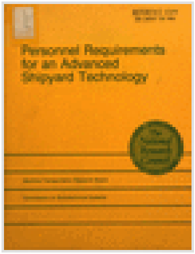

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Personnel Requirements for an Advanced Shipyard Technology

Prepared by the
Committee on Personnel Requirements for
an Advanced Shipyard Technology
~~of the~~
Maritime Transportation Research Board
Commission on Sociotechnical Systems
National Research Council

NATIONAL ACADEMY OF SCIENCES
Washington, D.C. 1980

1-0011

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the Councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the Committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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FOREWORD

This study was made under the auspices of the Maritime Transportation Research Board (MTRB) of the National Research Council, as part of the continuing program of advice to the federal government, directed toward improving maritime and maritime-related transportation. This study was undertaken at the request of MTRB's sponsors.

To assess the impact of shipyard technology on future shipyard personnel requirements, an interdisciplinary committee was formed. The Committee's members represented a diversity of backgrounds and maritime experience, as noted in the Preface. In addition, liaison representation was provided by two offices within the Maritime Administration, and by the Coast Guard, Naval Sea Systems Command, Bureau of Labor Statistics, Federal Preparedness Agency (now a part of the Federal Emergency Management Agency), and Shipbuilders Council of America. Dr. William A. McClelland, President, Human Resources Research Organization, served as Committee Chairman.

A three-member panel, comprising Messrs. Paul E. Atkinson and Albert L. Bossier, Jr., and Ms. Hazel Brown, reviewed this report on the Board's behalf.

I extend my thanks to the Committee, liaison representatives, and project manager for their fine work on this report. My thanks go also to the Board's review panel.

Finally, I want to join the study participants in recognition of the outstanding contribution of Dr. McClelland. His untimely death is a loss felt by all of us who had the pleasure of knowing and working with him. The levels of personal interest, professional commitment, sound judgment, and unfailing good humor that he manifested throughout the project were of the highest order.

RRONeill

R. R. O'Neill
Chairman
Maritime Transportation Research Board

September 1979

PREFACE

In recent years, there have been a number of changes in the technology available for shipbuilding that have raised the question of whether the men and women who will build the ships 10 to 15 years from now will be adequate to the tasks required of them. New construction materials, new construction techniques, computer graphics and lofting, numerical control equipment, and laser welding technology, to mention a few, have, in recent years, had an impact on the U.S. shipbuilding industry. Clearly, manufacturing technology will continue to change, and increasing adoption of advanced technology is likely to distinguish the industry's effort to effect cost reduction and improve productivity.

It has been the purpose of this Committee to examine both advanced technology and personnel requirements in order to determine the impact of technology in the next 15 years.

In order to examine the charge, a committee of seven members and seven liaison representatives was formed. Represented in this group were persons with broad experience in shipyard management, labor economics, maritime labor, education and training, maritime technology, and industrial psychology. Liaison representatives from five different agencies of government and a leading industry association participated in the study of the problem and the development of this report. I am grateful for the opportunity to have served with this group, and I am particularly pleased to recognize their dedication and effort in completing the study. Chapter 1 presents the background of the Committee's work.

The service of Mr. Lynn Walton, the Project Manager, deserves special recognition. In addition to his technical and administrative contributions, the Committee, as a whole, and I, particularly, are grateful for his persistence, patience, and perceptiveness. The high level of professional contribution and interest he manifested are greatly appreciated.

William A. McClelland

William A. McClelland
Chairman
Committee on Personnel Requirements
for an Advanced Shipyard Technology

August 1978

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COMMITTEE ON PERSONNEL REQUIREMENTS
FOR AN ADVANCED SHIPYARD TECHNOLOGY

WILLIAM A. McCLELLAND, Chairman; President, Human Resources Research Organization, Alexandria, Virginia

CLIFFORD F. ANDERSON, Associate Professor, College of Engineering, Mississippi State University

PAGE GROTON, Assistant to International President, International Brotherhood of Boilermakers, Iron Shipbuilders, Blacksmiths, Forgers and Helpers, AFL-CIO, Washington, D.C.

SHELDON E. HABER, Associate Professor of Economics, Department of Economics, George Washington University

*JOHN A. SERRIE, Consultant, Seatrain Lines, Inc., New York, New York

†J. ROBERT WINSTEAD, Vice President, Engineering, Sun Shipbuilding and Dry Dock Company, Chester, Pennsylvania

LAWRENCE R. ZEITLIN, Professor of Industrial Psychology and Organizational Behavior, City University of New York, Baruch College

Liaison Representatives

°KENNETH F. BISHOP, JR., CDR, USCG, Chief, Inspection Standards Development Branch, Office of Merchant Vessel Inspection, U.S. Coast Guard, Department of Transportation

JOHN J. GARVEY, Program Manager, Shipbuilding Research Program, Office of Advanced Ship Development, Maritime Administration, Department of Commerce

JOSEPH P. GOLDBERG, Special Assistant to the Commissioner, Bureau of Labor Statistics, Department of Labor

EDWIN M. HOOD, President, Shipbuilders Council of America, Washington, D.C.

HENRY M. HYATT, Senior Planning Officer, Resource Management Division, Federal Emergency Management Agency

---

*President, Seatrain Shipbuilding Corporation (through December 1977).

†Participated through August 1977.

°Through June 1978; now Senior Inspector, Materiel, USCG, Rotterdam, Netherlands.

*JONATHAN A. SISSON, CAPT, USN, Director, Industrial Activity Management Systems Division, Naval Sea Systems Command, Department of the Navy

THOMAS H. VODICKA, Manager, Shipbuilding Operations Group, Division of Production, Office of Ship Construction, Maritime Administration, Department of Commerce

†FRANK R. KESTERMAN, Alternate; Vice President and Secretary, Shipbuilders Council of America, Washington, D.C.

°EDWARD P. RUDDY, Alternate; Secretary, Shipbuilders Council of America, Washington, D.C.

Staff

S. LYNN WALTON, Project Manager, Maritime Transportation Research Board

VIRGINIA L. BOLTON, Staff Secretary, Maritime Transportation Research Board

Committee members serve as individuals, contributing their personal knowledge and judgment, and not as representatives of any organization with which they may be associated. Liaison representatives attend for their respective organizations to provide information or opinions on issues under discussion but have no vote on conclusions and recommendations.

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*Through June 30, 1978 (date of retirement from Navy).
†Since January 1, 1977.
°Through December 31, 1976.

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EXECUTIVE SUMMARY

Shipbuilding has been a labor-intensive industry, an industry that continues to operate in a business environment of conflicting uncertainties. Government policy expressed in legislative form states that there will be an adequate shipbuilding industry that will be available in the event of mobilization. To a degree, the government also conceives of the industry as a provider of jobs, many in geographic areas in need of an economic boost.

Under the Public Works and Economic Development Act of 1965, federal funds have been provided through the Economic Development Administration of the Department of Commerce to create jobs in areas that (a) are characterized by high unemployment or low family incomes, (b) have experienced or are expected to experience a sudden rise in unemployment due to the closing of a major source of income, or (c) have suffered a substantial loss of population due to the lack of job opportunities. The fact that a number of shipyards are located in such areas, and that educational level has not posed a barrier to entry-level employment in private shipyards, has broadened the significant federal interest in shipyards and in their potential as "employers of last resort". Shipyards have been used to support local economies, in fact, with considerable success.

There will be a U.S. shipbuilding industry during the next 15 years, but it will be a changing industry with changing manpower requirements. The numbers of workers employed could change appreciably, and the job mix certainly will.

The nature of the manpower pool on which the shipyards must depend is not likely to change in aptitude or other psychological characteristics. The skills required can be learned, and competition with related industries is unlikely to make significantly more extensive inroads into the shipyard labor pool. In specific locations, however, related industries will draw significantly on the skilled labor force on which shipyards depend. Those skills required by new technology may not be available in the shipyards, but they will be available.

Unless there are major and unpredicted changes in the economic, political, and social forces affecting the shipbuilding industry, the advent of new technology available to the shipyards in the next 15 years will not have an important impact on manpower requirements.

In terms of products, a greater variety of ships, oil rigs, barges, and related seagoing and sea-based structures are likely to be constructed in U.S. shipyards. Shipyards will continue to rely more and more on outside sources for components, as opposed to manufacturing all major ship components themselves. Greater use will be made of specialist firms (manufacturing, for example, boilers or navigation equipment or power plants). As a result, shipyard occupations are likely to be heavily focused on construction of major structural assemblies--on working with steel, cement, and other materials.

Manufacturing technology will continue to change as greater emphasis is placed on pre-outfitting, standardization of major ships' parts, modular construction, shipyard specialization, and use of specialized contractors. More sophisticated management information systems (MIS), computer graphics and lofting, numerical control (NC), laser welding technology, and new construction materials can be predicted.

Construction techniques that will be more widely adopted and exploited include simplification of material flow, greater use of mechanization, unit assemblies for machinery and prepackaged quarters modules, computer lofting and computer graphics, and standardization of equipment and structure. Prestressed concrete, stainless steel, ferro-cement, fiberglass-reinforced plastics (FRP), and enhanced coatings--all construction materials in use today--will find wider use.

What are the implications of advanced technology for shipyard personnel? The following are anticipated:

1. Changes in manufacturing technology may require changes in training program content (e.g., the use of MIS, production control, and quality control).

2. Shortages and turnover of skilled workers are encouraging the industry to shift from the craft approach, requiring broad knowledge on the part of skilled craftsmen, to the manufacturing approach, using less-skilled labor and characterized by more capital-intensiveness. It should be noted that educational level has not posed a barrier to entry-level employment in private shipyards.

3. Under the manufacturing approach, an increase in the number of operatives increases the requirement for

specialized technologists (although not, of course, on a one-for-one replacement basis). The technologists maintain equipment used by the operatives, and perform such tasks as quality control and production planning.

4. Repair and overhaul work continues to grow in sophistication, requiring increased reliance on vendor's personnel. Shipyards will depend more and more on vendors to provide new skills and to undertake initial training in the use and maintenance of new equipment by shipyard personnel and in the mastery of new manufacturing techniques. Re-fitting ships with new equipment also will require heavy reliance on vendors. It may not be cost-effective for shipyards to develop and maintain all the new skills required by new equipment and techniques. Some specialized technologists will be required to interpret vendor installation requirements for equipment, to assure shipyard readiness to install equipment when the vendor personnel arrive.

5. Product-line specialization can be expected to continue and possibly even increase. This will require that training of shipyard personnel be more intensive but span a relatively limited range.

6. The increasing complexity of ships, naval and commercial, will demand increasingly more effective planning and scheduling by operating managers. The days of elevating a mechanic to a planner or scheduler through on-the-job training alone are coming to an end. Extensive formal education and training in planning, scheduling, and control of work will be required of both upgraded mechanics and non-mechanic personnel. These functions are becoming increasingly important as shipbuilding and ship repair become increasingly more complex.

SHIPYARD MANPOWER NEEDS IN THE NEXT 15 YEARS

Given the moderate changes anticipated in the size and nature of the pool of general labor force over the next 15 years, and continuing improvement of shipyard management, at least four manpower trends might be expected:

1. Work reorganization will continue to respond to changing employment patterns and the retirement of skilled workers. Tasks will be delineated in greater detail, and fewer tasks will be combined to form the complex skilled jobs of the future. Training periods will be shortened.

2. Supervision and management will encompass more elaborate planning, involving both the greater use of equipment and mastery of management techniques. Training for shipyard management will have to cover skills in

business administration in addition to shipbuilding technology and marine engineering.

3. High-technology specialists will come primarily from vendors who provide major ship equipment assemblies and new equipment adopted for shipyard use in assembly operations. These vendors, especially those who have contracted with the yards for new equipment, will also be a major source of training for shipyard operations.

4. Mechanization of shipyard processes can be expected to have an impact on manpower skill requirements for both shipbuilding and non-ship work.

Thus, the economic implications of new shipyard equipment and facilities may require careful study. Shipyards are not likely to achieve a scale of operation adequate for efficiency without aggressively seeking employment for their facilities and capability. The economic sizing of the facility may depend on the level of marketing activities that the owner is willing to undertake.

Furthermore, because equipment breakdowns in a flow line can hamper production, automated equipment must be restored to service quickly. This requires specially trained maintenance personnel on the spot or quickly available. These can be shipyard or vendor personnel. The decision about which to use must be made at each shipyard, based on response times required and total equipment maintenance and repair demands anticipated.

CONCLUDING STATEMENT

The overall conclusion of this study is that the technological changes likely to occur in ship design and ship production in the next 15 years will not require significant changes in the nature of shipyard manpower characteristics or training requirements. The changes that will occur will evolve from the natural aging of the labor force. The gradual introduction of new production technology will be accommodated in due course in response to social, economic, and market conditions.

RECOMMENDATIONS

If there is one underlying theme that pervades the body of this report, it is the absence of adequate information on a wide variety of subjects that are of direct concern to the shipyard industry and the federal government. These include, as examples,

1) the mechanisms of inter-industry technology transfer, whose understanding could provide the basis for better judgments on the expected rate of adoption of new methods, techniques, processes, and materials by the shipyard industry;

2) the extent to which construction and related industries are in competition with the shipyards for the same skilled workers;

3) the extent to which the experiences of other industries (in these and other areas) can be usefully applied in the shipyard industry;

4) the effectiveness of training methods and materials with prospective employees of widely varying socio-economic and educational backgrounds, and abilities; and

5) the complex relationships among morale, motivation, and productivity.

Indeed, although shipyard manpower data are collected by the Maritime Administration, the Department of Labor, the Navy, and trade associations (among others), there is general agreement among these organizations on the need to develop a more complete, accurate, and consistent data base on the shipyard work force itself. Thus, the recommendations that follow focus on this basic problem: the shipyard manpower information gap.

1. In order to have a better data base for future manpower projections, consideration must be given to establishing a single, refined file of the growth and decline of those shipbuilding jobs that are unique to the industry or are used in great numbers by the shipyards. (Unlike other federal agencies concerned with manpower, the Maritime Administration is one federal agency that has a special concern for this function and is seeking to expand that capability.)

2. Private-sector organizations (professional and technical societies and trade associations) that are concerned with shipbuilding should establish working committees to sense, record, and collate--no less than annually--a summary of trends in shipbuilding techniques, materials, and management practices. The work of such groups should be of value to government agencies with a similar mission.

3. Consideration should be given to developing a quantitative model for forecasting manpower requirements, which can be applied routinely by interested government agencies. Such a model would be used for emergency planning, as well as for social and economic applications.

Chapter 1

INTRODUCTION

Throughout its history the United States has been a nation of shipbuilders. Seaborne commerce and the sealift of military forces have always required a national capacity to build ships for transoceanic, coastal, and inland waterway use. Innovations in building ships of commerce and ships of war have distinguished this American tradition. We have progressed from sail to steam, from wooden to steel hulls, from family-sized crews to floating cities of specialists, developing and adapting shipbuilding technology for the construction of ever more complex ships with ever more diverse and specialized purposes.

It has been and is today a matter of national policy that the United States will have a substantial shipbuilding industry (see Merchant Marine Act of 1970, amending the Merchant Marine Act of 1936, 46 U.S.C. 1101 et seq.). The industry will continue to be called upon to construct a great variety of vessels and seagoing structures for both civil and government uses. Yet while there is concern in the industry about future work loads, the technology upon which the shipbuilding industry must draw is changing, requiring shipbuilders and repairers constantly to examine, evaluate, reject, or adapt shipyard practices. New construction techniques, loss of experienced craftsmen, new materials, and new mixes of the shipyards' products, among other factors, contribute to a new uncertainty. Will personnel with the requisite skills and interests be available to build the ships, craft, and structures of tomorrow?

PURPOSE AND SCOPE

This study was undertaken to identify the changes in the nature of the requirements for shipyard personnel that may result from the introduction of advanced technology in the next 15 years. There is, however, more to the question than this bare-bones charge from the Maritime Transportation Research Board. As the charge was studied and refined, it became clear that there was an important secondary purpose, pursuit of which was essential to even a partial understanding of forecasts of manpower requirements. For example, what might the impact of varying cargo market penetration trends affecting U.S.-flag shipping, consequent shipbuilding business forecasts, inter-industry competition for shipyard personnel, legislative and regulatory trends, and shipyard personnel practices and management methods be? How might they influence the quantitative and qualitative characteristics and social pressures of the personnel required to build the ships of the future? These matters, too, deserve study if only because of their current, past, and projected contextual importance to shipbuilding. This report is not concerned with long-range trends in <u>total numbers</u> of personnel required.

In formulating a working approach to the study it was agreed that certain limiting considerations would be necessary. The scope of the study was defined by these four guidelines:

1. Shipyard positions to be considered are limited to (a) production, conversion, alteration, and repair trades and (b) management jobs that clearly are identified with the shipbuilding industry.

2. Any non-ship work performed in shipyards (e.g., structures for offshore drilling, mining, and power generation) is included in the scope of the study.

3. The primary focus of the study is on private shipyards; Navy and other government work in private yards is included, and, except for the implications of commercial shipyard manpower supply and demand, government shipyards are excluded.

4. Primary emphasis is placed upon oceangoing vessels.

Matters of maritime or labor policy are, however, outside the scope of the Commitee's deliberations, and these are alluded to only in the context of describing the shipyard industry.

PROJECT ORGANIZATION

The Committee was composed of seven members and seven liaison representatives. Management, labor, government, and academic backgrounds were represented. The members' training and experience included shipbuilding and ship design, labor economics, personnel and industrial psychology, and the training of shipyard managers. The liaison representatives were engaged in shipyard planning and operations, Naval vessel inspection and maritime policy implementation, labor statistics planning, federal emergency planning, and program planning and policy implementation for merchant shipping. Committee members and liaison representatives participated equally in the study, but final responsibility for making decisions as a committee or subcommittee was assumed only by committee members.

The Committee began its deliberations in February 1976 and met seven times as a full committee. The first phase of the project resulted in a definition of purpose and scope and the collection of information about the topic from both invited speakers and personal visits, as well as from the acquisition of relevant documents, written reports, and other recorded information. (A selective list is contained in Appendix F.) In the second major phase the Committee was broken into six sub-groups, each headed by a committee member and charged with preparing a draft chapter of this report. These task groups held a total of 11 meetings. Finally, the Committee as a whole reviewed the report and developed the recommendations that precede this chapter.

REPORT ORGANIZATION AND CONTENT

The report is divided into six chapters, the first of which serves to introduce the subject, "Personnel Requirements for an Advanced Shipyard Technology." Chapter 2, "The United States and World Shipbuilding," provides an industry profile and includes information on recent trends, both U.S. and worldwide. Advances in shipbuilding are discussed in Chapter 3, which focuses on "Industry Adjustments to Trends in Shipbuilding Techniques and Related Labor Requirements." Shipyard personnel--their level of employment, personal and motivational characteristics, education, jobs performed, job mixes, union affiliation, training, and turnover--are among the topics treated in Chapter 4, "Personnel Today." In Chapter 5, the context for the study is more specifically delineated. "Factors Affecting Current Shipyard Operations" that have a major impact on operations and personnel are stressed. Included are market factors, government regulations that affect shipyard administration and production, and matters of insurance and liability. Finally, in Chapter 6, the "Impact of Advanced Technology on Shipyard Personnel" is forecast.

A brief glossary, sample job descriptions, a selective bibliography, and a list of contributors are included in the Appendixes.

Chapter 2

THE UNITED STATES AND WORLD SHIPBUILDING

INDUSTRY PROFILE

The shipyard industry in the United States comprises 330 shipyards and boatyards scattered along the seacoasts, Great Lakes, and inland waterways. The vast majority are small yards engaged in boat repairing. As of 1978, only 28 private shipbuilding yards could construct vessels of 144.8 m (475 ft) in overall length.[1] These yards had a total of 84 building ways, including building basins (drydocks), whose capacities are given in Table 2-1. The geographic distribution of these yards is shown in Figure 2-1.

Ship repairs and conversions are performed both at yards devoted exclusively to repair work and at some shipbuilding yards. About 65 private yards were capable of drydocking and repairing ships 91.4 m (300 ft) and longer; of these, 43 could accommodate ships over 152.4 m (500 ft) long.[2] Employment in the private shipyard industry was estimated to be 168,600 in December 1978.

Specialization by market, product line, and service performed is commonplace. For example, market differentiation is discernible among naval shipbuilding, commercial shipbuilding for foreign trade, commercial shipbuilding for domestic trade, ship repair, and offshore oil exploration and production.

In naval shipbuilding, production line specialization is evident in submarines, aircraft carriers, surface combatants, and naval auxiliaries. Commercial shipbuilding product line categories include tankers, liquefied natural gas (LNG) carriers, roll-on, roll-off (RORO) vessels, containerships, barge-carrying (LASH and SeaBee) vessels, tugs, barges, drill rigs and platforms, Great Lakes coal and ore carriers, and other special-purpose vessels and craft. Service specialization is exemplified by new construction, drydock repairs, and topside repairs.

The degree of specialization is a function of work availability, market prospects, company resources, and management strategies. Since these factors change

Table 2-1

MAJOR U.S. PRIVATE SHIPYARDS AND NUMBER OF SHIPBUILDING WAYS BY LENGTH[a/]

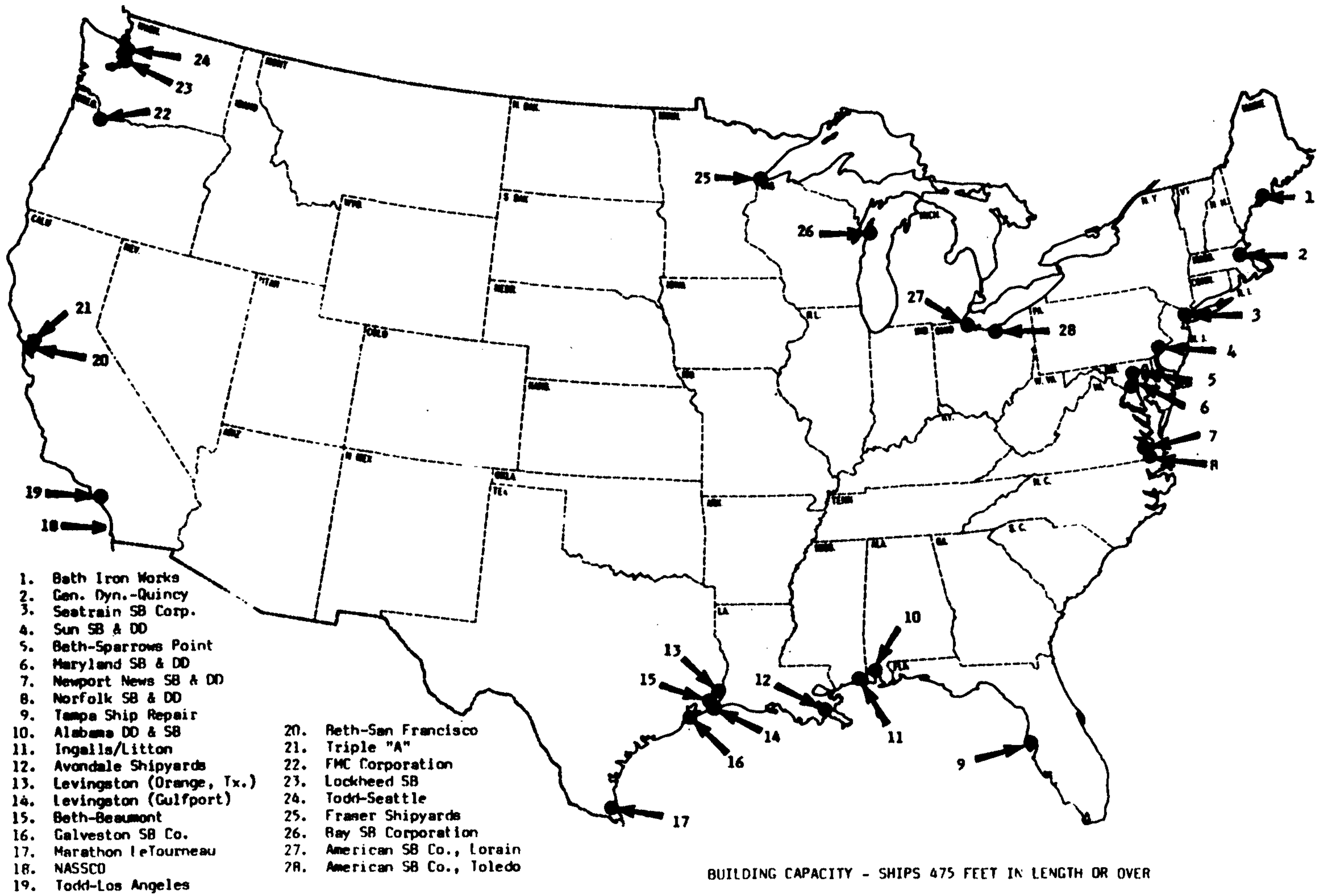
Length OA (In Feet):	475	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200	1300	1400	1600
ATLANTIC COAST																		
Bath Iron Works	3	3	3	3	2													
Beth-Sparrows Point	3	3	3	3	3	3	3	3	3	1	1	1	1	1	1			
General Dynamics, Quincy	5	5	5	5	5	5	5	5	1									
Maryland SB & DD	1	1	1	1	1	1	1	1										
Newport News SB & DD	7	7	7	7	7	5	5	5	5	3	2	2	2	1	1	1	1	1
Norfolk SB & DD	1																	
Seatrain SB Corp.	3	3	3	3	3	3	2	2	2	2	2	2						
Sun SB & DD	4	4	4	4	4	1	1	1	1	1	1	1	1	1	1	1	1	
TOTAL	(27)	(26)	(26)	(26)	(25)	(18)	(17)	(17)	(12)	(7)	(6)	(6)	(4)	(3)	(3)	(2)	(2)	(1)
GULF COAST																		
Alabama DD & SB	4	4	1															
Avondale Shipyards	12	9	9	8	8	8	8	8	8	8	8	8	5	5	5			
Beth-Beaumont	1	1	1	1	1	1	1											
Ingalls-E. Bank	6	6	5	5														
Ingalls-W. Bank	6	6	6	6	6	6	6											
Galveston SB	1	1	1	1	1													
Levingston (Orange TX)	1	1	1	1	1													
Levingston (Gulfport)	1	1																
Marathon LeTourneau	1	1	1	1	1	1	1	1	1	1	1	1	1					
Tampa Ship Repair	1																	
TOTAL	(34)	(30)	(25)	(23)	(18)	(16)	(16)	(9)	(9)	(9)	(9)	(9)	(6)	(5)	(5)			

Length OA (In Feet):	475	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200	1300	1400	1600
PACIFIC COAST																		
Beth-San Francisco	1	1																
FMC Corporation	1	1	1	1	1													
Lockheed SB	3	3	3	3	1													
National Steel & SB	4	4	4	4	3	3	3	3	3	1								
Todd-Los Angeles	2	2	2	2	2	2	2											
Todd-Seattle	1	1																
Triple "A"	3	3	3	3	3	2	2	2	2	2	1	1						
TOTAL	(15)	(15)	(13)	(13)	(10)	(7)	(7)	(5)	(5)	(3)	(1)	(1)						
GREAT LAKES b/																		
American SB-Lorain	2	2	2	2	2	1	1	1	1	1	1							
American SB-Toldeo	2	1	1															
Bay SB Corporation	2	2	2	2	2	2	1	1	1	1	1	1	1					
Fraser Shipyards	2	2	2	1	1	1	1											
TOTAL	(8)	(7)	(7)	(5)	(5)	(4)	(3)	(2)	(2)	(2)	(2)	(1)	(1)					
Grand Total All Coasts and Great Lakes	84	78	71	67	58	45	43	33	28	21	18	17	11	8	8	2	2	1

a/ Includes yards capable of building vessels 144.8 m (475 ft) or more in length overall.
b/ Maximum ship size that can transit St. Lawrence Seaway locks is 222.5 m (730 ft) in overall length and 23.8 m (78 ft) in beam.

Source: Maritime Administration, Office of Ship Construction, Division of Production, Report on Survey of U.S. Shipbuilding and Repair Facilities, 1978 (Washington: Dec. 1978), pp. 92-93.

FIGURE 2-1 Major U.S. private shipyards, 1978



Source: Maritime Administration, Office of Ship Construction, Division of Production, Report on Survey of U.S. Shipbuilding and Repair Facilities, 1978 (Washington: Dec. 1978), Exhibit I, p. 43.

constantly, there are shifts over time toward more specialization or more diversification, depending upon the perspective of individual yards.

A salient characteristic of the shipyard business is its cyclical nature. Major factors contributing to this are (a) market uncertainties, such as the national economy and federal appropriations for ship construction and repair, (b) product specialization, and (c) multiple-ship procurement. The fluctuations in the U.S. shipyard order book over the period from 1957 to 1977 are shown in Figure 2-2.

WORLD SHIPBUILDING ENVIRONMENT

In the broadest sense, commercial shipbuilding is a function of seaborne trade. Historically, there has been a close correlation between world shipbuilding output and trade growth (see Table 2-2). Boom and recession periods in the world economy influence demand for shipping and shipbuilding.

Most shipbuilding nations build ships for export. In some countries, shipbuilding and shipping are important contributors to employment and to favorable trade balances--e.g., shipbuilding exports account for 10 percent of total Japanese visible exports. Inasmuch as shipbuilding is a labor-intensive industry, many developing countries look upon shipbuilding as a bootstrapping industry and a cure to unemployment problems. Aside from the obvious economic motivations, all countries view commercial shipbuilding as an essential adjunct to their naval or defense establishments.

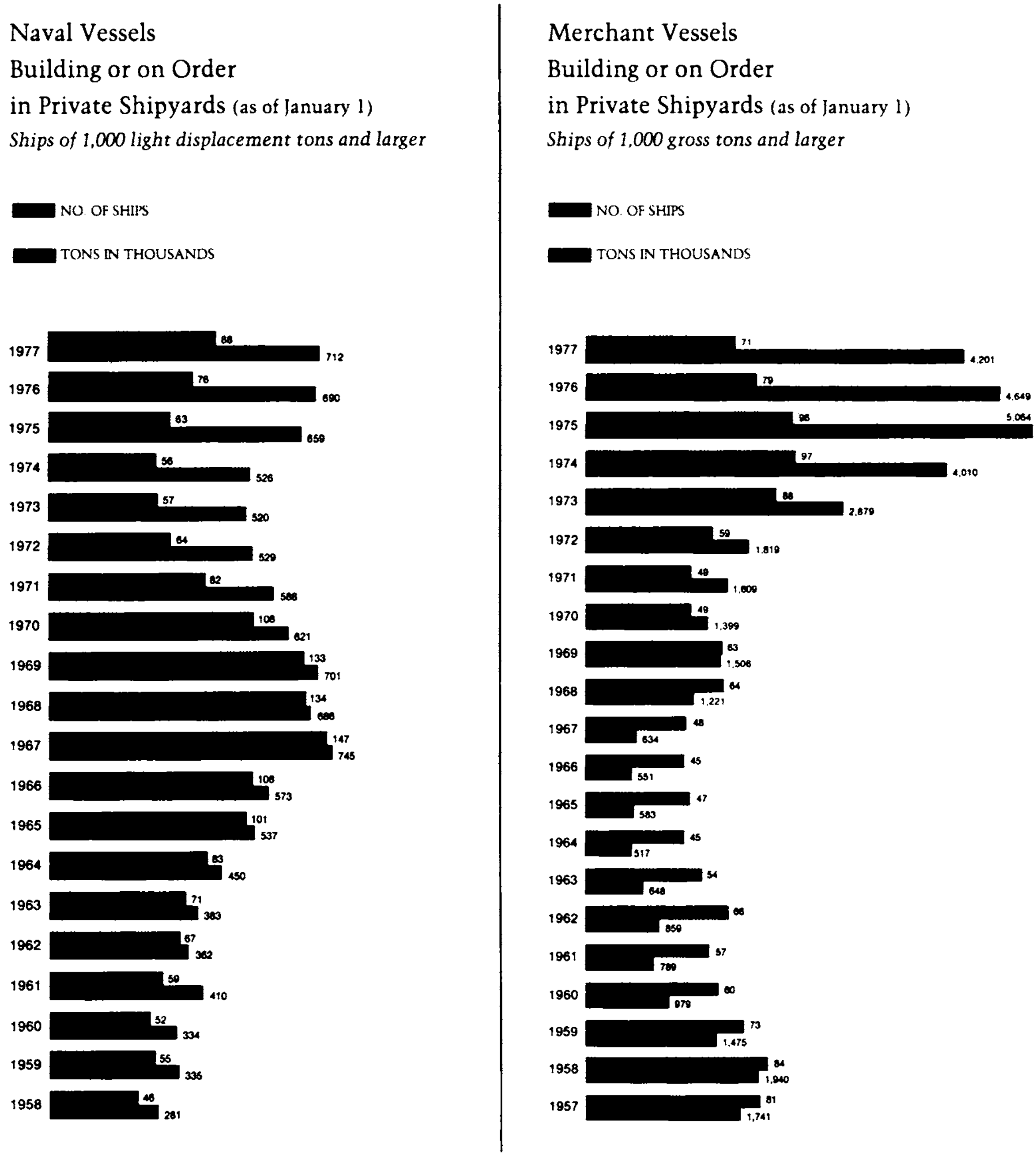
At the present time, world shipbuilding is depressed. Substantial excess capacity has existed in all major shipbuilding countries since the OPEC oil price increases of late 1973. The world's shipyards and shipbuilding nations are in a fierce contest for survival.

While the U.S. shipbuilding industry is influenced by conditions in the world shipbuilding business environment, it is influenced more by circumstances peculiar to U.S. shipbuilding alone--that is, by federal policy, statute, and regulation with respect to naval shipbuilding, subsidized commercial shipbuilding, and cabotage.[3]

Because of generally higher construction costs, the U.S. shipbuilding industry has not, on balance, been an export industry since the days of the clipper ships.[4]

The impact of the present and persistent worldwide shipping slump on shipbuilding in the leading industrial countries has received much attention recently. It reflects

FIGURE 2-2 Fluctuations in the U.S. shipyard order book, 1957-1977



Source: Shipbuilders Council of America, Annual Report, 1976 (Washington: Mar. 2, 1977), p. 27.

the close connection between seaborne trade developments and shipbuilding. The intense international competition in shipping and shipbuilding have made for rapid adjustments to projected trade increases. In the decade after 1963, as world trade increased by 142 percent in tonnage and by 240 percent in ton-miles, the world fleet increased 182 percent in deadweight tonnage; and this was accompanied by an increase of 272 percent in world shipbuilding output.

In large part, the surge in world ship orders and surplus tonnage stemmed from the constantly increased demands of the industrial nations for oil and from the rush to very-large and ultra-large crude carriers (VLCCs and ULCCs), which was accelerated by the closing of the Suez Canal. Other factors in the rapid expansion of shipyard capacity included the emergence of Japan as an aggressive and highly successful competitor for western vessel orders and the determination of some less-developed countries to create their own shipbuilding capacity as well as their own merchant fleets.[5]

This boom was halted by the OPEC oil price increases at the end of 1973, contributing to worldwide recession. With orders in world shipyards at an all-time high, and with tankers most prominent in these orders, the impact on shipbuilding was immediate and devastating. Not only did charter rates drop sharply, with many tankers placed in lay-up, but also, in many instances, construction was cancelled or terms were renegotiated downward for the building of the ships.

Tankers worth $50 million in 1973 would hardly go for $10 million in 1978, with some 30 million dwt in lay-up. Some tankers have gone into immediate lay-up following completion. The tanker surplus may not be in balance with world demand until well into the 1980s.

The world recession has had its impact on dry cargo shipping also, especially in the dry bulk sector. For example, the London Economist reported during the first quarter of 1978 that a 31,000-ton bulk carrier that cost $14 million to build in 1977 had been sold to China for $6 million.

Worldwide, the result has been direct concern over the survival of shipyards. The easy credit and other less publicized government aids provided shipbuilding in boom years have become more visible as increased efforts have been made to sustain shipyard production and employment.

In the United States, direct subsidies, ship financing guarantees, tax-deferred capital construction funds, limited cargo preference, and cabotage are the principal methods for supporting merchant shipping. In other countries, broad and

Table 2-2

COMPARATIVE GROWTH OF OCEANBORNE WORLD TRADE, WORLD FLEET CAPACITY, AND WORLD SHIPBUILDING OUTPUT, 1963-1974 a/

	Oceanborne World Trade		World Fleet Capacity		World Shipbuilding Output
Year	Cargo Tonnage Index	Ton-Mile Index	GRT b/ Index	Dwt c/ Index	GRT b/ Index
1963	100.0	100.0	100.0	100.0	100.0
1964	111.5	113.8	104.9	106.4	107.8
1965	121.2	124.3	109.9	115.0	131.1
1966	131.1	132.6	117.3	124.8	156.7
1967	137.9	153.7	124.8	136.0	168.9
1968	151.0	178.0	133.1	149.6	186.7
1969	165.5	199.3	145.1	163.7	207.8
1970	183.5	226.5	155.9	180.1	233.3
1971	190.5	249.3	169.4	202.2	271.1
1972	204.3	278.5	183.9	224.9	296.7
1973	230.4 d/	326.7 d/	198.7	252.1	337.8
1974	241.9 d/	340.1 d/	213.4	282.1	372.2

a/ Index basis: 1963 = 100.0.
b/ GRT = gross register tonnage.
c/ Dwt = deadweight tonnage.
d/ Estimated.

Sources: Fearnley & Eger, Lloyd's Statistical Tables.

varied indirect subsidies are the vehicles. These include loans at less than market interest rates sponsored or financed by government loan guarantees, accelerated depreciation, tax-deferred capital gains from ship sales and tax-free reserve funds, formal and informal restrictions on ship imports, duty-free imports of materials needed for ship construction, and cargo preference and cabotage restrictions.

In addition, many of the major maritime nations have responded to the worldwide shipbuilding slump with a variety of ad hoc measures. For example, in 1976 and 1977, some nations appeared to offer below-cost prices to those purchasing their ships; more recently, they have made efforts to reduce shipyard capacity. Some have spent millions in easy loans and gifts, designated as foreign aid, to obtain orders from developing nations. Some have subsidized, in their own yards, the building of ships for other nations--ships that are likely to compete with the building nations' own shipping. All these, however, are stop-gap measures. Shipyard prosperity will be a possibility only if and when the shipping market booms again.

GOVERNMENT POLICY AND THE PUBLIC INTEREST

Clearly, the fortunes of the U.S. shipbuilding industry are controlled by the policies of the federal government. National security has been, and remains, the cornerstone of support for the U.S. shipbuilding industry. This essentially has prevailed since the founding of the nation. There is a recognition of the interrelationships between Naval shipbuilding and the maintenance of a private shipbuilding industrial base that can be readily expanded during periods of national emergency. During World Wars I and II, U.S. private yards proved their importance to national security by producing phenomenal numbers of ships, both Naval and merchant.

The United States, like all maritime countries, has traditionally supported its maritime industry. The extent of support has waxed and waned in different periods, with varying views of national requirements for economic development, and with varying pressures as regards national preparedness and defense requirements. The U.S. experience in World War I, which was to be magnified substantially in World War II, resulted in enactment of the Merchant Marine Act of 1920. This Act expressed the basic U.S. policy toward commercial ship operations:

"That it is necessary for the national defense and for the proper growth of its foreign and domestic commerce that the United States shall have a merchant marine of the best equipped and most suitable types of vessels sufficient to carry the greater portion of its commerce and serve as a naval or military auxiliary in time of war or national emergency, ultimately to be owned and operated privately by citizens of the United States...."[6]

This policy was reaffirmed in the Merchant Marine Act of 1928 and expanded in the Merchant Marine Acts of 1936 and 1970.

Explicit subsidies, carefully administered, for shipbuilding construction and for ship operation were set forth in the Merchant Marine Act of 1936. In part, they were a reaction to the ineffective use of mail subsidies to aid the development of the merchant marine between 1928 and 1935. In part, in the face of continuing depression, they represented an effort to aid employment and trade growth. In the light of then-existing trade patterns, subsidies were limited to liner operators.

The Merchant Marine Act of 1970 was the outcome of a decade of studies directed at reassessing U.S. merchant marine policy. The Act was intended to halt the decline of the U.S. merchant fleet and to provide for balanced growth. A 10-year building program of some 300 merchant ships was projected. Reduced percentage levels of construction-differential subsidies (CDS) were sought. Through extension of operating-differential subsidies (ODS) and capital construction fund benefits, a new program to aid bulk carriers, including tankers, was established. Construction subsidies also were made available to non-liner vessels. Only a fraction of the projected ships has actually been contracted.

Ships for the U.S. merchant marine constitute virtually the entire commercial market for the U.S. shipbuilding industry. Hence, the health of the shipbuilding industry and that of the merchant marine are inextricably intertwined, and that correlation, throughout the world, is largely influenced by the actions or inactions of national governments. This applies also to the U.S. maritime industry.

In 1973, the Commission on American Shipbuilding stated that:

"...the most immediate need of the U.S. shipbuilding industry is a continuing, consistent, national maritime policy fully implemented at all levels. The Merchant Marine Act of 1970, enacted with the full support of the Administration and the Congress, is an impressive beginning....

"What is needed is a well established market. This market, to assist the shipbuilding industry in improving productivity and attracting investments, must be stable and characterized by series construction. If this market is to be attained, it must be, as in other countries, the result of a sustained, positive national policy."[7]

In addition to direct subsidies (ODS and CDS), several indirect subsidies offered by the U.S. government assist in making investment in U.S.-flag ships more attractive.[8] These include:

- Federal loan guarantees under the Federal Ship Financing Program (Title XI of the Merchant Marine Act of 1936), which result in long-term financing on favorable terms and conditions and at interest rates that are comparable to those available to large and financially strong corporations.
- Investment tax credits (10 percent) on new ships.
- Deferral of taxes on earnings from the operation of a vessel, proceeds from the sale of a vessel, and earnings from the investment of accumulated assets in a capital construction fund to be applied against new vessel construction.
- Transport of government-controlled cargoes, e.g., cargoes for the Strategic Petroleum Reserve, Public Law 480 aid cargoes, Department of Defense cargoes, and the bilateral agreements with the Soviet Union on grain purchases and transport.

While all the foregoing features are attractive, they do not assure full competitiveness for the U.S.-flag merchant marine.

In certain competitive or political situations, foreign countries can impose discriminatory freight rates to prejudice U.S. goods in world markets in the absence of a U.S. merchant fleet of sufficient size to exert downward leverage on freight rates.

NAVAL SHIPBUILDING

The shipbuilding, overhaul, and repair work of the U.S. Navy is distributed among eight government-owned Naval shipyards, employing 70,800 workers in December 1978, and a number of privately owned shipyards. Since 1967, all Navy new construction has been done by private yards. In addition, about one third of the Navy ship conversion, alteration, and repair work is performed by the private sector.

Within the private sector, 188 shipyards and shipwork contractors hold Navy master ship repair contracts. However, in terms of new construction capability, only 11 of these have current or recent new construction experience. In mid-1977, these 11 yards employed about 60 percent of the private shipyard work force.

At the close of 1978, 11 private shipyards were building 102 Naval vessels (of 1,000 light displacement tons and over) totaling 677,000 light displacement tons. The value of unfinished work was approximately $10.0 billion. Congressional Naval appropriations in fiscal 1979 included $3.8 billion for shipbuilding and conversion, and another $3.0 billion for overhauls and repairs (compared with fiscal 1978 levels of $5.8 billion and $3.0 billion, respectively).[9] While the value of Naval work has increased over the past 10 years, the size of the Navy's active fleet has dropped from 976 to 453 ships. However, the increasing complexity of naval ships has necessitated longer overhaul periods, so that overall industry work force levels have remained fairly constant.

COMMERCIAL SHIPBUILDING

Commercial shipyards build for (a) the domestic market, (b) a largely government-supported merchant marine engaged in "essential" U.S. foreign trade, and, to a limited extent, (c) special high-technology products where U.S. shipbuilding is most competitive, such as liquefied natural gas (LNG) carriers and offshore drill rigs and platforms.

The domestic trades include the inland waterways, Great Lakes carriage between U.S. ports, coastwise and intercoastal shipping, and trade between the continental United States and such noncontinguous states, territories, and possessions as Alaska, Hawaii, Puerto Rico, Guam, Wake, and American Samoa. Under provisions of the Jones Act (Merchant Marine Act of 1920, Sec. 27; 46 U.S.C. 833), the domestic cargo and passenger trades are restricted to vessels of U.S. construction, registry, ownership, and manning. The trade between the continental United States and the Virgin Islands is specifically excluded from the Jones Act. Participation in Great Lakes international service between U.S. and Canadian ports is, of course, open to vessels of both nations.

Because the U.S. market share in the domestic trades is essentially 100 percent, U.S. shipyards--particularly the small yards--can plan for the future with some degree of confidence with respect to the domestic market sector.

SUBSIDIZED FLEET

Until the Merchant Marine Act of 1970, only liner vessels were eligible for CDS and ODS. Under this subsidy policy, the U.S.-flag liner operators were able to modernize their fleets and gain a respectable share of U.S. liner imports and exports. Subsidized and unsubsidized U.S.-flag liners carried over 30 percent of U.S. commercial liner cargoes during 1974-1977.[10]

However, U.S.-flag vessels enjoyed only token participation in the non-liner trades. Hence, the Merchant Marine Act of 1970 expanded the eligiblity for subsidies to the petroleum and dry bulk trades. In 1977, U.S.-flag ships carried about 3.3 percent of U.S oil imports and about 2.0 percent of U.S. dry bulk imports and exports.[10] Since enactment of the 1970 Act, 29 tankers and 2 ore-bulk-oil carriers (OBOs) have been built under CDS (see Table 2-3). As of June 30, 1977, the subsidized U.S.-flag fleet comprised 187 vessels (Table 2-4), most of which were dry cargo liner ships.

UNSUBSIDIZED FOREIGN-TRADE FLEET

There is also an unsubsidized U.S.-flag foreign trade fleet of 393 ships (Table 2-5). Most of the freighters and bulk carriers are remnants of the World War II-built fleet whose average age puts them beyond competitive economic usefulness. Many of the tankers also are in this category. Overall, the average age of the ships in the unsubsidized foreign trade group is twice that of the subsidized segment. Because of the obvious obsolescence of many of these vessels, their replacement represents a significant market opportunity for shipbuilding and undoubtedly federal agencies are considering channeling this work to U.S. shipyards. Under present economics, however, few of these replacement vessels are likely to be built in U.S. yards[7]-- an issue of vital concern to several federal agencies.

SHIP REPAIR

Ships are repaired in all regions of the United States. Some yards are devoted exclusively to ship repair work, while others handle repair work as an adjunct to new construction. Collectively, U.S. private shipyards handle 30 percent of Naval vessel overhaul and repairs, as well as a considerable amount of both U.S.-flag and foreign-flag merchant ship repairs performed on the North American continent. Private shipyards are estimated to be receiving $1.6 billion annually from ship repair work, divided about evenly between Navy and commercial business. For many yards, the prospects for ship repair work are good and are

Table 2-3

CONSTRUCTION-DIFFERENTIAL SUBSIDY AWARDS SINCE ENACTMENT OF THE MERCHANT MARINE ACT OF 1970, BY SHIP TYPE, 1979

	Number of Ships	
Ship Type	Awarded	Delivered
Tanker	30	29
Barge Carrier (LASH)	11	9
Liquefied Natural Gas (LNG) Carrier	11	6
Containership	7	1
Dry Bulk	5	0
Integrated Tug-Barge	5	0
Roll-On, Roll-Off (RORO)	4	4
RORO-Container	3	0
Break-Bulk	3	0
Ore-Bulk-Oil (OBO)	2	2
Heavy Lift	2	2
Total	83	53

Note: Data are as of September 1979. Not included are vessels awarded CDS but subsequently cancelled.

Source: Maritime Administration, Office of Ship Construction, Division of Production.

Table 2-4

U.S.-FLAG SUBSIDIZED FLEET, JUNE 1977

Vessel Type	Number	Deadweight Tonnage	Average Age (Years)
Combination Passenger-Cargo	6	50,300	17.3
Freighter a/	111	1,539,000	13.9
Intermodal b/	47	1,160,900	5.4
Bulk Carrier c/	2	164,400	3.5
Tanker	21	1,347,100	1.4
Total	187	4,261,700	10.4

a/ Includes partial containerships as well as break-bulk general cargo ships.

b/ Full containerships, barge carriers (LASH and SeaBee), container-car carriers, and roll-on, roll-off (RORO) ships. Includes 3 government-owned ships totaling 40,300 dwt, which are subsidized under a use-charter agreement.

c/ Includes ore-bulk-oil carriers (OBOs).

Source: Maritime Administration, Office of Trade Studies and Statistics; published in Heine, Irwin M., The United States Merchant Marine--A National Asset: An Addendum (Washington: National Maritime Council, Feb. 1978), p. 3.

Table 2-5

U.S.-FLAG UNSUBSIDIZED FOREIGN-TRADE FLEET, JUNE 1977

Vessel Type	Number	Deadweight Tonnage	Average Age (Years)
Freighter a/	39	536,700	22.7
Intermodal b/	102	1,709,300	20.0
Bulk Carrier	16	364,900	29.1
Tanker	236	9,687,200	20.0
Total	393	12,298,100	20.6

a/ Includes partial containerships as well as break-bulk general cargo ships.

b/ Full containerships, barge-container and barge carriers (LASH), and roll-on, roll-off (RORO) ships.

Source: Maritime Administration, Office of Trade Studies and Statistics; published in Heine, Irwin M., The United States Merchant Marine--A National Asset: An Addendum (Washington: National Maritime Council, Feb. 1978), p. 4.

presently improving; stability is much greater than in new construction.

DRILL RIGS AND OFFSHORE SERVICE AND SUPPLY VESSELS

The offshore drilling rig market is one in which the United States has pioneered technology and is an acknowledged world leader, particularly in jack-up rigs. At least 10 U.S. shipyards have the capability to build and repair drill rigs.

The demand for drill rigs has been volatile. During the early 1970s, there was a great surge in ordering. By the end of 1975, there was a world oversupply. The number of rigs on order in U.S. yards dropped from 33 to only 7 at the end of 1976. At least one U.S. shipyard announced its intention to close because of the dearth of new orders. Then, just as quickly, oil exploration was stepped up, causing world demand for rigs to exceed supply, resulting in U.S. yards' receiving 14 new orders in 1977.

Also closely related to offshore oil industry activity is the demand for offshore service and supply vessels and ocean-classed tugs. Small shipyards specializing in the production of these specialized vessels have generally done well in domestic and export markets.

U.S. RANKING IN WORLD SHIPPING AND SHIPBUILDING

The current U.S.-flag privately owned merchant marine comprises fewer than half as many ships and has 1 million dwt less than it had in 1951, the peak year in size for the U.S.-flag fleet. It is, however, better balanced (among ship types), more productive, and a more competitive fleet.

In size, the U.S.-flag merchant fleet ranks tenth among the merchant fleets of the world, as shown in Table 2-6. In U.S. oceanborne foreign trade during 1976, the U.S.-flag fleet carried 30 percent of liner cargoes, less than 4 percent of U.S. oil imports, and less than 1 percent of U.S. dry bulk exports and imports.[10] Overall, the U.S.-flag merchant marine carried 5.2 percent of the U.S. oceanborne exports and imports in 1976 (Table 2-7), and ranked sixth in participation in U.S. oceanborne foreign trade.

In shipbuilding, the United States ranked fourth in the gross tonnage of merchant vessels (over 100 grt) completed during 1978 (Table 2-8).

Table 2-6

RANKINGS OF NATIONAL-FLAG MERCHANT FLEETS, DECEMBER 31, 1977

Country	No. of [1] Ships	Rank by [2] No. Ships	Dwt. (thousands)	Rank by Dwt.
Liberia	2,627	1	157,788,300	1
Japan	1,846	5	62,455,300	2
Norway	978	7	52,568,600	3
United Kingdom	1,377	6	51,105,500	4
Greece	2,379	3	49,825,000	5
Panama	2,041	4	31,250,500	6
France	415	—	20,815,100	7
U.S.S.R.	2,456	2	20,480,500	8
Italy	603	8	17,858,100	9
United States (Privately Owned)	571	11	17,321,400	10
Germany (West)	592	9	14,664,400	11
Spain	479	13	12,195,200	12
Sweden	286	—	11,965,000	13
Singapore	574	10	11,889,800	14
India	363	—	8,890,600	15
All Others[3]	6,509	—	100,235,200	—
Total	**24,096**	—	**641,308,500**	—

[1] Oceangoing merchant ships of 1,000 gross tons and over.
[2] By number of ships. Cyprus ranks 12th with 502 vessels aggregating 3,633,300 dwt., the People's Republic of China ranks 14th with 462 vessels aggregating 6,476,600 dwt., and the Netherlands ranks 15th with 443 vessels aggregating 7,686,500 dwt.
[3] Includes 269 United States Government-owned vessels of 2,650,300 dwt.

Source: Maritime Administration, MarAd 1978, Annual Report for Fiscal Year 1978 (Washington: U.S. Government Printing Office, May 1979), p. 32.

Table 2-7

RANKINGS OF NATIONAL-FLAG SHIPS

IN CARRIAGE OF U.S. OCEANBORNE FOREIGN TRADE, 1976

Rank	Flag	Cargo Tonnage (Millions of Long Tons) [a/]	Percent of Total
1	Liberia	243.1	33.1
2	Greece	65.8	9.0
3	Norway	50.1	6.8
4	Panama	45.2	6.2
5	United Kingdom	41.9	5.7
6	United States	38.4	5.2
7	Japan	27.9	3.8
8	Italy	20.2	2.8
9	Singapore	17.3	2.4
10	W. Germany	16.2	2.2
11	Netherlands	12.7	1.7
12	Sweden	11.4	1.6
13	Denmark	8.2	1.1
14	France	7.8	1.0
15	USSR	5.5	0.7
	Subtotal	611.7	83.3
	All other flags	122.9	16.7
	Total	734.6	100.0

a/ Total of waterborne exports and imports in U.S. foreign trade. Includes trans-Lakes cargo in U.S.-Canada trade totaling 30.0 million tons, and Special Category items whose tonnage was not separately indicated in Bureau of Census data.

Source: Maritime Administration, Office of Trade Studies and Statistics, Special Report CMM 7251 R, based on Bureau of Census data.

Table 2-8

RANKINGS OF MAJOR SHIPBUILDING NATIONS
BY GROSS TONNAGE OF MERCHANT SHIP DELIVERIES, 1978[a/]

Rank	Nation	Number of Ships Completed	Gross Register Tonnage
1	Japan	1,046	6,307,155
2	Sweden	36	1,407,017
3	United Kingdom	91	1,113,331
4	United States	151	1,033,142
5	W. Germany	134	844,530
6	Spain	120	821,111
7	Poland	66	702,182
8	South Korea	54	604,286
9	USSR [b/]	156	528,084
10	Brazil	41	441,821
11	France	42	439,940
12	China (Taiwan)	17	436,069
13	E. Germany	55	409,727
	Subtotal	2,009	15,108,395
	All Other Nations	609	3,085,725
	World Total	2,618	18,194,120

a/ Vessels over 100 grt.
b/ Incomplete data.

Source: Lloyd's Register, Annual Summary of Merchant Ships Completed in the World During 1978 (London: 1979).

SHIPBUILDING CAPABILITY AND ECONOMIC IMPACT

The low ranking in the world market of the U.S. shipbuilding industry today does not stem from lack of capability or versatility. The industry has demonstrated that it can build a variety of vessel types and sizes, and it has pioneered in the development of many new ship types and design concepts. It proved also, during World Wars I and II, its ability to expand capacity rapidly.

The value of the physical shipbuilding plant in the United States is not presently known. It is known that, in the last 10 years, the industry has invested more than $1.2 billion in facilities and equipment improvements. These investments were made in response to changing ship sizes and characteristics and the ever-changing nature of shipbuilding markets.

The dollar value of work performed and anticipated over the 1972-79 period, as shown in Table 2-9, would appear to indicate a healthy and growing business environment. This, however, is not the case. The figures in this table reflect the completion of peak ordering during 1973-74. The years since 1974 have been poor in terms of new orders. As shown in Table 2-10, the tonnages of ships ordered during these years are only a fraction of the 1974 levels. Two projections of private shipyard workloads over the next 5 years are given in Figures 2-3 and 2-4. The more pessimistic industry forecast (Figure 2-4) implies major lay-offs after 1978; the forecast by the Navy also projects a decline, although a less drastic one.

Coupled with the problems of instability of workload, most shipyards also have the problem of low profitability. The Pentagon's "PROFIT '76" study concluded that, over the previous 5 years, shipbuilders had had the highest level of capital investment but the lowest level of profits, related to sales, of any group of defense contractors.[11] The Navy Department is in the process of defining these relationships more precisely.

The U.S. shipbuilding industry has an important interrelationship with support industries; few ship components are manufactured in the shipyards themselves. Since almost all such purchases are made in the United States, the shipyard industry has a significant impact on the national economy.

The economic multiplier associated with the shipyard industry is estimated to be 2.16.[12] Considering the estimated value of shipyard work to be completed in 1978 and 1979 of $7.3 billion and $7.6 billion, respectively (Table 2-9), the annual contribution to gross national product, using the 2.16 multiplier, is on the order of $15 billion.

Table 2-9

SHIPBUILDING AND SHIP REPAIR INDUSTRY TRENDS AND PROJECTIONS, 1972-1979

	(In Millions of Current Dollars, Except as Noted)							
	1972	1973	1974	1975	1976	1977 a/	1978 a/	1979 a/
Industry Totals								
Employment (Thousands)								
Total	144.6	152.1	162.2	166.9	166.3	176.3	178.0	173.0
Production Workers	118.0	120.6	129.0	133.4	132.1	139.3	140.6	137.0
Value of Work Done b/	3,281	3,958	4,825	5,615	5,896	6,640	7,290	7,581
Value Added	1,881	2,216	2,547	2,923	3,287	3,559	3,907	4,063
Value of Work Done on Ships Only								
Nonpropelled New Ships	362	386	460	643	645	665	710	746
Self-propelled New Military Ships	1,100	1,333	1,714	1,768	1,957	2,195	2,414	2,499
Self-propelled New Non-Military Ships	816	1,202	1,290	1,806	1,825	2,055	2,251	2,318
Repair, Military Ships	387	393	533	554	644	770	870	918
Repair, Non-Military Ships	484	523	713	688	715	771	847	898
N.s.k. c/	52	52	2	54	47	50	51	52
Total	3,201	3,888	4,712	5,513	5,883	6,507	7,144	7,429

a/ Estimated by Maritime Administration and Shipbuilders Council of America.
b/ Includes value of all products and services sold by the shipbuilding and repair industry (SIC category 3731).
c/ N.s.k. = shipbuilding and repairs not specified by kind.

Source: Shipbuilders Council of America, Annual Report, 1978 (Washington: Mar. 14, 1979), p. 4. Data from Bureau of Census, Bureau of Labor Statistics, Maritime Administration, and Shipbuilders Council of America.

Table 2-10

VESSELS ORDERED FROM PRIVATE SHIPYARDS, 1970-1978 [a/]

Year	Naval Vessels Ordered		Merchant Vessels Ordered	
	Number	Light Displacement Tonnage (Thousands)	Number	Gross Tonnage (Thousands)
1970	6	132	13	580
1971	15	88	24	617
1972	14	86	48	1,551
1973	7	39	43	2,013
1974	16	171	25	1,766
1975	16	106	14	635
1976	20	91	16	339
1977	15	89	13	266
1978	25	119	30	394

a/ Vessels of 1,000 tons and over.

Source: Shipbuilders Council of America, Annual Report (Washington), years 1974 (p. 33) and 1978 (p. 29).

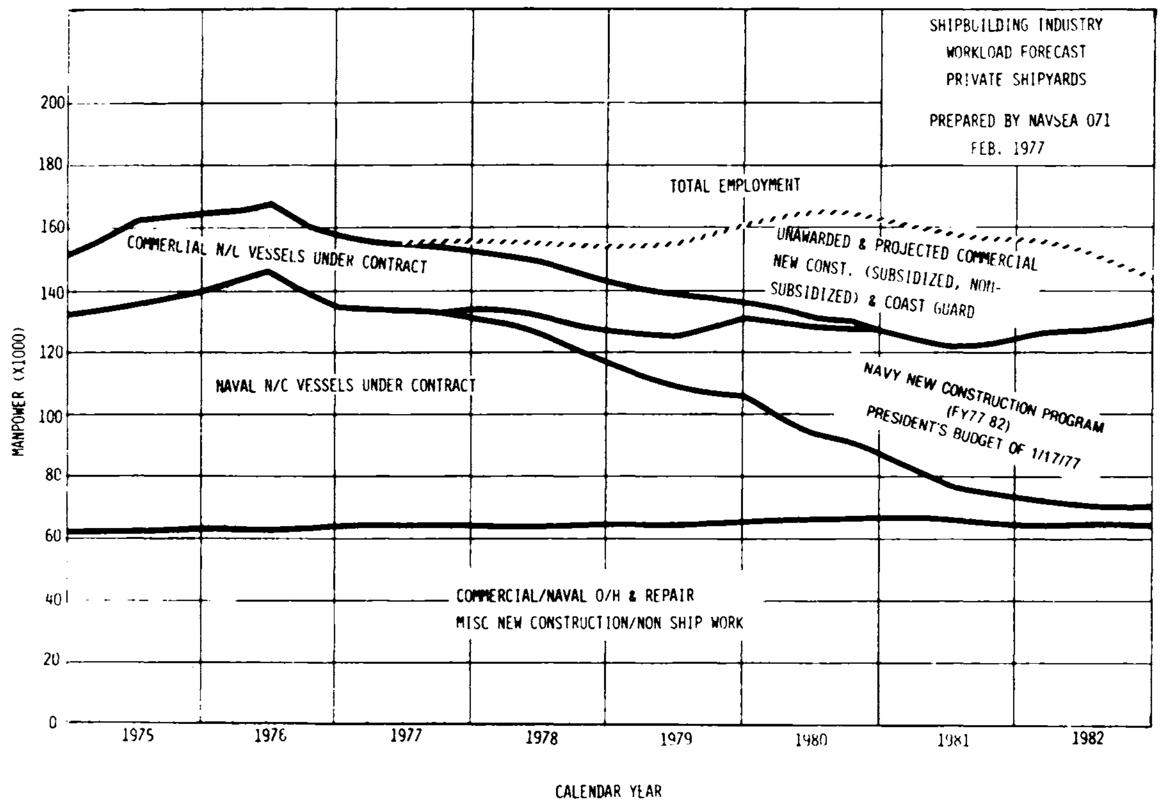


FIGURE 2-3 Shipyard workload, 1975-77, and forecast, 1977-82: U.S. private shipyard industry

Source: Department of Defense, Coordinator of Shipbuilding, Conversion and Repair, Annual Report on the Status of the Shipbuilding and Ship Repair Industry of the United States,1976, Report No. DD-I&L(A) 1141 (Washington: Naval Sea Systems Command), p. 1-18.

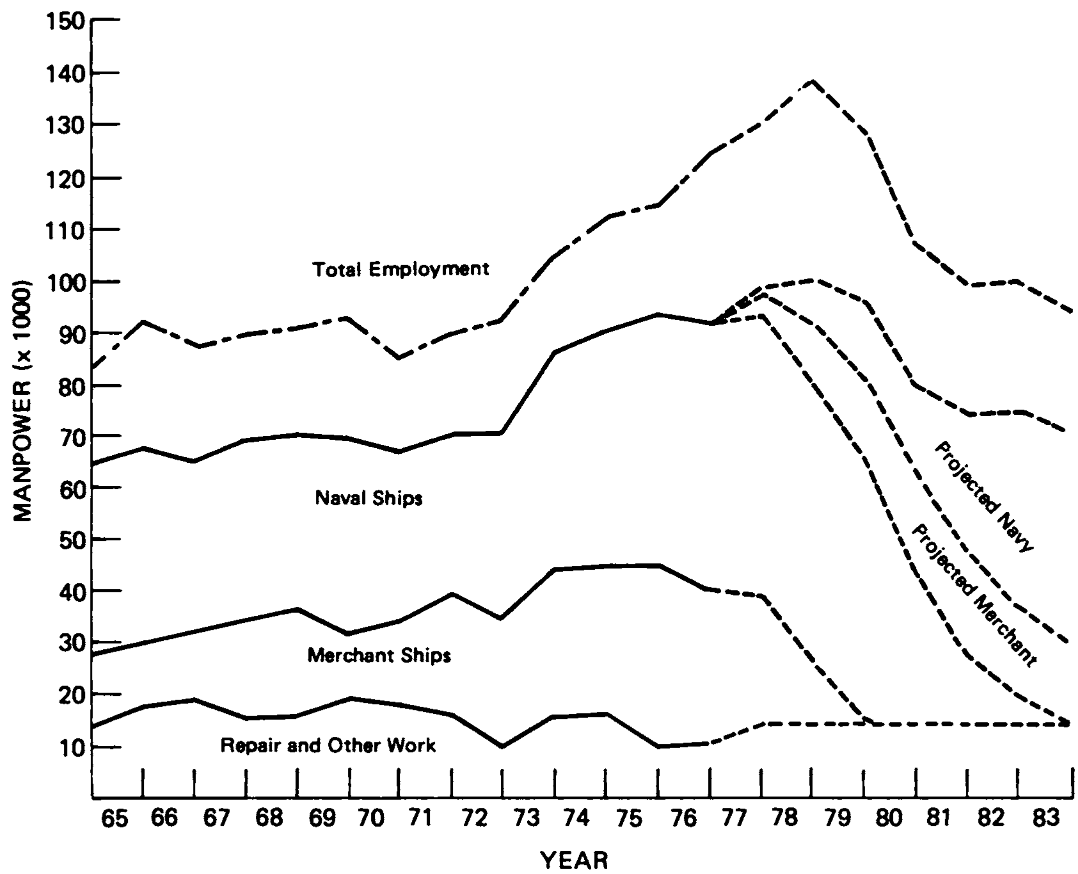


FIGURE 2-4 Shipyard workload, 1965-1976, and forecast, 1977-1983: 27 major U.S. private shipyards

Source: Shipbuilders Council of America, 1977.

Table 2-11

DIRECT AND INDIRECT REQUIREMENTS OF THE U.S. SHIPBUILDING INDUSTRY FROM 20 LEADING SUPPLYING INDUSTRIES, 1970

Supplying Industry	Shipyard Industry Requirements (Millions of Dollars)
1. Primary Iron and Steel Manufacturing	$422.7
2. Primary Nonferrous Metal Manufacturing	280.0
3. Heating, Plumbing, and Fabricated Metals	228.5
4. Wholesale and Retail	218.2
5. Engines and Turbines	180.9
6. General Industrial Machinery	168.5
7. Other Transportation	128.1
8. Business Services	124.2
9. Other Fabricated Metal Products	117.9
10. Real Estate and Rental	80.5
11. Electric, Gas, Water, and Sanitary Services	75.1
12. Metalworking Machinery and Equipment	64.8
13. Lumber and Wood Products	61.3
14. Finance and Insurance	57.1
15. Electrical Transmission Equipment	57.0
16. Motor Vehicles and Equipment	54.1
17. Business Travel	50.6
18. Maintenance and Repair Construction	44.9
19. Machine Shop Products	43.4
20. Stone and Clay Products	39.9

Source: Port Authority of New York and New Jersey, Economic Impact of the U.S. Merchant Marine and Shipbuilding Industries: An Input-Output Analysis (Washington: Maritime Administration, May 1977), p. 33.

In addition, the shipbuilding industry makes substantial positive dollar contributions to personal income, corporate income, and federal, state, and local taxes.

Heading the list of the 20 trading or supplying industries of the U.S. shipbuilding industry is the steel industry (Table 2-11).[13] It should be noted that the data in this table reflect 1970 prices. Shipbuilding normally accounts for 12 percent of the market for structural steel plate and shapes, and 2 percent of the total market of U.S. steel producers. The shipyard market represents only a small fraction of the total business volume of most supplier industries. Thus, shipyards generally do not benefit from economies of scale. In many cases, limited markets for ship components do not justify mass production by suppliers. In other cases, where shipyards require standard items that are mass-produced, the amounts purchased are insufficient to qualify for quantity discounts from the suppliers.

MANPOWER

Total employment in the private shipyards averaged 170,200 in 1978. Of these, over two thirds were employed in the 28 major shipyards listed in Table 2-1. Employment in Naval shipyards was 70,800 in December 1978. Some salient characteristics of the U.S. shipyard work force are detailed in Chapter 4.

NOTES

1 Maritime Administration, Office of Ship Construction, Division of Production, Report on Survey of U.S. Shipbuilding and Repair Facilities, 1978 (Washington: Dec. 1978), p. 3.

2 Ibid., pp. 103-113.

3 Cabotage is trade or transport in coastal waters or between two points within a country. Every major maritime nation has cabotage laws, reserving such carriage to vessels of its own flag.

4 Exceptions include naval vessels and craft for certain friendly nations, and offshore drilling platforms and rigs--sectors in which U.S. technology is superior.

5 Schoedel, Alan F., "The Troubled World of Shipbuilding", in Shipbuilding: The World Picture in 1978 (New York: Twin Coast Newspapers, Inc., 1978), p. 5.

6 Merchant Marine Act, 1920, Sec. 1 (46 U.S.C. 861); confirmed and reaffirmed by the Merchant Marine Act, 1928, Sec. 1 (46 U.S.C. 891). See also Merchant Marine Act, 1970, amending Merchant Marine Act, 1936 (46 U.S.C. 1101 et seq.).

7 Commission on American Shipbuilding, Report of the Commission on American Shipbuilding, Vol. I (Washington: U.S. Government Printing Office, Oct. 1973), pp. 10-11.

8 These are not unique to the United States, as virtually all maritime nations have similar indirect subsidies. See, e.g., (1) Temple, Barker & Sloan, Inc. and Chase Econometric Associates, Inc., The Maritime Aids of the Six Major Maritime Nations; prepared for Maritime Administration, Office of Policy and Plans (Washington: Maritime Administration, Sept. 1977); and (2) Maritime Administration, Office of International Activities, Maritime Subsidies, 1978 (Washington: U.S. Government Printing Office, Dec. 1978).

9 Shipbuilders Council of America, Annual Report, 1978 (Washington: Mar. 14, 1979), pp. 24-25, 29.

10 Maritime Administration, MarAd 78, Annual Report for Fiscal Year 1978 (Washington: U.S. Government Printing Office, May 1979), p. 33.

11 Department of Defense, Office of the Assistant Secretary of Defense (Installations and Logistics), Office of the Deputy Assistant Secretary of Defense (Procurement), Profit Study Group, Profit '76 Summary Report

(Washington: Dec. 1976). See also Office of Naval Research, The Profitability of the U.S. Shipbuilding Industry, 1947-1976, draft report (Washington: 16 May 1978).

12 Port Authority of New York and New Jersey, Economic Impact of the U.S. Merchant Marine and Shipbuilding Industries: An Input-Output Analysis (Washington: Maritime Administration, May 1977).

13 Ibid., p. 33.

Chapter 3

INDUSTRY ADJUSTMENT TO TRENDS IN SHIPBUILDING TECHNIQUES AND RELATED LABOR REQUIREMENTS

Traditional shipbuilding methods, both in the United States and abroad, have consisted of a series of sequential steps wherein the vessel was fabricated by manufacturing individual parts, largely under the control of the shipyard, and assembling them in a piece-by-piece system. The manufacturing system was--and still is, in many instances--characterized by a proliferation of labor-oriented processes requiring many varied skills. The typical shipyard complex tended to stretch along a waterfront area which, as industry grew up around it, became extremely restricted with little provision for expansion.

Over the last 50 years, shipbuilding has become less labor-intensive, the industry's objective being to minimize total cost by increasing use of automated equipment. This tendency has accelerated since the early 1960s, especially in Japan and Europe, where highly specialized, modern ship factories have evolved partly as a function of reduced labor availability and partly because of the economic incentives for simplifying and standardizing the shipbuilding process. Older techniques, however, are still used successfully in many yards.

CURRENT TRENDS IN SHIPYARD ORGANIZATION AND MANAGEMENT

Component Costs

Coupled with the physical problems stemming from lack of available acreage for shipyard expansion, the growing shortage of skilled labor in many of the trades required for ship fabrication has increased costs enormously. Gradually, many of the items previously manufactured by the shipyard have come to be purchased from outside suppliers. Paint, turbines, propellers, air ports, reduction gears, furniture--to name a few such items--had become high-cost drains upon the shipyard's financial resources. Gradually, "make or buy" decisions have come to include fairly large assemblies and components.

Modular Construction

Modern shipbuilding strategy centers on the efficient flow of material to construct large sections or assemblies of ships in panel lines, joining these to form modules or blocks, and then joining the modules to form the completed hull. Fabrication procedures are carefully determined to take maximum advantage of the ability to mass-produce simplified components and to pre-outfit as much as possible during the stage of construction when access is easiest. (Pre-outfitting, downhand welding, and other shipbuilding terms are defined in the Glossary, Appendix B.)

The system should provide for as much downhand welding as is feasible. Downhand welding is a more efficient construction process because it allows work under more controlled conditions. It reduces man-hours, makes the work less onerous, and enhances the quality of the finished product, while also reducing the skill and training requirements.

Pre-Outfitting

Outfitting has long been a time-consuming process and an extremely expensive portion of the overall construction cost. Concentrated in the last stages of the building process and usually done at a wet dock, the physical effort required to put each item on board the vessel, move it into place, install it in the proper location, and test it required unnecessarily large amounts of manpower, staging, and time. To reduce the large use of manpower and to save time, current procedure is to pre-outfit or modular-outfit new ships. This takes maximum advantage of the ready access to portions of the ship during early assembly stages for the relatively sturdy outfit, such as piping, and for the modular construction of fully outfitted units, such as superstructures. In these modules, piping, electric cable, machinery, electrical and electronic equipment, and furnishings all are installed before the assembly is placed on the ship.

Design and Construction Compatibility

Important in this trend is the need to design the vessel's structure so that the building process is simplified and lends itself to efficient and economical production techniques. Standardized plating thicknesses, maximum use of essentially identical bulkhead and deck panels, common bow and stern modules with alternate midbodies for different services, standardized deck houses, modular staterooms, standardized turbine rating in agreed-upon steps of horsepower, and other simplifications of design offer many opportunities for reduced cost.

The most apparent deterrent to the success of this strategy has been the reluctance of individual owners to forgo the luxury of a custom-built product to suit their individual needs and desires. Enlightened marketing efforts must be undertaken to inform prospective owners of the cost-benefit relationships of such vessels. Reduced cost will prove to be the most effective argument, as can be seen from the experience of various foreign shipyards during the last decade.

Specialization Versus Diversification

Some U.S. shipyards have become specialists in certain types of vessels, at least currently. Examples include General Dynamics' Quincy yard--liquefied natural gas (LNG) carriers; Avondale--LASH vessels and LNG carriers; and Bethlehem Steel's Beaumont yard--offshore drilling rigs.

Specialized facilities for construction of specific ships may be suitable for certain segments of the marine industry. Highly diversified capability establishes a base to shift quickly into varied markets as they evolve, but usually is accompanied by high fixed costs, which are a function of under-utilized specialized equipment, material flows and production systems that are unsuited to certain work, and retention of workers with high levels of specialized skills that are not in constant demand.

Potential for Cost Reduction

An illustration of the economic relationships that guide management in the quest to reduce costs or increase productivity is shown in Table 3-1 for a typical U.S.-built 250,000-dwt tanker.

Material costs, while constantly varying, do not allow much flexibility in cost reduction for a given ship contract. The efforts in cost reduction should center on the items shown in the box in Table 3-1; i.e., labor components of steel erection and hull outfit. The values shown reflect cost distribution for a large, simple tanker or bulk carrier and would be altered somewhat for more complicated vessels such as containerships, LNG carriers, or Navy, Coast Guard, National Oceanic and Atmospheric Administration (NOAA), or Corps of Engineers vessels. The outfit percentage for such vessels could be as high as 50 percent. The cost reduction incentives are still concentrated in labor of fabricating and erecting steel and installing outfit items, depending upon the type of ship.

Table 3-1

CONSTRUCTION COST BREAKDOWN, TYPICAL U.S.-BUILT TANKER, IN PERCENT [a/]

	Steel	Outfit	Hull Engineering	Machinery	Total
Materials	14	4	2	4	24
Labor	26	9	4	3	42
Overhead	18	6	3	3	29
Profit	3	1	- [b/]	- [b/]	5
Total	61	20	9	10	100

a/ Generalized data, based on U.S. costs for 250,000-dwt tanker. All figures are percentages of total construction cost, rounded. Overhead is computed as 71 percent of labor costs; profit, as 5 percent of all costs. Totals may not add, due to rounding.

b/ Less than 0.5 percent.

Japanese shipyards, while highly specialized, are the best example of this trend in labor reduction; similar developments are taking place throughout the world, including the United States. Much greater effort has been employed overseas to enhance production capability; however, many U.S. shipyards are actively seeking more economic production systems and will continue to do so in the foreseeable future.

The following discussions of construction techniques, equipment technology, and new materials highlight the current trends and anticipated techniques in the U.S. shipbuilding industry.

CONSTRUCTION TECHNIQUES

Trends

The search for increased productivity and lower costs starts with design for production, and greater attention to industrial engineering, resulting in the simplification of material flow, greater use of mechanization, greater use of three dimensional sub-assemblies, and more pre-outfitting for all assemblies. Most shipyards have shifted gradually from a diversified manufacturing system to fabrication and erection, or assembly, facilities. This trend will continue. Newport News Shipbuilding and Dry Dock Company years ago stopped manufacturing reduction gears, turbines, and boilers; Avondale Shipyards has sold its paint manufacturing company, and others probably will soon follow suit. The same trend is apparent among the Naval shipyards, which inactivated four of their seven foundries in 1971.

Unit Assemblies for Machinery

Slow- and medium-speed diesel power plants may be installed in U.S. ships in the near future as whole units. Rather than assemble a pump, condenser, compressor, and other components, yards now receive from the vendor a refrigeration unit with all components preassembled on one flat. For the gas turbine-powered Spruance-class destroyer (DD-963) and guided missile frigate (FFG) classes of ships, the Navy has decided not to train mechanics at each shipyard to overhaul the gas turbines. Rather, the Navy doctrine is to pull the unit, install a replacement, and ship the unit to be repaired to a single facility--a naval air rework facility that also overhauls aircraft gas turbines. This, however, has created problems in integrated ship propulsion plant testing, in which the shipyard lacks expertise in gas turbines. If a gas turbine malfunctions during testing, the shipyard must call on the manufacturer or the naval air rework facility for technical assistance.

Customers may request vendor assistance for new materials and techniques that are not normally shipyard responsibilities. Limits may be imposed on the extent of subcontracting by (a) the need to meet production schedules, which requires control over work scheduling and materials flow, and (b) the consideration that ultimate control should be vested in the shipyard.

Effect of Labor Shortages

The major impetus for subcontracting of fabrication and assembly comes not from the designers but from economic pressures (competition and the need to increase productivity)--i.e., from management, rather than technical, concepts. There are few examples of technology-driven subcontracting, such as early numerical control (NC) technology.

Opinions differ in the case of the adoption of AUTOKON by Scandinavian yards in the early 1960s. Some hold that the shortage of loftsmen was a major factor (and that the Japanese yards similarly resolved the same problem). Others believe that the driving force was increased productivity, resulting from (a) greater accuracy in plate and shape cutting, which reduced manpower requirements in fit-up and welding, and (b) simplicity and accuracy of repeatability for series production (i.e., for ships produced after the lead ship).

Computer Lofting

Smaller shipyards, such as McDermott Shipyards in Morgan City, Louisiana, also have instituted a program of providing NC equipment in the fabrication areas. Many yards, large and small, are lofting with computer-aided systems. Improved dimensional control, lack of qualified loftsmen, and costs are all factors.

Quarters Modules

Pre-outfitted deckhouses are common in many shipyards, with some of the builders of smaller vessels lifting entirely fitted-out house assemblies, even including linens and mattresses, onto the hulls of offshore supply boats. Prepackaged quarters, with living spaces constructed at locations remote from the shipyard, are delivered complete and ready for installation with only wiring and plumbing connections to be made. A recent conversion of a cruise vessel employed installation of prefabricated sections, at sea, by a handful of shipyard employees who stayed with the ship. Such systems can easily be used for new construction.

Modular wet spaces of fiberglass-reinforced plastic (FRP) permit relatively simple installation by less skillful workmen than are required for traditional construction, with reduced costs and easier control of work interferences by trades. (This last refers to physical interference, e.g., between those installing duct work and those installing wiring--a work scheduling problem.)

Work Platforms

Work package platforms, designed especially for hull construction, propeller handling, rudder installation and removal, and painting, are common in Japan and gaining acceptance in the United States.

Management Information Systems and Computer Graphics

More sophisticated management information systems (MIS) have been developed, partly because of the complexity of control needs for naval vessels. Planning, scheduling, material control, and follow-up (including cost analyses) are handled by computers, with computer technologists and technicians in increasing demand to establish and maintain the systems. Computer graphic design and analysis systems are steadily gaining acceptance. Computer graphics, NC, computer lofting, automation and semi-automation, and other modern systems have improved dimensional control and reduced tolerance problems. Because much more accurate fit is possible than heretofore, both the man-hours required for field adjustments (trimming and fitting assemblies together) and the amount of scrap are reduced.

Welding

Welding, introduced during World War II, has matured and grown steadily more sophisticated. Automatic and semi-automatic equipment has increased production speed, improved quality, reduced cost, and somewhat reduced the need for highly qualified hand welders. One-side welding systems, pioneered in Japan but now used more widely, have eased panel assembly handling problems and simplified the construction process. Automated vertical welding systems again increase quality and reduce cost.

Standardized Structure

Trends toward standardized structure and equipment are expected to continue and gain wider acceptance. Standard bow and stern sections, engine rooms, and even midbodies can markedly reduce costs by taking advantage of series production of components, building for stock, and interchangeability of assemblies. Although this has been resisted by almost all U.S. ship operators in the past, the economic incentives are high and future acceptance of the principle should be greater.

Technical and Professional Personnel Increases

In general, the trend will be toward a greater proportion of technical and professional personnel in the ship production labor force than in the past. Japan and other shipbuilding nations have successfully used this practice to increase efficiency and reduce overall costs. While productivity, as such, is difficult to measure between shipyards constructing different ships, it can be measured reasonably well at a given shipyard at different times if the product remains similar in nature.[1] Applying engineering and business talent to the production process should provide superior systems and lower overall costs. Gradual replacement of hand operations by semi-automated or automated equipment systems will require larger numbers of technicians to operate and maintain the production facilities.

EQUIPMENT TECHNOLOGY

Computers in the Construction Process

As previously mentioned, computer graphics and computer design analysis are a sound basis for enhanced production capability. Systems such as AUTOKON and STEERBEAR--to name just two--can perform such functions as fairing, shell plate expansion, piece parts programming, nesting, preparation of NC tapes for drawing and flame cutting, materials lists for steel, bending information for transverses and longitudinals, hydrostatic calculations, and preparing administrative information. The NC equipment for pipe bending, already operating successfully in Japan, will gain wider acceptance and dovetail neatly with greater use of pre-outfitting of assemblies and modules. Introduction of such systems will reduce and eventually eliminate dependence on traditional mold lofts and require computer operators and technicians oriented toward the production or manufacturing side of shipbuilding.

Previous computer uses have centered upon the accounting or design functions. Greater effort should be devoted to designs for production and cost reduction rather than to design as an abstract exercise (and the heavy emphasis upon resistance characteristics). As much as half of a ship's total operating costs result from initial investment, upon which design for production has a direct impact. The computer's ability to handle large amounts of information and perform many diverse calculations will allow more accurate assessment of relative values for particular designs.

Lasers and Plasma Cutting

Laser technology for alignment, for instance, will gradually replace traditional methods and again require a more technical approach to craft work. Laser welding simply adds a slightly different dimension to training of current welders.

Plasma cutting, presently able to operate to thicknesses of 20 mm (about 0.8 in.) and speeds of 1800 mm per min (5.9 fpm), will provide more efficient cutting speeds than can conventional cutting techniques. Compact, relatively light machines are available and in use, and can be operated by remote control or NC. One present limitation is the formation of noxious gases; however, development should reduce this limitation. Slightly modified training will be required as wider acceptance of these units develops.

Materials Handling

Materials handling system will be improved by use of air-lift, water-bearing, and other similar devices to move equipment and assemblies within the shipyard. No unique developments specific to shipyards are apparent, and no particular training or skill problems should develop from their use other than those associated with routine maintenance.

Machinery Modules

Slow-speed (less than 90 rpm) propellers and their associated tunnel sterns and slightly altered engine-room equipment should not impose unusual labor demands upon the shipbuilding operation. On the other hand, gas turbines provide a means of readily modularizing power plant systems and permitting the use of "plug-in" units, albeit large ones, that can be removed for repair and quickly replaced with standby units. Responsibility for construction and repair of these units may shift from the shipyard, traditionally the assembler of the unit if not also the manufacturer of the components, to an outside entity. This would tend to minimize the shipyard's need for such technologists, but really just shifts the need for training and employment to an allied industry.

Metric Conversion

The impending U.S. change to the International System of metric units (SI)[2] has already started in the marine industry. Those shipyards routinely repairing foreign-built ships are used to working with plans and physical arrangements in the metric system. Apart from acceptance of the need to convert and provision of metric tools over a period of time, the primary need is to train the entire shipyard staff (white and blue collar workers) to think in the metric system. Students in the Marine Engineering Technology program at Mississippi State University are required to work in the metric system and no difficulties have been encountered after a brief period of initial adjustment.

NEW MATERIALS

For many years, the traditional shipbuilding material has been primarily mild steel, with wood and aluminum used for small vessels and some portions of larger ships. Emphasis upon fire resistance has largely eliminated wood from seagoing vessels, however. New materials, and the attendant need for workers capable of handling them, can generate a need for training programs in certain specialized areas. Prestressed concrete, stainless steel, and aluminum are already in use or proposed for wider use in LNG carriers. Ferro-cement is in use for small vessels, as is fiberglass reinforced plastic (FRP). The latter two materials have reasonably wide acceptance in the small boat industry, with no need for elaborate training programs.

Prestressed Concrete

Prestressed concrete is being proposed for LNG vessels; has been used for floating drydocks, barges, offshore oil and gas production platforms, and liquefied petroleum gas (LPG) floating storage vessels; and will be used to a much greater extent in the future. Although it is not historically a widely accepted shipbuilding material (in spite of the uses of concrete in World Wars I and II), the technology for design and construction is understood and those fabricators using the material are expected to develop their own training programs, in house. Any widespread use of prestressed concrete for large LNG vessels of the type proposed by Dytam Marine, Inc., probably would require shipyard training of some proportion, but not on an industry-wide basis.

Coatings

Enhanced coatings have been accepted by the marine industry for years, and new materials will no doubt be forthcoming. No special training program appears needed, in view of past experience.

Limited Problems for Personnel

In general, the use of radically different materials is expected to be limited to a relatively small segment of the total shipbuilding industry. As the use of these materials grows, required training of skilled supervisory personnel should keep pace through the combined efforts of the shipyards and marine equipment suppliers.

GENERAL OBSERVATIONS

Some general observations concerning the personnel trends anticipated in the U.S. shipbuilding industry follow.

1. No drastic changes seem likely in shipyard personnel skill requirements over the next 15 years.

2. This does not imply the absence of change in manufacturing technology, which, loosely defined, embraces such areas as industrial engineering, work planning and flow scheduling, production management and control, quality control, and the ability to query a data bank for useful information. Developments in these areas may require changes in training program content.

3. Shortages and turnover of skilled workers are encouraging the industry to shift from the craft approach, requiring broad knowledge on the part of skilled craftsmen, to the manufacturing approach, using less-skilled labor and characterized by more capital-intensiveness.

4. Under the manufacturing approach, there is a requirement for more specialized technologists. For example, the transition from mild steel to special steels introduces a special quality-control function. A welding engineer must inspect (and perhaps reject) the steel, determine the proper welding procedures, and inspect the completed weld to ensure a bond with strength compatible with that of the metals being joined together--functions previously performed by the skilled welder himself. Similarly, advances in paints and surface preparations have led to a need for a paint chemist to test their properties and to determine the proper conditions and methods of application. Thus, both advancing technology and retirement of skilled workers have led to segmenting the broad

knowledge of the old-time skilled craftsmen. Specialization of trades is also shifting from crafts such as that of the blacksmith to newer fields such as electronics. More specialists are required in quality control, production planning, and other areas of manufacturing technology. This applies to both new construction and repair.

5. Repair and overhaul work continues to grow in sophistication, requiring increased reliance on vendor's personnel.

6. When introduction of a new technology requires the training of shipyard personnel, management often views the initial training as the responsibility of the equipment vendor or manufacturer. New skills are often provided by vendors until yards need these skills full-time.

NOTES

1 Commission on American Shipbuilding, Report of the Commission on American Shipbuilding (Washington: U.S. Government Printing Office, Oct. 1973), Vol. II, pp. ix-xi, 72-82, 100-101, 216-218, 227; and Bath Iron Works Corp., Improved Planning and Production Control, prepared for the Maritime Administration, National Shipbuilding Research Program (Bath, ME: Aug. 1977).

2 This refers to the International System of Units--or Système International d'Unités (hence, SI)--adopted in 1960 by the General Conference on Weights and Measures. See (1) Maritime Transportation Research Board, Maritime Metrication: A Recommended Metric Conversion Plan for the U.S. Maritime Industry (Washington: National Academy of Sciences, 1976); and (2) Maritime Administration, Office of Ship Construction, Maritime Metric Practice Guide (Washington: Dec. 1978).

Chapter 4

PERSONNEL TODAY

THE LABOR COMPONENT IN SHIPBUILDING

In an age of advancing technology, the shipbuilding industry remains an enigma, constructing vessels by the use of labor-intensive methods, using techniques justified as much by tradition as by production expedience. There has been an increasing trend toward mechanization techniques in all major yards. Nevertheless, direct labor costs in U.S. shipyards are between 40 and 50 percent of the finished product cost, depending upon type of ship, and are a major reason for the construction-differential subsidy necessary to make domestic yards even marginally competitive with foreign facilities.

In U.S. yards, the labor component cost of a vessel is nearly twice the cost of materials. This ratio has remained relatively constant since 1961, increases in labor efficiency being largely offset by rising wages.[1] (See Chapter 3 for brief discussion of construction costs.)

High as these figures are, they tend to underemphasize the total labor component in shipbuilding. For a ship, labor costs constitute 70 to 85 percent of the value added. Value added is the total expenditures for factors of production, excluding raw materials and including depreciation. The share of value added going to labor is represented by the ratio of wages and salaries paid to employees to the total expenditures for all factors of production. The larger this ratio, the more labor-intensive an industry is--i.e., the higher is the proportion of final product costs that labor represents. In the 15-year period from 1958 to 1972, the share of added value received by labor in U.S. shipbuilding averaged 77 percent, never falling below 71 percent and rising as high as 84 percent.[2] Parenthetically, it should be observed that the labor component of shipbuilding is approximately equal, on a percentage basis, to that in the construction of a fine violin.[3] The labor-intensiveness of the industry is underscored by noting that, among 22 industries, U.S. shipbuilding ranks fifteenth in assets per employee and third in sales per invested dollar.[4]

LABOR UTILIZATION IN SHIPYARDS

A ship is assembled piecemeal of parts fabricated in or under the direct control of the shipyard, by a work force largely consisting of skilled craftsmen. For the most part, ships built in U.S. yards are individually designed, custom items. Even in series production, there is a tendency for successive ships in the series to incorporate design and production changes, and these must be accommodated by the labor force. This "job shop" approach requires workers with sufficient skill to be able to perform the specialized tasks required in each variation of ship design. Each of the tasks, considered individually, is relatively simple. It is the number and variety of the operations performed that require shipyard personnel to be highly skilled and to undergo lengthy training apprenticeships. And skilled they are: The two similar custom, large-scale fabrication industries, construction and shipbuilding, have a worker skills distribution that is entirely different from that of other manufacturing industries in the United States. In particular, both shipbuilding and construction employ a far higher percentage of craftsmen than of operatives or laborers, and slightly smaller percentages of managers, administrators, and technical professionals.

Since the start of World War II, the shipyard work force has been changing slowly from a craft orientation toward one more heavily loaded with operatives and lesser skilled workers. For years, the major shipbuilders have been reducing the amount of fabrication done in their yards and have been shifting from assembly to pre-assembly. During World War II, the impetus was efficiency. More recently, the advent of supporting industries has made it impractical for many shipyards to maintain the required facilities and skills for specialized fabrication. Other industries with more stable work loads proved more attractive to both the skilled workers and the young men willing to enter apprenticeship programs and become the craftsmen of the future. Costs of component fabrication increased to the point where it became economical for shipyards to purchase many of the items previously manufactured in the yards.

A number of foreign yards, faced with similar problems, opted to reduce dependence upon skilled labor by specialization and by acquisition of special-purpose capital equipment whose use could result in significant labor savings in series production of ships. In addition, several of these countries made shipbuilding an element of economic priority and helped finance such capital expenditures and stabilize shipyard work loads. Because U.S. shipyard orders fluctuate greatly, most domestic yards have tried to minimize fixed costs by staying labor-intensive, adjusting the size of the work force to meet production schedules.

Capital investment in Japanese shipbuilding, for example, is approximately twice that in the United States per ton of output. Significantly, labor costs per ton of output in Japan are approximately half those in U.S. yards. Whereas in Japanese yards, and to some extent in Swedish and West German yards, special-purpose equipment is designed to substitute for labor, in most U.S. yards, capital equipment usually takes the form of equipment that extends fabrication capability to subassemblies of greater size without substantially reducing the labor component of construction.[4] Parenthetically, it should be noted that the Japanese approach of utilizing capital-intensive specialized equipment is particularly susceptible to a protracted downturn in the market, since capital costs must be borne even when business is lacking.

DIVERSIFICATION OF SHIPYARD ACTIVITIES

The flexibility inherent in the labor-intensive approach of the U.S. shipbuilding industry has helped some U.S. yards to expand their operations into non-ship areas in the face of reduced ship demand. This diversification serves the dual purpose of increasing profit opportunities and stabilizing the work force against fluctuations in shipbuilding demand. As examples: Avondale Shipyards constructs offshore drilling rigs; Bethlehem Steel operates both a shipyard and an adjacent steel plant at Sparrows Point, Maryland, where steel products such as bridge and tunnel parts and storage tanks, as well as ships, are constructed; and Sun Shipbuilding and Dry Dock Company has moved into heavy metal construction, refinery equipment, and steel plate work.

TOTAL SHIPYARD EMPLOYMENT

Total shipyard employment in the United States at the end of 1978 was about 239,000. Over 70 percent of these workers (168,600) were employed in private yards; and, of these, over two thirds were employed in the 28 major yards listed in Table 2-1. Approximately 70,800 were employed in Naval shipyards.[5] Table 4-1 gives the distribution of private shipyard employees by geographic area for the last 7 years. Table 4-2 gives the employment in Naval shipyards for a similar period.

About half of all private shipyard employees (50.5 percent) are located on the Atlantic coast, with about 30 percent on the Gulf coast, and the remaining 20 percent on the West coast, Great Lakes, and inland.

A recent Navy study vividly portrays another important characteristic of shipyard employment, its cyclical nature.[6]

Table 4-1

U.S. PRIVATE SHIPYARD EMPLOYMENT, ALL EMPLOYEES, ANNUAL AVERAGE, TOTAL AND BY REGION, 1972-1978 a/

Year	Annual Average Employment (Thousands)					
	Total	North Atlantic	South Atlantic	Gulf	Pacific	Great Lakes and Inland
1972	146.3	41.7	29.1	51.0	17.3	7.2
1973	148.9	40.2	30.3	53.0	17.1	8.2
1974	160.8	42.9	28.6	57.9	23.2	8.2
1975	154.1	47.3	27.3	47.7	23.4	8.4
1976	168.3	53.7	28.7	52.3	24.5	9.1
1977	174.3	58.7	29.7	54.1	22.8	9.1
1978	170.2 b/	57.0	29.0	50.6	24.1	9.6

a/ During 1978, the Bureau of Labor Statistics (BLS) changed the benchmark used in compiling data on private shipyard employment, and revised its previously published data for 1972-1977 accordingly. Comparable BLS data for years prior to 1972 are not yet available.

b/ Total employment in private shipyards, according to the BLS, stood at 168,600 in December 1978.

Source: Bureau of Labor Statistics; published in Shipbuilders Council of America, Statistical Quarterly, 4th Quarter, 1978, p. 1.

Table 4-2

U.S. NAVAL SHIPYARD EMPLOYMENT, ALL EMPLOYEES, ANNUAL AVERAGE, TOTAL AND BY REGION, 1969-1978

Year	Annual Average Employment (Thousands)			
	Total	Portsmouth, Boston,[a] Philadelphia	Norfolk, Charleston	Puget Sound, Hunter's Point,[a] Mare Island, Long Beach, Pearl Harbor
1969	91.0	27.6	20.6	42.8
1970	83.0	24.4	19.1	39.5
1971	75.5	20.8	18.5	36.2
1972	70.1	18.7	17.7	33.7
1973	64.5	16.1	17.3	31.1
1974	64.4	13.7	18.5	32.2
1975	64.6	13.4	18.6	32.6
1976	65.4	13.7	18.9	32.8
1977	67.6	14.3	19.7	33.7
1978	70.6 b/	15.7	21.0	33.8

a/ Boston yard closed on July 1, 1974; Hunter's Point yard, on June 29, 1974.

b/ Total employment in Naval shipyards, according to the Bureau of Labor Statistics, stood at 70,800 in December 1978.

Source: Shipbuilders Council of America, Statistical Quarterly, 4th Quarter, 1978, p. 2.

Figure 4-1 shows the variation in employment within and among the 11 largest U.S. private shipyards during the period from 1960 to 1977.

Employment in shipyards is clearly influenced by the level of subsidy payments and by the amount of direct government work. For most of the years since World War II, Navy contracts have utilized substantially more than 50 percent of the shipyard production workers. Table 4-3 gives the dollar value of ships under construction or newly contracted, divided into commercial and Naval categories. Table 4-4 gives the dollar value of repairs and conversions by category. Bearing in mind that labor represents about half of new construction cost, and an even greater percentage of repair or conversion cost, it can be seen that the greatest determinant of shipyard employment is government work.

MALE-FEMALE EMPLOYMENT

Shipyard workers are predominantly male (96 percent) and white (85 percent). Considering only production workers--about 75 percent of the total employed--the percentage of minorities is 30 percent and of women, 2 percent.[7]

MINORITY EMPLOYMENT

The percentage of blacks employed is highest in the South Atlantic and Gulf regions (about 30 percent) and lowest in the New England region (about 4 percent). The low employment of blacks in the New England region is due primarily to their low representation in the labor pool in this area.[8] The percentage of blacks and other minorities is somewhat higher in Naval yards as a result of strong government efforts to equalize employment opportunities for these groups.

In each region, the percentage of blacks employed in shipbuilding is larger than in the construction industry for that region, often by a considerable margin. Blacks comprise more than one fourth of the shipbuilding work force in the Mid Atlantic region but only about 10 percent of the construction work force. In the South Atlantic and Gulf Coast region, the disparity between shipbuilding and construction is smaller, 24 percent versus 22 percent, with shipbuilding still holding the edge as a minority employer.

Table 4-3

U.S. PRIVATE SHIPYARD ORDER BOOK, AS OF JANUARY 1, 1968-1979

Year	Value of Unfinished Shipbuilding Work a/ (Millions of Dollars)			Percentage of Naval Work
	Commercial Ships	Naval Ships	Total	
1968	$ 788	$ 1,649	$ 2,437	68
1969	800	1,700	2,500	68
1970	765	1,719	2,484	69
1971	765	1,925	2,690	72
1972	1,058	2,255	3,319	68
1973	2,950	3,160	6,110	52
1974	3,770	3,603	7,373	49
1975	4,350	5,424	9,774	55
1976	3,400	6,500	9,900	66
1977	3,000	6,802	9,802	69
1978	2,120	7,508	9,628	78
1979	2,120 b/	10,016 b/	12,136 b/	83

a/ Includes ships under construction at start of year or contracted for during previous years. Excludes work performed in Naval and Coast Guard yards.

b/ Preliminary data.

Source: Shipbuilders Council of America, Annual Report, 1978 (Washington: Mar. 14, 1979), p. 30. Percentages derived.

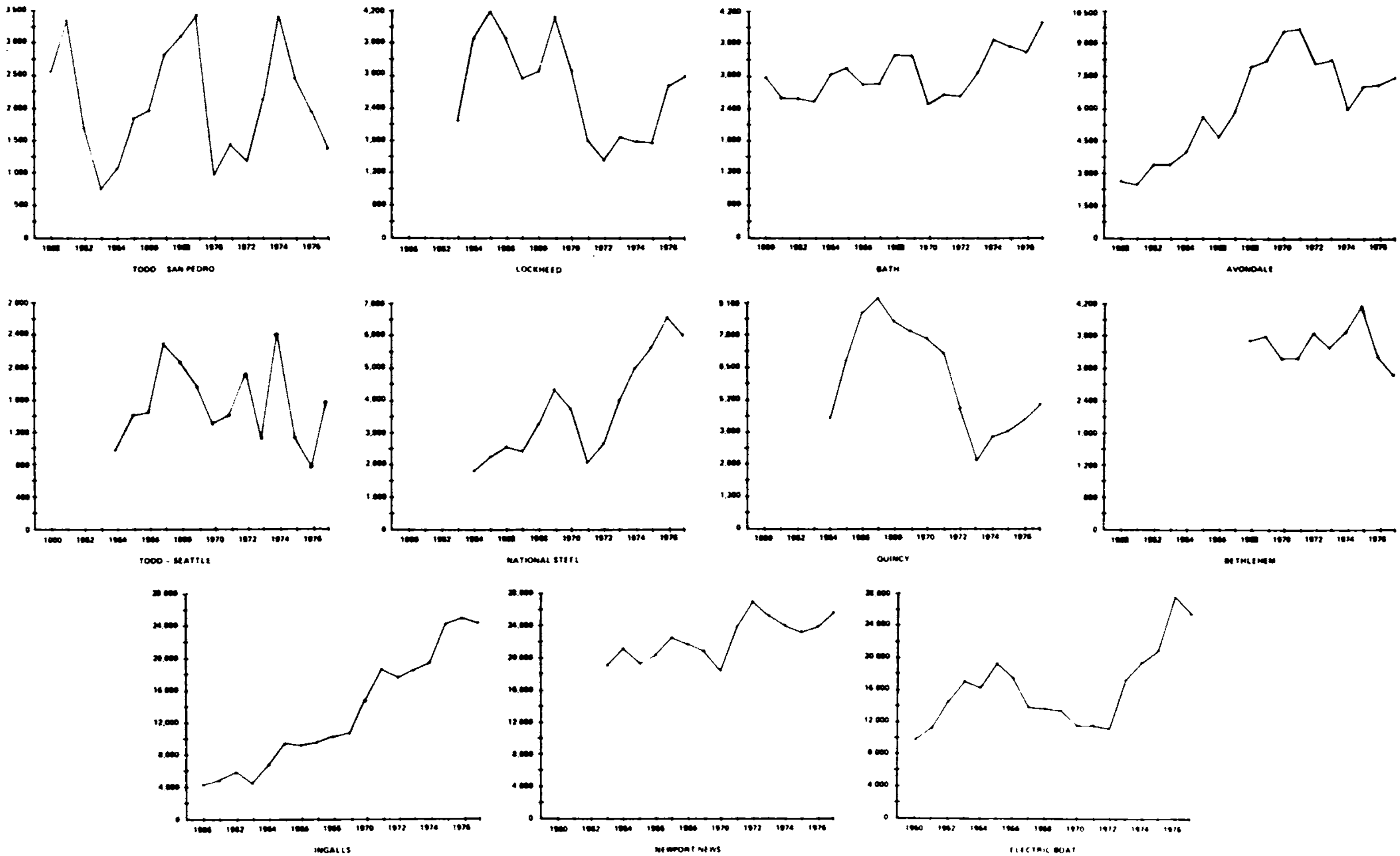


FIGURE 4-1 **EMPLOYMENT HISTORY AT THE ELEVEN MAJOR SHIPYARDS: 1960 - 1977**

Source: Department of the Navy, Office of the Assistant Secretary of the Navy (Manpower, Reserve Affairs, and Logistics), Naval Ship Procurement Process Study: Final Report (Washington: July 1978), Exhibit XIII, p. 21.

Table 4-4

VALUE OF REPAIR AND CONVERSION WORK PERFORMED BY U.S. PRIVATE SHIPYARDS, 1968-1978

Year	Value of Repair and Conversion Work a/ (Millions of Dollars)			Percentage of Naval Work
	Commercial Ships b/	Naval Ships	Total	
1968	$ 458	$ 363	$ 821	44
1969	532	384	916	42
1970	431	359	790	45
1971	450	325	775	42
1972	484	387	871	44
1973	523	393	916	43
1974	713	533	1,246	43
1975	688	554	1,242	45
1976	715	644	1,359	47
1977	771 c/	770 c/	1,541 c/	50
1978	847 c/	870 c/	1,717 c/	51

a/ Private yards only; excludes work performed in Naval and Coast Guard yards.

b/ Includes work on Military Sealift Command ships.

c/ Estimated.

Source: Shipbuilders Council of America, Annual Report, 1978 (Washington: Mar. 14, 1979), p. 31.

Table 4-5

PERCENTAGE DISTRIBUTION BY AGE OF EMPLOYED MALES IN SELECTED INDUSTRIES, 1970

Industry	16-24	25-34	35-44	44-54	55 and over	Total
Construction	13.2	22.8	23.7	22.1	18.1	100.0
Manufacturing	15.1	24.3	22.3	21.9	16.4	100.0
Durable Goods	14.3	24.7	22.7	22.5	15.9	100.0
Motor Vehicles	13.4	26.9	23.6	22.5	13.3	100.0
Aircraft	9.2	25.0	26.4	26.7	12.7	100.0
Shipbuilding and Boatbuilding [a/]	13.9	22.7	19.7	25.6	18.1	100.0
Private Wage and Salary Workers	15.9	25.7	20.1	21.3	17.0	100.0
Government Workers	9.5	16.2	18.9	36.5	18.9	100.0
Railroad Equipment	14.6	22.9	18.8	25.8	18.8	100.0

a/ Includes repairing.

Source: Bureau of the Census, U.S. Census of Population: 1970, Industry Characteristics, PC(2)-7B, (Washington: U.S. Government Printing Office, 1973), Table 34.

AGE DISTRIBUTION

The overall age distribution of shipyard workers is bimodal, with peaks in the 18- to 34-year range and in the 45-and-over range. This apparent bimodal age distribution results from the fact that there are two discrete populations of shipyard workers. In private yards, younger workers predominate, with 51 percent under the age of 40, and half of those (25.7 percent of the total) in the 25-to-34 age group. In government yards, 65 percent of the workers are over 40, with the majority of these (36.4 percent of the total) in the 45- to 54-year group. Table 4-5 gives the overall age distribution for private and government yards and provides a comparison with other industries.

The anomalous age distribution of workers in government yards is a consequence of World War II. A high percentage of the workers who entered the yards then remained as Civil Service employees. This group of workers is marching in lock-step toward retirement in the next decade, and, because of a declining work load, a sufficient number of their replacements are not yet in the employment pipeline.

EDUCATIONAL LEVEL

Shipyard worker educational level shows a disparity between private and government yards, further reinforcing the concept of two worker populations. The majority of workers in government yards have completed high school (60.5 percent) while less than half of the workers in private yards have done so (48.6 percent). Table 4-6 compares the educational accomplishments of shipyard workers with those of workers in related industries. The government shipyard workers rank near the top, exceeded only by aircraft industry workers. Private shipyard workers, on the other hand, rank near the bottom of the list, exceeding in educational level only construction workers. One conclusion that can be reached from this table is that educational level does not constitute a bar to entry-level employment in private shipyards.

INCOME LEVEL

At the end of 1976, average yearly straight-time earnings of approximately $13,000[9] plus some overtime or additional family income placed the shipyard worker on the lower fringes of the middle class. Over the years, shipyard workers have worked a shorter week, on the average, and have taken home higher incomes than the workers in all durable goods industries.

Table 4-6

EDUCATIONAL ATTAINMENT OF EMPLOYED MALES IN SELECTED INDUSTRIES, 1970

Industry	Percentage of Employed Males [a] Completing Years or More of: High School	College
Construction	43.8	3.9
Manufacturing	55.8	9.9
Durable Goods	56.5	9.6
Motor Vehicles	54.1	5.7
Aircraft	73.0	18.5
Shipbuilding and Repairing [b]	52.3	5.7
Private Wage and Salary Workers	48.6	5.7
Government Workers	60.5	5.9
Railroad Equipment	54.5	5.7

a/ Age 16 and over.

b/ Includes boatbuilding and repairing.

Source: Bureau of the Census, Census of Population: 1970, Industrial Characteristics, PC(2)-7B (Washington: U.S. Government Printing Office, 1973), Table 3.

PAY AND BENEFITS

Average hourly earnings of production workers in the private shipbuilding and repair industry were $5.66 at the end of 1976. Regionally, workers in Atlantic coast shipyards averaged $5.55 per hour, Gulf coast workers averaged $5.26, Great Lakes workers averaged $5.56, and Pacific coast workers averaged $6.83. Almost all workers were paid on an hourly basis, and over 90 percent were covered by union contracts.[9] Table 4-7 gives worker earnings. (In December 1978, average hourly earnings stood at $7.36; corresponding regional figures were not available.)

Virtually all shipyard workers were covered by benefits packages that included paid holidays and vacations and at least partial payment for the costs of medical, hospitalization, and surgical insurance; 90 percent of the workers were covered by retirement pension plans.[9] Tables 4-8 and 4-9 give the selected supplementary wage benefits.

OCCUPATIONAL DISTRIBUTION

The labor-intensiveness of shipbuilding is again demonstrated in Table 4-10. Nearly 85 percent of all employees fall within the blue-collar categories of laborer, operative, craftsman, and kindred workers. Only motor vehicle manufacturing and construction employ a higher percentage of blue-collar workers than shipbuilding and ship repair. The distribution of occupational classes differs slightly between private and government yards, primarily as a function of the greater electrical and mechanical complexity of Naval vessels. The percentage of machinists, electricians, and other skilled craftsmen is somewhat greater in government yards and the percentage of operatives is somewhat less.

Shipbuilding and repair is basically a craft-oriented industry, with a significantly higher percentage of craftsmen and kindred workers than operatives. In this respect it is similar to construction but quite unlike other types of manufacturing. There is a strong emphasis, both in tradition and in practice, on the skills of the individual craftsman. Table 4-11 summarizes the broad distribution of job categories in selected industries and illustrates the high percentage of craftsmen in construction and shipbuilding compared with other U.S. manufacturing industries. Other similarities between U.S. shipbuilding and construction are apparent. Both are mature industries whose basic methods of operation were formalized before the advent of modern production technology. Both build labor-intensive, high-cost products, largely on a non-series

Table 4-7

NUMBER OF WORKERS AND AVERAGE STRAIGHT-TIME HOURLY EARNINGS IN SELECTED OCCUPATIONS IN SHIPYARDS, UNITED STATES AND SELECTED PORTS, 1976

Occupation	United States[1]		Atlantic Coast		Gulf Coast		Great Lakes		Pacific Coast	
	Workers	Average hourly earnings[2]	Workers	Average hourly earnings[2]	Workers	Average hourly earnings[2]	Workers	Average hourly earnings[2]	Workers	Average hourly earnings[2]
PRODUCTION										
BOILERMAKERS	779	$6.46	247	$6.21	-	-	-	-	342	$7.19
ELECTRONICS TECHNICIANS										
CLASS A	148	6.27	47	6.03	-	-	-	-	22	7.73
GRINDERS-CHIPPERS	1,537	5.90	980	5.8[illegible]	-	-	-	-	223	6.51
INSPECTORS										
CLASS A	90	6.26	-	-	25	$6.80	-	-	-	-
CLASS B	876	6.08	499	6.12	-	-	-	-	-	-
CLASS C	303	5.42	-	-	-	-	-	-	-	-
LOFT WORKERS	264	6.58	79	6.15	59	6.14	15	$5.91	86	7.56
MACHINE-TOOL OPERATORS, PRODUCTION										
CLASS A	922	6.06	-	-	-	-	-	-	-	-
CLASS B	324	5.18	142	5.11	-	-	-	-	-	-
MACHINISTS, PRODUCTION	1,160	6.10	692	5.91	217	6.15	23	6.28	143	6.82
MARINE ELECTRICIANS	4,161	5.99	1,844	5.77	-	-	89	6.13	679	7.17
MARINE MACHINISTS	3,310	6.05	1,781	5.78	702	5.65	40	6.35	742	7.04
MARINE PIPEFITTERS	4,953	6.13	2,211	5.75	1,024	5.82	82	6.14	1,552	6.88
MARINE RIGGERS	2,999	6.20	1,641	5.82	418	5.72	-	-	819	7.19
PAINTERS	3,377	5.96	1,575	5.76	900	5.50	75	5.52	765	7.00
POWER-SHEAR OPERATORS	51	6.11	23	6.23	-	-	-	-	-	-
SHEET-METAL WORKERS	2,514	6.04	-	-	528	5.71	20	5.97	517	7.05
SHIPFITTERS	8,514	6.09	2,851	5.90	2,563	6.10	-	-	1,803	6.88
SHIPWRIGHTS	1,961	6.11	864	5.69	514	5.74	-	-	468	7.27
WELDERS, HAND										
CLASS A	8,198	6.17	3,628	6.12	3,130	6.13	-	-	343	7.57
CLASS B	5,683	5.72	1,028	5.44	1,393	5.25	166	4.93	2,289	6.55
WELDERS, MACHINE (ARC OR GAS)	2,623	6.39	782	6.10	1,019	5.79	-	-	822	7.41
WELDERS, MACHINE (RESISTANCE)										
CLASS A	218	6.45	-	-	-	-	-	-	-	-
MAINTENANCE										
CARPENTERS, MAINTENANCE	262	5.65	78	5.93	-	-	-	-	-	-
ELECTRICIANS, MAINTENANCE	583	5.81	395	5.87	-	-	-	-	-	-
HELPERS, MAINTENANCE TRADES	166	4.90	113	5.30	-	-	-	-	-	-
MACHINE-TOOL OPERATORS (TOOLROOM)	146	5.87	-	-	-	-	-	-	-	-
MACHINISTS, MAINTENANCE	297	6.17	139	5.92	70	5.66	-	-	84	7.02
MECHANICS, MAINTENANCE	406	5.86	273	5.94	-	-	-	-	-	-
PIPEFITTERS, MAINTENANCE	238	5.78	184	5.84	-	-	-	-	-	-
TOOL AND DIE MAKERS	29	6.18	-	-	-	-	-	-	-	-
MATERIAL MOVEMENT AND SERVICE										
CRANE OPERATORS	1,712	6.16	760	6.04	517	5.92	52	5.99	248	7.49
ELECTRIC BRIDGE (TRAVELING)	539	6.00	307	5.93	-	-	-	-	74	7.58
GANTRY CRANE	403	6.15	193	6.01	124	5.83	-	-	64	7.24
MOBILE (TRUCK) CRANE	236	6.12	43	6.22	149	5.95	-	-	31	7.36
OTHER (INCLUDING COMBINATION OF TYPES)	534	6.42	237	6.18	-	-	52	5.99	79	7.65
GUARDS	731	$4.34	380	$4.84	258	$4.11	-	-	-	-
JANITORS, PORTERS, OR CLEANERS	689	4.96	475	5.13	116	4.37	-	-	41	$5.10
LABORERS, MATERIAL HANDLING	758	5.16	444	5.22	164	3.37	-	-	-	-
POWER TRUCK OPERATORS	467	5.60	170	5.43	-	-	-	-	207	6.62
FORKLIFT OPERATORS	436	5.80	-	-	-	-	-	-	206	6.62
POWER-TRUCK OPERATORS (OTHER THAN FORKLIFT)	31	5.86	30	5.81	-	-	-	-	-	-
TRUCKDRIVERS	462	5.59	165	5.66	207	4.99	-	-	63	7.34

[1] Includes data for ports in addition to those shown separately.

[2] Excludes premium pay for overtime and for work on weekends, holidays, and late shifts.

NOTE: Dashes indicate no data reported or data do not meet publication criteria.

Source: Bureau of Labor Statistics, Industry Wage Survey: Shipbuilding and Repairing, September 1976, Bulletin 1968 (Washington: U.S. Government Printing Office, Sept. 1977), Table 2, "Occupational Averages," p. 5.

Table 4-8

PERCENT OF PRODUCTION AND RELATED WORKERS IN SHIPYARDS HAVING FORMAL PROVISIONS FOR SELECTED SUPPLEMENTARY WAGE BENEFITS, UNITED STATES AND SELECTED PORTS, 1976

Benefit	United States 1/	Atlantic Coast	Gulf Coast	Great Lakes	Pacific Coast
All production workers	100	100	100	100	100
Paid holidays 2/					
Workers in establishments providing paid holidays	99	100	97	100	100
5 days	3	-	10	-	-
6 days	2	2	2	-	-
7 days	6	-	14	-	7
8 days	10	-	-	-	52
9 days	3	-	2	74	-
10 days	35	26	59	26	11
11 days	41	60	10	-	30
12 days	1	2	-	-	-
Paid vacations 3/					
Workers in establishments providing paid vacations	100	100	100	100	100
After 1 year of service:					
1 week	76	85	86	100	30
Over 1 and under 2 weeks	23	15	12	-	70
2 weeks	1	-	-	-	(4)
After 2 years of service:					
1 week	60	83	84	100	-
Over 1 and under 2 weeks	23	17	13	-	70
2 weeks	8	1	3	-	30
Over 2 weeks	(4)	-	-	-	-
After 3 years of service:					
1 week	31	5	84	50	-
Over 1 and under 2 weeks	17	28	12	-	-
2 weeks	46	52	4	41	100
Over 2 weeks	7	14	-	-	-
After 5 years of service:					
2 weeks	52	35	84	100	30
Over 2 and under 3 weeks	30	20	13	-	70
3 weeks	16	35	-	-	-
Over 3 weeks	2	2	3	-	-
After 10 years of service:					
2 weeks	8	4	17	47	-
Over 2 and under 3 weeks	37	21	61	-	51
3 weeks	20	26	19	53	41
Over 3 and under 4 weeks	10	15	-	-	8
4 weeks	17	35	3	-	-
After 15 years of service:					
2 weeks	3	4	5	-	-
Over 2 and under 3 weeks	(4)	-	1	-	-
3 weeks	36	40	31	47	30
Over 3 and under 4 weeks	39	10	50	53	70
4 weeks	22	39	13	-	(4)
Paid vacations[3]—Continued					
After 20 years of service:					
2 weeks	3	4	5	-	-
Over 2 and under 3 weeks	(4)	-	1	-	-
3 weeks	20	18	31	-	30
Over 3 and under 4 weeks	20	1	50	-	70
4 weeks	29	46	13	100	(4)
Over 4 and under 5 weeks	3	4	-	-	-
5 weeks	16	35	-	-	-
After 25 years of service:					
2 weeks	3	4	5	-	-
Over 2 and under 3 weeks	(4)	-	1	-	-
3 weeks	17	18	21	-	30
Over 3 and under 4 weeks	27	-	50	-	70
4 weeks	22	35	12	47	(4)
Over 4 and under 5 weeks	9	12	18	-	-
5 weeks	18	36	-	53	-
Over 5 weeks	3	3	-	-	-
After 30 years of service:					
2 weeks	3	4	5	-	-
Over 2 and under 3 weeks	(4)	-	1	-	-
3 weeks	17	10	21	-	30
Over 3 and under 4 weeks	27	-	50	-	70
4 weeks	17	20	12	47	(4)
Over 4 and under 5 weeks	1	1	-	-	-
5 weeks	30	56	18	53	-
Over 5 weeks	5	4	-	-	-
Health, insurance, and retirement plans 5/					
Life insurance	94	100	85	100	93
Noncontributory plans	77	74	78	72	93
Accidental death and dismemberment insurance	65	47	79	30	93
Noncontributory plans	52	27	64	30	93
Sickness and accident insurance or sick leave or both 6/	69	62	86	100	84
Sickness and accident insurance	60	62	85	100	84
Noncontributory plans	37	36	22	72	84
Sick leave (full pay, no waiting period)	9	30	-	-	(4)
Sick leave (partial pay or waiting period)	2	4	1	-	-
Long term disability	7	13	2	-	-
Noncontributory plans	7	13	2	-	-
Hospitalization insurance	99	100	96	100	100
Noncontributory plans	64	73	38	26	100
Surgical insurance	95	100	96	100	100
Noncontributory plans	64	73	30	26	100
Medical insurance	99	100	96	100	100
Noncontributory plans	64	73	30	26	100
Major medical insurance	96	100	95	100	100
Noncontributory plans	64	73	29	26	100
Retirement plans 7/	95	99	86	100	100
Pensions	95	99	86	100	100
Noncontributory plans	76	98	26	100	100
Severance pay	1	-	-	-	-

[1] Includes data for ports in addition to those shown separately.
[2] Limited to full-day holidays provided annually. Additional half-day holidays were provided by some establishments.
[3] Vacation payments, such as percent of annual earnings, were converted to an equivalent time basis. Periods of service were chosen arbitrarily and do not necessarily reflect individual establishment provisions for progression. For example, changes in proportions at 10 years may include changes between 5 and 10 years.
[4] Less than 0.5 percent.
[5] Includes only those plans for which the employer pays at least part of the cost and excludes legally required plans such as workers' compensation and social security; however, plans required by State temporary disability insurance laws are included if the employer contributes more than is legally required or employees receive benefits exceeding the legal requirements.
[6] Unduplicated total of workers receiving sick leave or sickness and accident insurance shown separately.
[7] Unduplicated total of workers covered by pension and retirement severance pay plans shown separately.

NOTE: Because of rounding, sums of individual items may not equal totals.

Source: Bureau of Labor Statistics, Employee Earnings and Supplementary Benefits: Shipbuilding and Repairing, September 1976, Summary 77-5 (Washington: U.S. Government Printing Office, Mar. 1977), Table 4, p. 6.

Table 4-9

COMPARISON OF EMPLOYEE BENEFITS FOR 152 COMPANIES, 1955-1975

ITEM	1955	1957	1959	1961	1963	1965	1967	1969	1971	1973	1975
All industries (152 companies)											
1. As percent of payroll, total	22.7	24.8	25.5	26.9	27.8	28.0	30.2	31.9	34.4	36.5	40.3
a. Legally required payments (employer's share only)	2.8	3.1	3.5	4.0	4.6	4.2	4.9	5.3	5.6	6.6	7.1
b. Pension and other agreed-upon payments (employer's share only)	8.2	8.8	9.4	9.4	9.5	9.9	10.4	11.1	12.4	13.1	14.7
c. Paid rest periods, lunch periods, etc.	2.2	2.3	2.1	2.5	2.5	2.6	3.1	3.3	3.5	3.5	4.1
d. Payments for time not worked	7.6	8.5	8.7	9.2	9.3	9.4	9.8	10.2	10.8	11.1	11.9
e. Profit-sharing payments, bonuses, etc.	1.9	2.1	1.8	1.8	1.9	1.9	2.0	2.0	2.1	2.2	2.5
2. As cents per payroll hour	46.7	55.5	63.1	71.8	79.6	86.6	102.0	119.1	145.9	178.2	230.9
3. As dollars per year per employee	970	1142	1299	1476	1646	1793	2114	2460	2990	3677	4731
All manufacturing (65 companies)											
1. As percent of payroll, total	21.0	23.7	24.4	25.9	26.6	27.3	30.0	32.0	35.8	38.6	42.9
a. Legally required payments (employer's share only)	3.1	3.4	4.0	4.5	5.1	4.6	5.4	5.9	6.5	7.5	8.2
b. Pension and other agreed-upon payments (employer's share only)	6.8	8.0	8.6	8.5	8.4	9.0	10.0	10.8	12.8	14.0	16.1
c. Paid rest periods, lunch periods, etc.	3.0	3.0	2.7	3.3	3.4	3.6	3.8	4.0	4.1	4.2	4.6
d. Payments for time not worked	6.3	7.4	7.6	8.2	8.3	8.6	9.0	9.6	10.4	10.8	11.6
e. Profit-sharing payments, bonuses, etc.	1.8	1.9	1.5	1.4	1.4	1.5	1.8	1.7	2.0	2.0	2.4
2. As cents per payroll hour	44.3	53.5	62.7	70.9	77.6	86.0	100.8	118.9	151.1	187.1	238.4
3. As dollars per year per employee	942	1107	1293	1452	1621	1818	2116	2504	3150	3913	4923

SOURCE: CHAMBER OF COMMERCE, ANNUAL REPORT OF 1976 (EMPLOYEE BENEFITS DIVISION)

Source: Excerpted from Department of Defense, Coordinator of Shipbuilding, Conversion and Repair, Annual Report on the Status of the Shipbuilding and Ship Repair Industry of the United States, 1976, Report No. DD-I&L(A) 1141 (Washington: Naval Sea Systems Command, Apr. 26, 1977), Table 2-3, pp. 2-19 and 2-20.

Table 4-10

PERCENTAGE DISTRIBUTION OF EMPLOYED MALES (EXCLUDING CLERICAL AND SALES WORKERS) BY OCCUPATION IN SELECTED INDUSTRIES, 1970

Occupation	All Industries	Construction	Manufacturing: All	Manufacturing: Durable Goods	Motor Vehicles	Aircraft	Shipbuilding and Repair a/
Professional, Technical and Kindred Workers	19.8	4.8	11.7	13.4	8.9	31.0	12.0
Accountants	1.2	0	1.0	1.1	1.1	1.6	0.8
Draftsmen	0.5	0.5	0.8	1.3	1.0	1.7	1.6
Engineers	2.1	2.3	3.8	5.4	3.4	17.1	4.6
Technicians	1.4	1.3	2.5	3.0	2.5	5.1	3.0
Managers and Administrators (Non-Farm)	11.1	10.2	6.1	5.8	3.0	5.6	3.7
Craftsmen and Kindred Workers	18.5	60.3	23.2	25.6	25.2	28.7	52.6
Blacksmiths and Boilermakers	0	0.3	0.2	0.1	0.2	0.1	2.3
Carpenters	1.5	14.9	0.5	0.8	0.2	0.3	8.1
Electricians	0.8	4.9	0.9	1.1	1.3	1.8	4.7
Foremen, n.e.c.	2.8	3.6	5.5	5.6	5.8	5.8	5.9
Machinists	0.7	0.1	1.9	2.7	1.3	3.7	5.8
Mechanics and Repairmen	4.3	2.8	3.8	4.0	6.5	8.5	4.3
Painters b/	0.6	4.9	0.3	0.3	0.5	0.4	3.3
Plumbers and Pipefitters	0.7	5.5	0.5	0.5	0.7	0.4	5.1
Stationary Engineers	0.3	0.7	0.3	0.2	0.2	0.3	0.3
Operatives	25.5	9.5	50.8	46.9	55.4	31.3	24.8
Assemblers	1.6	0.1	5.4	8.3	16.8	7.8	1.1
Painters c/	0.2	-	0.5	0.8	1.5	0.6	1.0
Welders and Flame Cutters	0.9	1.4	2.2	3.4	5.5	1.5	11.4
Laborers (Non-Farm)	6.0	14.2	5.5	5.8	4.2	1.2	4.6
Service Workers (Non-Household)	15.0	1.1	2.7	2.6	3.3	2.3	2.3
All other d/	6.1	-	-	-	-	-	-
Total Employment (in Thousands)	57,360	4,248	16,832	10,121	904	592	232

a/ Includes boat building and repair.
b/ Construction and repairmen.
c/ Except construction and maintenance.
d/ Includes farm workers (farmers, managers, foremen, and laborers) and private household workers.

Source: Bureau of the Census, U.S. Census of Population: 1970, Occupation by Industry, PC(2)-7C (Washington: U.S. Government Printing Office, 1972), Table 8.

Table 4-11

CATEGORIES OF WORKERS IN SELECTED INDUSTRIES IN PERCENT, 1970

Worker Category	Industry					
	All Industry	All Manufacturing	Motor Vehicle	Aircraft	Shipbuilding and Repair	Construction
Laborers and Service Workers	21.0	8.2	7.5	3.5	6.9	15.3
Operatives	23.5	50.8	55.4	31.3	24.8	9.5
Craftsmen, Foremen, and Kindred Workers	18.5	23.2	25.2	28.7	52.6	60.3
Managers and Administrators, Technical Professions	30.9	17.8	11.9	36.6	15.7	15.0

Source: Derived from Bureau of the Census, U.S. Census of Population: 1970, Occupation by Industry, PC(2)-7C (Washington: U.S. Government Printing Office, 1972), Table 8.

production basis. Rigorous working conditions are typical of both industries, and both are highly unionized.

UNIONISM IN THE SHIPBUILDING INDUSTRY

Unionism has played a role in shipbuilding for over 140 years, fluctuating with the importance of the industry up through World War II, when unions became firmly entrenched in the industry. The high percentage of blue-collar workers in shipyards provides a formidable power base that can influence the pace of job change and technological advancement. A craft orientation has tended to inhibit the most effective allocation of manpower resources.

Flexible labor utilization is limited by a number of rules that restrict the area of activity and the responsibility of trades (e.g., a burner may not weld and a welder may not burn). Such rules complicate production planning and control. This complexity is apparent when it is realized that the average shipyard employs between 75 and 100 trades or levels of trades for work on a given series of ships. Table 4-12 lists the major shipbuilding unions by yard and area.

Most yards are organized on a craft basis; as such, each craft or group of crafts functions as a separate seniority unit. A worker may change job classifications and transfer from one unit to another, if the lines of progression allow, so long as he is qualified to do so and providing that there are no qualified people from the unit in question on layoff. In most cases, the transferee loses his accumulated seniority. Yard-provided benefits are retained in the transfer.

SHIPYARD JOBS

Shipbuilding requires a variety of skills. Table 4-13 gives a breakdown of the production work force by job title and number. The most common production job title is welder (16 percent), followed by shipfitter (10 percent), machinist (8 percent), electrician (7 percent), pipefitter (6 percent), painter (5 percent), rigger (4 percent), sheetmetal worker (4 percent), chipper (3 percent), and burner (3 percent). Only a few of the jobs listed in this table are specific to shipyards. Among these are loftsman, shipwright, and, to a limited extent, rigger. Aside from specific job functions unique to shipbuilding, a comparison of private shipyard job descriptions furnished by the SCA, Coast Guard (USCG) "Position Descriptions" for shipyard jobs, and U.S. Civil Service classification standards (excerpts from which are contained in Appendixes C, D, and E, respectively) reveals a virtual identity between shipyard

Table 4-12

SHIPYARD UNIONS, SELECTED YARDS

Company and Shipyard	Location	Union
North Atlantic		
*Bath Iron Works Corp.	Bath, ME	IUMSWA
Bethlehem Steel Corp., Shipbuilding Department, Boston Yard	East Boston, MA	IUMSWA
*General Dynamics, Quincy Shipbuilding Division	Quincy, MA	IUMSWA
*General Dynamics, Electric Boat Division	Groton, CT	MTC
Middle Atlantic		
Todd Shipyards Corp., Brooklyn Division	Brooklyn, NY	IUMSWA
*Seatrain Shipbuilding Corp.	Brooklyn, NY	SIU
Bethlehem Steel Corp., Shipbuilding Department, Hoboken Yard	Hoboken, NJ	IUMSWA
*Sun Shipbuilding and Dry Dock Co.	Chester, PA	IBB
*Bethlehem Steel Corp., Shipbuilding Department Sparrows Point Yard	Sparrows Point, MD	IUMSWA
Bethlehem Steel Corp., Shipbuilding Department, Key Highway Yard	Baltimore, MD	IUMSWA
*Maryland Shipbuilding and Drydock Co.	Baltimore, MD	IUMSWA
*Newport News Shipbuilding and Dry Dock Co.	Newport News, VA	PSA or USA [a/]
*Norfolk Shipbuilding and Drydock Corp.	Norfolk, VA	IBB
South Atlantic [b/]		
Savannah Machine and Shipyard Co.	Savannah, GA	IAMAW, IBB, IUOE, UBCJA, BPDPHA, IBT, SMWIA

Table 4-12 (continued)

Jacksonville Shipyards, Inc.	Jacksonville, FL	IBB
Merrill-Stevens Dry Dock Co.	Miami, FL	IAMAW
*Tampa Ship Repair and Dry Dock Co., Inc.	Tampa, FL	IBB
Gulf		
*Alabama Dry Dock and Shipbuilding Co.	Mobile, AL	IUMSWA
*Ingalls Shipbuilding Division, Litton Industries	Pascagoula, MS	MTC
*Avondale Shipyards, Inc.	New Orleans, LA	---
Boland Marine and Manufacturing Co.	New Orleans, LA	IBB
Todd Shipyards Corp., New Orleans Division	New Orleans, LA	IUMSWA
*Bethlehem Steel Corp., Shipbuilding Department, Beaumont Yard	Beaumont, TX	IAMAW
*Levingston Shipbuilding Co.	Orange, TX	IAMAW
Todd Shipyards Corp., Galveston Division	Galveston, TX	IBB
Todd Shipyards Corp., Houston Division	Houston, TX	IBB
Southern California		
*National Steel and Shipbuilding Co.	San Diego, CA	IABSOI
Bethlehem Steel Corp. Shipbuilding Department, San Pedro Yard	San Pedro, CA	IUMSWA
*Todd Pacific Shipyards Corp., Los Angeles Division	San Pedro, CA	IUMSWA
Northern California		
*Bethlehem Steel Corp., Shipbuilding Division, San Francisco Yard	San Francisco, CA	MA/MTD
Todd Shipyards Corp., San Francisco Division	Alameda, CA	MA/MTD

Table 4-12 (continued)

Pacific Northwest		
*FMC Corporation, Marine and Railway Equipment Division	Portland, OR	MA/MTD
Northwest Marine Iron Works	Portland, OR	MA/MTD
Willamette Iron and Steel Co., Portland Marine Division	Portland, OR	IAMAW
*Lockheed Shipbuilding and Construction Co.	Seattle, WA	MA/MTD
*Todd Shipyards Corp., Seattle Division	Seattle, WA	IBEW
Great Lakes		
*American Shipbuilding Co., AMSHIP Division	Lorain, OH	IAMAW, IBEW UAJAPPI, IBB BPAT, IBFO, IUOE, UBCJA
*American Shipbuilding Co., AMSHIP Division	Toledo, OH	
*Bay Shipbuilding Corp.	Sturgeon Bay, WI	IBEW
*Fraser Shipyards, Inc.	Superior, WI	IBB
Marinette Marine Corp.	Marinette, WI	IBB

Table 4-12 (continued)

Unions:

BPAT -- Brotherhood of Painters and Allied Trades, AFL-CIO.

BPDPHA -- Brotherhood of Painters, Decorators and Paper Hangers of America, AFL-CIO.

IABSOI--International Association of Bridge, Structural and Ornamental Ironworkers, AFL-CIO.

IAMAW -- International Association of Machinists and Aerospace Workers, AFL-CIO.

IBB -- International Brotherhood of Boilermakers, Iron Shipbuilders, Blacksmiths, Forgers and Helpers, AFL-CIO.

IBEW -- International Brotherhood of Electrical Workers, AFL-CIO.

IBFO -- International Brotherhood of Firemen and Oilers, AFL-CIO.

IBT -- Truck Drivers and Helpers local, affiliated with the International Brotherhood of Teamsters, Chauffeurs, Warehousemen and Helpers of America.

IUMSWA -- Industrial Union of Marine and Shipbuilding Workers of America, AFL-CIO.

IUOE -- International Union of Operating Engineers, AFL-CIO.

MA/MTD -- Master Agreement with Metal Trades Department of the AFL-CIO, Pacific Coast Metal Trades District Council, and local Metal Trades Council.

MTC -- local Metal Trades Council, AFL-CIO.

PSA -- Peninsula Shipbuilders Association.

SIU -- United Industrial Workers, affiliated with Seafarers International Union of North America (Atlantic, Gulf, Lakes and Inland Waters District), AFL-CIO.

SMWIA -- Sheet Metal Workers International Association, AFL-CIO.

USA -- United Steelworkers of America, AFL-CIO.

UAJAPPI -- United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry of the United States and Canada, AFL-CIO.

UBCJA -- United Brotherhood of Carpenters and Joiners of America, AFL-CIO.

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* Indicates yards with facilities to construct vessels of 144.8 x 20.7 m (475 x 68 ft) or larger.

a/ Results of representational election are being contested; issue has been remanded by the courts to the National Labor Relations Board for determination.

b/ Includes Gulf Coast of Florida.

Source: Maritime Administration, Office of Maritime Manpower, May 1, 1979.

Table 4-13

SHIPYARD PRODUCTION WORKERS BY JOB TITLE

Job Title	Number of Jobs
Automotive Operator, Mechanic	379
Blacksmith (All Fires)	102
Boilermaker	233
Caulker, Chipper	1,517
Carpenter-Joiner	493
Carpenter	907
Coppersmith	97
Crane Operator (All Types)	834
Docking and Berthing Crew	339
Electrician (Inside-Outside)	3,556
Electronic Technician	48
Electronic Mechanic	152
Engine Locomotive Brakeman	110
Flame Cutter (Burner)	1,345
Forging Machine Operator, Heater	295
Galvanizer	5
Helper	37
Hydraulic Mechanic	37
Mechanic (Heat Treating)	134
Laborer	875
Loftsman	418
Machinist (Inside-Outside)	4,082
Mariner Types	25
Maintenance (Inside-Outside)	877
Material Chaser	308
Nuclear	1
Painter	2,520
Pipe Coverer (Insulator)	421
Pipefitter	3,136
Pipe Sketcher	2
Refrig.-Air Conditioning Mechanic	1
Radiographer (X-Ray)	4
Rigger	2,230
Riveter (Bucker and Heater)	11
Sandblaster	114
Sheetmetal (Inside-Outside)	1,979
Shipfitter	5,039
Shipwright	253
Tacker	9
Toolmaker (Cutter and Grinder)	53
Warehouse Man	301
Marker (Welder)	3
Welder (Elec.), Automatic, Hand	8,033
Non-Production	7,991
Stage Builder	116
Tank Tester	45
Tool Repair	110
Tool Keeper	262
Welder-Wireroom, Cleaner	7
Handyman	70
Hooker-On	166
Quality Control Technician	304
Total	50,386

Source: Sample taken by Maritime Administration, covering 11 major U.S. private shipyards, ca. 1974.

jobs and their non-shipyard counterparts. Training and skills requirements for shipyard and non-shipyard jobs are the same. Indeed, each USCG Position Description is referenced directly to the Civil Service description for the same job title. For the most common shipyard position, welder, the only difference in the skills requirement for shipyard and non-shipyard work is that the shipyard welder who works on Naval contracts must demonstrate a knowledge of the requirements of the welding specifications of MIL-STD-278D and NAVSHIP 0900-000-1001. Critical non-shipyard welding positions impose similar specifications unique to the particular job.

Table 4-14 gives the skill mix for selected occupations by type of shipyard. It is clear that the relative percentages of workers in each skill category change as a function of the overall shipyard task. The Naval shipyards, devoted entirely to the repair and modification of relatively sophisticated Naval vessels, require a larger proportion of pipefitters, electricians, and machinists than do the commercial construction and repair yards. Because of the non-uniformity of shipyard work load and the varying demand for skilled workers as a function of a specific contract, it is likely that shortages and surpluses of a particular trade classification will appear. This tendency for local shortages to develop will be intensified by inter-yard competition for the same class of worker if large contracts are distributed among several yards, or if the industry as a whole experiences a surge. Further, as the competition from outside the industry increases for a skilled trade (e.g., welders, electricians), a generalized shortage develops in the shipyards.

SKILLED WORKER SHORTAGES AND SURPLUSES

Table 4-15 reveals shortages and surpluses among skilled trades for a number of shipyards. One study of labor shortages in 1975 identified five trades as critical in a significant number of Naval shipyards. These were marine machinists, inside machinists, pipefitters, boilermakers, and electricians.[10] Skill shortages (and surpluses) appear to be a complex function of fluctuating demand, competition from within the industry, competition from outside the industry, specificity of the skill to shipyard work, training lag time for the skill, and personal mobility of the worker and his family.

Despite the barriers between trades, shipbuilding unions have often been able to accommodate situations in which flexibility and the interchange of labor would operate to the mutual advantage of both union and shipyard, either to alleviate the effects of a temporary labor shortage or to avoid layoffs. The Commission on American Shipbuilding, in

Table 4-14

SKILL MIX FOR SELECTED OCCUPATIONS BY SHIPYARD TYPE

OCCUPATION	CONSTRUCTION SHIPYARDS (15)		REPAIR SHIPYARDS (27)		NAVAL SHIPYARDS (10) a/	
	NUMBER EMPLOYED	PERCENT OF TOTAL	NUMBER EMPLOYED	PERCENT OF TOTAL	NUMBER EMPLOYED	PERCENT OF TOTAL
SHIPFITTER	5406	21%	967	14%	1896	7.1%
WELDER	6422	25%	1625	23.5%	2593	10%
MACHINIST INSIDE/OUTSIDE	3801	15%	1477	21%	6842	26%
ELECTRICIAN INSIDE/OUTSIDE	2567	10%	621	9%	3719	14%
SHEETMETAL WORKER	1661	6%	294	4%	1763	7%
PIPEFITTER	3207	12%	748	11%	4147	16%
ELECTRONICS MECHANIC	302	1%	6	0.1%	2138	8%
LOFTSMAN	210	1%	28	0.4%	106	0.4%
RIGGER	2143	8%	939	14%	2063	8%
BOILERMAKER	204	1%	218	3%	922	3.5%
TOTAL	25923	100%	6923	100%	26189	100%

a/ 100 percent repair work.

Source: MARK-BATTLE ASSOCIATES, INC. AS OF 30 JUNE 1973

Source: Department of Defense, Coordinator of Shipbuilding, Conversion and Repair, Annual Report on the Status of the Shipbuilding and Ship Repair Industry of the United States, 1975, Report No. DD-I&L(A) 1141 (Washington: Naval Sea Systems Command, March. 29, 1976), Table 5-5, p. 5-12.

Table 4-15

AVAILABILITY OF SKILLED SHIPYARD EMPLOYEES BY OCCUPATION FOR SELECTED LABOR MARKETS

	SHIPFITTER	WELDERS	MACHINISTS INSIDE	MACHINISTS OUTSIDE	ELECTRICIANS	SHEETMETAL WORKERS	PIPEFITTERS	ELECTRONIC MECHANIC	LOFTSMAN	BOILERMAKERS	LEAD BURNER	PIPE COVERER (INSULATOR)	CRANE OPERATOR	FIRE CONTROL MECHANIC	OTHER
SUPSHIP															
BATH	5	4	5	3	4	5	3	4	5	5	–	6	5	4	
BROOKLYN	4	4	4	4	4	4	4	4	4	4	4	4	4	3	
CHARLESTON	4	3	4	4	4	4	3	3	4	3	4	4	4	3	
GROTON	4	3	3	4	4	4	3	4	4	–	3	3	4	–	
JACKSONVILLE	3	2	4	4	4	2	3	4	–	4	–	4	4	4	
LONG BEACH	4	3	4	4	4	4	2	4	4	2	4	4	4	4	
NEWPORT NEWS	1	1	3	2	1	1	1	3	3	3	3	2	3	3	
NEW ORLEANS	3	2	4	3	3	4	2	2	4	3	3	4	4	2	
PASCAGOULA	1	1	1	1	1	1	1	1	1	1	1	4	4	1	
PORTSMOUTH	2	2	4	3	2	3	2	3	3	4	4	3	4	3	
SAN DIEGO	4	4	4	4	4	4	4	4	3	4	4	4	4	4	
SEATTLE	5	5	4	6	6	6	6	5	4	5	4	4	4	5	
STURGEON BAY	2	2	3	3	4	4	3	2	2	4	3	4	4	3	
PHILA NSY INDMANDEPT	2	2	1	2	2	4	2	3	1	2	3	3	3	3	
PEARL	3	3	4	3	4	4	3	3	2	2	2	3	4	2	
SAN FRANCISCO	4	4	4	4	4	4	4	3	2	4	3	4	4	4	
NAVAL SHIPYARDS															
CHARLESTON	1	2	1	1	2	2	1	2	2	1	1	1	4	2	
LONG BEACH	4	4	3	3	5	4	1	5	4	1	–	1	3	5	
PORTSMOUTH	1	3	4	4	3	4	3	4	4	4	4	2	3	4	
PEARL HARBOR	2	3	2	2	5	3	1	6	4	2	4	1	4	4	
PHILADELPHIA	3	5	3	2	5	3	2	5	2	2	–	2	2	4	
NORFOLK	3	4	2	5	5	4	4	5	–	2	–	2	4	4	
PUGET SOUND	2	3	1	3	3	2	1	5	1	1	–	1	4	2	
MARE ISLAND	1	2	1	1	3	2	1	4	4	3	4	2	1	3	*

KEY:
1. SERIOUS SHORTAGE
2. SUBSTANTIAL SHORTAGE
3. MODERATE SHORTAGE
4. LITTLE OR NO SHORTAGE
5. MODERATE SURPLUS
6. SUBSTANTIAL SURPLUS

* A serious shortage of sailmakers is reported, and also a substantial shortage was reported for skills of rigger, toolmaker, and shipwright/joiner.

Source: NAVSEA 07D

Source: Department of Defense, Coordinator of Shipbuilding, Conversion and Repair, Annual Report on the Status of the Shipbuilding and Ship Repair Industry of the United States, 1975, Report No. DD-I&L(A) 1141 (Washington: Naval Sea Systems Command, Mar. 29, 1976), Table 1-7, p. 1-16.

its 1973 report, concluded that further increases in the flexibility of labor utilization in U.S. shipyards would reduce building costs, provide steady employment, and contribute to worker morale by decreasing monotony. The strengthening of strict work rules of craft specialization, on the other hand, might lead to transient fluctuations in shipyard employment, despite a constant construction work load. Because schedules, types of ships under construction, and material delivery dates largely determine the workers in each craft specialty needed at any given moment,[11] it is not always practicable to keep predetermined numbers of welders, electricians, shipfitters, machinists, etc., employed at a continuous pace.

The size of the labor market surrounding the shipyard determines the yard's ability to draw workers in time of need and, conversely, the shipyard worker's ability to find alternative employment in a related industry. Shipyards in relatively isolated areas dominate the local labor market; hence, the labor pool on which to draw is limited and the local labor market's ability to retain workers in the area in times of slack shipbuilding demand is similarly limited.

HOURLY AND ANNUAL EARNINGS

In determining the ebb and flow of workers in the labor market, wages must be compared to those paid in related industries. Table 4-16 illustrates the average hourly earnings of shipyard production workers in comparison with those of workers in other manufacturing industries. Construction workers have a notably higher hourly earning capacity; however, on an annual basis, this disparity vanishes. Tables 4-17 and 4-18 reveal that construction workers earn less than shipyard workers when the seasonal nature of the construction trades is taken into account.

Average yearly earnings of shipbuilding and repair workers tend to be lower than the hourly or weekly figures indicate. This is attributable to the intermittency of employment that has characterized the industry in recent years.

PERSONNEL TURNOVER

The Bureau of Labor Statistics (BLS) reports an unusually high turnover rate for the shipbuilding industry when compared with other related industries. Table 4-19 gives the turnover rate for males in a group of related production industries. In 1970, shipbuilding ranked higher than construction in personnel accessions and separations. Table 4-20 details changes in the turnover rate since 1965 and reveals considerable improvement in the ability of the

Table 4-16

AVERAGE HOURLY EARNINGS OF PRODUCTION WORKERS IN SELECTED INDUSTRIES AS A RATIO OF AVERAGE HOURLY EARNINGS IN SHIPBUILDING AND REPAIRING, 1950-1974 [a]

Years	Industry					
	Construction	All Manufacturing	Durable Goods	Motor Vehicles	Aircraft	Railroad Equipment
1950-54	1.11	0.85	0.91	1.05	0.98	0.98
1955-59	1.10	0.83	0.89	1.01	0.97	0.99
1960-64	1.10	0.79	0.85	1.00	0.95	0.98
1965-69	1.20	0.83	0.88	1.06	1.00	1.01
1970-74	1.36	0.87	0.93	1.15	1.06	1.10

a/ Five-year averages. Shipbuilding and repairing = 1.00.

Source: Derived from Bureau of Labor Statistics, Employment and Earnings Statistics for the United States, 1909-74, Bulletin 1312-10 (Preliminary), (Washington: U.S. Government Printing Office, 1975).

Table 4-17

AVERAGE ANNUAL EARNINGS IN SELECTED INDUSTRIES AS A RATIO OF AVERAGE ANNUAL EARNINGS IN SHIPBUILDING AND REPAIRING, MALES: 1960, 1965, AND 1970

	1960	1965	1970
Construction	0.86	0.84	0.98
Manufacturing	1.10	1.03	1.06
Motor Vehicles	1.27	1.21	1.10
Aircraft	1.31	1.30	1.33
Other Transportation a/	0.97	0.96	0.91
Shipbuilding and Repair	1.00	1.00	1.00
Boatbuilding and Repair	0.73	0.70	0.73
Railroad Equipment	1.16	1.06	1.05

a/ Includes mobile homes, campers, and cycling equipment in addition to the industries listed.

Source: Social Security Administration, "Continuous Work History Sample" data file; in Martin, John Charles, "The Labor Market of the United States Shipbuilding Industry," unpublished Ph.D. dissertation, Graduate School of Arts and Sciences, George Washington University (Washington: Sept. 30, 1978), Table VI.4.

Table 4-18

AVERAGE ANNUAL EARNINGS IN SELECTED INDUSTRIES AS A RATIO OF AVERAGE ANNUAL EARNINGS IN OTHER TRANSPORTATION EQUIPMENT, MALES, 1969 a/

Occupation	All Industries	Construction	Manufacturing	Motor Vehicles	Aircraft
Professional, Technical, and Kindred Workers	1.10	0.98	1.01	1.19	1.19
Accountants	1.09	0.97	0.81	1.10	0.90
Draftsmen	0.98	0.93	1.02	1.39	1.14
Engineers	1.10	1.05	1.10	1.13	1.20
Technicians	0.90	0.79	0.93	1.25	1.05
Managers and Administrators (Non-Farm)	0.91	0.94	1.13	1.19	1.13
Clerical Workers	0.88	1.19	0.93	1.10	1.09
Sales Workers	0.93	1.07	1.06	1.17	1.34
Craftsmen and Kindred Workers	1.06	1.04	1.13	1.37	1.23
Blacksmiths and Boilermakers	1.00	1.23	1.01	1.12	1.00
Carpenters	1.15	1.17	1.11	1.32	1.32
Electricians	1.22	1.30	1.20	1.50	1.20
Foremen, n.e.c.	0.99	1.00	1.01	1.23	1.20
Machinists	1.04	0.94	1.05	1.25	1.07
Mechanics and Repairmen	0.92	1.04	1.02	1.16	1.10
Painters b/	0.95	0.95	0.99	1.16	1.10
Plumbers and Pipefitters	1.20	1.24	1.19	1.50	1.14
Stationary Engineers	1.01	1.03	1.11	1.30	1.27
Operatives	0.99	1.18	1.03	1.18	1.23
Assemblers	1.20	1.23	1.20	1.29	1.40
Painters c/	1.03	-	1.21	1.26	1.14
Welders and Flame Cutters	1.07	1.24	1.04	1.10	1.19
Laborers (Non-Farm)	0.09	0.98	1.01	1.35	1.29
Service Workers (Non-Household)	0.90	0.93	0.99	1.32	1.32
All Occupations d/	1.07	1.05	1.10	1.18	1.33

a/ "Other Transportation Equipment" includes shipbuilding and repairing, boatbuilding and repairing, railroad equipment, and miscellaneous transportation (principally mobile homes, campers, and cycling equipment).

b/ Construction and repairmen.

c/ Except construction and maintenance.

d/ Includes farm workers (farmers, managers, foremen, and laborers) and private household workers.

Source: Bureau of the Census, U.S. Census of Population: 1970, Occupation by Industry, PC(2)-7C, (Washington: U.S. Government Printing Office, 1972), Table 4.

Table 4-19

TURNOVER RATES IN SELECTED INDUSTRIES, MALES, 1960-65 AND 1965-70

1960-65	Separation Rate a/	Accession Rate a/	Percent of Accessions Not in Work Force
Construction	47.9	54.9	27.6 b/
Manufacturing c/	34.3	36.1	18.9
Motor Vehicles	35.3	45.1	16.1
Aircraft	46.4	42.7	11.0
Shipbuilding	46.8	51.6	19.0
Miscellaneous Transportation Equipment d/	59.8	71.7	27.7
Other Industries e/	33.7	40.6	31.2
1965-70			
Construction	47.8	51.9	25.3 f/
Manufacturing c/	35.7	41.6	21.6
Motor Vehicles	42.4	43.8	14.9
Aircraft	38.7	43.5	11.0
Shipbuilding and repairing	54.0	56.5	21.1
Miscellaneous Transportation Equipment d/	61.3	70.5	31.1
Other Industries e/	34.4	44.5	35.1

a/ These long-term turnover rates are defined as follows: the accession rate is the percent of workers in an industry in a given year who were not in the same industry 5 years earlier; the separation rate is the percent of workers in an industry in a given year who were not in the same industry 5 years later. (Note: under the latter definition, a worker who was laid off and rehired within the period would not be reported as separated.)

b/ Not in work force or not working in covered industries in 1960.
c/ Excludes transportation equipment industries.
d/ Includes boatbuilding and repairing, mobile homes and campers, and cycling equipment.
e/ All industries except construction and manufacturing.
f/ Not in work force or not working in covered industries in 1965.

Source: Social Security Administration, "Continuous Work History Sample" data file; in Martin, John Charles, "The Labor Market of the United States Shipbuilding Industry," unpublished Ph.D. dissertation, Graduate School of Arts and Sciences, George Washington University (Washington: Sept. 30, 1978), Table VIII.1.

Table 4-20

ANNUAL AVERAGES OF MONTHLY ACCESSION AND SEPARATION RATES
PER 100 EMPLOYEES, U.S. SHIPBUILDING AND REPAIRING INDUSTRY, 1965-1976

Annual Monthly Average For	Accession Rates		Separation Rates		
	Total	New Hires	Total	Quits	Layoffs
1976 [a/]	6.1	3.8	6.4	2.2	2.7
1975	6.4	3.8	5.8	2.0	2.5
1974	7.4	4.9	6.5	2.6	2.2
1973	7.9	4.8	7.5	2.7	3.3
1972	8.1	3.9	7.8	2.1	4.2
1971	8.6	3.9	8.6	2.0	5.3
1970	7.4	3.7	8.1	2.2	4.6
1969	8.3	5.0	8.0	3.0	3.7
1968	9.1	4.9	8.6	2.7	4.6
1967	8.6	4.6	8.9	2.4	5.4
1966	9.7	5.4	9.6	3.1	5.2
1965	9.8	5.1	9.0	2.2	5.8

[a/] 1976 - January thru October

Source: Department of Labor, Bureau of Labor Statistics

Source: Department of Defense, Coordinator of Shipbuilding, Conversion and Repair, Annual Report on the Status of the Shipbuilding and Ship Repair Industry of the United States, 1976, Report No. DD-I&L(A) 1141 (Washington: Naval Sea Systems Command, Apr. 26, 1977), Table 1-13, p. 1-35.

shipyards to retain workers since that time. Turnover is highest among the relatively young workers (entry-level jobs), although the separation rate is high among workers 55 and over. This indicates an aging work force in which retirement plays a considerable part in turnover. Table 4-21 shows the relationship of turnover to age in selected industries.

Costs attributable to turnover are likely to be high since they integrate personnel acquisition costs, training costs, and separation costs.

TURNOVER AND WORKER INTERCHANGE WITH RELATED INDUSTRIES

Under contract with the Maritime Administration, the Center for Naval Analyses performed a study called the Shipyard Worker Employment and Turnover Study (SWETS) tracing the occupational history of all males who worked in shipbuilding firms from early 1957 to early 1972.[12] The study attempted to determine whether shipyard personnel turnover involved permanent loss of workers from the shipbuilding industry or whether there was a constant ebb and flow into and out of the industry as a function of work load.

This study confirmed the finding that entry level workers constitute the bulk of turnover and further revealed that, once having left shipyard employ, they rarely return to shipbuilding. Well over half of all permanent leavers had less than 1 year's employment in shipbuilding. Those leaving shipbuilding on a permanent basis tended to opt for the more stable employment in manufacturing (32.6 percent) or in service industries (29.0 percent) rather than for the greater occupational instability of contract construction (17.5 percent). The length of tenure in shipbuilding made little difference in the choice of a new industry, save that men with more than 3 years' shipbuilding experience tended to go less into other manufacturing and service jobs and more into natural resource occupations (e.g., petroleum and mining, farming, and fishing) than might be expected.

Table 4-22 indicates the destination industries of released shipyard workers.

SHIPYARD WORKER MOBILITY

Willingness or unwillingness to relocate complicates the problem of worker mobility between shipyards in response to changes in labor demand. Shipbuilding labor recruiters feel that one of the most important factors influencing job desirability is geographic location of the yard. Environments viewed negatively make it more difficult to

Table 4-21

ACCESSION AND SEPARATION RATES OF MALE WORKERS BY AGE, SELECTED INDUSTRIES, 1965-1970 a/

	Under 25	25-34	35-44	45-54	55 and Over	Total
			Accession Rate b/			
Construction	94.9	60.9	42.3	36.3	31.7	51.6
Manufacturing	82.0	29.3	13.3	10.2	9.8	26.6
Durable Goods	82.5	35.5	16.9	12.4	11.6	29.3
Motor Vehicles	95.5	57.2	31.8	21.2	17.4	43.5
Aircraft	98.8	69.4	34.3	24.5	23.8	43.3
Shipbuilding c/	96.7	70.8	51.9	41.4	24.7	56.1
Railroad Equipment	97.5	67.5	46.7	27.0	26.3	50.2
			Separation Rate d/			
Construction	63.3	45.7	38.6	41.1	61.1	47.7
Manufacturing	23.5	15.0	12.5	14.8	46.4	20.6
Durable Goods	29.5	19.9	15.2	16.6	48.6	23.7
Motor Vehicles	56.4	40.7	31.0	29.4	69.8	42.3
Aircraft	64.2	47.5	30.4	25.2	56.7	38.7
Shipbuilding c/	68.0	53.4	50.1	44.5	63.4	53.9
Railroad Equipment	75.3	46.0	37.8	23.9	53.8	44.5

a/ Excludes workers in non-covered industries, notably those in Naval shipyards.

b/ The percentage of male workers in the given industry in 1970 who worked in other industries or were not in the work force in 1965.

c/ Includes repairing.

d/ The percentage of male workers in the given industry in 1965 who worked in other industries or were not in the work force in 1970.

Source: Social Security Administration, "Continuous Work History Sample" data file; in Martin, John Charles, "The Labor Market of the United States Shipbuilding Industry," unpublished Ph.D. dissertation, Graduate School of Arts and Sciences, George Washington University (Washington: Sept. 30, 1978), Table VIII.2.

Table 4-22

NUMBER AND PERCENT OF MALE EMPLOYEES PERMANENTLY LEAVING SHIP CONSTRUCTION BY SELECTED DESTINATION INDUSTRY GROUPS, 1957-1972 a/

Destination Industry Group	Number of Men	Percent of Sample
Building Construction	235	4.7
Structural Steel Construction	27	0.5
Special Trade Contractors	144	2.9
All Other Construction	471	9.4
Metal Industries	336	6.7
Non-Electrical Machinery	270	5.4
Automotive and Aerospace	146	2.9
Other Manufacturing	884	17.6
Natural Resources	117	2.3
Overland Transportation	217	4.3
Water Transportation	153	3.0
Wholesale and Retail Trade	645	12.8
Service Stations	133	2.6
Finance and Real Estate	478	9.5
Repair and Maintenance Services	95	1.9
Misc. Services	107	2.1
Government and Military	103	2.1
All Other Employment	460	9.2
Total	5,021	100.0

a/ Data includes only the first quarter of 1972.

Source: Social Security Administration, "One-Percent Longitudinal Employee-Employer Data File;" in Martin, John Charles, "The Labor Market of the United States Shipbuilding Industry," unpublished Ph.D. dissertation, Graduate School of Arts and Sciences, George Washington University (Washington: Sept. 30, 1978).

attract and retain workers. Conversely, workers will tolerate a number of negative occupational factors if these are counterbalanced by a particularly attractive location. According to a recent study of worker mobility, the New England area and the Northwest appear to be the regions most difficult to move workers out of, although for different reasons. Workers in the New England area generally have strong ties of family and tradition, whereas the Northwest is attractive because of the physical environment and the leisure-time activities that environment makes possible.

The relative attractiveness of geographic area is illustrated by the following example. On April 17, 1973, the Department of the Navy announced closure of the Boston Naval Shipyard and the Hunters Point Naval Shipyard (San Francisco), effective July 1, 1974. At that time, these yards had 5,150 and 5,600 employees, respectively. The Boston yard managed to place only about 1,500 workers in other jobs in total and only 473 in other Naval shipyards. More than half of those placed in other Naval yards went to the Naval shipyard at Portsmouth, New Hampshire. At Hunters Point, however, 3,500 workers were placed in other jobs, many out of the area, and 1,900 workers of this total were relocated to other Naval shipyards across the country.

The Navy's explanation for this difference in worker mobility is that the Boston workers were older, had greater seniority, were home owners, had teenage children in school, had close relatives in the area, and were tied to the New England region by other social and economic factors. Many of the workers at Hunters Point were not as irrevocably tied to the location and, hence, were considerably more mobile. Consequently, when the yards closed, most of the Boston workers chose to leave the industry rather than the area, choosing to minimize the social rather than the economic disruption of their lives. The Hunters Point workers made the other choice, many staying within the industry at the cost of a change in location.[13]

SWETS provided additional information on whether a worker leaving shipyard employment would be available in the local labor pool if he could be induced to re-enter the industry. The study found that the bulk of the workers leaving shipyard employment chose other jobs in the local area and thus remained in the local labor supply. Where relocation did occur, it was, as might be expected, within the same general geographic region.

CONSENSUS OF TURNOVER AND MOBILITY STUDIES

Both SWETS and the BLS study identify personnel turnover as a major problem in shipyards. The BLS estimates the average annual shipyard personnel accession rate for the

1965 through 1976 period as 97.4 percent, while the separation rate (including quits, layoffs, and retirements) for the same period was 94.8 percent. The slight edge of accessions over separations implies a gradual growth of the average work force over this period. Table 4-20 gives the average monthly accession and separation rates for the shipbuilding and repair industry. Averaging the accession and separation rate provides a crude estimate of worker turnover. In the shipbuilding industry, the average rate from 1965 through 1976 was about 96.1 percent per year.

In the context of industrial employment, such figures are not unusual. Companies in automobile parts production report turnovers in excess of 120 percent per year; light manufacturing (electrical equipment) companies report turnovers of up to 140 percent per year. Even "white-collar factories"--insurance companies, brokerage firms, and banks report turnover of approximately 75 percent per year.[14]

Unskilled and semi-skilled workers with short tenure represent the bulk of all leavers. Most of these leave within a few months of employment. The bulk remain within the local labor pool and are available for re-employment when economic conditions improve. The training costs incurred by shipyards for entry level workers who leave are just about balanced by the training provided by the previous employers of those entering.

TRAINING OF SHIPYARD WORKERS

The effect of turnover in the shipbuilding industry that is the most troublesome for the existing personnel structure to accommodate is the necessity for compressing job training requirements to allow for a reasonable supply of trained personnel. Table 4-23 lists shipyard jobs with associated training times to qualify as a First-Class Journeyman, extracted from the SCA job descriptions (see Appendix C). The jobs are listed in order of percentage of shipyard workers employed in each category.

Most shipyards, faced with the impossibility of meeting these training requirements, have adopted short-term, intensive training courses for trades in which turnover is most rapid, notably welders and shipfitters. Newport News Shipbuilding and Dry Dock Company reports that membrane welders (for LNG vessels) are trained in a 12-week program, and other yards report similar compression of training.

Apprentice programs are not emphasized in civilian yards. The annual output of apprentice programs in most repair yards is negligible, and only a few construction yards have programs of any magnitude. Naval yards, because of their lower turnover and higher emphasis on skilled

Table 4-23

SELECTED SHIPYARD PRODUCTION JOBS AND ASSOCIATED TRAINING TIMES TO QUALIFY AS A FIRST-CLASS JOURNEYMAN

Job a/		Training Time b/	Percent Employed c/
1.	Welder (Combination)	8,000 hours	16
2.	Shipfitter	8,000 hours	10
3.	Machinist	6,000 hours	8
4.	Electrician	8,000 hours	7
5.	Pipefitter	8,000 hours	6
6.	Rigger	8,000 hours	4
7.	Flame Cutter (Burner)	2,000 hours	3
8.	Crane Operator	1,000 hours	1
9.	Marine Draftsman	10,000 hours	1
10.	Shipwright	8 to 10 years	1

a/ These are the 10 most common production jobs, listed in order of the percentage of private shipyard workers employed in each category.

b/ Source: Shipbuilders Council of America. See Appendix C.

c/ Computed from Table 4-13.

trades, do train apprentices. As of January 31, 1977, there were 6,105 apprentices in training in all trades in Naval shipyards. This number has been increasing in recent years. Table 4-24 gives the number and distribution of apprentices currently in training in Naval yards.

WHITE-COLLAR WORKERS IN THE SHIPYARD

Shipyards employ a relatively small percentage of white-collar workers, managers, administrators, and technical professionals (15.7 percent). The conjoint effect of changes in shipbuilding technology, production methodology, procedures of personnel administration, and governmental rules and reporting requirements has been to mandate an increase in this segment of the shipyard work force. In consequence, it is expected that the percentage of white-collar shipyard workers may well double during the next decade.

The shipbuilding industry employs three basic categories of white-collar non-production workers. These are:

- Technical professionals--e.g., naval architects, design engineers, power plant engineers, production and industrial engineers, engineering technologists.

- Operating managers, businessmen--e.g., line managers, production managers, expediters.

- Staff personnel--e.g., finance, sales, personnel, reliability.

TRAINING OF TECHNICAL PROFESSIONALS

Three schools train most of the naval architects and marine engineers employed in U.S. shipyards. These are the University of Michigan, Webb Institute of Naval Architecture, and Massachusetts Institute of Technology. A number of engineering personnel have come to shipbuilding from other industries. Although the U.S. Naval Academy, the U.S. Coast Guard Academy, the U.S. Merchant Marine Academy, and the state maritime academies offer training in marine engineering and naval architecture, their proportion of the technical professional sector of the shipyard work force is small. A number of graduates of these academies have found their way into managerial positions, however.[15]

None of the educational programs mentioned has an orientation toward ship production, and it is the consensus of the industry that a significant period of actual shipyard experience is necessary to complete the education of engineering personnel. This facet of education for the marine industry has generally been neglected by U.S. educational institutions. For every engineer employed in basic ship design, many technical professionals are needed to work out the structural details, piping and electrical routes, etc., as well as the sequence and procedures of construction. Shipyards have been forced to provide such training for their own employees; the best known of such programs has been that operated by Newport News Shipbuilding and Dry Dock Company.

In 1968, the education of production-oriented marine technologists was initiated at one institution, Mississippi State University. The steady demand for graduates of this Marine Engineering Technology program indicates the worth of production orientation in marine technical education.

A number of shipyards have programs that pay the employee's tuition for selected technical and engineering courses offered by local institutions, as preparation for work in the design shops and other technical areas in the yard.

TRAINING OF OPERATING MANAGERS

Training of managerial personnel in shipyards is generally performed on the job. Many of the graduates of the traditional programs in naval architecture and marine engineering eventually find their way into the managerial and business side of shipyards operations, but their managerial and business skills are acquired through experience. No formal training programs for personnel in these job categories appear to exist in the industry itself.

Since the managerial and business operations of shipyards are related to those in other heavy manufacturing industries, it would seem reasonable to assume that shipyards would attract graduates of business and professional schools in heavily industrialized states that serve as a source of personnel for these industries. This has not proved to be the case. Recruiters for shipyards seldom seek recent graduates of business and professional schools, preferring instead to seek management personnel already employed in the industry (i.e., from other shipyards). This strategy, while expedient in the short term, has the effect of forcing up salaries and producing a degree of management inbreeding that may not be altogether beneficial, insulating the industry from both new blood and recently developed management techniques. The MBA student who opts for training in the shipbuilding industry is an anomaly. At present, only one institution, the University of Michigan, offers training at the master's level in both shipbuilding technology and business.

Table 4-24
NAVAL SHIPYARD APPRENTICE ENROLLMENT, JANUARY 1977

Trades	NAVAL SHIPYARDS								Totals
	PTSMH	PHILA	NORVA	CHASN	LBEACH	MARE	PUGET	PEARL	
Shipfitter	55	37	54	70	31	66	61	34	408
Sheetmetal Mechanic	24	30	49	37	28	62	59	21	310
Blacksmith	4	3	7	3	2	1		8	28
Welder	34	45	73	61	41	83	74	20	431
Boilermaker		44	43	31	35	10	22	27	212
Toolmaker	1	5		18			9	4	37
Electronics Mechanic (Maintenance)						15	2		17
Machinist (Maintenance)	3		12		1	16			32
Inside Machinist	67	76	92	137	47	83	97	82	681
Outside Machinist	57	52	73	135	52	152	92	91	704
Air-Conditioning Equipment Mechanic	8		28	17	9	12	12	17	103
Pipefitter	89	85	123	163	44	177	101	93	875
Coppersmith			2	1					3
Insulator	13	24	17	23	24	8	18	22	149
Joiner					6				6
Molder	4	17	10	3	8		5	2	49
Patternmaker		2	4		2		4		12

Optical Instrument Repairer		2		3					5
Electronic Measurement Equipment Mechanic				3					3
Electronics Mechanic	27	16	54	31	60	57	37	43	325
Machinist (Ordnance)					18	55			73
Fire Control Mechanic	7	7	27	8	19	26			94
Shipwright	8	11	17	21	11	18	15	16	117
Boatbuilder		1	7						8
Millman				1					1
Woodcraftsman	8	15	13	26			14	13	89
Painter	11	15	18	37	15	19	21	16	152
Electroplater			4	5			11		20
Rigger	15	34	37	63	26	44	42	20	281
Fabric Worker	8		7	8		28	6	10	67
Metal Inspector								8	8
Auto Mechanic		3	1	4					8
Heavy Mobile Equipment Mechanic	5	3	16	5		11	6		46
Heavy Duty Equipment Mechanic					8				8
Boiler Plant Operator	3		2			6	3		14

Table 4-24 (continued)

Trades	NAVAL SHIPYARDS								Totals
	PTSMH	PHILA	NORVA	CHASN	LBEACH	MARE	PUGET	PEARL	
Boiler Plant Equipment Mechanic	1			1					2
Electrical Power Controller				2			7		9
Wharf Builder			3						3
Carpenter	6			2			3		11
Instrument Mechanic	1	2		1					4
Totals	541	575	917	1,014	528	1,110	823	597	6,105

SOURCE: NAVSEA 0723

Source: Department of Defense, Coordinator of Shipbuilding, Conversion and Repair, Annual Report on the Status of the Shipbuilding and Ship Repair Industry of the United States, 1976, Report No. DD-I&L(A) 1141 (Washington: Naval Sea Systems Command, Apr. 26, 1977), Table 1-12, pp. 1-26 through 1-28.

Acquiring skills through experience alone is a slow and rather costly procedure. If an increased number of managerial professionals is required in future years, it is expected that the shipbuilding industry will forge closer ties to the educational establishment and will encourage the inclusion of management, production, personnel, and business courses in the training of marine technical professionals. Alternatively, technical professionals with experience in shipyards might be encouraged to return to school for postgraduate training, perhaps leading to the MBA degree.

STAFF AND ADMINISTRATIVE PERSONNEL

The administrative load in shipyards has increased several-fold in the last decade as a number of governmentally mandated record-keeping and reporting requirements have been imposed on the production process. Salient among these are increased requirements for personnel administration documentation to ensure compliance with Occupational Health and Safety Administration (OSHA) and Equal Employment Opportunity Commission (EEOC) regulations, the Longshoremen's and Harbor Workers' Compensation Act, labor contracts, and insurance coverage. Additionally, the use of numerous subcontractors and suppliers requires a fairly extensive contract preparation and administration function.

The skills required in these administrative, financial, and personnel functions are virtually identical to those required in similar functions in other manufacturing industries. To the extent that all U.S. manufacturing industries coexist in the same regulatory environment, all are in competition for the same supply of trained personnel. Fortunately, the schools and colleges of the country are capable of generating large numbers of personnel trained in these business and administrative skills.

The problem is basically one of communicating shipyard needs to the educational community. Shipyards might find it less economical to teach an employee basic administrative skills than to require that the employee take a university course in the subject. Large numbers of college graduate and undergraduate students never think to look for employment at a shipyard, not because the work is dirty or dangerous, but because they are unaware that their skills are applicable there.

MOTIVATION AND MORALE OF SHIPYARD WORKERS

There is little evidence that worker morale is directly related to productivity, as such, in U.S. shipyards or, in fact, in any other major segment of U.S. industry. There is a growing weight of evidence, however, that worker morale may indirectly affect productivity through such mechanisms as turnover, labor unrest, excessive sick time, grievances, and disciplinary problems.[16]

With regard to turnover, economic and opportunity factors appear to play the dominant role. It is only when factors relating to staying and leaving are almost even that morale and job satisfaction shift the balance one way or the other.

A major study of worker motivation in the shipbuilding industry, completed in 1976, concluded that shipyard workers are relatively satisfied with their jobs in comparison with other industrial workers.[17] Most workers considered their job important from both a personal and a national point of view, and achieved an identification with the product that was absent in most other industries. Although the workers found satisfaction in the content of the shipbuilding job, most were dissatisfied with the organizational structure. Most felt that management was not adequately concerned with them as persons and that they had no influence in the decisions made by the yard. Managers, they felt, were more concerned with machines than with the workers who operate them.

The greatest complaint of production workers about working conditions involved inadequate scheduling, planning, coordination and communication among crafts, shifts, and working groups in the shipyard. The second greatest source of complaints involved inadequate machines, equipment, and materials. Unsatisfactory aspects of the physical working environment proved the next major source of worker irritation. Work safety was the physical factor most often mentioned.

Wages in the shipyard were perceived as adequate, but not exceptional. Wages became increasingly motivating when they were tied to production in some form of incentive plan.

SOCIAL AND POLITICAL INFLUENCES ON SHIPYARD LABOR UTILIZATION

In shipbuilding, labor supply and demand are not linked in the usual economic sense. A ship is not a consumer item, and does not have to be built at an economic price. Thus shipbuilding can be viewed as a means of implementing a variety of governmental policies that only incidentally involve ships. A ship can be an export item for a developing nation or a major source of foreign exchange for an industrial nation. Its construction can be highly capital-intensive or more labor-intensive, and the trade-off between capital and labor can be used to solve a national or local labor supply-demand mismatch. The particular approach taken is a function of the national objectives; for a given set of policy objectives, there will be an optimal course of action. In the United States, the basic problem concerning shipbuilding policy is the requirement to maintain a shipbuilding industry, in the face of adverse shipbuilding economic conditions, adequate for the national requirements of waterborne trade and mobilization and capable, to a degree, of absorbing labor. See Chapter 2 for a more detailed discussion of the social and political influences on shipbuilding.

SHIPYARDS AS "EMPLOYERS OF LAST RESORT"

Because shipyards are labor-intensive industries deriving most of their support directly or indirectly from public funds (e.g., government contracts, construction subsidies, Naval work), they can be viewed as elements in a social policy of full employment. Shipyards near urban areas of high unemployment are well suited for this role, absorbing workers during slow periods in the local economy and releasing them when economic activity revives.

That government contracts are relatively independent of local economic conditions makes such equalization plans possible. There is considerable support for such an approach, both for social reasons and because there is evidence that providing employment subsidies in areas of high unemployment is less costly than welfare. (Public law mandates that when the closing of a federal government facility causes unemployment to exceed a specified threshold, the Economic Development Administration (EDA), U.S. Department of Commerce, shall take steps to create alternative employment. For example, EDA utilized the Seatrain shipyard--located in the former Brooklyn Navy Yard--to provide employment for workers of minimal skills.)

The record of the shipbuilding industry in providing opportunities for minority employment is impressive. The Shipbuilders Council of America reports that nearly 30 percent of the U.S. private shipyard work force is composed of minority group members, most employed as the result of federal and state mandated equal-opportunity programs. Since 1970, the number of minority workers employed in shipyards has increased by more than 75 percent and the greatest gains have been posted in black employment in urban areas of chronic unemployment. Shipbuilding employs a larger percentage of black workers than does construction, and indeed, a greater percentage of blacks than does the average of all other industries. In upper-level blue-collar jobs--craftsmen and skilled operatives--in the Mid-Atlantic, New England, and Pacific regions, the black share of positions is twice as great in shipbuilding as in either construction or the manufacturing industry average.

Factors other than the more restrictive practices of construction trade unions may account for the significantly greater percentage of black shipyard workers. The high rate of turnover in shipbuilding results in a high demand for labor regardless of race. Additionally, many major shipyards are located in the metropolitan areas of cities with large black populations, and the accessibility of shipbuilding jobs to central city residents further increases their attractiveness. Finally, age, education, and skill level apparently do not constitute a bar to entry-level shipyard employment, making such jobs feasible for young persons who lack credentials for employment in other industries.[2]

The possible use of shipyards as "employers of last resort" in high unemployment areas would have a number of implications with respect to the utilization of labor in shipyards. Larger numbers of untrained personnel, with possibly poorer work motivation, would have to be absorbed in an industry that heretofore had had a craft orientation.

If the experience in other manufacturing industries, notably the motor vehicle industry, is a guide, turnover and supervisory problems would increase. Lower skill levels would require a realignment of ship construction skills, and tasks would have to be structured for skills learned after shortened training periods. Technology would be used as a skills supplement, the judicious use of technically sophisticated but operationally simple equipment making possible the employment of marginally trained workers.

A lowering of the average skill level of the shipyard worker would, of necessity, change the way the shipyard labor force is organized. A heavy additional load would be imposed upon engineering and supervisory personnel. Tasks would have to be delineated in far greater detail since the typical worker might not have a broad experiential background upon which to draw. This does not necessarily mean that the ship itself would have to be less sophisticated, but rather that construction would have to be divided into simpler modules, with closer supervisory control at all steps in construction.

An example of this approach already being employed in some shipyards is the design of ship modules that permit fabrication largely with downhand welding. A downhand welder can be trained in a fraction of the time required to train a welder who can weld a good overhead seam. The additional design effort required to permit downhand welding often pays off in the reduction of the skill level required to fabricate the module (as well as in reduced man-hour requirements and improved quality of the finished product).

The additional design effort, supervision, and quality control requirements inherent in this type of construction will require an increase in the number of supervisory, technical, and administrative personnel as task responsibilities are transferred from blue collar workers to management. The simultaneous increase in the numbers of lesser skilled workers and of supervisory, technical, and administrative personnel and the decrease in the numbers of skilled workers and craftsmen will tend to bring the employment distribution in the shipyards more into line with those in other manufacturing industries.

ADVANCING TECHNOLOGY AND THE UTILIZATION OF LABOR IN SHIPYARDS

Advances in shipbuilding technology are likely to have a significant influence on labor use in shipyards. Although changes in ship design and in materials may well require some modification of the skills used in shipbuilding, the most significant impact on personnel utilization is likely to arise from changes in the technology of ship production.

The trend toward purchase and subcontractor installation of ship components may well reduce the variety of skills required in the shipyard, at the expense of increasing the burden on engineering and middle-management personnel. Scheduling and coordination of activities of the specialist firms, from initial specification through delivery to installation and test of the equipment, will require more personnel in these categories.

The heavy reliance on vendors may have a side benefit in that it places the burden of learning new ship component equipment technology upon the vendor rather than upon the shipyard. Since the pace of technological change is increasingly rapid, particularly in areas of shipbuilding other than hull construction, shipyards will not be faced with the problem of maintaining an aging work force of increasingly obsolescent skills.

Production technology--although sometimes evaluated in terms of cost savings, direct or indirect (e.g., pollution control, safety), or of increasing the size, quality, or fabrication rate of the product--is usually considered as a way of reducing the labor component of shipbuilding by reducing the absolute number of workers or the average skill level. Capital expenditure on high-technology production equipment is rarely made for its own virtue but rather is dictated by anticipation of a favorable cost-benefit ratio. The Japanese yards that have invested heavily in specialized series-production equipment have done so to decrease the labor component in shipbuilding to approximately half that of U.S. yards, and thus to lower significantly the delivered cost of ships.

Whatever the reason for adoption, technological advances in ship production usually involve mechanizing some human functions with a consequent change in the labor skill mix required in the shipyard. Human muscular, perceptual, control, and decision-making functions are all suitable candidates for mechanization. The criteria for choosing the functions to be mechanized are complex, involving the availability of the skills necessary to implement those functions in the labor supply, the training lag for specific skills, safety factors, social and political considerations, labor peace, and--not least important--technical feasibility. As technology evolves, this last criterion becomes less restrictive. At the moment it is possible to provide mechanical or electronic replacements for a large proportion of the human activities involved in shipbuilding. Table 4-25 describes the state of the art in mechanizing certain work-related human capabilities, as of 1978.

It should be noted that the technological ability to substitute machines for people is not commensurate with the distribution of skills in the general labor force. In highly automated manufacturing processes (e.g., automobile production), machines displace the middle skill levels (production machinists, welders, painters)--not the low levels (laborers, material handlers) or high levels (engineers, management). The same appears true of shipyards: machines replace or reduce requirements for middle skill levels (e.g., welders--the most common shipyard job), but not the sledgehammer wielder or the naval architect.

One concomitant to the increase in production technology in shipyards is the requirement for a class of skilled workers and technicians who will occupy a critical position in the production process. These repairmen, installers, and programmers will be required in smaller numbers than the craftsmen they replace but they will be no less important to the production process. The key problem in the transition of production technology to the shipyard may well be the availability and relative costs of training such personnel. Clearly there is no advantage from the shipyard's point of view if the increase in technical staff costs is greater than the savings realized from lowering the overall personnel skill level in the yard.

The problem is basically transitional since, judging from experience in other industries, the amount and degree of support required by high technology production equipment decreases as the equipment is refined and as operating personnel become more familiar with its use. The primary danger is that temporary solutions to problems in shipyards have a habit of becoming permanent practices as one craft or another defines the new job requirements as within its area of jurisdiction.

But while technology can be used to replace people in the production process, it also can be used to amplify the capabilities of workers who, unassisted, would not be able to meet the requirements of a given job. Assume, for the moment, the hypothesis that shipyards are under an obligation to serve as employers of undertrained workers. They will then need to be in a position to use modern production technology to substitute for skills previously acquired through long apprenticeship. Thus, while the investment in a fully automatic panel welding line would be one possible substitute for a shortage of skilled welders, an alternative, both socially and financially more desirable, might be to equip novice welders with apparatus which need only be guided by the operator to produce a perfect weld. This composite hypothetical man-machine system would offer the advantage of using human capabilities in an area difficult to mechanize (flexible physical mobility, pattern recognition) while electronically supplementing training in an area relatively easy to mechanize (precise control of repetitive operations). With the cost of electronic intelligence (microcomputers, power control circuitry) dropping at a rate of nearly 30 percent per year, providing such a skill supplement to shipyard workers may make it possible to lower the average skill level required in ship construction and thus successfully use less-trained workers. In this manner, the labor cost of shipbuilding might well be reduced, while the heavy investment in capital equipment could be avoided, and shipyards could fulfill any mandated employment obligations.

Table 4-25

EASE OF MECHANIZATION OF WORK-RELATED HUMAN CAPABILITIES, "STATE OF THE ART"

Human Capability	Ease of Mechanization	Typical Industrial Jobs
1. Simple physical capability.	1. Very easy mechanization. Largely complete in industries where economically justified.	1. Laborer, material handler, track worker, farm hand, janitorial work, stoker.
2. Basic perceptual/motor capability (sensing and positioning of objects).	2. Easy to moderate in the case of repetitive activities.	2. Simple assembly jobs, basic machine work, simple welding.
3. Complex perceptual/motor capability (pattern recognition, information transformation, language).	3. Very difficult, except in the case of simple monotonic functions or tasks. Slow progress in this area to date.	3. Driving, typing and keypunching, office work, complex assembly, complex machine shop work, most craft work.
4. Deterministic decision making (logical decisions, calculations, most mathematics).	4. Very easy mechanization.	4. Computation tasks, listing, bookkeeping, financial and accounting clerical work, storage and retrieval of information.
5. Probabilistic decision making (ambiguity or judgment required on one or more criteria).	5. Moderately difficult. Significant progress in recent years. The difficulties are conceptual rather than technical.	5. Decision-making aspects of most supervisory, managerial, and personnel-related jobs. Estimating, forecasting, etc.
6. Synthesis, creativity.	6. Very difficult.	6. Planning, designing, sales, some management activities, some craft-related activities.

NOTES

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5 Statistical Quarterly (Washington: Shipbuilders Council of America), 4th Quarter, 1978.

6 Department of the Navy, Office of the Assistant Secretary of the Navy (Manpower, Reserve Affairs, and Logistics), Naval Ship Procurement Process Study: Final Report (Washington: July 1978), p. 21.

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Chapter 5

FACTORS AFFECTING CURRENT SHIPYARD OPERATIONS

In the complex environment in which shipbuilding takes place, the many factors that can and do affect the adoption and utilization of advanced technology have both predictable and uncertain effects upon the employment of shipyard personnel.

This chapter examines some of these effects, with special emphasis upon those judged to be of greatest relevance to the employment and welfare of shipyard personel. In the following sections the economics of the shipbuilding market are noted, non-technical and socially oriented regulations are summarized, and shipyard product regulation is treated. Market factors directly affect the kinds and numbers of shipyard personnel employed and the kinds of jobs that must be performed to manufacture the product. Less directly, but significantly, market factors influence the kind of training and advancement opportunities for shipyard personnel. Shipyard work, like that in most other heavy industries, is potentially hazardous. Heavy machinery and materials, high noise levels, and air laden with solid material require safety equipment and procedures. In recent years legislation has been enacted to improve health and safety conditions in shipyards and to ensure equal employment opportunity. Technical regulations that directly affect the product are discussed, although their effects on the numbers and kinds of personnel and the environment in which they work are less obvious. Finally, matters of workers' compensation and product liability receive brief treatment.

MARKET FACTORS

As with any competitive industry, a major influence on shipyard operation is the availability of business. For U.S. yards today, world shipbuilding market conditions are not of major importance. What _is_ important is that U.S. shipbuilders' business opportunities are strongly affected by the federal budget. Because both Naval shipbuilding and subsidized merchant ship construction appropriations are subject to year-by-year variation, the industry's ability to make long-term business predictions is, at best, tenuous.

Inability to quantify and qualify the marketplace of the future is the second major factor affecting U.S. yards. Although the statement is less true than 15 years ago, U.S. shipbuilding remains a labor-intensive industry. The ability to return the investment in automated equipment, through savings, is so unstable that shipyard management has difficulty in justifying long-term investment in capital equipment to its stockholders and financial sources.

A third factor that tends to restrict using capital for labor-saving and automated equipment in U.S. shipyards results from a combination of the two factors mentioned above. When a major portion of the federal budget goes to military vessels, a work-mix profile results that tends to require a larger proportion of installation trades (e.g., electricians, pipefitters, machinists). Military vessel construction demands mechanics of a high level of skill. Therefore, the workers in the installation trades must have spent the equivalent of a reasonable apprenticeship to perform the demands placed upon them. A trade mix in a yard constructing military vessels may be 70 percent installation and 30 percent steel trades with a similar mix of supporting white-collar personnel. If the next program receiving the attention of the government happens to be commercial, such as tankers or ore/bulk/oil carriers (OBOs), an entirely different work-mix profile is required. A tanker may require 70 to 80 percent steel trades (welders, shipfitters, riggers, painters) and 20 to 30 percent installation trades. As a result, the yard is hiring certain trades and laying off other trades concurrently. Having numbers of skilled mechanics alone does not suffice. Management must have the work-mix to meet the requirements of the product. The tendency of each U.S. ship to be a job-shop operation compounds the severity and the limitations of an indefinite market.

In summary, the indefinite nature of the market inhibits prudent capital investment, with few exceptions. This ties shipbuilders to a job-shop trade environment that is whipsawed between demands of military programs and those of alternative commercial programs. As shipyard management sees it, this further inhibits capital investment and creates hiring and training problems; and that further limits the availability of capital and brings into question the wisdom of investment.

Forecasts of the workload for private shipyards were presented earlier (see Figures 2-3 and 2-4).

INDEPENDENT REGULATORY AGENCIES AND THE ADMINISTRATION OF SHIPYARDS

The maritime industry comes under the jurisdiction of a number of federal and state regulations that influence shipyard employment patterns and work practices. Brief mention of the agencies that implement three such government programs follows, together with some of the manpower implications.

Occupational Safety and Health Administration (OSHA)

An agency of the Department of Labor, OSHA issues occupational safety and health standards and related regulations; conducts investigations and inspections to ensure compliance; and issues citations for noncompliance. Its marine jurisdiction covers workers engaged in longshoring, shipbuilding and repairing, and related employment. Many standards and codes, originally developed by consensus for voluntary industry use, have been incorporated by reference into OSHA's voluminous regulations, so that compliance has become legally enforceable. The OSHA standards applicable to shipyard operations are found in Title 29 of the Code of Federal Regulations. Parts 1915 through 1918 include Safety and Health Regulations for Ship Repairing, Shipbuilding, Shipbreaking, and Longshoring, respectively; and Part 1919 covers Gear Certification. Scaffolds, ladders, rigging gear and equipment, and personal protective equipment are some of the workplace appurtenances covered by OSHA standards. However, while OSHA does have jurisdiction over the ship construction and ship repairing process, the ship's installed machinery, piping systems, and electrical machinery are under Coast Guard jurisdiction on vessels that are required to be certificated.

OSHA compliance officers may inspect at any time, are required by statute to investigate all employee complaints, and also are required to conduct a thorough compliance inspection at each visit. All violations noted result in citations and, most probably, a monetary penalty for each violation.

States, and most cities, also have health and safety regulations, compliance with which is enforced by state or city personnel.

OSHA regulations affect almost every activity in shipyard and marine terminal operations. These effects are most important to personnel responsible for equipment certification, company training for inspectors, safety training for employees, work procedures and equipment inspection, health equipment use, and administrative record-keeping.

Environmental Protection Agency (EPA)

The goal of the EPA is to ensure protection of the environment by the systematic abatement and control of pollution. It develops and enforces environmental quality standards, with emphasis on air and water quality. It is charged with making public its written comments on environmental impact statements, and with publishing its determinations where these hold that a proposal is unsatisfactory from the standpoint of public health or environmental quality. The EPA also conducts research, monitoring, and technical assistance in such areas as the safety and effectiveness of pesticides and advanced technology for solid-waste disposal.

Inasmuch as shipyards are onshore facilities located along the navigable waters of the United States and use polluting substances such as oil and acid, they come under the regulatory umbrella of the EPA. Simply stated, if the shipyard activity adversely affects the neighborhood, EPA can become involved. The basic authority for EPA's pollution prevention regulations is the Federal Water Pollution Control Act (33 USC 1251 et seq.). Under this authority the EPA has promulgated regulations concerning pollution substances, discharge permits, discharge monitoring, pollution prevention equipment, spill reporting, spill clean-up, noise pollution, sand and grit discharges, and civil penalties.

EPA regulations that most concern shipyards are found in Title 40 of the Code of Federal Regulations, Subchapter N, "Efficient Guidelines and Standards," and Subchapter D, "Water Programs," part 112, "Oil Pollution Prevention."

These regulations may require shipyards to: (a) purchase and maintain monitoring equipment, (b) purchase and maintain pollution control equipment, (c) obtain necessary permits, (d) clean up or contract for clean-up of spills, (e) train personnel to accomplish all the above, and (f) pay monetary penalties, if assessed.

Compliance with EPA standards--as with the OSHA regulations--requires an investment by the shipyard that affects profits or product cost.

For a shipyard of any size to comply with OSHA standards, trained personnel must be assigned to checking equipment and workplaces, as well as handling the required reports and associated paperwork.

Equal Employment Opportunity

Except for some small shipbuilding facilities, all shipyards doing work for the federal government must comply with federal statutes on equal opportunity. Fair employment is not seen as a problem in shipbuilding, especially for entry-level jobs. A second step--advancement of minorities and women into upper management levels within the blue-collar and the white-collar work forces--has been a much more difficult matter. Minority professional graduates of colleges and universities have been relatively few; and direct shipyard recruiting on college campuses, although focused heavily on recruitment of minorities and women in recent years, has generally been done only by some of the larger yards. In addition, shipyards have been no more attractive an employer for them than for professional white males. Shipyards have had to create programs to produce their own supervisory candidates and professionals, and additional training programs will be needed.

The proportion of minority professional graduates, is, however, increasing. The National Academy of Engineering's Committee on Minorities in Engineering (CME) coordinates a national effort to increase minority participation in engineering. Most of the CME's financial support is provided through the National Advisory Council on Minorities in Engineering (NACME), formed in 1973. Through a combination of local and regional university, industry, and community-based programs, the minority percentage of total full-time undergraduate engineering enrollment has nearly doubled over the past five years (from 4.6 percent in 1973 to 8.8 percent in 1978). The percentage of minority engineering graduates increased from 3.5 to 4.3 percent over the same period. This effort, whose goal is to increase minority enrollment to 18 percent by the mid-1980s, has the support of many technical and professional organizations, including the Society of Naval Architects and Marine Engineers.

Equal opportunity programs within the shipbuilding industry have also increased employment of females and the handicapped. The number of blue-collar female employees has increased across all trade disciplines. In some of the facilities, as many as 10 percent of the blue-collar workers are female; in others, as few as 1 percent. Increased training and employment of females in blue-collar jobs could have a major influence on the facilities required and on the construction sequence. For one thing, shipyard administrators report that the percentage of female applicants qualified and willing to work on platforms and limited-access staging is substantially lower than that for male applicants. Training and experience should ameliorate unfavorable attitudes. Performance of heavier work, as in fabrication and joining of sub-assemblies, has been less socially acceptable for females, historically. Further increase in the use of machines to provide the force for heavy lifting and moving, and increased visibility and experience for women in such jobs, can serve to decrease the number of jobs for which physical demands favor male employees.

As to the physically handicapped and people with drug and alcohol problems, shipyards are seriously concerned about employing them because of the nature of the work environment. Working at height, the need for strength, and the need for careful judgments about work are characteristic of ship construction labor. There are some exceptions, of course, and handicapped persons can be usefully and safely employed in some jobs.

The cost of educational facilities for upgrading people, the cost of separate facilities for female workers, and the increased cost within industrial relations organizations of the shipyards have not resulted in a significant increase in the cost of the ships.

PRODUCTION REGULATION

There are federal and professional controls on the maritime industry that indirectly affect shipyard personnel. By and large, this impact is in training and safety areas. Several organizations charged with exercising these controls will be briefly recognized.

Coast Guard Regulations

While the federal regulations they enforce only indirectly affect shipyard personnel, the Coast Guard has important regulatory functions in the shipbuilding industry. The Coast Guard approves design standards for vessel construction to ensure vessel seaworthiness, crew safety, and environmental protection.

The Coast Guard accomplishes this task through marine inspection officers assigned to shipyards for the period of construction. Designs are first approved by one of four Coast Guard technical field offices. The Marine Inspection Officers work from the approved plans and inspect to ensure that all stages of ship construction are in compliance with the plans. The Marine Inspection Officers witness pre-operational testing and finally authorize issuance of a "Certificate of Inspection," required by law before a steam vessel is placed in service.

After a vessel is placed in service, other Coast Guard inspection requirements continue throughout the life of the ship. These include periodic drydock inspections, special inspections, and annual inspections, most of which are accomplished in shipyards. Generally speaking, the marine industry looks upon the Coast Guard as a competent technical organization that is performing a difficult job as well as any other governmental agency could.

The Coast Guard also has pollution control enforcement functions that affect with shipyards. The recent National Environmental Protection Act and the Ports and Waterways Safety Act empower the Coast Guard to regulate as necessary to prevent and control oil pollution originating from shipyards, ships while in shipyards, and ships in general. For this Coast Guard role, regulation is still not well developed. New rules and regulations are postulated that have a potential multibillion-dollar impact. Further, the costs and benefits of regulatory changes have not always been thoroughly analyzed before the changes were issued.

American Bureau of Shipping (ABS) Rules

The ABS is the U.S. vessel classification society. In its primary function of certifying the soundness and seaworthiness of merchant vessels, it is the ABS' responsibility to verify that submitted plans adhere to accepted standards for construction of hull and machinery embodied in its Rules.

The ABS Rules are internationally recognized, and ABS certification is generally accepted by the Coast Guard as evidence of compliance with certain of its regulations. To remain "in class," vessels must be recertified periodically, as well as when converted or when major repairs are necessitated by a marine casualty. Original, periodic, and damage surveys are conducted by ABS surveyors, based in major U.S. and foreign ports.

Shipbuilders or owners are charged fees for the classification service, which, although not a legal requirement, offers considerable benefits. It helps protect the builder and owner against legal liability arising from marine casualties, helps the insurance underwriter determine the nature and degree of risk (thus making it easier for the owner to obtain coverage and possibly lowering the premiums), and reassures shippers that they are not unduly risking their goods by utilizing that particular vessel.

Traditionally, the ABS has relied upon applying the empirical factors codified in its Rules. However, increasingly over the past 20 years, evaluating technological innovations has necessitated the use of other, supplemental methods, such as finite-element analysis, vessel instrumentation, and model testing, with increasing reliance on electronic data processing. Continuous revision and updating of the Rules are required; the ABS publishes not only semi-monthly supplements but also special daily reports.

Other Regulatory Agencies

In addition to the Coast Guard, a number of federal agencies (e.g., U.S. Public Health Service, Federal Communications Commission) have regulatory authority over various aspects of shipbuilding, conversion, and repair. However, compared with Coast Guard regulations, their regulations have only modest manpower implications.

INSURANCE AND LIABILITY

Of the major factors affecting shipyard operations, matters of insurance and liability, while of great importance to the industry, are of lesser direct effect upon shipyard personnel. Insofar as these matters adversely influence shipyard operations and cause jobs to be lost, of course, they are important to personnel working in the yards. Insurance, workers' compensation, and product liability are topics deserving a summary treatment.

Longshoremen's and Harbor Workers' Compensation Act

Workers' compensation has become one of the most serious regulatory problems confronting shipyards, both large and small. Liabilities under the Longshoremen's and Harbor Workers' Compensation Act (LHWCA), administered by the U.S. Department of Labor, are essentially uninsurable. This is because there are no maximums specified for certain categories of claims and because the 1972 amendments extended federal jurisdiction from the water's edge to undefined land areas concurrently considered by many to be under the jurisdiction of the various state workers' compensation laws. The lack of definition in the "situs" of an injury and "status" of workers considered to be engaged in "maritime" employment under the LHWCA creates an open-ended liabliity for insurers. Consequently, the insurance industry has almost totally stopped writing insurance for shipyards and other industries covered by the LHWCA. It has become necessary for shipyards to become self-insured or go out of business.

The cost impact of the LHWCA is difficult to project because of the long-term nature of certain workers' compensation benefits, which carry escalation factors related to increases in the cost of living. The Shipbuilders Council of America estimates that the cost of

Workers' Compensation incurred by its members increased approximately 400 percent from 1972 to 1976. The combined cost of benefits, medical expenses, reserves against future liabilities, litigation costs, and the costs of medical, safety, and administrative overhead constitutes a financial obligation that can affect the number of jobs available. In fact, some smaller companies have already been forced to go out of business.

Maritime Product Liability

Until recently, upon delivery of a ship, the shipyard's builders' risk insurance coverage terminated, the shipowner's liablity insurance coverage took effect, and the liability of the shipyard and of its vendors was limited to replacement cost of omitted or defective parts. A 1975 court decision held that the standard contract clause, used for decades by the Maritime Administration and industry, did not preclude subsequent recovery of larger consequential damages.

At present, the implications of this decision are uncertain. The impact upon shipbuilding personnel depends upon outcomes of specific suits.

CONCLUSION

In this chapter, a variety of factors external to the actual operations of building ships have been discussed. These factors include the market for U.S.-built ships and certain rules and regulations bearing upon maritime operations. The employment, training, health, and safety of shipyard personnel are involved, for clearly such factors affect the number and kinds of shipyard jobs, the nature of the work performed, the mix of skills required, the layout of work areas, the health and safety equipment required, equal opportunity for employment, and compensation for job-related injuries and health problems. While the shipyard environment is complex in economic, political, and social terms, it is concluded that such factors do not bear heavily and directly upon the influence of advanced technology on the men and women who build ships and other maritime products.

Chapter 6

IMPACT OF ADVANCED TECHNOLOGY ON SHIPYARD PERSONNEL

Earlier chapters of this report have dealt with the nature and status of the shipbuilding industry, the demography of shipyard manpower, the environment (economic, political, and social) in which the industry operates, and shipbuilding technology. How will the industry's manpower be affected by advanced technology during the next 15 years?

The occupations of interest have been constrainted to only those skilled occupations that (a) are unique to the shipbuilding industry or (b) are employed in substantial numbers by the industry. In the former category are such trades as shipwright, loftsman, and marine machinist; in the latter are such as welder, shipfitter, machinist, electrician, and pipefitter.

Mid-level managerial shipyard positions also were included in the scope of the study--positions involving planning, scheduling, coordinating, production technology, and general supervisory skills.

One assumption was made about the manpower pool. The variation that is likely to occur in the aptitudes, special skills, and motivation of the manpower pool will not be sufficiently great to influence the forecast this report offers.

Two final assumptions were made. Future ships and offshore platforms can be expected to be increasingly sophisticated. Further, production technology also will advance. This will be true for both naval and commercial vessels.

Any forecast of the impact of advanced technology upon industry manpower requirements must necessarily be based upon assumptions about national objectives and future economic circumstances that can affect the industry. Three business scenarios were considered: (a) a continued decrease in predicted business; (b) a "steady state," involving no major changes from today's level of business; and (c) an optimistic forecast of improved business. The Committee approached its assigned task, however, so as to de-emphasize business factors in order to permit conclusions that are relatively independent of future shipyard workloads.

SHIPYARD MANPOWER

As emphasized in Chapter 4, the shipbuilding industry is labor-intensive, with labor costs representing half of the direct finished product cost and up to 70 to 85 percent of value added. Moreover, that product is very frequently a customized product. Individually considered, the tasks required to build a ship are not complex. Yet their number and variety have required development of high-skill and lengthy training periods.

While several other shipbuilding nations have substituted capital equipment for labor to a markedly greater degree, U.S. shipbuilders have opted for a more labor-intensive process. Shipyard employment tends to vary proportionally with changes in governmental work and subsidy payments, with trade mix, and with mix of general and special equipment.

Shipyard jobs are largely (about 85 percent) in the blue-collar category. Basically, shipbuilding (and repair) is a craft-oriented industry and rather similar to the construction industry in the predominant roles unions play, rigor of working conditions, labor intensiveness, and high-cost product.

While there are a half dozen or so jobs that are specific to shipbuilding (e.g., loftsman, shipwright, marine machinist, marine draftsman, and, to a limited extent, rigger), the vast majority of production jobs found in shipyards have close counterparts in other industries, and have similar training and skill requirements.

The mix of typical shipyard jobs with which this report deals (e.g., welder, shipfitter, machinist, electrician, and pipefitter) and other occupations varies as a function of the shipyard task. Labor shortages develop and surpluses occur as a function of such factors as competition for the workers, fluctuating demand, and mobility in the labor market. Educational level, however, is no barrier to entry-level employment in private shipyards.

Not surprisingly, the overall turnover rate is high, but it is comparable to those of other heavy manufacturing industries. It is surprising, however, that the turnover rate in private shipyards is also high among older workers.

The declared U.S. policy to maintain the shipbuilding industry and to provide direct and indirect support from public funds can lead to viewing shipyards as an element in social policy. Shipyard employment can contribute to the local economy in difficult times, and industry experiences support the employment of unskilled workers.

GOVERNMENTAL REGULATIONS

Government regulations affect many aspects of shipyard operation. These include financial reporting, occupational safety and health, and environmental protection. Two factors of considerable significance to a labor-intensive industry typified by rigorous working conditions are Occupational Safety and Health Administration (OSHA) standards and workers' compensation laws. These regulations will affect the physical environment of the shipyard. Insofar as they result in new and changed production procedures, they will affect the training and skill requirements of the production worker.

ADVANCED TECHNOLOGY

Manufacturing technology will continue to change in the next decade. In Chapter 3, such manufacturing changes as pre-outfitting, standardization of major ships' parts, modular construction, shipyard specialization, and use of specialized contractors were discussed as part of the industry's effort to reduce costs and improve productivity. In addition, important changes in production have taken place because of the use of more sophisticated management information systems (MIS), computer graphics and lofting, numerical control, laser welding technology, and new construction materials. Such changes in manufacturing technology will have an effect upon the content of training programs. This is particularly true for shipyard managerial positions, but blue-collar workers also must receive training in new production technology.

Construction techniques that will be more widely adopted and exploited include simplification of material flow, greater use of mechanization, unit assemblies for machinery and prepackaged quarters modules, computer lofting and computer graphics, and standardization of equipment and structure. Prestressed concrete, stainless steel, ferro-cement, fiberglass-reinforced plastics, and enhanced coatings--all construction materials in use today--will find wider use.

What are the implications of advanced technology for shipyard personnel? The following are anticipated:

1. Changes in manufacturing technology may require changes in training program content (e.g., the use of MIS, production control, and quality control).

2. In response to shortages and turnover of skilled workers, coupled with economic pressures to increase productivity, the industry already is shifting from the craft approach, requiring broad knowledge on the part of skilled craftsmen, to the manufacturing approach, embodying changed concepts of work organization and work flow. It should be noted that educational level has not posed a barrier to entry-level employment in private shipyards.

3. Under the manufacturing approach, an increase in the number of operatives increases the requirement for specialized technologists (although not, of course, on a one-for-one replacement basis). The technologists maintain equipment used by the operatives, and perform such tasks as quality control and production planning.

4. Repair and overhaul work continues to grow in sophistication, requiring increased reliance on vendor's personnel. Shipyards will depend more and more on vendors to provide new skills and to undertake initial training in the use and maintenance of new equipment by shipyard personnel and in the mastery of new manufacturing techniques. Re-fitting ships with new equipment also will require heavy reliance on vendors. It may not be cost-effective for shipyards to develop and maintain all the new skills required by new equipment and techniques. Some specialized technologists will be needed to interpret vendor installation requirements for equipment, to assure shipyard readiness to install equipment when the vendor personnel arrive.

5. Product line specialization can be expected to continue and possibly even increase. This will require that training of shipyard personnel be more intensive but span a relatively limited range.

6. The increasing complexity of ships, naval and commercial, will demand increasingly more effective planning and scheduling by operating managers. The days of elevating a mechanic to a planner or scheduler through on-the-job training alone are coming to an end. Extensive formal education and training in planning, scheduling, and control of work will be required of both upgraded mechanics and non-mechanic personnel. These functions are becoming increasingly important as shipbuilding and ship repair become increasingly more complex.

SHIPYARD MANPOWER NEEDS IN THE NEXT 15 YEARS

Given the moderate changes anticipated in the size and nature of the pool of general labor force over the next 15 years, and continuing improvement of shipyard management, at least four manpower trends might be expected:

1. Work reorganization will continue to respond to changing employment patterns and the retirement of skilled workers. Tasks will be delineated in greater detail, and fewer tasks will be combined to form the complex skilled jobs of the future. Training periods will be shortened.

2. Supervision and management will encompass more elaborate planning, involving both the greater use of equipment and mastery of management techniques. Training for shipyard management will have to cover skills in business administration in addition to shipbuilding technology and marine engineering.

3. High-technology specialists will come primarily from vendors who provide major ship equipment assemblies and new equipment adopted for shipyard use in assembly operations. These vendors, especially those who have contracted with the yards for new equipment, also will be a major source of training for shipyard operations.

4. Mechanization of shipyard processes can be expected to have an impact on manpower skill requirements for both shipbuilding and non-ship work.

Thus, the economic implications of new shipyard equipment and facilities may require careful study. Shipyards are not likely to achieve a scale of operation adequate for efficiency without agressively seeking employment for their facilities and capabilities. The economic sizing of the facility may depend on the level of marketing activities that the owner is willing to undertake.

Furthermore, because equipment breakdowns in a flow line can hamper production, automated equipment must be restored to service quickly. This requires specially trained maintenance personnel on the spot or quickly available. These can be shipyard or vendor personnel. The decision about which to use must be made at each shipyard, based on response times required and total equipment maintenance and repair demands anticipated.

CONCLUDING STATEMENT

The overall conclusion of this study is that the technological changes likely to occur in ship design and ship production in the next 15 years will not require significant changes in the nature of shipyard manpower characteristics or training requirements. The changes that will occur will evolve from the natural aging of the labor force. The gradual introduction of new production technology will be accommodated in due course in response to social, economic, and market conditions.

Appendix A

CONTRIBUTORS

The following made significant contributions to the Committee's work:

Raymond L. Agent
President
Personnel Services, Inc.
Wilmington, Delaware

George T. Buckley
Vice President
Marsh & McClennan
New York, New York

Joseph Cox
Maritime Advocacy Group
Office of Standards Development
Occupational Safety and Health Administration
Washington, D.C.

John L. Foley
Vice President
American Bureau of Shipping
New York, New York

Barney Heaps
Director of Planning
Seatrain Shipbuilding Corporation
Brooklyn, New York

Latimer T. Young
Industrial Specialist
Division of Production
Office of Ship Construction
Maritime Administration
Washington, D.C.

Appendix B

GLOSSARY

Downhand Welding--positioning the weld in the horizontal plane, so that the puddle of weld metal is positioned by gravity. Use of this welding technique requires less training and acquired skill than do vertical and overhead welding.

Enhanced Coatings--protective finishes, generally of higher quality than paints. Some are designed to protect against impact and abrasion, as well as corrosion; others provide special surface features (e.g., self-polishing yacht coatings and self-polishing anti-foulant coatings).

Fairing--a manual or mathematical process of verifying that the three dimensional coordinates of each specified point on a ship's hull define a single point, and that the points are aligned in specified mathematical relationship to the surrounding points.

Ferro-Cement--a composite material consisting of closely spaced, multiple layers of steel mesh completely impregnated with cement mortar (a thick paste of Portland cement and sand). Although a form of concrete, it differs significantly from conventional reinforced concrete, both in ease of fabrication and in structural properties. Ferro-cement can be formed into sections less than 25 mm (1 in.) thick; and it can be assembled over a light framework into the final desired shape and mortared directly in place, even upside down, without the use of forms. Its use makes it possible for form compounded shapes with simple techniques, inexpensive materials, and, if necessary, unskilled (but properly supervised) labor. Thin ferro-cement panels can be designed to high levels of strain and deformation, far beyond the limits of reinforced concrete, with complete structural integrity and watertightness.

Field Adjustments--trimming and fitting assemblies together.

Fitting-Out--the process of provisioning a ship, usually after delivery, with all necessary disposable items (e.g., food, medical supplies, charts).

LASH (Lighter-Aboard-SHip)--a system in which fully loaded barges (lighters) are lifted aboard and transported by oceangoing ship.

LNG Carrier--a ship designed to carry liquefied natural gas (LNG). The LNG (a mixture of methane and ethane) is transported at very low temperature (below -161°C, or -258 °F), occupying only about 1/600 of the volume it takes up as a gas.

Lofting--the process of transferring the design of a vessel, in the form of specific layout and dimensions, to the shipbuilding materials. Lofting involves describing the shape of the vessel's hull by dimensioning from three basic reference planes.

LPG Carrier--a ship designed to carry liquefied petroleum gas (LPG). The LPG (a mixture of butane and propane) may be transported at ambient temperatures, under pressure; but, in larger volumes, it is transported under extreme refrigeration (below -55°C, or -67°F).

Manufacturing Technology (MT)--"the development and implementation of new techniques, processes, or equipment for producing goods or rendering services, where the following terminology is specified:

"Development is the generation of heretofore non-existent production capability, the enhancement of an existing capability by a real change, or the adaptation of an existing capability to new uses. Capability is the ability to produce an item and is distinguished from capacity which is the rate at which a capability can be sustained.

"Producing is an effort which has as its goal the creation, alteration, or overhaul of end items, components, or materials, or the rendering of related services. Producing includes direct processing of the produced item but also applies to indirect operations such as management control systems, materials handling systems, computer aids to manufacturing, group technology, development of engineering data in support of production processes, testing, and all other aspects of new production, overhaul, or remanufacture.

"Goods are materials, components, subassemblies, systems or any material end products which require the application of money, manpower, or equipment to produce.

"Services are any end products other than goods, and refer to such functions as testing, demilitarizing, transporting, management systems, etc."

[Source: Commander, Naval Sea Systems Command, "Navy Five Year Manufacturing Technology (MT) Program; request for proposals", memorandum dated Aug. 3, 1978, Enclosure 1.]

Mechanization--the performance by equipment of work previously done by people, or the substitution of equipment for people in the performance of work.

Modular Construction--a method by which a ship is divided into significant structural units (modules; e.g., bow, stern, deck house, machinery space) that are built and outfitted off location and erected essentially complete.

Nesting--arranging parts to be cut from a steel plate so as to minimize scrap.

Numerical Control (NC) Technology--the use of machinery, controlled by signals recorded on tapes, discs, etc., that facilitates the machining of complex configurations or the repeated machining of items, and also provides ease of modification in machining instructions.

Outfitting--the process of adding non-structural and non-propulsion items to a ship (e.g., electrical and piping systems, sheet metal and joiner work, paint). This should be distinguished from Fitting-Out (defined above).

Pre-Outfitting--the installation of pipe, cable, ventilation equipment, foundations, and components within a structural unit or structural module prior to erection.

Value Added--the total expenditures for factors of production, excluding raw materials, and including depreciation. The share of value added going to labor is represented by the ratio of wages and salaries paid to employees to the total expenditures for all factors of production. The larger this ratio, the more labor-intensive an industry is--i.e., the higher is the proportion of final product costs that labor represents.

Appendix C

SHIPYARD JOB DESCRIPTIONS, PRIVATE YARDS, WITH TRAINING TIMES FOR JOURNEYMAN ENTRY RATINGS

This appendix supplements Chapter 4. It includes selected job descriptions and associated apprenticeship training times. These were extracted, verbatim, from a more comprehensive set of job descriptions developed by the Shipbuilders Council of America.

The 10 selected jobs, listed in order of the percentage of private shipyard production workers employed in each, are:

1) Welder (Combination)

2) Shipfitter

3) Machinist

4) Electrician

5) Pipefitter

6) Rigger

7) Flame Cutter (Burner)

8) Crane Operator

9) Marine Draftsman

10) Shipwright

For comparison, U.S. Coast Guard shipyard "Position Descriptions" and U.S. Civil Service classificaiton standards are given in Appendixes D and E, respectively, for the two most common shipyard production jobs: Welder and Shipfitter.

(1) WELDER, COMBINATION

WELDER, COMBINATION (welding) 812.884. Welds metal parts together, according to layouts, blueprints, or work orders, using both gas welding (WELDER, GAS) or brazing (BRAZER-ASSEMBLER) and any combination of arc welding processes (WELDER, ARC; WELDER, ATOMIC; WELDER, GAS-SHIELDED ARC; WELDER, HAND; SUBMERGED ARC). Performs related tasks, such as flame cutting and grinding. May repair broken or cracked parts, fill holes, and increase size of metal parts. May position and clamp together components of fabricated metal products preparatory to welding, but does not perform layout, fitting, and aligning as described under WELDER-FITTER.

WELDER, REPAIR (welding) maintenance welder. Repairs worn or damaged machined, fabricated, cast, forged, or welded parts as specified by sketches, diagrams, or sample parts, using arc or gas welding equipment. Examines workpiece and measures dimensions for conformance to specifications, using tape, rule, or square. Tests workpiece for defects, using magnetic testing machine (INSPECTOR, MAGNETIC (machine shop)). Chips or grinds out holes, bubbles, or cracks in workpiece preparatory to filling with weld (GRINDER-CHIPPER I (any industry)). Cleans grease or corrosion from workpiece, using wire brush or grinder. Clamps broken parts together in jig or vise and welds them using gas or arc welding process, according to type and thickness of metal. May cut defective part from assembly, using bandsaw or cutting torch, and re-weld new piece into place. May straighten bent pieces, using hand torch, straightening press, or jack and stanchion. May weld layers of metal onto damaged parts to obtain original dimensions and be designated as WELDER, SALVAGE. May specialize in filling holes, bubbles, and cracks in defective castings and be designated as WELDER, CASTING REPAIR (Foundry)

Approximately 8,000 hours are required to qualify as a First Class Journeyman in this occupation by means of apprentice programs. Approximately 6,000 hours of on-the-job and in-plant training are required for entry into Journeyman ranks as a Welder.

(2) SHIPFITTER

SHIPFITTER (ship and boat building and repair). 806.381. Fitter. Lays out and fabricates metal structural parts, such as plates, bulkheads, and frames, and braces them in position within hull of ship for riveting or welding. Lays out position of parts on metal, working from blueprints or templates and using scribe and handtools. Locates and marks reference lines, such as centerlines, buttocklines, and frame lines. Positions parts in hull of ship, assisted by RIGGER. Aligns parts in relation to each other, using jacks, turnbuckles, clips, wedges, and mauls. Marks location of holes to be drilled and installs temporary fasteners to hold part in place for welding or riveting. Installs packing, gaskets, liners, and structural accessories and members, such as doors, hatches, brackets, and clips. May prepare molds and templates for fabrication of nonstandard parts. May tack-weld clips and brackets in place prior to permanent welding. May roll, bend, flange, cut, and shape plates, beams, and other heavy metal parts, using shop machinery, such as plate rolls, presses, bending brakes, and joggle machines.

Approximately 8,000 hours are required to qualify for First Class Journeyman in this occupation by means of the apprentice programs. Approximately 6,000 hours of on-the-job and in-plant training are required for entry into Journeyman ranks as a Shipfitter.

(3) MACHINIST, MARINE

MACHINIST, MARINE (ship and boat building and repair).

MACHINIST, OUTSIDE

MACHINIST, OUTSIDE (ship and boat building and repair). 623.281. Engineer, steam; machinist, installation; machinist, marine; marine erector; marine machinist; outfitter, ouside-installation man. Installs ship machinery such as propelling machinery, auxiliary motors, pumps, ventilating equipment, and steering gear, working from blueprints and using handtools, calipers, and micrometers. Lays out passage holes on bulkheads, decks, and other surfaces for connections, such as shafting and steam lines. Installs below-deck auxiliaries, such as evaporators, stills, heaters, pumps, condensers, and boilers and conects them to steampipe systems. Tests and inspects installed machinery and equipment during dock and sea trials. May set up and operate such machine shop tools as lathe, boring mill, planer, shaper, slotter, and milling machine to fabricate replacement parts.

Approximately 8,000 hours are required to qualify for First Class Journeyman in this occupation. About 6,000 hours of on-the-job and in-plant training are required for entry into Journeyman ranks as a Machinist.

(4) ELECTRICIAN

ELECTRICIAN (ship and boat building and repair). 825.381. Electrician, marine; electrician, outside. Installs and repairs wiring, fixtures, and equipment for all electrical services aboard ship and in shipyard facilities, following blueprints and wiring diagrams:

Installs conduit to bulkheads with brackets and screws, using handtools, and threads wires through conduit to terminals, such as connection boxes, circuit breakers, voltage regulators, and switch panels. Strips insulation from wire ends to terminals, using stripping pliers and soldering iron. Connects power-supply circuits to radio, radar, sonar, fire control, and other electronic equipment. Tests electrical characteristics, such as voltage, resistance, and phase angle, in circuits, using voltmeters, ohmmeters, and phase rotation indicators. May construct instrument panels, using handtools, rulers, dividers, and power drills, following specifications. May be designated according to work location as ELECTRICIAN, SHIP; ELECTRICIAN, SHOP; ELECTRICIAN, YARD.

Approximately 8,000 hours are required to qualify for First Class Journeyman in this occupation. About 6,000 hours of on-the-job and in-plant training are required for entry into Journeyman ranks as a Marine Electrician.

(5) PIPEFITTER

PIPEFITTER (ship and boat building and repair). 862.281. Pipefitter, marine. Lays out, installs, and maintains ships' piping systems, such as steam heat and power, hot water, hydraulic, air pressure, and oil lines, following blueprints, and using handtools and shop machines:

Plans layout of pipe sections, allowing for location of bulkheads, machinery, passageways, holes, and obstructions. Cuts and bores holes in bulkheads and decks for installation of pipes. Operates shop machines to cut and thread pipe and pipe fittings, such as valves, traps, and thermostats. Packs pipe with sand to avoid contortion of pipe and bends pipe to specified shape on pipe-bending fixture. Bolts or welds pipe brackets to support pipe systems. Connects pipes to fixtures, such as radiators, laundry and galley equipment, pumps, and tanks, using wrench, and solders joints to seal connections, using hand torch. Repairs, packs, and adjusts valves. Tests installed system for leaks and to insure that system meets specifications, using hydrostatic and other pressure-test equipment.

Approximately 8,000 hours are required to qualify for First Class Journeyman by means of an apprentice program. Approximately 6,000 hours of on-the-job and in-plant training are required for entry into Journeyman ranks as a Pipefitter.

(6) RIGGER

RIGGER (ship and boat building and repair). 806.281. Erector; loft rigger; outside rigger. Installs and repairs rigging and weight-handling gear on ships and attaches hoists and pulling gear to rigging to lift, move, and position machinery, equipment, structural parts, and other heavy loads aboard ship:

Forms slings and towing bridles by looping and splicing cable or by crimping metal sleeve around cable end and body of cable, using crimping tool. Splices and ties rope to form nets, ladders, and other rigging. Installs hooks, swivels, and turnbuckles in rigging. Reeves lines through blocks and pulleys. Sews canvas or leather covers on rigging at friction points, using sail twine and sailmakers' palm and needle. Selects and attaches gear, braces, and cushions, according to weight and distribution of load, availability of hoisting machinery, and presence of obstacles, such as the ship's structural members and jutting buildings, which might interfere with maneuverability of incorrectly rigged hoisting gear. Signals workers operating cranes or other equipment to move load. Installs beam clamps, ape eyes, gallows frames, and other supporting structures for rigging gear. Controls movement of heavy equipment through narrow openings or in confined spaces, using jacks, pulley blocks, chainfalls, and rollers. Lays out and handles lines, snubs lines on cleats or bollards, or hauls in lines with capstans to assist SHIPWRIGHT in ship drydocking operations. Installs or repairs ship's rigging, such as mast or antenna rigs, small boat handling gear, and winch or windlass rigging. Installs masts, booms, yardarms, and gaffs, working aloft as required. Rigs and hangs scaffolds and stages that require blocks and pulleys.

Approximately 8,000 hours are required to qualify for First Class Journeyman in this occupation by means of the apprentice programs. Approximately 6,000 hours of on-the-job and in-plant training are required for entry into Journeyman ranks as a Rigger.

(7) FLAME CUTTER, HAND

FLAME CUTTER, HAND (welding) I. 816.884. Burner, hand; cutter, gas; flamegouger; torch cutter. Cuts, trims, or scarfs metal objects to dimensions, contour, or bevel specified by blueprints, layout, work order, or oral instructions, using flame-cutting torch:

Lifts and positions workpiece onto table, manually or using jib or crane. Connects hoses from torch to oxygen tank and fuel gas tank, such as acetylene or propane. Selects torch tip, gas pressures, and speed of cut, and allows for width of cut according to thickness and type of metal as computed from charts. Installs torch tip and turns handle to start and adjust pressure of fuel gas. Lights torch and adjusts flow of oxygen to obtain desired mixture, as indicated by color and size of flame. Directs flame on workpiece to heat it to oxidizing temperature, as indicated by color of metal. Squeezes lever or trigger to release additional jet of oxygen which burns path through metal. Guides flame along cutting line, observing cutting to judge angle, distance of torch, and speed of movement. Removes and inspects finished workpiece. Chips or grinds burrs from edges, using power chisel or portable grinder. May lay out cutting lines, using rule, square, and compass, or by tracing from template. May cut damaged or worn pieces from metal structure, such as bridge or building frames, ship plates, or pipelines. May install special tip to cut grooves into metal joints, preparatory to welding, and be designated as FLAME SCARFER.

FLAME-CUTTING TRACER-MACHINE OPERATOR (welding). Pantograph Operator. Sets up and operates machine which follows outline or track of template and transfers action through series of levers to cutting torch positioned over workpiece:

Positions, aligns, and clamps or screws template onto adjacent table. Positions tracer wheel, stylus, or magnetized roller onto edge of template, and guide wheel onto track, or beam of photoelectric cell over edge of work piece. Starts machine which moves tracer along track or edge of template and transfers movement to bug-type welding head through series of levers. May manually guide stylus or tracer wheel along edge of template or sketch drawn on table. May be designated by type of machine as ELECTRONIC-EYE FLAME-CUTTING-MACHINE OPERATOR; MAGNETIC FLAME-CUTTING-MACHINE OPERATOR; TRACK TEMPLATE FLAME-CUTTING-MACHINE OPERATOR.

Approximately 2,000 hours are required to qualify as a First Class Journeyman in this occupation by means of apprentice programs. Approximately 1,000 hours of on-the-job and in-plant training are required for entry into Journeyman ranks as a Flame Cutter.

(8) TOWER-WHIRLER-GANTRY OPERATOR

TOWER-WHIRLER-GANTRY OPERATOR (ship and boat building and repair). 921.883. Gantry-crane operator; portal-crane operator; shipways-crane operator; tower-crane operator; tower-gantry-crane operator; whirley operator. Operates electrically powered derrick, mounted on pedestal or structure (gantry) which travels along ground tracks, to lift and move heavy objects, such as plates, assemblies, and machinery:

Moves levers in response to ground signals to rotate boom, alter angle of boom, move crane along tracks, and raise or lower load.

Approximately 1,000 hours of on-the-job and in-plant training are required for entry into Journeyman ranks.

(9) DRAFTSMAN, MARINE

DRAFTSMAN, MARINE (professional & kindred) 014.281. Performs duties of DRAFTSMAN I, but specializes in making drawings of structural and mechanical features of docks, ships, and other marine structures and equipment. Works from general design drawings and notes made by ARCHITECT, MARINE or MARINE ENGINEER.

DRAFTSMAN, HULL (professional & kindred). Develops detailed drawings and specifications used in fabrication and construction of hulls and related subassemblies:

Makes all drawings, such as horizontal and longitudinal cross sections, deck plans, transverse bulkheads, rigging details, cargo boom and fittings, watertight doors, stern frame and rudder arrangements and airports, using his knowledge of various types of ships, including principal dimensions, lines, beam members, and structural details.

DRAFTSMAN, HYDRAULIC (ship and boat building and repair). Plans, designs, and draws up specifications for hydraulic machinery and hydraulic systems used on board ships and, occasionally, for hydraulic machinery and systems used in the shipyard.

DRAFTSMAN, SHEET-METAL (ship and boat building and repair). Specializes in preparation of complete, accurate scale drawings of sheet-metal parts and equipment used in construction and repair of vessels.

DRAFTSMAN, SHIP ENGINEERING (professional and kindred). Prepares assembly and detail drawings of marine engines and auxiliary ship equipment:

Performs basic calculations of marine engine design and draws details of engines, steam turbines, boilers, pumps, condensers, and feed water heaters, piping, and auxiliary apparatus. Lays out details of foundations and supports of power and operating equipment in ships of different types, based on knowledge of materials of construction and ability to calculate and proportion dimensions of parts. Completes finished drawings in connection with any part of mechanical equipment of ship. Prepares and checks propeller specifications and designs for them. Designs parts, such as shafting, bearings, and steering equipment.

To qualify for the position of Draftsman, 10,000 hours are required. Approximately 6,000 hours of on-the-job and in-plant training are required for entry into the lower Draftsman ranks.

(10) SHIPWRIGHT

SHIPWRIGHT (ship and boat building and repair). 860.381. Carpenter, ship; woodworker. Constructs or repairs ships, following blueprints or ship's plans:

Sights, plots, and marks reference points and lines on building dock or way to maintain alignment of vessel during construction or repair, using transit, plumb bob, tapes, and levels. Builds keel and bilge blocks, cradles, and shoring for supporting ships in drydock, marine railways, shipways, or building docks, using power and hand woodworking tools. Positions and secures blocking and other structures on dock platform, according to ship's blueprints. Aligns vessel over blocks (DOCKMAN). Establishes reference points and lines on ship's hull for locating machinery and other equipment, in accordance with ship's alignment and shape. Fabricates and installs furring pieces, aprons, uprights, and other wood framing in ship. Shapes, finishes, and installs wooden spars, masts, and wood framing in ship. Shapes, finishes, and installs wooden spars, masts, and cargo and boat booms. Trims wooden frame and other timbers, using broadax and adz. Spikes or bolts metal fittings, plates, and bulkheads to wooden parts of ship, using brace and bits, augers, mauls, and wrenches.

Approximately 8 to 10 years are required to qualify for First Class Journeyman in this occupation.

Appendix D

SHIPYARD POSITION DESCRIPTIONS, U.S. COAST GUARD

This appendix supplements Chapter 4. It includes "Position Descriptions" provided by the Coast Guard Shipyard, Curtis Bay, Maryland. In each case, the information in the heading of the "Position Description" (U.S. Civil Service Commission, Optional Form 8) has been abridged, but the "Description of Duties and Responsibilities" section is quoted in full. The selected jobs are:

1) Welder
2) Shipfitter

These examples were selected for two reasons. First, welder and shipfitter are the most common shipyard production jobs, representing about 16 percent and 10 percent of the private shipyards' production work force, respectively. Second, these are the jobs in which other industries (notably the construction industry) compete most vigorously with shipyards for workers.

As noted under "Shipyard Jobs" in Chapter 4, only a few jobs are specific to shipyards. Among these are loftsman, shipwright, and, to a limited extent, rigger. Comparison of private shipyard job descriptions, Coast Guard "Position Descriptions" for shipyard jobs, and U.S. Civil Service classification standards reveals a virtual identity between shipyard jobs and their non-shipyard counterparts. Training and skill requirements for shipyard and non-shipyard jobs are the same. Indeed, each Coast Guard "Position Description" is referenced directly to the Civil Service description for the same job title. For the most common shipyard position, welder, the only difference in the skills requirement for shipyard and non-shipyard work is that the shipyard welder who works on Naval contracts must demonstrate a knowledge of the requirements of the welding specifications of MIL-STD-278D and NAVSHIP 0900-000-1001. Critical non-shipyard welding positions impose similar specifications unique to the particular job.

For comparison, see the private shipyard job descriptions and Civil Service classification standards given in Appendixes C and E, respectively.

(1) WELDER

Agency Position No.: Y-2538

Class (Service, Series, Grade): WG-3703-10

Department and Subdivisions:

Department of Transportation

U.S. Coast Guard

YARD

Production Department

Welding Shop

Description of Duties and Responsibilities

A. Typical Work Performed: The employee performs all kinds of journeyman welding tasks in flat, horizontal, vertical and overhead positions involved in the construction, repair, maintenance, overhaul and conversion of a wide variety of types and sizes of marine craft and vessels and in connection with miscellaneous manufacturing projects performed at the YARD. He lays out work from specifications and oral instructions. Selects most effective welding sequence. Sets up jigs and fixtures. Bolts, clamps, blocks, tack welds, lifts, and holds with chain hoist, levers, or block and tackle, or otherwise secures parts in proper alignment for welding. Clears area to be welded with files, wire brushes, portable grinding wheel and scaling or chipping hammers. When using arc welding equipment, he connects power cables and grounds to electrode holder, feeds, generator, transformer, and items to be welded. Connects inert gas or other gas feeds when required. Selects proper size and type electrodes or welding rods for type of weld. Takes fire and other safety precautions. Adjusts controls for polarity, voltage, amperage, and power feeds. Draws arc and welds items with proper joint. When using shielded arc welding methods, controls flow of gases such as hydrogen, helium or argon, or of powered fluxes from hopper. When operating automatic electric welding equipment, he selects proper type and size of wire electrode, and sets regulator voltage, current, arc length, and length and speed of travel. Welds the various components of a ship, including the shell, framing, inner bottoms, tanks, boilers, decks, bulkheads, superstructures, masts, stacks, ventilation ducts, Class I piping and similar components; welds pre-fabricated sub-assemblies, buoys, davits, pressure vessel tanks, piping and similar items. Such duties involve welding of all types of metals and alloys, varying in thickness from 28 gauge to 3 inches. After welding, removes slag from line of weld and smoothes welds with grinding wheel or hammers. Makes adjustments and minor repairs to welding heads or tips, torches, electrodes and equipment controls. Operates various types of A.C. and D.C. electric arc welding equipment, portable, automatic and semi-automatic, with carbon and metallic electrodes and including particularly inert gas shielded, flux shielded (submerged arc), and atomic hydrogen shielded methods. When using gas welding equipment, connects tanks, hose, regulators, torch and welding rod. Takes fire and other safety precautions. Applies proper fluxes to welding rod and work piece, or uses coated rods, as required by the nature of the weld. Lights torch, adjusts flame for carburizing, neutral, or oxidizing effect as required, and welds items with proper joint. Uses principally oxyacetylene and oxyhydrogen equipment. He performs duties such as the following on an incidental basis. Operates gas cutting hand torch or portable electric arc cutting machine to trim parts before welding to insure proper alignment or fit, to remove obstructions or to cut materials when necessary on site. Builds up metal surfaces of equipment for machining by flame spraying methods. Flame sprays rubber compound and other powdered substances on parts as protective coatings. Brazes and solders metals as required. Preheats items to be welded with torch or heating equipment. Performs various flame heat treating operations such as hard surfacing, stress-relieving and annealing by use of torches, asbestos blankets, etc. Produces welds subject to X-ray analysis, magnaflux inspection, dye check, and water- or gas-tight pressure or other tests.

B. Factor Statements:

1. Knowledge and Skill: The employee must have a thorough knowledge of all phases of the welding trade including theory and practice, and of the equipment, tools, materials and supplies used. He must be thoroughly versed in trade methods and the proper sequence of performing trade tasks and be thoroughly familiar with the standard trade practice, techniques, methods and procedures to perform both electric and gas welding.

He must be a skillful workman, thoroughly versed in the applications of the various processes of welding. He is required to have a thorough understanding of the characteristics of the different machines and how to connect the secondary leads; regulate current, voltage and polarity; and also have a thorough understanding of the various types of electrodes. Must thoroughly understand welding symbols, procedures and sequences, and be accurate, careful and quick and possess the muscular coordination necessary to produce sound welds with the proper penetration and without undercut or undue distortion within reasonable time limits. Should have a thorough knowledge of the design of joints and the skill to produce satisfactory welds with manual and semi-automatic equipment.

Must pass an appropriate pre-employment practical welding test authorized by the Civil Service Commission.

2. Responsibility: Is under the general supervision of a Foreman Welder. Assignments are usually received verbally and are general in nature, such as location and scope of job, machines, methods, sequences and electrodes to use, and the best procedure to obtain good, sound welds. He then is expected to complete his work independently. Jobs are spot-checked upon completion for satisfactory workmanship.

He is responsible for producing sound welds of high quality to a toleance of 1/32" without undue distortion and within reasonable time limits and for the economical and effective use of electrodes and equipment. He must insure protection from spark or spatter damage of any woodwork, cables, glass, tile or deck covering within the vicinity of his welding operation and is responsible for the prevention of fires due to stray sparks landing in shavings, oil waste or other inflammable debris. He is charged with the care and preservation of all machines and equipment used by him and is responsible for the observance of all rules and regulations applicable to his position, particularly those related to safety. On occasions, the employee instructs, trains, and supervises apprentices who might be assigned to work with him. When this occurs he makes frequent and close inspections of their work.

3. Physical Demands: The employee must be in good general physical condition since he may be required to work in close quarters and from ladders, scaffolding and platforms. He does a considerable amount of standing, stooping, bending, kneeling, lifting and climbing. He frequently lifts objects that weigh up to approximately 50 pounds and may carry them for a distance of 100 feet. He must meet the physical qualification standards established by the Civil Service Commission, which include the ability to distinguish basic colors.

4. Working Conditions: The work is performed within the shops, on shipways, in skid areas, and on waterborne vessels, often under adverse weather conditions. Throughout the performance of his duties, the employee is exposed to various shipyard hazards and possible injuries. Since climbing is essential to the efficient performance of the

duties, there is a chance of slipping and falling. He will be exposed to vibration from shop machines and to fumes inhalation, burns, welding flashes, cuts, bruises, scrapes, shocks, broken bones; dust, dirt, grime and noise can be found in the immediate work area. He will be required to work aloft on masts and on the drydock, and also in closed compartments aboard ships and in the shop.

(2) SHIPFITTER

Agency Position No.: Y-2535 (1st Amendment)

Class (Service, Series, Grade): WG-3820-10

Department and Subdivisions:

Department of Transportation

U.S. Coast Guard

YARD

Industrial Department

Structural Group

Shipfitting Shop

Description of Duties and Responsibilities

A. Typical Work Performed: The employee performs all kinds of journeyman shipfitting tasks involved in the construction, repair, maintenance, overhaul and conversion of a wide variety of types and sizes of marine craft and vessels and in connection with miscellaneous manufacturing projects performed at the YARD. He reads blueprints, develops templates, lays out, fabricates, sub-assembles the various components involved, such as shell plates, frames, watertight and non-watertight bulkheads, deck beams, superstructures, foundations, ladders, pipe rails and many other items. Erects hull components on site in accordance with center lines, base lines, buttock lines, water lines, such as struts, shaft tubes, foundations, and all other hull appendages. He is required to perform incidental flame cutting and trimming of metals with gas hand torch, and tack welding with coated electrode, metallic arc, in this erecting and repair to vessels.

B. Factor Statements:

1. Knowledge and Skill: Must have a thorough knowledge of marine blueprint reading and laying out; some knowledge of mechanical drawing; a thorough knowledge of the practices, processes and materials of his trade; a good working knowledge of allied trades; and a thorough working knowledge of shop mathematics. He must have a knowledge of mold loft practice and a thorough knowledge of shipbuilding terms, definitions and abbreviations. (The foregoing involves the development and fabrication of all types of metals and alloys required in shipbuilding and repair, and

manufacturing of other items at the YARD, varying in thickness from 1/8" to 12" and working to tolerances of 1/32".)

In addition, the employee must have a general working knowledge of the varius metal forming machines required in fabricating ship structures, such as plate rolls, press brakes, angle rolls, cold presses, shears and punches. He must also understand the operation of portable electric and air-powered tools that are required in his trade, such as chipping hammers, grinding, reaming and drilling machines.

He must possess a high degree of accuracy, skill and aptitude in developing, laying out and fabricating his work; be adept and exact in the making of templates; be deft and skillful in the use of the equipment and tools of his trade; and quick enough to complete his work within reasonable time limits. Is expected to keep pace with technological developments in his trade.

2. Responsibility: Is under the general supervision of a Foreman Shipfitter who makes the job assignments, issues blueprints, drawings, sketches and gives oral instructions concerning the sequence and procedure to follow to attain good quantity and quality of work. The work is spot-checked by the Foreman upon completion to insure satisfactory performance. Supervises helpers or apprentices who are assigned to work with him.

The employee is also responsible for drawing out the right kind and quantity of material to accomplish his work without undue waste, to keep a check on the various components that make up his job as they are processed through the Fabricating Shop, and to deliver these components to the ship for installation so that delays are avoided and the job completed within the time set.

Must exercise adequate care of tools, equipment and supplies, protecting them against loss, theft or damage, and promptly reporting such occurrence. He is responsible for the observance of all rules and regulations applicable to his position, particularly those related to safety.

3. Physical Demands: Must be in good general physical condition since he may be required to work in close quarters and from ladders or scaffolding. He will be required to do a considerable amount of standing, stooping, bending, kneeling, lifting and climbing. He frequently lifts objects of at least 75 pounds on his own and may carry them for a varying distance up to 500 feet. He will be required to handle heavier loads for distances of 10 to 15 feet. May be assisted by other workmen and has available for use Krane

Kars, etc. He must meet the physical qualification standards established by the Civil Service Commission for this position, which include the ability to distinguish basic colors.

4. Working Conditions: The work is performed within the shops, on shipways, in skid areas, and on waterborne vessels, often under adverse weather conditions. Throughout the performance of his duties, the employee is exposed to various shipyard hazards and possible injuries. Since climbing is essential to the efficient performance of the duties, there is a chance of slipping and falling. He will be exposed to vibration from shop machines and to fumes inhalation, burns, welding flashes, cuts, bruises, scrapes, shocks, broken bones; dust, dirt, grime and noise can be found in the immediate work area. He will be required to work aloft on masts and on the drydock, and also in closed compartments aboard ships and in the shop.

Appendix E

CLASSIFICATION STANDARDS, U.S. CIVIL SERVICE

This appendix supplements Chapter 4. It includes U.S. Civil Service Commission classification standards covering the two jobs for which Coast Guard "Position Descriptions" are given in Appendix D:

1) Welder

2) Shipfitter

As noted under "Shipyard Jobs" in Chapter 4, only a few jobs are specific to shipyards. Among these are loftsman, shipwright, and, to a limited extent, rigger. Comparison of private shipyard job descriptions, Coast Guard "Position Descriptions" for shipyard jobs, and Civil Service classification standards reveals a virtual identity between shipyard jobs and their non-shipyard counterparts. Training and skill requirements for shipyard and non-shipyard jobs are the same. Indeed, each Coast Guard "Position Description" is referenced directly to the Civil Service description for the same job title. For the most common shipyard position, welder, the only difference in the skills requirement for shipyard and non-shipyard work is that the shipyard welder who works on Naval contracts must demonstrate a knowledge of the requirements of the welding specifications of MIL-STD-278D and NAVSHIP 0900-000-1001. Critical non-shipyard welding positions impose similar specifications unique to the particular job.

For comparison, see the private shipyard job descriptions and Coast Guard "Position Descriptions" given in Appendixes C and D, respectively.

The classification standards that follow are quoted, in full, from the Civil Service Commission's Job Grading System, WG-3703-10 (Welder; TS-30, May 1974); WG-3703-8 (Welding Worker; TS-30, May 1974); and WG-3820-10 (Shipfitter; TS-29, March 1974). Where the job description for Welder refers to that for Welding Worker, excerpts from the latter are inserted parenthetically.

(1) WELDER (WG-3703-10)

General: In comparison with the application of a variety of electric resistance welding processes and equipment, or the use of one or more manual welding processes to carry out standard previously done welding operations as described at the WG-8 level, WG-10 Welders use accepted trade methods and a variety of manual welding processes, for example, several different gas torch processes, various electric arc processes including inert gas-shielded ones, or a number of both kinds of processes, to weld all types of commonly used metals and alloys of various sizes, shapes, and thickness, including dissimilar metals such as copper to steel.

In comparison with the WG-8 level, WG-10 Welders also assure complete penetration when required as well as complete fusion of base and filler metals. They control the metals and the welding techniques to prevent distortion or burning of the metals, and to meet weld dimensions, tolerance, strength, and other requirements. The welds are made in all positions, including flat, horizontal, vertical, and overhead.

(WG-8 Welding Workers apply a variety of electric resistance welding methods and equipment, or one or more manual welding processes, to carry out standard, previously done welding operations. For example, they operate various electric resistance welding machines such as spot, seam, and flash, or use a manual gas torch welding process such as oxyacetylene, to join a variety of different kinds of parts or components. They determine the welding techniques and machine settings to be used, assemble and set up the parts to be welded, and make the required welds following guides such as resistance welding control charts, specifications, accepted shop practices, and oral or written instructions from the supervisor. Depending on the process used and the requirements of the work, welds are usually made in flat or horizontal positions.)

Skill and Knowledge: In comparison with the WG-8 level, WG-10 Welders apply knowledge of a wider range of manual welding processes and make more difficult welds.

For example, the gas welding torch processes used by WG-10 Welders involve processes such as oxyacetylene, oxyhydrogen, and other industrial gases. The arc processes used (including inert gas-shielded ones) involve methods such as gas metal-arc, gas tungsten-arc, gas carbon-arc, plasma-arc, and atomic hydrogen welding. WG-10 Welders apply a knowledge of welding standards and how various metals and alloys such as different kinds of steel, aluminum, cast iron, nickel, monel metal, brass, copper, bronze, magnesium, beryllium, and titanium react to different welding processes and techniques. They weld metal parts and structures that may vary in size, shape, and thickness from very thin (for example, 0.025 inches or less) to very thick (for example, armor plating), requiring multiple welding passes, and weld dissimilar metals such as copper to steel. In comparison with the WG-8 level, WG-10 Welders also use greater skill to make welds that require complete penetration as well as complete fusion of base and filler metals even when welding in hard to reach places.

As needed, WG-10 Welders devise special jigs and fixtures to hold the parts to be welded. They use techniques such as preheating, heat sinks, and stress relieving to maintain specified dimensions and to prevent distortion or burning of the parts being welded. Incidental to the welding work, they also apply a knowledge of several related trade procedures, for example, brazing, soldering, flame- and arc-cutting, surface hardening, annealing, and metal spraying.

(WG-8 Welding Workers apply skill and knowledge to set up and operate various electric resistance welding machines, or to use one or more manual welding processes, for example, a gas welding process such as oxyacetylene or oxyhydrogen, and an arc welding process such as gas carbon-arc or gas metal-arc, to weld parts made of commonly used metals. Welding Workers at the WG-8 level assure proper spacing, pressures, and heat cycles when operating electric resistance welding machines. They control the torch or arc, and the positioning and feeding of the welding rod or electrode when welding manually, to prevent burning of base metals and to obtain the desired penetration and weld bead dimensions.)

(As needed, WG-8 Welding Workers apply skill in using jigs and fixtures and in clamping pieces together to assemble and set-up the parts to be welded. When welding contoured shapes, they adjust the arms of the electric resistance welding machine to obtain set-ups which will provide access to all surfaces to be joined. Incidental to the welding work, WG-8 Welding Workers also may apply knowledge of one or two related trade processes, for example, flame-cutting when close tolerances do not have to be met.)

Responsibility: WG-10 Welders determine the work to be done and the steps needed to accomplish it. They plan and lay out the work from blueprints, sketches, drawings, specifications, and work orders. They determine the welding techniques to use and select the proper materials such as the right size and type of welding electrodes and rods.

In comparison with the WG-8 level, WG-10 Welders apply a variety of manual welding processes to make more difficult welds, including welds in hard to reach places, that must meet close tolerance, strength, and other requirements, for example, evenness of fit and smoothness of contour.

The work is done with little or no in-progress check. Final products are reviewed to see that completed welds are free from cracks, slag, or other defects, and meet specifications and accepted trade standards. Welds are subject to radiographic, magnetic particle, dye penetrant, pressure inspection, and other tests. The supervisor is called on for advice on unusual problems.

(WG-8 Welding Workers perform welding operations on the basis of written or oral instructions from the supervisor, and blueprints, sketches, and work orders that clearly show what is to be done. At this grade level, Welding Workers select the techniques, machines, materials, and, when needed, the jigs and fixtures commonly used to do the assigned work.)

(Welding Workers are responsible for making welds to meet specifications, and to assure proper penetration and freedom from pockets, scales, or other defects. Work is only spot-checked during its progress. The supervisor advises on unusual problems and checks the overall work for adequacy.)

<u>Physical Effort</u>: Physical effort required at this grade is the same as that described at the WG-8 level.

(The work involves standing, walking, stooping, bending, kneeling, climbing, and crawling. Work may be done in awkward and cramped positions such as when welding in hard to reach places. Welders frequently handle objects weighing from 20 to 50 pounds and, occasionally, objects weighing in excess of 50 pounds, in setting up work and equipment and in completing assignments.)

<u>Working Conditions</u>: Working conditions at this grade are the same as those described at the WG-8 level.

(The work is done indoors and outdoors, sometimes in bad weather, in areas that may vary from "clean rooms" to areas that are noisy, dirty, and smoky. Welding involves exposure to fumes, infrared and ultraviolet radiation, heat, flying sparks, the glare of torches and heated materials, the possibility of eye injury, electrical shock, burns, broken bones, and the chance of cuts when working with sharp objects. There is discomfort when wearing protective clothing, gloves, and flash shield or eye goggles.)

(2) SHIPFITTER (WG-3820-10)

Duties: WG-10 Shipfitters modify, fabricate, repair, assemble, and install various metal structural parts of ships and other vessels. WG-10 Shipfitters typically:

-- Work from blueprints, design memos, sketches, mold loft templates, and onsite measurements to lay out various structural parts, such as shell, deck, and bulkhead plates, I-beams, channel bars, struts, angle bars, frames, and foundations.

-- Roll, bend, flange, cut, and otherwise shape plates, beams, and other heavy metal parts, using various shop machinery, such as plate rolls, hydraulic presses, bending brakes, joggle machines, and combination punching, shearing, and mitering machines.

-- Assemble the various pieces to form the required part. Using marking and layout tools, such as soapstone, chalk line, scratch awl, center punch, marking point, carpenter's square, spirit level, and straight edge, they establish sets of working lines, such as waterlines, centerlines, buttock lines, and frame lines. They constantly check and correct locations of parts during assembly by reference to working lines, blueprints, and mold loft templates. They request and direct any burning or chipping required to assure accurate fitting of parts. They reinforce assembly to minimize welding distortion, using strongbacks, turnbuckles, bolts and clips, and other types of braces.

-- Install and fit parts on ships. Locate position of pieces from reference lines and set parts in the proper position. Align and adjust parts using jacks, turnbuckles, shoring, saddles, clips, wedges, mauls, and hammers. Straighten distorted parts, using heated torches, flatters, mauls, and sledge hammers. Line up parts for welding or bolting, installing temporary fasteners as required. Install packing, gaskets, liners, and similar items where necessary. Mark holes to be drilled, and establish final target and working lines.

-- Remove, repair, or replace damaged parts of ship structures.

-- May do structural metal work on tanks, buildings, bridges, cranes, and other structures.

In addition, WG-10 Shipfitters may mix and cast various plastic compositions using prefabricated molds and patterns to produce plastic components for ships and submarines, such as sonar domes and other items. They cut, fit, assemble, and install various structural assemblies, such as submarine sails, using fiberglass plates.

Skill and Knowledge: WG-10 Shipfitters must have a knowledge of blueprint reading, mechanical drawing, and geometric and trigonometric principles used in developing and laying out patterns, and a knowledge of standard shipfitting practices, processes, and materials. They must know shipfitting terms, definitions, and abbreviations, and be familiar with a ship's layout.

In addition, WG-10 Shipfitters must know how to use the various metal forming machines required in fabricating ship structures, such as plate rolls, press brakes, angle rolls, cold presses, shears, and punches. They must also know how to operate and use portable electric and air-powered tools, such as chipping hammers and grinding, reaming, and drilling machines.

WG-10 Shipfitters must possess a high degree of accuracy and skill in developing, laying out, and fabricating their work; be adept and exact in making templates; be deft and skillful in using the equipment and tools of the shipfitting trade; and quick enough to complete their work within reasonable time limits. They are expected to keep pace with technological developments in the trade.

Responsibility: WG-10 Shipfitters usually work alone or as part of a small group under general supervision, carrying out standard assignments independently and special tasks in accordance with specific instructions. Work is subject to spot check in progress and inspection upon completion. They are responsible for determining the kind and quantity of materials required to accomplish the work without undue waste, and the necessary sequences and procedures to follow in order to produce quality work within specified time requirements. They are also responsible for following safety rules and regulations and for the proper and safe operation of tools and equipment.

Physical Effort: WG-10 Shipfitters frequently lift, pull, push, and carry heavy structural parts, tools, and equipment weighing up to 50 pounds. Cranes, hoists, chainfalls, or other workers are available when lifting and moving heavier pieces. They walk frequently to and from machines, shops, and various points aboard ships. They stand continuously while working at a bench in the shop, assembling parts, or operating machines. They frequently stoop, kneel, and crawl when making measurements and laying out placement lines for assemblies or installing work in cramped places. They also frequently climb ladders or stagings on high assemblies in shops and aboard ship while assembling and installing structural parts.

Working Conditions: WG-10 Shipfitters work within shops and aboard ships, often under adverse weather conditions. Shipfitters are continuously exposed to such hazardous and unpleasant work-site conditions as vibration, excessive noise, fumes, flying particles, welding flashes, dust, dirt, and grime; thus, employees are subject to damage to eyes and respiratory system, broken bones, bruises, cuts, shocks, and burns. Various protective devices such as hard hats, gloves, safety shoes, and glasses are used to minimize these conditions. They are also exposed to serious injury from slipping and falling while working aloft on masts, in the drydock, and from ladders and stagings. They frequently work in unpleasant and cramped areas of ships having minimum lighting and ventilation.

Appendix F

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report identifies changes in the nature of shipyard manpower characteristics and training requirements that may result from introduction of advanced technology during the next 15 years. Its scope is limited to (a) production, conversion, alteration, and repair trades and (b) management jobs that clearly are identified with the shipbuilding industry. The main focus is on private shipyards; Navy and other government work in private yards is included, and, except for the implications of commercial shipyard

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20. Abstract (continued)

manpower supply and demand, government shipyards are excluded. Non-ship work performed in private yards is included.

The report describes the level of employment, personal and motivational characteristics, education, earnings, jobs performed, job mixes, union affiliation, training, and turnover of shipyard personnel. It also provides a U.S. shipyard industry profile, including information on recent trends, both U.S. and worldwide; describes industry adjustments to trends in shipbuilding techniques and related labor requirements; and summarizes major factors affecting current shipyard operations and personnel, including market factors, government regulations that affect shipyard administration and production, and matters of insurance and liability. Appendixes include a selective bibliography, brief glossary, and sample job descriptions.