI-KURE.

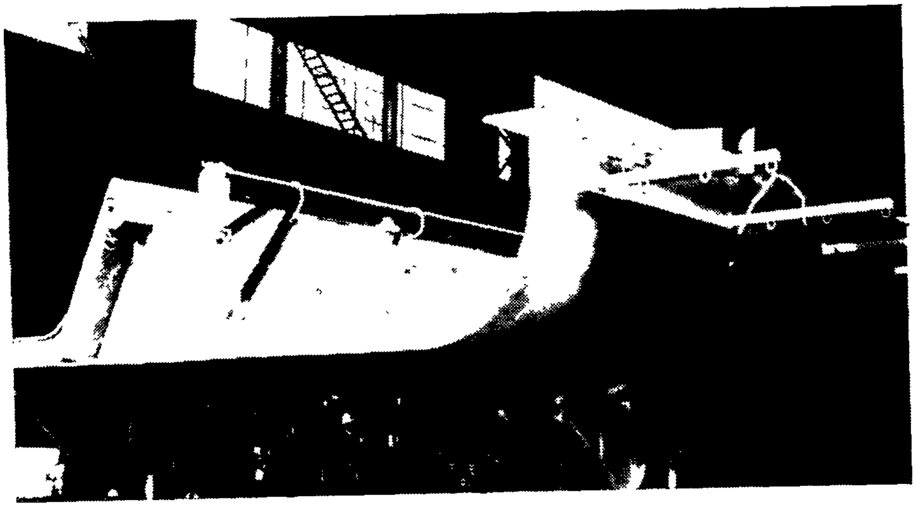


Figure 3.13 UPPER SIDE BLOCI<--IHI-KURE

Note: o pipes, pie hangers and deck stantions are coated prior to installation.

o Welds are power tool cleaned prior to block painting.

o Succeeding coats are staggered.

Figure 3.14 shows hull blocks at IHI-KURE after erection.

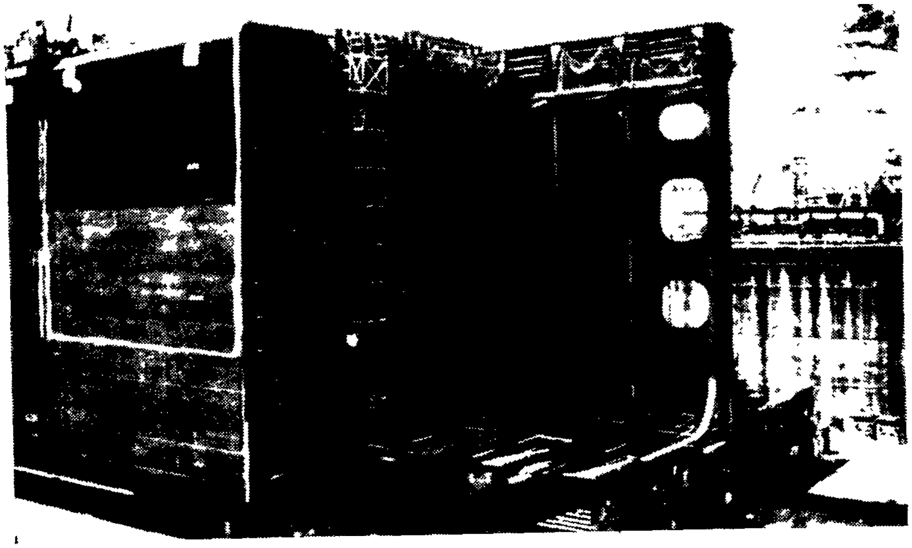


Figure 3.14 HULL BLOCKS AFTER ERECTION --IHI-KURE

Note: o Erection welds are to be coated.

o The coating is in excellent condition.

- o An automated butt welder is used.
- o The coal tar apoxy coated wing ballast tank is pictured.
- o The cargo tank block is to be coated "in sittu."

Figure 3.15 shows the engine room at IHI-KURE.

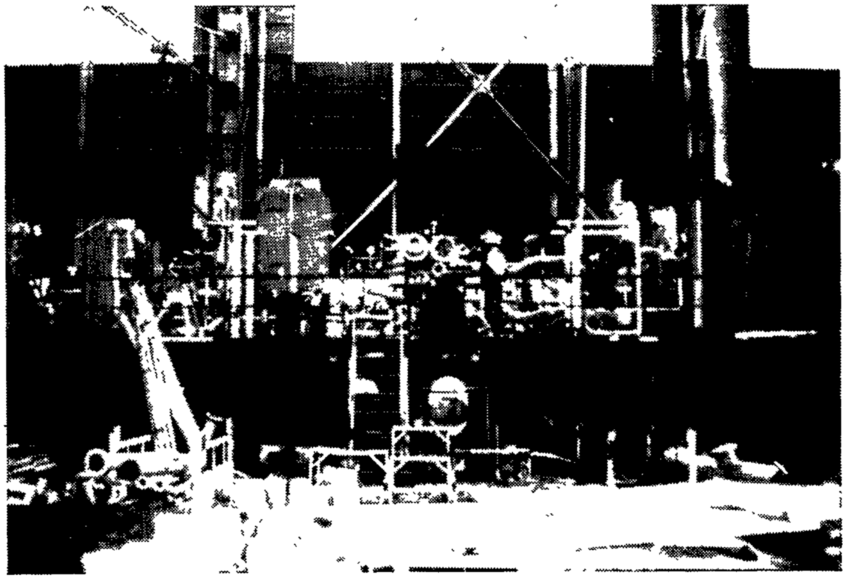


Figure 3.15 DOUBLE BOTTOM FLAT BLOCK - - IHI-KURE

Note:

- 0 Parts and assemblies are kitted.
- 0 Craft interference is minimal.
- 0 Most outfitting has been completed.

Figure 3.16 is a close up of the engine room pictured in figure 3.15.

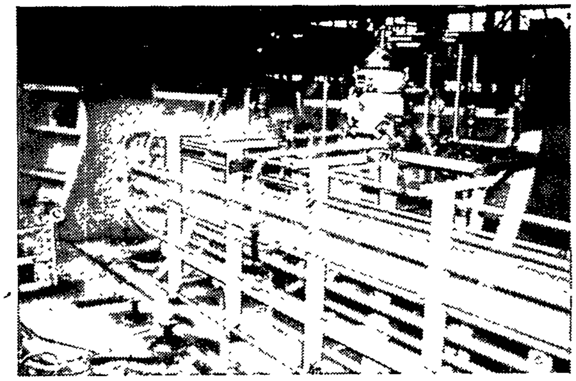


Figure 3.16 CLOSE-UP OF ENGINE ROOM -- IHI-KURE

Note:

- o Piping and hangers are assembled adjacent to the block and installed as assemblies.
- o The paint system is generally in good condition.
- o Burn damage from welding which also occurs on the overhead of the double bottom are power tool cleaned and touched up on the block.

The deck house block at IHI-KURE is shown in figure 3.17.

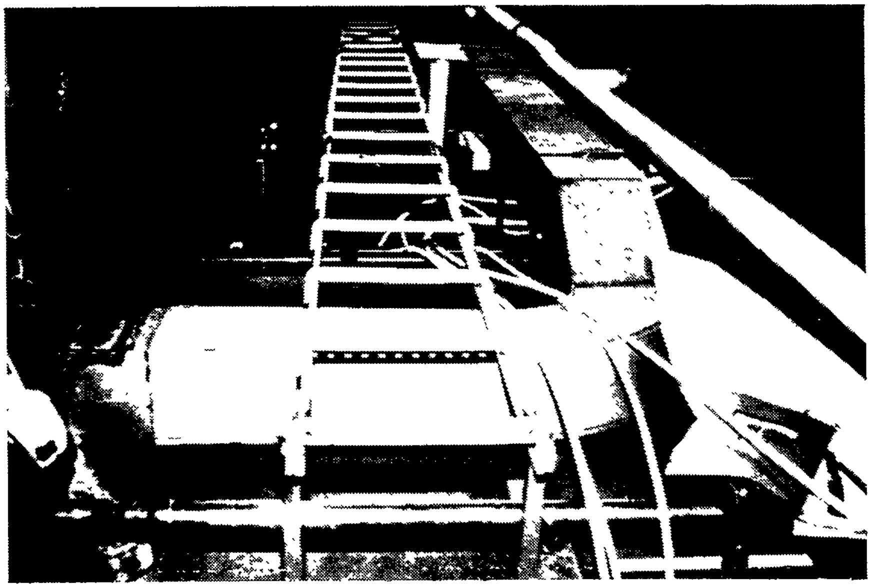


Figure 3.17 DECK HOUSE BLOCK--IHI-KURE

Note:

- o The deck house is inverted and outfitting is done downhand.
- o Power tool cleaning and touch up of damaged paint are done before the block is turned over.

Figures 3.18 and 3.19 show the top and bottom of the main engine room respectively. These photographs are also from IHI-KURE.

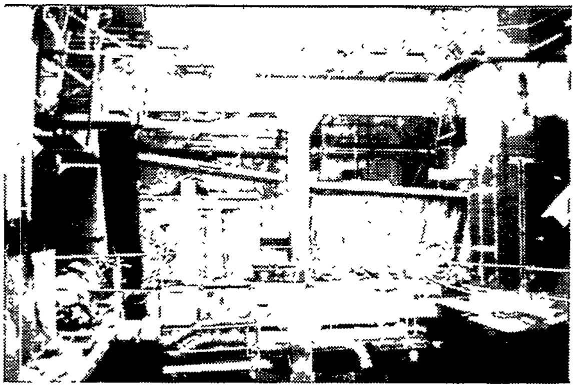


Figure 3.18 TOP OF MAIN ENGINE ROOM -- IHI-KURE

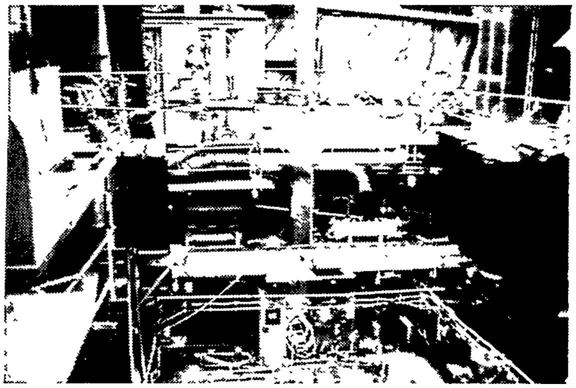


Figure 3.19 BOTTOM OF MAIN ENGINE ROOM -- IHI-KURE

Note:

- A good degree of equipment installation done on the block.
- Coating is done to varying degrees at block interfaces.
- The appearance is clean and uncluttered.
- Coating damage is to be power tool cleaned and primed and intermediate coats applied.
- A final coat of bleached coal tar epoxy is to be applied.

3.7.2 Piping

Piping and small parts such as wire hangers, brackets, ladders and other equipment that does not require high performance coating are pickled. The Japanese prefer phosphoric acid pickling, but other mineral acids are available.

Piping that requires inorganic zinc and high performance epoxy systems is blasted to Sa 2.5 or Sa 3.0 both internally and externally, as specified. prior to pipe coating, the welds of product piping are ground smooth if required. See figures 3.20 and 3.21.

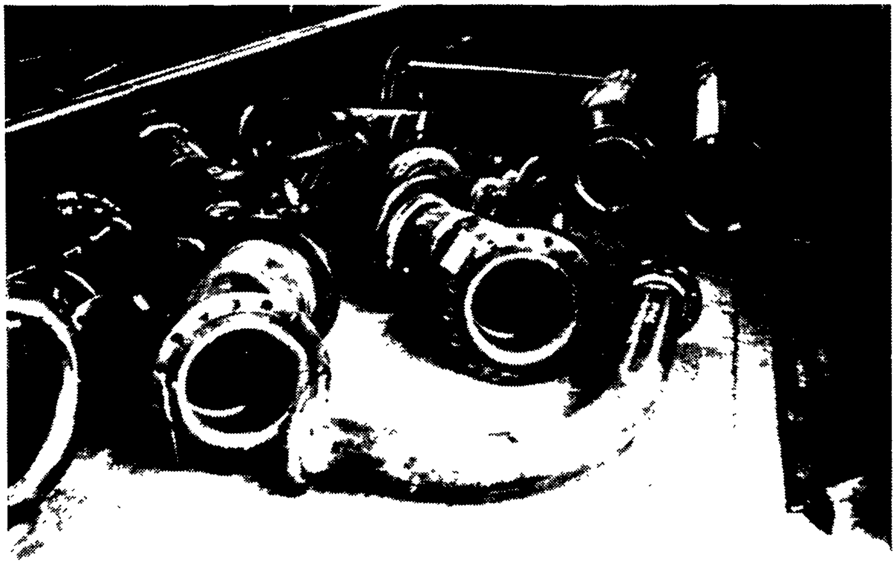


Figure 3.20 PIPING BEFORE COATING -- KANASASHI

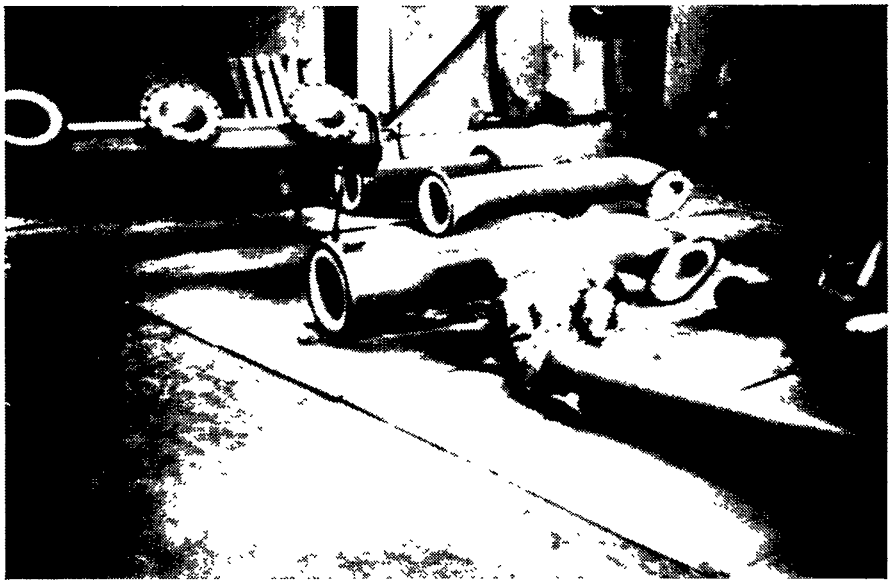


Figure 3.21 PIPING AFTER COATING -- KANASASHI

3.8 TANKS

3.8.1 General

Tanks are among the most corrosion prone areas of a ship. The corrosion varies in severity with the tank type and use, and it is not uniform over the entire tank surface because of irregular mechanisms and conditions. This results in preferential pitting, the greatest threat to the useful life of a tank.

In particular, the ballast tank is affected by the amount of ballasting, temperature, humidity, and repeated stress concentrated in certain areas. In general, any unprotected tank corrodes heavily. For example, a cargo tank may suffer local corrosion from sulfer if it is carrying crude oil. Table 3-4, provided by Chugoku Marine Paints, Ltd., shows the corrosion rate of unprotected tanks; rates were recorded by several investigators. Such corrosion may be controlled by a coating system or by a partial coating system combined with an application of supplemental anodes.

Table 3-4

CORROSION RATES OF UNPROTECTED TANK (MIL/YR)

	cook	Nelson	Dillon	JUPP	Kurz	Logan	SAKAE
Ballast, Atmosphere			0.19				
Gasoline, Ballast, Atmosphere				0.25	0.25	0.38	
Gasoline, Atmosphere			0.17			0.17	
Crude oil, Ballast, Atmosphere	0.231			0.08			0.11
Crude oil, Atmosphere							0.10
Fule, heavy oil, Ballast, Atmosphere		0.13					

3.8.2 Ballast Tanks

For ballast tanks, the standard ZPTM surface preparation and coating method is preferred for productivity. The shop primed block is power tool cleaned. Then either a single coat of high build coal tar epoxy or two coats of a lower build coal tar epoxy are applied to a dry film thickness of 250 microns (10 mils). See figures 3.7 and 3.14.

In addition to standard surface preparation procedures, the Japanese offer higher quality surface preparation and coating of ballast tanks. When the shipowner requests this premium, at an extra cost the coating is still done at the block stage. In these special cases:

- o Abrasive blasting (SSPC-SPIO, Near White Blast) is used to remove shop primer in the place of disc sanding and wire brushing of the primer.

- o full stripping replaces limited edge stripping,

Figure 3.22, a photo taken at Sumitomo, pictures a non-standard prepared, coated ballast tank, abrasive blasted to a Sa3. Two coats of water base inorganic zinc were applied to a dry film thickness of 150 micron (6 mils). Edges, holes, and production welds were striped, and the erection welds were power tool cleaned and coated with two coats of coal tar epoxy.

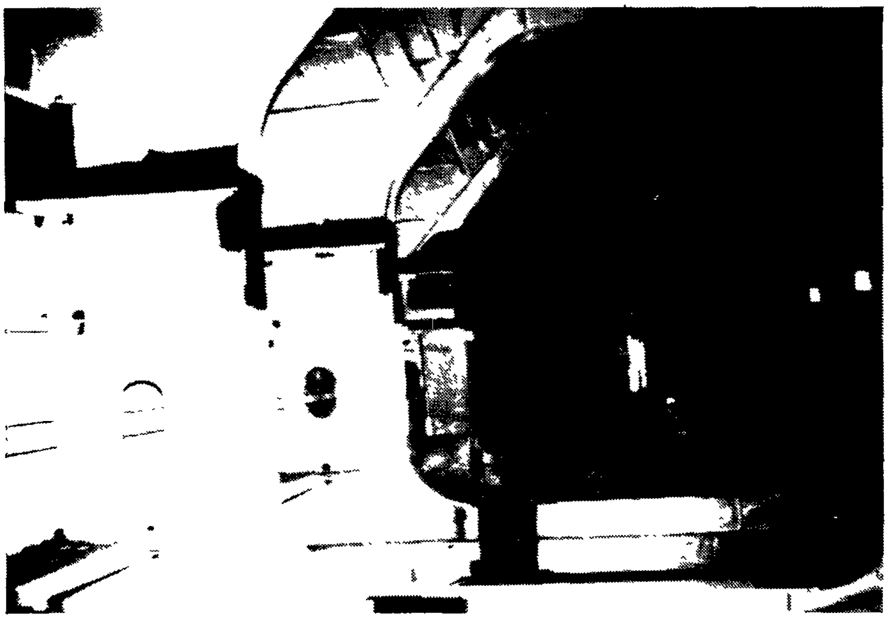


Figure 3.22 NON-STANDARD BALLAST TANK COATING PREPARATION- -SUMITOMO

3.8.3 Cargo Tanks/Product Carriers

The surfaces of these “critical” tanks are coated and prepared “in sittu” after erection by highly specialized sub-contractors. Meticulous care is taken in all operations to achieve the best possible quality. If the contract specifies, all edges such as stringers and gussets are ground to a 2R radius. Welds, splashes and other surface defects are ground smooth as demonstrated in figure 3.23. These edge preparations were observed at both Sumitomo and Kanasashi shipyards.

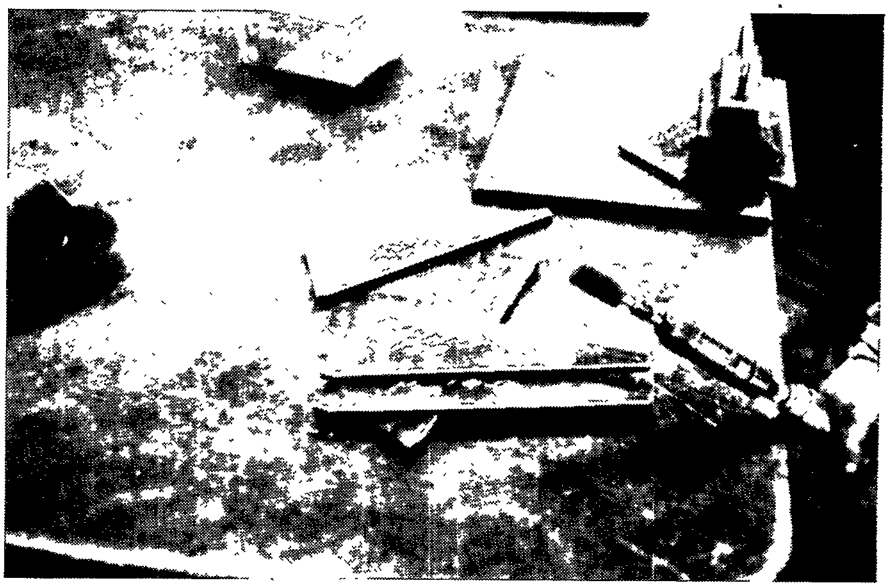


Figure 3.23 GRINDING EDGES -- KANASASHI

Appendix A is an edited version of the specification for coating product carrier cargo tanks by Mikami Marine Engineering Co., Ltd. at the Nippon Kokan Kabushiki Kaisha, Shimizu Shipyard. It shows the range and extent of detailed planning before work begins. Every effort was made to anticipate and avoid potential problems. This application of logic to work results in increased productivity. Preparation, coating application and curing requirements were defined, and a detailed work schedule and a blasting sequence were provided.

Section 4 of the specification illustrates careful planning and projects possible production problems. To avoid errors or delays, it graphically provides the ambient temperature ranges and the sea water temperature at the site during the actual coating period. For example, the data predicts possible ambient December temperatures below the required minimum 5°C (40°F) coating curing temperature. In this case, the tank coating would be in progress on the second ship at this time, but careful analysis indicated that only the areas of the tank surface that were below sea level would be coated at that time. Therefore, no problems with the curing of the coating would result because substrate temperature in these areas would match the water temperature, which would be above the required 5°C (40°F) minimum.

In preparing the surfaces of these pictured tanks for coating, a Sa 3.o blast was obtained by production although a Sa 2.5 blast was specified; see figure 3.24. After blasting, a 50 micron (2 mil) amine aduct, cured, phenolic epoxy holding primer was applied immediately, refer to figure 3.25. Welds, edges, holes, corners, and other hard to spray areas were brush striped before the mid-coats and finish coats were applied. Before applying each new coat, runs and sags from the previous coat were removed by disc sanding. Each coat was inspected, and voids and low mileage areas were recoated. Consequently, the quality and appearance of the completed coats were exceptional. Figure 3.26 shows the application of the mid-coat down to the bottom section, which will be blasted and coated after the final coat is applied to the top section, and figure 3.27 shows the completed tank.

3 4 B AS QUA
M KAM

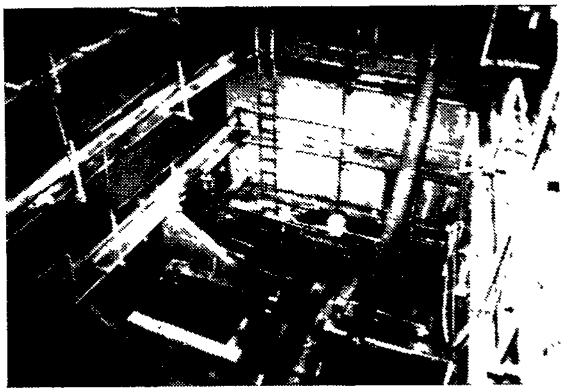


Figure 3.25 HOLDING PRIMER
--MIKAMI

3 6 M D OAT A D AT
BO OM SE ON
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Figure 3.27 COMPLETE TANK
--MIKAMI

3.9 COATING SUBCONTRACTORS

The importance in Japan of subcontractors specializing in coating application was discussed in section 2.4. Nakatagumi CO., Ltd., and Mikami Marine Engineering Co., Ltd., the two major coating application contractors visited, used similar planning and production methods. Both have equipment which is excellent in quality, quantity and, especially, condition. The individual units in combinations are capable of meeting system requirements for any job.

Every aspect of each job from shipboard equipment mounting systems to the smallest hose is carefully engineered to enhance productivity and minimize the amount of equipment needed.

Nakatagumi Co., Ltd. is unique in that it has its own blasting and coating facility at Nagasaki. Table 3-5 below summarizes the facility's maximum daily production capacity, and the facing table 3-6 describes the facility and equipment.

TABLE 3-5

DAILY CAPACITY MAXIMUM

OPERATION	M2(ft^2)/day
Steel Blasting	5,000
Spray Coating	10,000
Cleaning	5,000
Touching Up	30,000
Staging	2,500

Nakatagumi Co., Ltd. is also unique in that it has developed a method for blasting ship tanks with steel grit which is recycled through a system of its own design. Using steel grit instead of copper nickle slag has several advantages.

- Improved coating adhesion
- Reduced dust and resulting increased visibility
- Cleaner work place
- Better general environment
- Higher productivity

Grit blasting is now being used only on new ships, but a system for blasting corroded tanks is being investigated. Furthermore, to improve clean up and abrasive recovery, expanded steel scaffolding is used by contractors.

Figure 3.28, taken at Nakatagumi Co., Ltd., shows two ships being worked on at the same time.

TABLE 3-6

NAKATAGUMI NAGASAKI FACTORY

Facility and Equipment

1-2 Fukahori, Nagasaki Japan

FACILITY	AREA	53,691.03 m2
	BUILDING	23,304.26 m2 11 SHOPS
	STRUCTURAL AMOUNTS	15 sets
	CRANE AT PIER NO.3-4	25 ton x 30 m, 12 ton x 50 m
	CRANE AT PIER NO.5	20 ton x 34 m, 17 ton x 40 m

EQUIPMENT

10.	Items	Capacity	Number	Remarks
1	ELECTRICITY		2,000 KW	3,000 KW avail.
2	COMPRESSOR	300 KW	1 SET	
3	COMPRESSOR	150 KW	4 SET	1,000 KW total
4	PACKED BLASTER	0.25 M^3	24 SETS	Remote-Control
5	VACUUM RECYCLER	75 KW	13 SETS	
6	VACUUM RECYCLER	55 KW	6 SETS	
7	DUST COLLECTOR	200 M3/MIN	4 SETS	
8	DUST COLLECTOR	40 M3/MIN	2 SETS	
	HANIKAMU DEHUMIDIFIER	250 M3/MIN	7 SETS	
9	FREEZING DEHUMIDIFIER	250 M3/MIN	6 SETS	
11	FREEZING DEHUMIDIFIER	125 M3/MIN	2 SETS	
	WORKING FAN	5.5 KW	25 SETS	
12	S/G HOPPER	20 TON	36 SETS	
14	STEEL GRIT	#70, #50	1,500 TON	
15	STEEL SCAFFOLDING	4 M	6,700 SHEETS	
16	STEEL SCAFFOLDING	3 M	13,500 SHEETS	
17	STEEL SCAFFOLDING	2 M	5,450 SHEETS	
18	STAGING PIPE	5 M	8,250 EACH	
19	STAGING PIPE	4 M	4,600 EACH	
20	STAGING PIPE	2-3 M	7,300 EACH	
21	PIPE CRAMP		37,000 EACH	
22	AIRLESS PAINTING MACHINE		20 SETS	
23	EXPLOSION PROOF MERCURY LAMP	220Vx400W	20 SETS	
24	HATCH COAMING COVER		40 EACH	
25	BUTTERWORTH COVER		140 EACH	

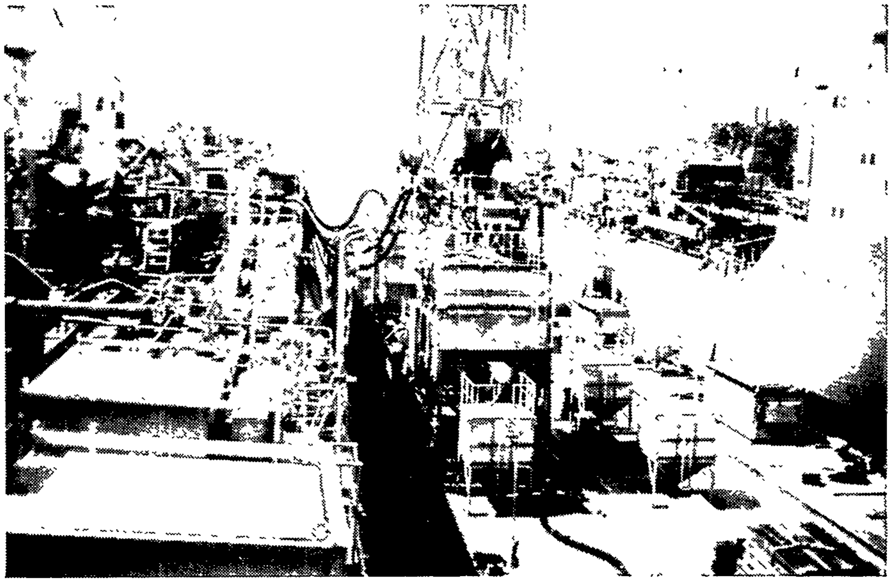


Figure 3.28 TWO SHIPS WORKED ON AT ONCE -- NAKATAGUMI

Figure 3.29 pictures deck mounted dehumidification equipment at the facility.

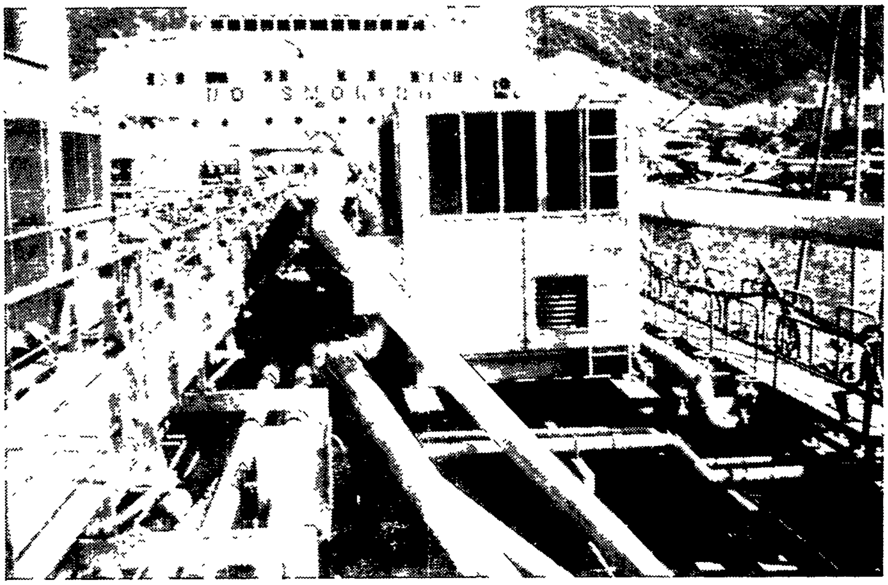


Figure 3.29 DEHUMIDIFICATION EQUIPMENT-- NAKATAGUMI

Figure 3.30 illustrates the quality and quantity of the available equipment.

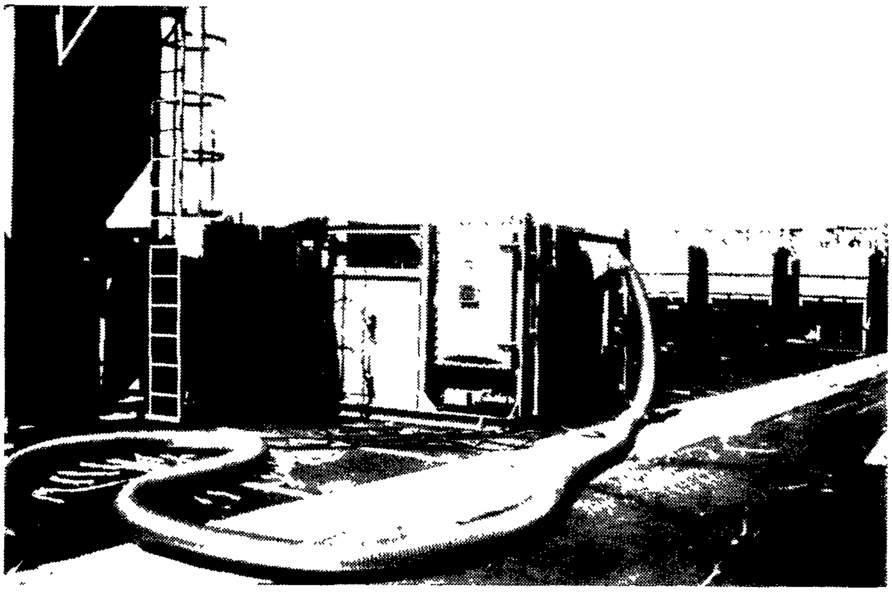


Figure 3.30 AVAILABLE EQUIPMENT-- NAKATAGUMI

3.10 PRODUCTION AIDES

A variety of production aides is used in the Japanese yards. Whenever it is economically feasible to make permanent scaffolding, jigs and fixtures for repetitive operations, they are provided. Pin-jig fixtures are used extensively throughout production. In addition, substitute fixtures are used in places like IHI-Tokyo, where curved blocks are set on a bed of sand which assumes the blocks' contours rather than a pin-jig.

At Sumitomo Oppama another production aide is a semi-automated system for manufacturing "egg crate" structures. This system employs an egg-box automatic assembling apparatus which inserts longitudinal frames into small slits in transverse frames that are precision cut with a numerically controlled cutting machine. Combined with this apparatus are several automatic welding machines which vertically fillet weld each intersecting point.

In general, well designed, permanent adjustable scaffolding is a predominant production aide in Japan. However, sometimes temporary staging is installed in tanks and on deck house exteriors at the block stage. This temporary scaffolding is erected and dismantled easily, and permanent stainless steel staging clips are provided for tank scaffolding. The Japanese make all scaffolding roomy and safe to relax workers and, thus, promote productivity. However, the permanent adjustable scaffolding saves many manhours of erection time that temporary staging would require.

Permanent staging for the superstructure block outfitting at IHI-KURE is pictured in figure 3.31. Note that the staging is on a wheel rail system which makes adjustments to the size of the house possible.

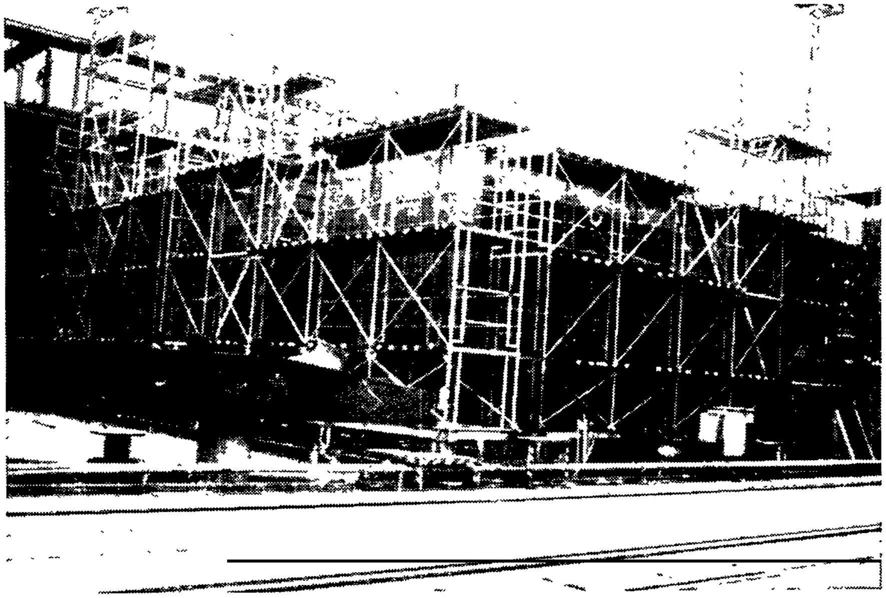


Figure 3.31 PERMANENT STAGING ON WHEEL RAIL SYSTEM -- IHI-KURE

Figures 3.32 and 3.33 show permanent staging at IHI-Tokyo for the exterior hull. It adjusts to the hull width and pivots on a central axis to follow the ship's contour.

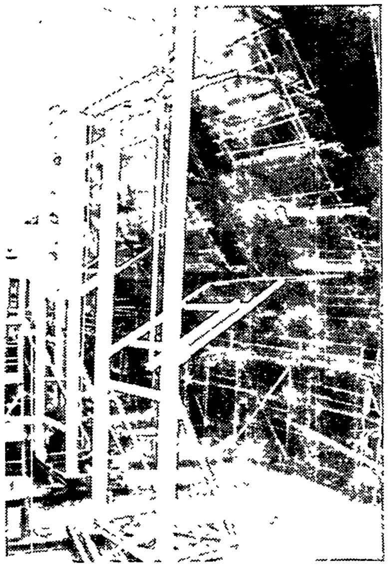


Figure 3.32 PERMANENT STAGING FOR HULL EXTERIOR-VIEW 1 --IHI-TOKYO

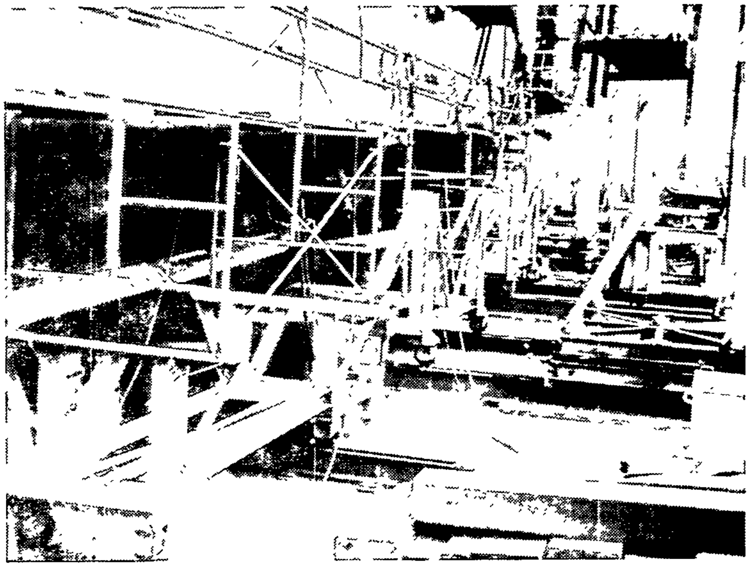


Figure3.33 PERMANENT STAGING FOR HULL EXTERIOR-VIEW 2--IHI-T0KYO

Cargo hold staging for small break cargo vessels at IHI-Tokyo is shown in figure 3.34.

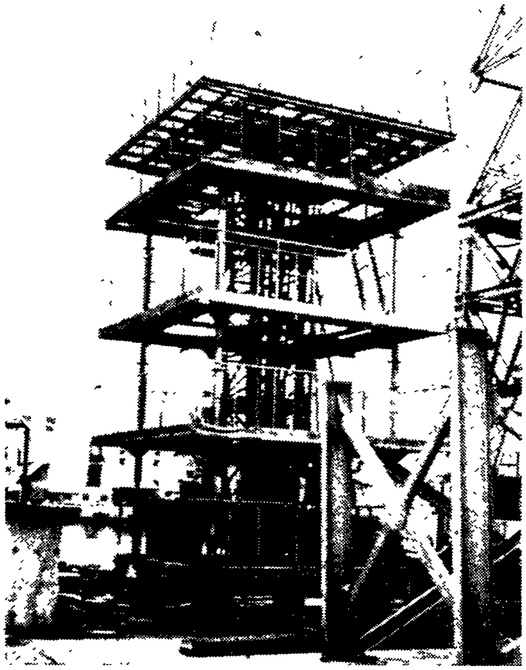


Figure 3.34 CARGO HOLD STAGING FOR SMALL BREAK CARGO VESSELS -- IHI-T0KYO

Finally, figure 3.35 depicts moveable shelters for the block fabrication/outfitting areas of IHI-Tokyo.

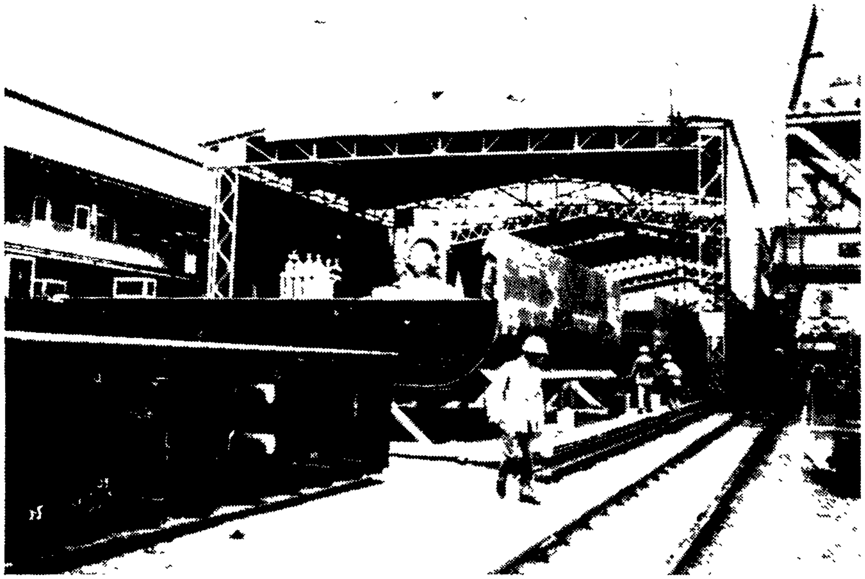


Figure 3.35 SHELTERS FOR BLOCK FABRICATION OUTFITTING AREAS --IHI-TOKYO

Section Four

COATING MATERIALS

4.0. COATING MATERIALS

4.1 GENERAL

The unique relationship between the Japanese and the marine coating suppliers and the importance of material selection to overall productivity has been discussed in section 2.5, Intra-Industry Relations, and section 3.1, Methodology: Zone Painting Method (ZPTM).

A review of products available from Japanese Coating manufacturers indicates a broad spectrum of generic types of materials available including bleached coal tar epoxies, phenyl tank coating, self polishing antifoulants and a water base epoxy system for use in void spaces.

While the choice of generic types is large, fewer variations within a type are available. Thus, reducing the proliferation of formulations increases coating manufacturing efficiency yet provides the basic needs of the industry.

4.2 SHOP PRIMER

By all evidence, the Japanese have made at least one very firm value judgment about coating materials. They have assigned top-ranking importance to the selection of shop primer, regarding the proper shop primer as a significant factor which can contribute both to the coating standards of performance they want AND TO THEIR OVERALL GOALS OF SHIPBUILDING PRODUCTIVITY.

Thus, there are, as might be expected, a number of properties that Japanese shipbuilders require in their pre-construction primers. These include:

- Ease of application
- Optimal handling time
- Quick hard-dry time (l-4 minutes)
- Anti-corrasivity (7-9 months)
- Good adhesion to steel substrate
- High resistance to solvents & chemicals
- Weldability (should not generate pits or blowholes, nor affect strength of weld)
- Reasonable frame Citability (should not slow cutting processes)
- Low toxicity
- Few polluting agents (no heavy metals)

- Flammability safety
- Reasonable cost
- Suitability for EPM system

A modified alkylsilicate inorganic zinc shop primer is considered the material that best meets these requirements. The material is applied at .6 roils (15 microns), somewhat thinner than the nominal 1 mil (C25 microns) normally applied in the U.S. This reduction in thickness, no doubt, increases the weldability of the material.

Even though applied more thinly, the material forms a continuous, uniform film. The superior film forming characteristic of the material may be due to modification of the basic alkylsilicate with an organic resin. The material appeared to have excellent corrosion resistance because very minimal corrosion of primer surface was noted. However, overcoating at the block stage and speed of production schedules may be important contributions to the excellent appearance of the primed structures.

Table 4-1 indicates the general composition of Chugoku's modified alkylsilicate inorganic zinc shop primer. An American equivalent of this composition is not known because the kind of organic resin used in modification is not identified.

TABLE 4-1

GENERAL COMPOSITION OF CHUGOKU'S MODIFIED ALKYLSILICATE INORGANIC SHOP PRIMER

	Materials	Weight
BASE	Alkyl-silicate	32.0
	Catalyst	2.0
	Alcohol	6.0
PASTE	Special organic resin	0.5
	Tinting pigment	8.0
	Anti-sagging agent	1.0
	Alcohol	10.0
	Zinc powder	40.0
Total		100.0

Shop Primer Composition (Courtesy of Chugoku Marine Paints Limited)

4.2.1 Shop Primer Development History

The history of the evaluation of shop primers for the Japanese Shipbuilding Industry from 1955 until today is interesting primarily because the industry's desire for increased productivity was the driving force.

The history of shop primers can be explained by two key properties affecting yard production:

- Weather resistance
- Resistance to burn back

A simplified history of the development is depicted graphically in figure 4.1 (Courtesy Chuguk Marine Paints Limited).

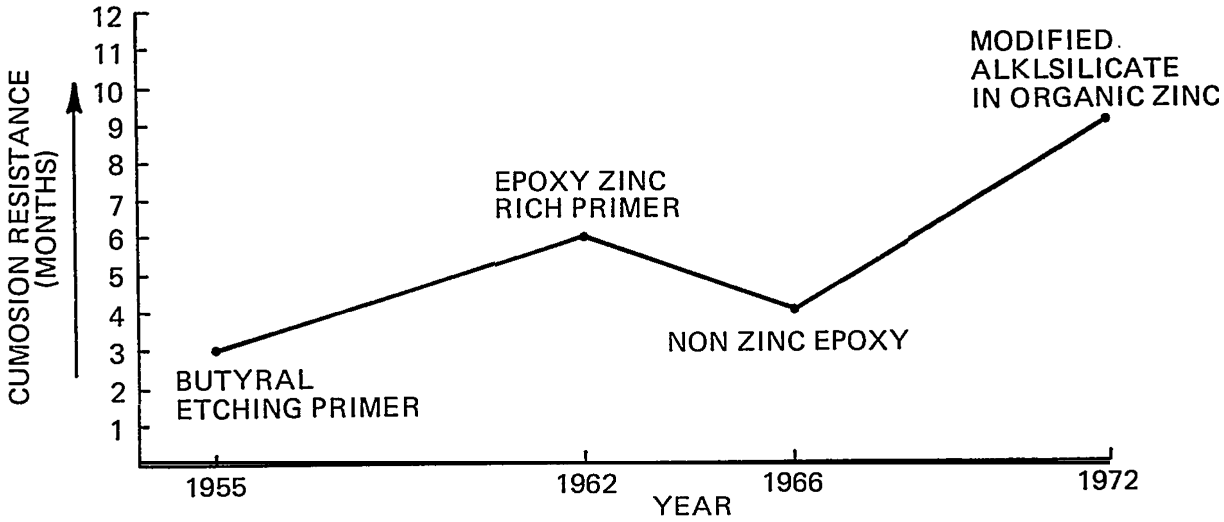


Figure 4.1 SHOP PRIMER DEVELOPMENT HISTORY

Figure 4.2 shows the burn back characteristics of three generic types of shop primers.

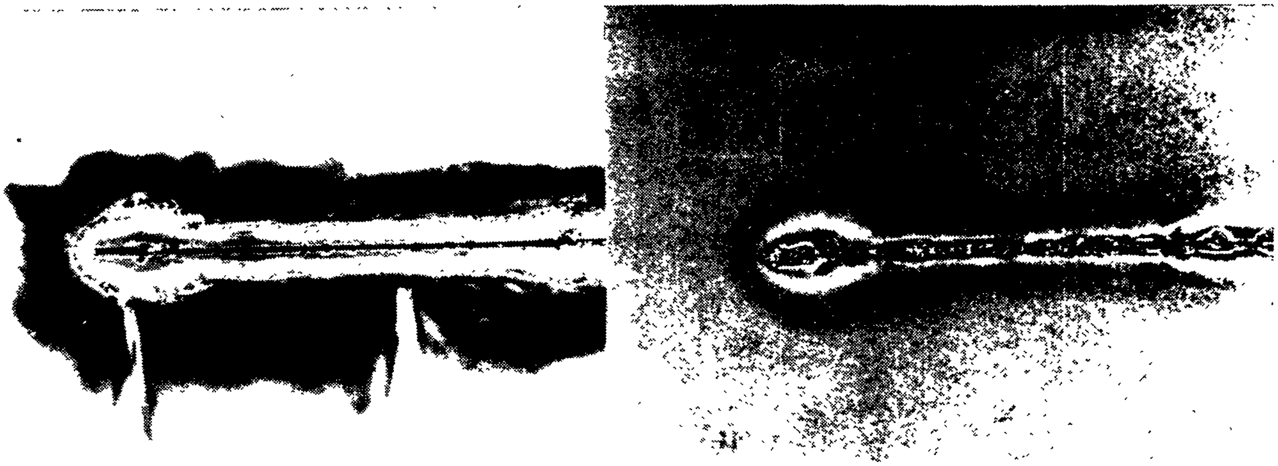
4.2.2 Shop Primer Touch-Up

The ZPTM dictates that rather than removing the primer prior to the application of subsequent coating, it is power tool cleaned and touched up. The modified inorganic zinc alkylsilicate shop primer is never touched up with itself for two reasons: 1) it tends to mud-crack when applied in excess of 40 microns, and 2) a minimum of 7 days cure is required prior to top coating with organic coatings. If the minimum cure time is not adhered to, loss of adhesion of the primer to the substrate may occur.

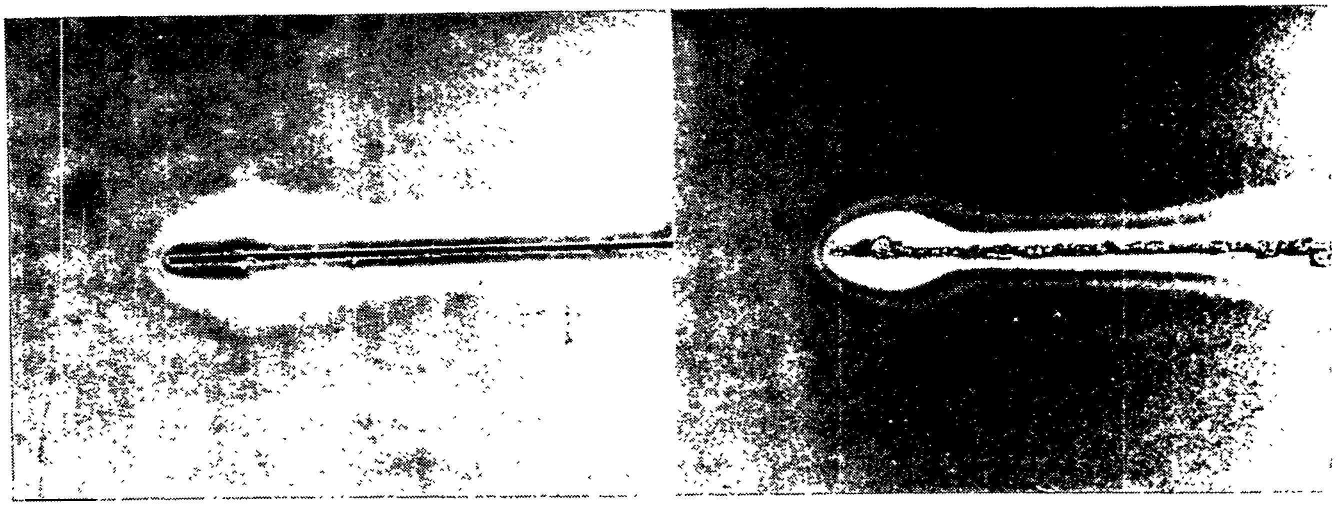
Discoloration of heat-damaged parts

MODIFIED ALKLSILICATE INORGANIC ZINC

EPOXY ZINC RICH



BUTYRAL ETCHING PRIMER



THE FACE THE REVERSE

Figure 4.2 BURNBACK CHARACTERISTICS OF SHOP PRIMERS

The touch-up materials used vary with the type of top coats to be applied. Table 4-2 depicts types of touch-up material used for different top coats and the minimum per coating time required.

TABLE 4-2

TOUCH-UP MATERIALS FOR INORGANIC ZINC SHOP PRIMER

	Touch-up Material	Mininum Overcoat time	Subsequent Top-coat
Modified Alkylsilicate in Organic Zinc Shop Primer	Zinc-Rich Epoxy	2 hours @ 20°C	Organic
	Solvent base . Inorganic Zinc"	30 minutes @ 20°c	Solvent base Inorganic Zinc
	Solvent base Inorganic Zinc	8 hours @ 20°C	Waterbase Inorganic Zinc

4.3 GALVANIZED STEEL PRIMER

Historically, paint adhesion to galvanized steel has proven to be a problem. Even with the use of vinylbutyral etching type primers, less than ideal adhesions are obtained in a marine environment. Chugoku Marine Paints, Ltd. has developed two primers which provide excellent adhesion to galvanize as verified by mandrel bend and impact tests.

The adhesion failure mechanisms involved are the reaction of the zinc with the acid and hydroxide radicals of the coating resin to form zinc salts which affect the adhesion of the paint film. Additionally, moisture migrates through the paint film reacting with galvanize to form zinc hydroxide salts, also affecting film adhesion.

As shown in figure 4.3, the corrosion rate of zinc at pH 10 is minimal.

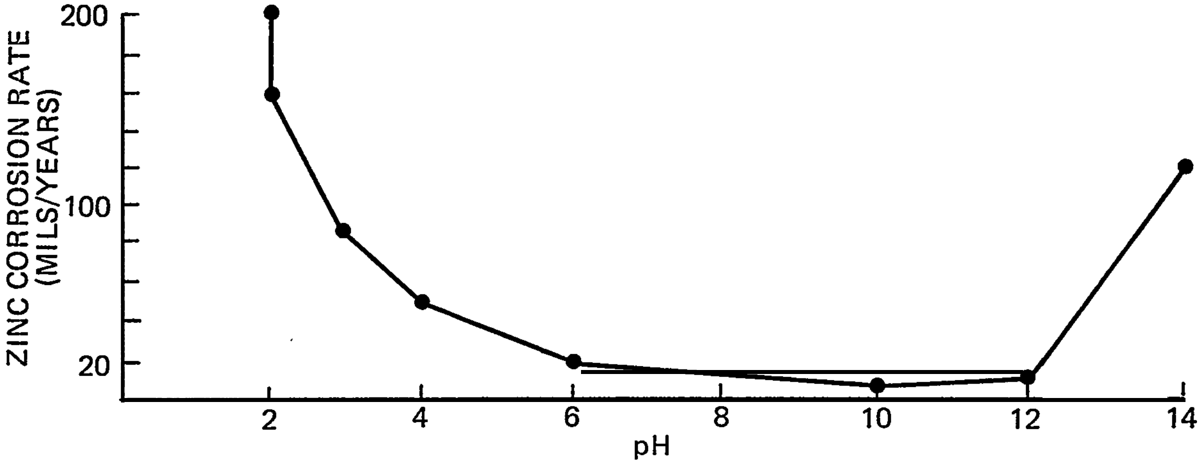


Figure 4.3 RELATIONSHIP OF pH VALUE AND ZINC CORROSION RATE

According to Chugoku Marine Paint,Ltd. literature, the primers are based on an alkaline resistant epoxy resin to which a buffering material which maintains the zinc primer interface at a pH of 10 is added to minimize the oxydizing reactions which lead to salt formation and adhesion failure. "Galvanite" is the trade name for the primers which are available both in a single and two package system. The former is recommended for normal exposure while the latter is specified to immersion service.

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Appendix A

PRODUCT CARRIER
CARGO TANK COATING SPECIFICATIONS

APPENDIX A

HULL NOS. 389/390 TANK COATING

1. Tanks to be coated:

(1) No. 1 (P, C & S)
(2) No. 2 (P, C & S)
(3) No. 3 (C)
(4) No. 4 (P, C & S)
(5) No. 5 (P, C & S)
(6) No. 6 (C)
(7) No. 7 (P, C & S)
(8) No. 8 (C)
(9) Slop Tank (P & S)

P - Port
C - Center Line
S - Starboard

2. Painting Specification:

Process	Surface & Painting Treatment	No. of Cts	DFT (ave. micron)
1 Treatment prior to painting	(a) Cut edges are treated to lC - 2C. (b) Welding beads are treated according to KOC. (c) Loose weld spatters are removed.		
2 Surface Treatment	Whole surface is blast cleaned. Welded parts, areas where shop primer has been burnt and rusting areas are blasted to S1S Sa2:5 or better (SSPC SP10 63T -), while for other areas, blasting is carried out to a grade of 70% or more of removal rate of shop primer.		
3 Holding Primer		1	50
4 Primer		1	100
5 Finish		1	100

Note: (i) On manually welded parts, edges, holes, corners, etc., where paint application is difficult, stripe coats are given prior to each mid and primer coat.

(ii) Total dry film thickness (TDFT) is to be 250 microns (10 mils).

3. Work Process:

(i) Process & Contents of Work

Parts	Contents of Work
Each tank	Opening of access holes required for the work
Whole area	Installing stagings Maskings of fittings not to be coats (such as heating pipes, valves, etc.)
Above stages	Sand-blasting Cleaning Inspecting surface cleaning Applying holding primer Applying coats before and after each coat of mid-coat primer and finish coat Touching up following application of midcoat primer and finish coat Measuring film thickness Final inspecting
Whole area	Removing of stagings
Bottom zone	Removing used sands Sand-blasting Removing used sands and cleaning Inspecting surface cleaning Applying holding primer Applying stripe coats before and after each coat of midcoat primer and finish coat Touching-up following each coat of midcoat primer and finish coat and cleaning Measuring of film thickness Final inspecting
Each tank	Access holes repair and coating
Whole area	Curing of coated film
Whole area	Fresh water washing

(ii) WORK SCHEDULE **FOR EACH TANK:**

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	⤳	55
M	M	S/B–	CL	—	P1			T/U	P2		CH	T/U		P3		CH	T/U		U/F	TOS								VC			S/B–VC–		CL–P1			T/U	P2	CH	T/U	P3	CH	T/U		F	H			W/D

S/B = SAND BLASTING CL = CLEANING PI = APPLICATION OF HOLDING PRIMER T/U = STRIP COATS OR TOUCH-UP COATS OF EACH COAT

P2 = APPLICATION OF MIDCOAT PRIMER P3 = APPLICATION OF FINISH COAT CH = FILM INSPECTION

U/F = TANK TOP/WALL COMPLETED TOS = REMOVAL OF STAGES VC = REMOVAL OF USED SANDS M = MASKING OF HEATING COILS, VALVES, ETC. H = REPAIR OF ACCESS HOLES

NOTE: (a) SAND-BLASTING IS TO BE DONE FROM 18:00 TILL 07:00.
(b) PAINTING WORK OTHER THAN SAND-BLASTING IS TO BE DONE FROM 08:00 TILL 18:00.

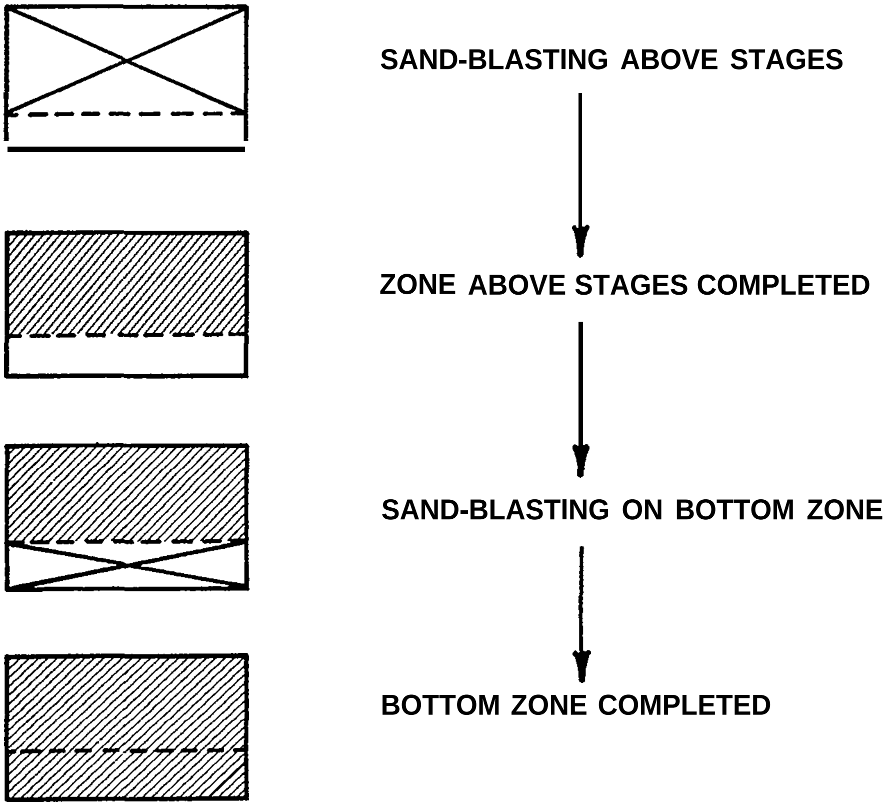
(iii) SITE & PERIOD FOR THE WORK:

(1) SITE: ON BERTH AND ALONGSIDE PIER AT NKK SHIMIZU YARD.

BEFORE INITIATING COATING, ALL THE FITTINGS INSIDE AND OUTSIDE THE TANK SHOULD HAVE BEEN FULLY INSTALLED AND FIRE EQUIPMENT FOR THE ADJOINING TANKS COMPLETED.

(2) PERIOD FOR THE WORK:

HULL NO. 1 EARLY JUNE, 1981–MID. OCTOBER, 1981 HULL NO. 2 EARLY SEPTEMBER, 1981–MID. JANUARY, 1982.



TANK SURFACE PREPARATION AND COATING SEQUENCE

4. Surrounding Conditions for Painting Works:

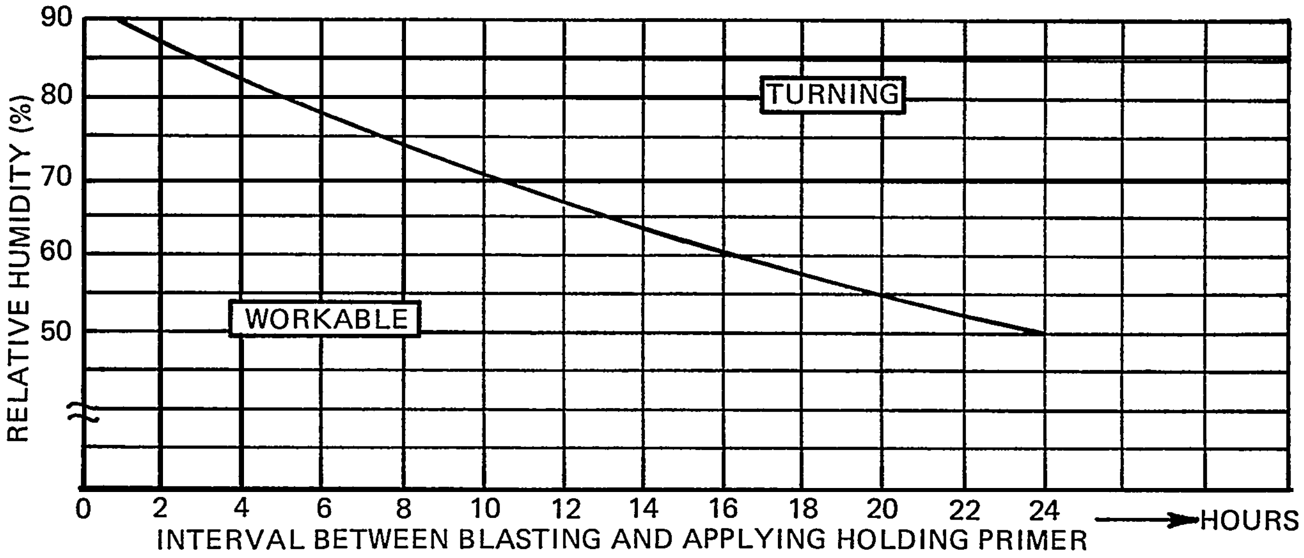
(1) The work is to be carried out under the following conditions:

Ambient temperature - Not below 5°C
Humidity - 80% maximum or the temperature of the surface to be coated must be 3°C higher than the dew point of the surroundings.

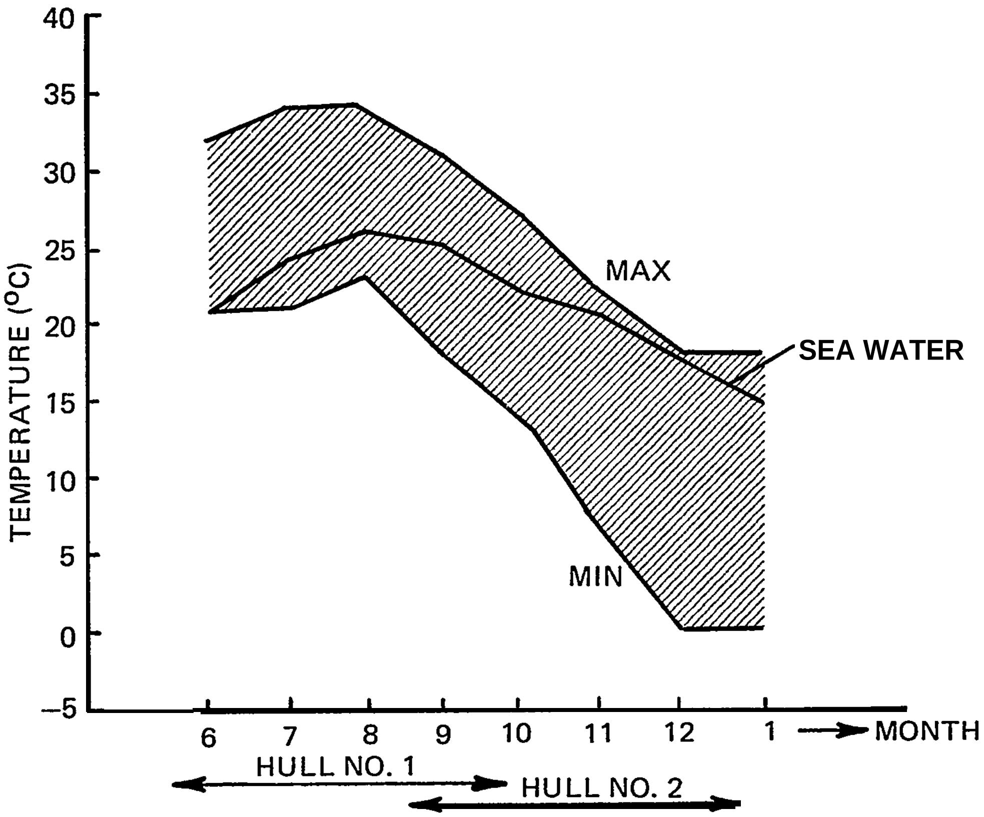
(2) Temperature and humidity of internal tanks are to be measured by hygrometer or 'Assmann's Aspiration Psychrometer'. Single hygrometer shall be placed in the wing tank (P) & (S) and center line tank.

(3) Time between sand-blasting and application of holding primer.

Turning will take place if the blasted surface is left for two long; therefore, to obtain the best performance of the paint film, the time between sand blasting and applying the holding primer is to be controlled according to the following chart.

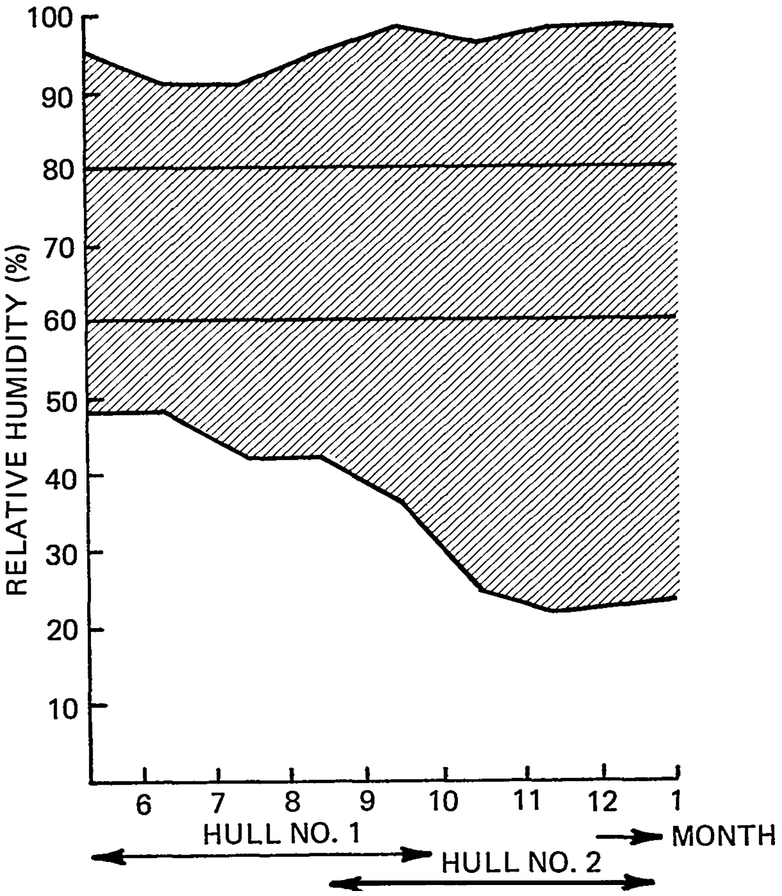


The work is to be controlled under the condition of a relative humidity of 60%RH **or below,** as far as practicable and if and when the humdidity goes over 60%RH, then the humidity will be controlled with compressed air and/ or dehumidification.



The temperature of the tank bottom below sea level becomes the same as that of the water. For the coating film to cure, a minimum temperature of 5°C is required. The temperature of the tank surfaces that are above water is the same as the ambient air temperature. Towards the end of the construction period of the second ship, the air temperature may drop below 5°C since the sea water temperature which remains above 5°C is the consideration at that time when submerged tank bottoms are being coated.

(5) Relative Humidity Envelope at Shimizu Bay During Scheduled Work



Month	6	7	8	9	10	11	12	1
Days when RH is 60% or over (%)	85	90	80	85	60	65	65	50

Table 1: The percentage of days, by month, when relative humidity at Shimizu Bay is above 60 percent.

Month	6	7	8	9	10	11	12	1
Days when RH is 80% or over (%)	60	35	23	35	42	32	48	22

Table 2: The percentage of days, by month, when relative humidity at Shimizu Bay is above 80 percent.

Table 1 applies to sand-blasting, while Table 2 is for paint application and curing.

To secure the environmental conditions for the coating work, necessary equipment such as dehumidifiers, coolers, etc. and control heaters shall be provided.

5. Characteristics of Paints to be used:

(1) Coating interval between holding primer midcoat primer;

Figure 1

Temperature	Coating interval	
	Minimum	Maximum
5°C - 10°C	48 hrs	28 days
20°C	12 hrs	14 days
30°C	8 hrs	7 days

(2) Curing time of holding primer;

Figure 2

Air temperature		5-10°C	20°C	30°C
Curing time	Set to touch	3 hrs	2 hrs	0.5 hrs
	Dry hard	48 hrs	12 hrs	8 hrs
	Full cure	28 days	14 days	7 days

Overcoating time (20°C): Min. 12 hrs. Max. 14 days

(3) Coating interval between midcoat primer and finish coat.

Figure 3

Temperature	Coating interval	
	Minimum	Maximum
5°C - 10°C	48 hrs	28 days
20°C	16 hrs	14 days
30°C	12 hrs	7 days

(4) Curing time of midcoat primer and finish coat.

Figure 4

Air temperature		5-10°C	20°C	30°C
Curing time	Set to touch	3 hrs	2 hrs	1 hrs
	Dry hard	48 hrs	16 hrs	12 hrs
	Full cure	28 days	14 days	7 days

Overcoating time (20°C): Min. 16 hrs. Max. 7 days

(5) Time to be allowed for drying before ballasting or cargo loading;

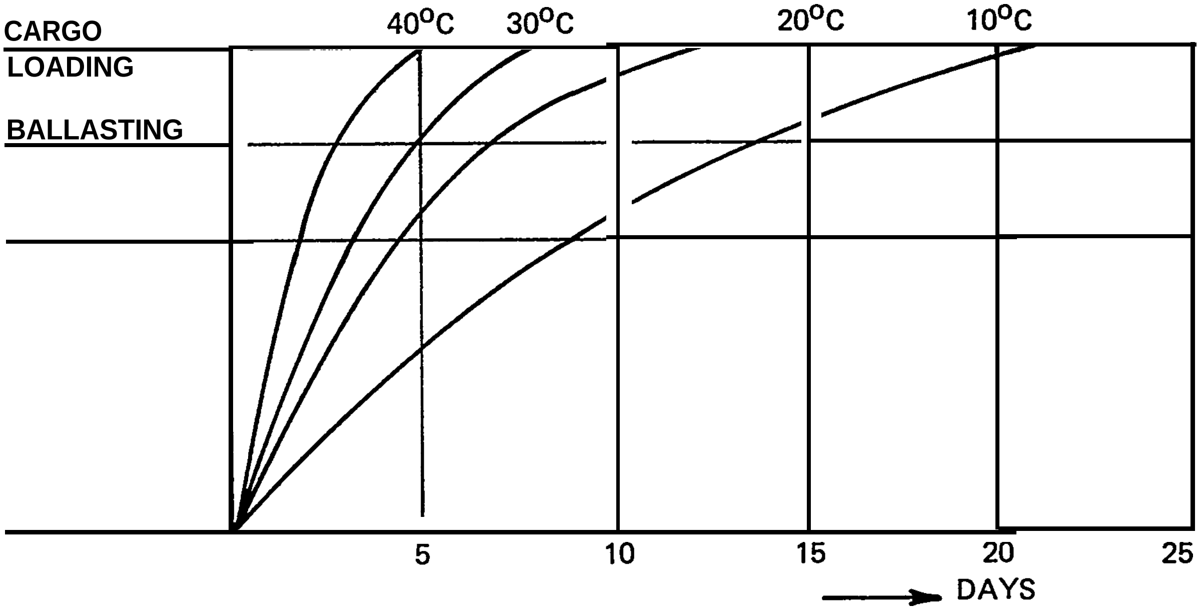


Illustration 1: Days required for film's drying before ballasting or cargo loading

Even when the tank inside is flooded with ballasting, the curing of film takes place depending on temperature.

6. Inspection:

(1) Inspection item and allotments:

	Inspection items	Owner	Yard	Maker
1	Interim check for blasting			0
2	Final check for blastng			0
3	Owner's inspection for blasting	0	0	0
4	After application of holding primer			0
5	After stripe coats			0
6	After application of mid-coat primer and finish coat			0
7	After each touch-up coat			0
8	Check on cleaning prior to each coat			0
9	Measurement of film thickness			0
10	Final Inspection (incl. above stage)	0	0	0
11	Keeping inspection record			0

(2) Surface preparation:

(a) Inspection immediately after the blasting is in accordance with painting specification. Parts to be repaired shall be indicated with markings and repaired.

(b) Keeping records, including photos, is required.

(3) Inspection of paint file:

Inspection is performed by the naked eye. Areas with insufficient paint film or with dust coats, dirt, etc. are indicated with markings and then are cleaned and repair painted.

(4) Inspection of paint film thickness:

Paint film thickness is measured with microtestor and areas lacking in the specified thickness are marked and repair painted.