

SHIP PRODUCTION COMMITTEE
FACILITIES AND ENVIRONMENTAL EFFECTS
SURFACE PREPARATION AND COATINGS
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MARINE INDUSTRY STANDARDS
WELDING
INDUSTRIAL ENGINEERING
EDUCATION AND TRAINING

September 1989
NSRP 0310

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

1989 Ship Production Symposium

Paper No. 8: Flexible Standards: An Essential Innovation in Shipyards

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

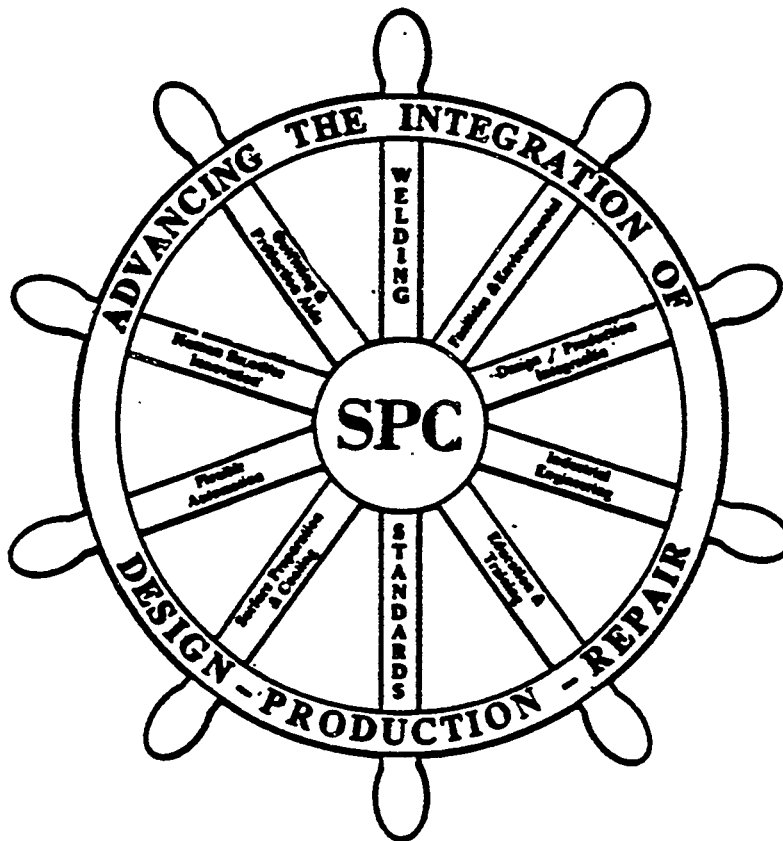
Report Documentation Page				Form Approved OMB No. 0704-0188	
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1. REPORT DATE SEP 1989		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE The National Shipbuilding Research Program 1989 Ship Production Symposium Paper No. 8: Flexible Standards: An Essential Innovation Shipyards				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Surface Warfare Center CD Code 2230 - Design Integration Tools Bldg 192 Room 128 9500 MacArthur Blvd Bethesda, MD 20817-5700				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES 14	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

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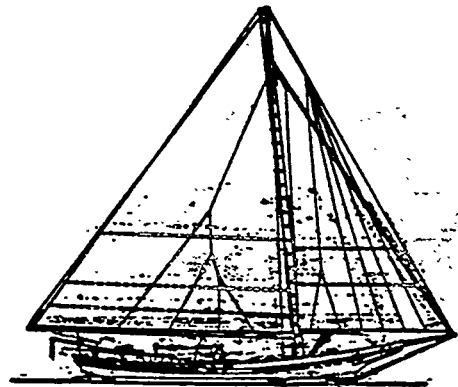
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THE NATIONAL SHIPBUILDING RESEARCH PROGRAM 1989 SHIP PRODUCTION SYMPOSIUM

NSRP
0310



SEPTEMBER 13-15, 1989
SHERATON NATIONAL
Arlington, Virginia



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Flexible Standards: An Essential Innovation in Shipyards

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ABSTRACT

Following a pattern established by Japan after World-War II, a number of other Asian countries are encouraging labor-intensive shipbuilding as means to develop their economies. For them, low-cost labor abounds. As a consequence, established shipbuilders elsewhere in the world market cannot be competitive for ordinary ships including multiple such ships of the same type. Their only alternative is to develop an organization that routinely ferrets out and solves new problems arising from custom-designed ships and different products other than ships, regardless of quantities, i.e., flexible-system production.

An indispensable feature of effective flexible-system production is a file of standards which can be adapted to changing requirements, including requirements for modernizing naval ships, while at the same time permitting reapplication of significant corporate experience. This paper addresses such flexible standards and their significance.

INTRODUCTION

Where the word "standard" is mentioned in the presence of traditional shipyard managers, they immediately fantasize about a material paradise. Regardless of manufacturing sources, all valves of the same type and nominal size would be geometrically identical, pumps for a specific service of a particular capacity would have the same foundation interfaces and the same nozzle locations, and so on. For the purpose of completing their dream, they envision standardized work methods to match a marketplace in which only their designs for runs of standard-series ships would be in demand. That's *l'ara*. If it ever existed, it's gone with the wind.

Some traditionalists compound their self-celusion with the expressed intent to continue to build, convert, and overhaul just ships. This narrow focus, actually a rigid standardization of

corporate purpose, has caused shipyards to close or go into bankruptcy. Years ago one such firm turned away from an opportunity to focus on development of its construction process and to direct it wherever markets dictated. More recently, a manager in a private shipyard which has just Navy work, addressed the need to diversify by saying, "The door is always open." That inadequate response infers continued dependence on just the Navy and no intent to market elsewhere.

Despite profound changes in our economic world, by the 1973 Oil Shock and already by the growing influence of glasnost, traditionalists on both sides of the disintegrating iron curtain continue to associate security with stability. For free nations, security is inherent in flexibility, i.e., the abilities of industry managers to quickly shift from making plowshares to swords. For modern industrialists, security is also inherent in flexibility, i.e., regardless of what is being produced, constantly developing their manufacturing systems. No one has made this solution clearer and provided better pertinent definitions than Robert B. Reich in a paper appropriately titled "The Next American Frontier":

"Flexible-system production is rooted in discovering and solving new problems; high volume, standardized production basically involves routinizing the solutions to old problems. Flexible system production requires an organization designed for change and adaptability; high volume, standardized production requires an organization geared to **stability.**" [1]

Flexibility in this context does not mean the absence of standardization. But, the word "standard" in flexible system production is dynamic; it means more than the usual dictionary definition, "something established by authority, custom or general consent." In

modern industrial systems the word "standard" must be thought of, paradoxically, as something subject to continuous change. The word should be used as if it was set off in quotation marks because what is meant is a standard of the moment. As soon as something better is detected, a new or revised standard is adopted!

For most matters for which standards are useful, there is no time for achieving general agreement. A modern manufacturing system features unrelenting analyses which constantly identify even minute improvements. Authority, custom or general consent applies to acceptance of the system for constant improvement and not to the improvements per se. The latter are automatically incorporated in the forever changing standards.

FLEXIBLE MATERIAL STANDARDS

Traditionalists are right when they first think of material when standards are mentioned. But the need for material standardization transcends traditional concerns. Materials are tangible and thus comprise the soundest basis for production control. The most effective shipbuilders equate material volume to work volume. Using statistical methods they have, for work package after work package of the same problem category, identified some physical characteristic of material that varies directly with man-hours. Thus, as designers define and refine material requirements, a solid basis emerges for estimating required production man-hours. Moreover, the man-hours are expressed statistically, i.e., for each category of work, with a mean value and standard deviations so as to reflect real-world variation.

As long as the distribution of the variations approximates a normal curve, man-hour allocations and scheduling are based on the premise that jobs will probably go over or under in accordance with a prescribed variation pattern. But, the operational words in the foregoing paragraph are "same problem category", an aspect of group technology. Thus, if a drain pump of a specific type was included in an outfitting work package, it would not matter if a drain pump of a different type was substituted provided it had equivalent capacity and provided the problems inherent in associated work remain unchanged. The pumps' foundation interfaces as well as suction and discharge piping could differ significantly without changing the work classification.

Having appreciation of the foregoing, the most effective shipbuilders have over the years built computer files of so-called standards. In one case, the files are based on as many as four stan-

dard machinery arrangements which anticipate four different main-engine types. For each auxiliary-machine position in an arrangement two or three different vendors' catalog items are certified as shipyard standards. The items are functionally equivalent but physically different. Moreover, the auxiliary-machinery market is constantly monitored. When better buys are discovered, based on evaluations of the effects on required shipyard man-hours as well as on price, new vendor catalog items displace old ones in the files.

For the purpose of declaring vendors' equipments as shipyard standards, preference is given to those vendors who each produce machines of the same basic design for a range of capacities. Thus, each standard machinery arrangement for a particular main-engine type can expand or contract with engine horsepower. As any of two or more vendors' equipments can be employed for each auxiliary-machine position without impact on the normal performance of work, what could be more flexible and at the same time practical?

When during contract negotiations the customer agrees on the selection of one of the four main-engine engine types and usage of the flexible material standards, the shipyard simultaneously knows all auxiliary-machinery requirements as well as requirements for large valves, strainers, etc. which are treated the same way. Upon contract award or very soon thereafter, the definition is narrowed down to two, or some other reasonable number of vendors' products for each requirement.

Limiting prospective bidders to reasonable numbers makes it practical to maintain critically-needed material histories and material codes in a shipyards computer file. In some shipyards this includes design details, approval records, price and delivery histories, vendors' prior agreements with procurement terms and conditions, and vendors' guarantee performances. Thus, in the moment of action sparked by contract signing, for each requirement only two steps remain for a procurement decision-issuing requests for bids which asks only for price and delivery, and evaluating a limited number of vendor responses. Three responses, perhaps one or two more for certain equipments, are judged to be optimum for balancing need for competition against a yard's capacity to maintain required material information in a computer file.

Instead of investigating, some managers quickly respond, "Neat! But, we can't use such standards. We're building warships; the government would not permit us to limit the list of bidders. One shipbuilder who so responded took a

second look, initiated a survey, and discovered that there were over a thousand material items in three different warships for which specifications were separately written and for which only one supplier responded with the same product. How many thousands more are there for which there are only two or three suppliers? Thus defacto standardization exists and few, if any, exploit it. The most significant problem for some of those items is not how to limit the bidders list. Instead, it is one of creating a second or third source, something the U.S. Navy's office of Competition Advocate General has been doing on a much larger scale.

The former Competition Advocate General, Rear Admiral Stuart F. Platt, U.S. Navy (Retired) recently offered pertinent advice:

"Getting up to date on computerized information systems is the greatest single barrier to continued gains in efficiency in the procurement process. The fact that we still rely to a large degree on a paper-based procurement system is ludicrous. Internal automation is the most attractive automation opportunity we have here. It will begin paying off almost immediately, in reduced overhead, faster and better decision making, and higher quality goods and services."

Elsewhere in the same article Admiral Platt advised:

"There are no fast fixes. Improvements will best be made from a disciplined inspection of the system's fundamentals. Common sense calls for a procurement process that is prompt, equitable, and administered with a firm hand that allows room for good judgement." [2]

Thus, U.S. shipyard managers including those in naval shipyards, should investigate how their material management systems support their operations. They would find that they have justification to change how government procurement regulations are being implemented. Traditional material managers should be pressed to identify and test the specific procurement regulations that are believed to inhibit productivity in the work place. If they are proven barriers to implementing flexible standards as thus far described, managers should be unrelenting in their pursuit of pertinent regulation changes. Nothing can facilitate promptness more than flexible material standards.

Good judgement dictates that equitability should not apply only to Suppliers. A vendor's sales practices, credibility and after-delivery services

usually impact more on a yard's productivity than the vendor's price. Thus, equitability should be interpreted as meaning benefit for all, i.e., designers, buyers, suppliers and production workers through manifest increases in productivity and quality. It is for this reason that Dr. W. Edwards Deming insists that U.S. industry must learn to deal with fewer suppliers for productivity reasons! It is for the same reason that in the most effective shipyard in Japan, the purchasing department reports to the production control manager. There, material, man-hour allocations and scheduling are inextricably linked. The linkage is the substance of corporate experience which becomes ineffective when too many suppliers are involved. The linkage is applied in a more profound way than can be surmised from just understanding flexible material standards.

FLEXIBLE STANDARD ARRANGEMENTS AND DETAILS

Eleven-years ago, Mr. Y. Ichinose presented a paper which disclosed how standards, including flexible standards, were organized and employed by Ishikawajima-Harima Heavy Industries Co., Ltd. (IHI) of Japan. This insightful paper advised:

"It is obvious that a comprehensive computerized design system, consistent from design through production, could not be effectively realized without standards or modules."

Conversely the paper also advised:

"Standards and modules show their greatest advantage when integrated with a comprehensive computer system."

Mr. Ichinose, then president of IHI Marine Technology, Inc., concluded:

"In the 80s it is hoped that the...demand for new ship construction will increase. Although the major demands may still concentrate on conventional ship designs, it is foreseeable that modern technology and sophistication in ship design may require more complexity in various ship's systems. This complexity can still be solved by refining the standards and modules to cope with the state of the art of the future era, so we remain convinced that shipbuilding can be changed to a mass-production industry without losing the ability to provide sufficient 'tailor made' features to satisfy the individual demands of ship owners." [3]

In the context of Mr. Ichinose's fore-

[1] Reich, Robert B., "The Next American Frontier," The Atlantic Monthly, March 1983.

[2] Platt, Stuart F., "Busting the Navy Trusts," U.S. Naval Institute Proceedings, May 1989, pp. 120-125.

[3] Ichinose, Yoshinobu, "Improving Shipyard Production with Standard Components and Modules," Proceedings SNAME Spring Meeting/STAR Symposium, April 26-29, 1978; Paper No. 10.

[4] Sasaki, H., "IHI's Experience of Technical Transfer and Some Considerations on Further Productivity Improvement in U.S. Shipyards," National Shipbuilding Research Program Ship Production Symposium, August 26-28, 1987; Paper No. 2.

[5] The Society of Naval Architects of Japan recorded in its 1967 English-language annual report of shipbuilding developments that, "Statistical control 'epoch makingly' improved quality, laid the foundation of modern ship construction methods and made it possible to extensively develop automated and specialized welding." There is urgent need to repeat this statement until the last traditionalist succumbs.

[6] "Japanese shipbuilding Quality Standard (Hull Part)" periodically updated and published by the Research Committee on Steel Shipbuilding, The Society of Naval Architects of Japan.

[7] The Commission on Merchant Marine and Defense, Third Report of the Commission on Merchant Marine and Defense: Armendices, U.S. Government Printing Office, September 30, 1988, p. 214.

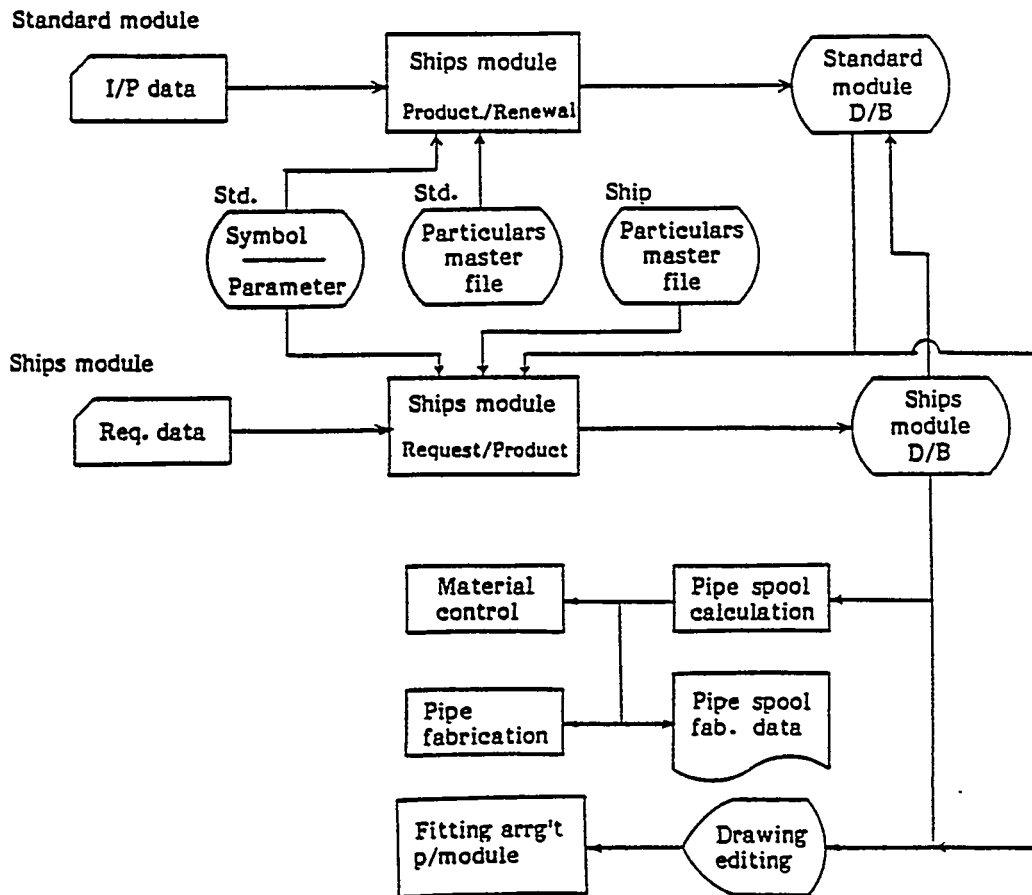


FIGURE 1: FRESCO-F Process Flow

Technical drawing of a mechanical assembly, likely a valve or pump component. The drawing includes a cross-section view on the left and a side view on the right. Dimensions are given in millimeters (mm) and inches (in). Key dimensions include 25, 50, 100, 278, 231, 20, 678, 889, and 716. The drawing is labeled with 'FD022C-', 'FD022E-', and 'FD022A-'.

FIGURE 2: Condensate Pump Unit

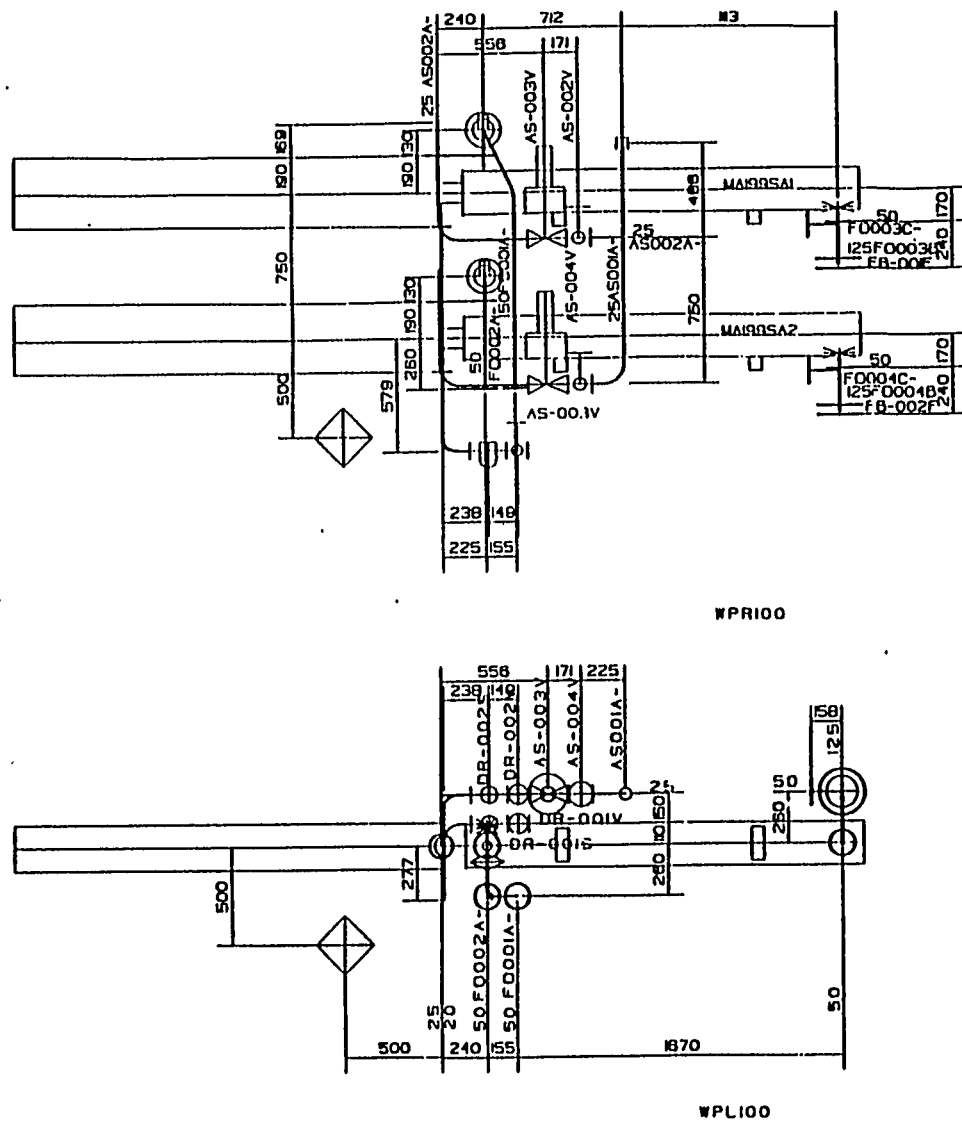


FIGURE 3: Purifier H.F.O. Heater Unit

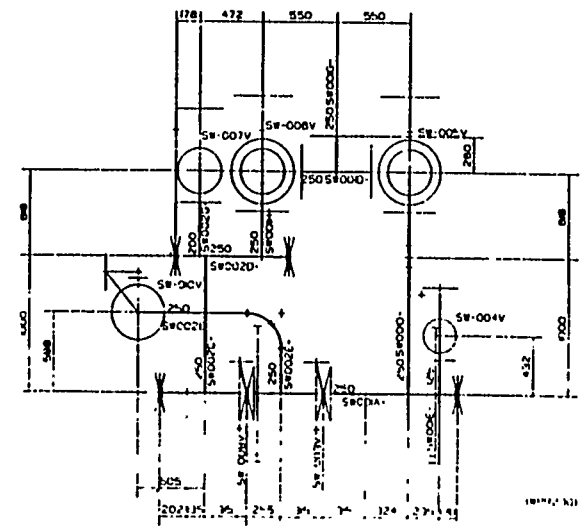
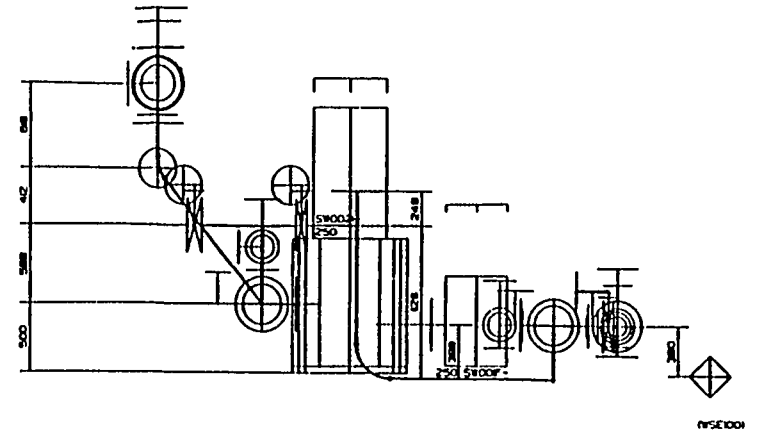
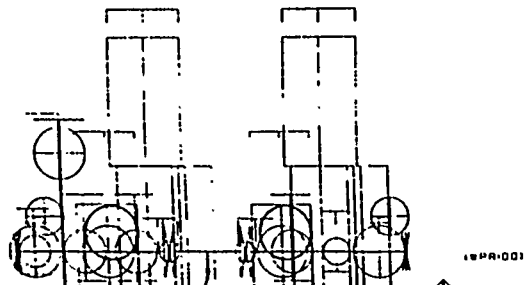


FIGURE 4: Fire and G.S. Pump Unit.

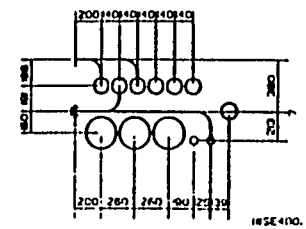
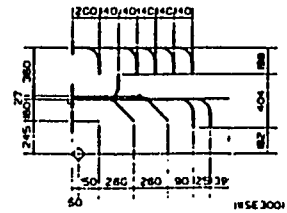
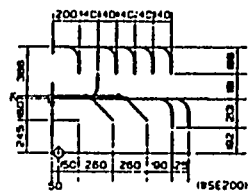


FIGURE 5: Lower E.R. Flat Unit (near D.G.)

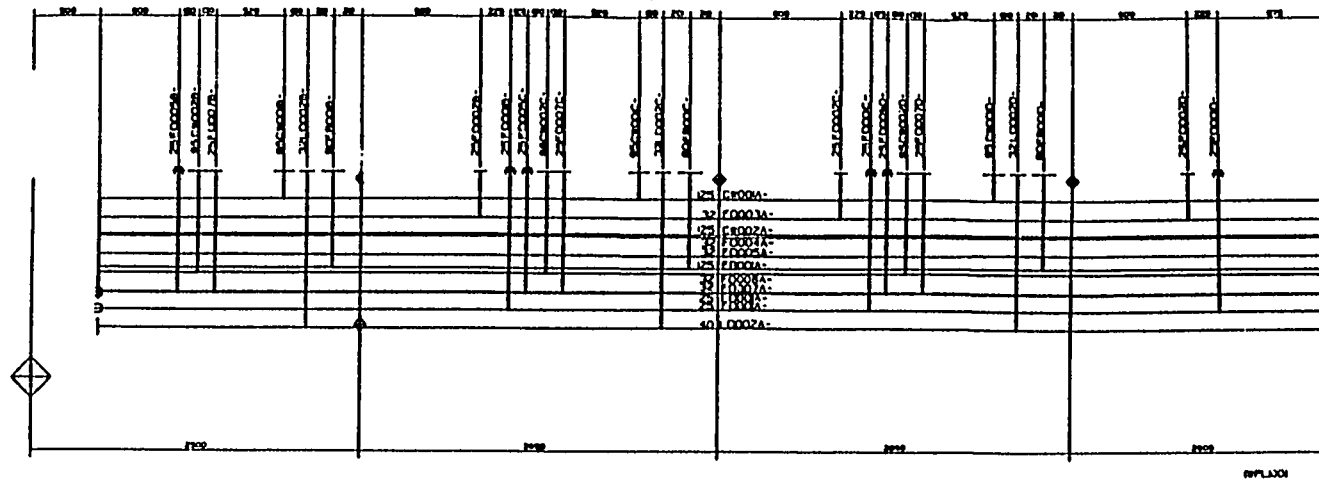


TABLE 1: Typical Performance Indicators (circa 1983-1984)

Hull Construction:

$$\text{Steel Yield Rate} = \frac{\text{Net Weight}}{\text{Invoice Weight}} \times 100 = > 93\%$$

Pipe Fitting:

Man-Hours/Ton	Fabrication	27.5 mh/t
" " "	Installation	40.0 mh/t
Man-Hours/Piece	Fabrication	1.6 mh/pc
" " "	Installation	2.3 mh/pc

$$\text{Pipe Piece Refab Rate} = \frac{\text{Refabrication Number}}{\text{Total Number Fabricated}} \times 100 = < 2\%$$

Electrical:

Man-Hours/Meter for Total Cable Length 0.18 mh/m

Painting:

Man-Hours/Square Meter	Zone 1	0.10 mh/m ²
" " " "	" 2	0.12 "
" " " "	" 3	0.10 "
" " " "	Total	0.11 "

Material Marshaling

$$\text{Pallet Completion} = \frac{\text{Lost Line Items}}{\text{Total Line Items}} \times 100 = < 1.8\%$$

TABLE 2: Principal Dimensions of Three FFG-7 Class Frigates

Differences from Design Principal
Dimensions (in inches)

	Shipyard X	Shipyard Y	Shipyard Z
Length overall	-13 ¹ / ₄	-6 ¹ / ₄	-7 ¹ / ₈
Length between perpendiculars	-3 ¹ / ₈	-3 ¹ / ₄	-1 ¹ / ₈
Beam (midship, main deck)	-1 ¹ / ₂	-2 ¹ / ₄	-1 ¹ / ₂
Beam (midship, design waterline)	-2 ⁷ / ₈	-4 ¹ / ₄	-1 ¹ / ₈
Depth (midship, main deck)	-1 ¹ / ₈	+2	-1 ¹ / ₈

Deviations Beyond Allowed
Tolerances (in inches)

	Shipyard X	Shipyard Y	Shipyard Z
Length overall	-8 ³ / ₄	-1 ³ / ₄	-2 ³ / ₈
Length between perpendiculars	accept.	accept.	accept.
Beam (midship, main deck)	-1 ¹ / ₂	-1 ³ / ₈	accept.
Beam (midship, design waterline)	-1 ⁷ / ₈	-3 ¹ / ₄	-1 ¹ / ₈
Depth (midship, main deck)	-1 ¹ / ₈	+1	-1 ¹ / ₈

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