Propulsion plant feasibility study report subtask 3: economic analysis of selected standards candidates.

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SHIP PRODUCIBILITY PROGRAM
TASK S-1
PROPULSION PLANT
FEASIBILITY STUDY
REPORT
SUBTASK-3
ECONOMIC ANALYSIS
OF
SELECTED STANDARDS CANDIDATES

Prepared for

BATH IRON WORKS CORP.

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TABLE OF CONTENTS

Page

Page

SHIP PRODUCIBILITY PROGRAM

TASK S-I : PROPULSI0N PLANT STANDARDS FEASIBILITY

SUB-TASK 3: ECONOMIC ANALYSIS

5.0 ECONOMIC ANALYSIS OF SELECTED STANDARDS CANDIDATES

5.1 INTRODUCTION

Subtask 1 of this report resulted in a forecast for U.S. Shipbuilding programs for the period 1974 through 1975.

In Subtask 2, based on the results of this forecast, the probable power plants for the ships to be built during the period in question were classified and technically analyzed. As a result of the technical analyses and evaluations of these power plants, four groups of standards were proposed and several candidates from each group were selected for further economic analysis.

This sub-task reports the results of the economic analyses performed on these selected candidate standards. It also introduces a method of generalization for estimating advantages applicable to similar standards in each group which were not economically analyzed. The savings predicted by generalization for each of the standards candidates are then used in estimating the overall cost savings that are attainable when applied all together into the design and construction of a sample ship.

5.2 METHODOLOGY

5.2.I Method of Analysis

In performing the economic analyses for selected standards candidates in all groups, the following approach was used:

1. A format was developed for each group of candidate standards describing the contents of the standard and listing the standardized parameters.

2. The "existing approach" -- that is, the method of production that is currently being used in U.S. Shipyards for completing the work necessary to produce the hardware and/or the services covered by the subject candidates -- was defined clearly since this establishes the basis of comparison.

3. General assumptions that had to be made for all economic analyses were established. These assumptions are listed in 5.2.2.2. Specific assumptions applicable only to the candidate being analyzed were listed in the beginning of the economic analysis for that candidate.

4. Based on the general assumptions, the "standards approach" -- that is, the method of production which would be used in U.S. Shipyards if the "standard" in question were implemented -- was also defined.

5. Cost items for each approach were subdivided to the level of detail required for significant cost resolution. Analyses were performed for each cost item to determine the direct labor and material cost required to perform the work described in the subject cost item.

6. In breaking down the cost items, for purposes of providing simplicity, costs which are the same for both the existing and standards approaches were identified but not quantitatively analyzed.

7. In addressing all the cost items shown on Table 5.1 which was suggested for use by Bath Iron Works Corporation, it was found that many of the items had inconsequential influence upon the total value and that the differences in these items between the "standards approach" and the "existing approach" were negligible. Therefore those cost items marked (X) were included in the analysis only when found to be sufficient to affect the outcome.

8. Total comparative direct labor man-hours and material costs required for the candidate in question were determined for each approach.

9. By deducting the totals for the Standards approach from the totals for the existing approach, savings in terms of direct labor man-hours and material costs were obtained for the candidate in question. These savings indicate the advantages which are available through the use of standards for that candidate only. The savings are estimated in terms of total cost reduction in dollars.

10. A method for generalization of economic analyses was developed, which is described in 5.2.3.

Economic Analysis ol Method Alternatives

Cost Variance		Back-up Data Ref.	Present Method	Proposed Method
1. Material Dizect				
2 .Material Indirect				
3. **Subcontract Cost**	⊗			
4. Direct Labor & Fringes				
5. **Indirect** Labor & Fringes				
6. **Engineering** Labor & Fringes				
7. **Supervision, Clerical & Fringes**				
8. **Supplies**	⊗			
9. **Set-up**				
10. Scrap/Salvage	⊗			
11. Warranty	⊗			
12. **Inventory**				
3. Other	⊗			
14. Overtime & Shift premium	⊗			
15. **Maintenance &** Repairs				
16. **Taxes & Insurance**	⊗			
17. Utilities	⊗			
18. Floor Space	⊗			
*19. **Depreciation**	⊗			
20. **Subtotal**				
21. Less Project Expense	⊗			
22. **Total**				

* For capital investments only; describe schedule used.

TABLE 5-1

⊗ Items which have negligible influence on the net savings for the cost analyses in question.

11. Using the "generalization method" the economic advantages obtained for those candidates on which analyses were performed were extrapolated to predict the advantages obtainable for other candidates in each group.

12. The results of analyses were tabulated in the form of a matrix listing overall savings for all candidates in each group.

13. Using the above-mentioned matrix, the savings in terms of overall cost reduction in dollars were synthesized for a ship to be. fitted with a 26,000 SHP geared Steam Turbine Propulsion plant, as well as for a ship with 14,000 SHP diesel propulsion plant.

14. Based on the overall cost reduction in dollars for the ship in question, the probable savings in dollars were estimated for other ship types in the forecast. For this purpose, the percentage savings based on the total acquisition cost was assumed constant for all propulsion plants as discussed in 5.2.5.

15. Using the estimated savings for each type and size of ship, the overall savings available to the industry through implementation of standards, as delineated in Sub-task 2, for each year of the forecast period, as well as for the complete forecast period (for the total number of ships to be constructed within the period) were predicted.

16. It was recognized that there could be other advantages due to the adoption of Standards, such as elimination of delays in shipyard approval of drawings and reductions in delivery periods of standardized equipment. These advantages are considered to be within the scope of latent cost savings. For a discussion of latent costs refer to 5.2.2.3.h.

5.2.2 Basic Guidelines

For the purposes-of this sub-task, the definitions of the terms used, the general assumptions made and the criteria followed were established.

5.2.2.1 Definitions

The terms as used throughout this analysis are defined as follows:

Overhead	Fixed costs including building depreciation, maintenance, taxes, insurance, management salaries, utilities, etc.
Direct Material	That which becomes incorporated in the final product, including trim waste.
indirect Material	That used to facilitate construction but does not become a permanent part of the final product, i.e. fixtures, tools, temporary guides, and shims, etc.
Direct Labor	That expended on changing the condition of and adding value to direct material.
Indirect Labor	That expended to facilitate producing the final 'product but does not add value *to* the direct material, i.e. set-up, crane operation, and other material handling, etc.
Net Wage Reduction	Amount of net savings in wages only, in 1974 dollars, which can be expected if the Standard approach is used.
Percent Savings in Wages	"Net wage reduction" expressed as a percentage of total wages for the specific standard.
Net Material cost Reduction	Amount of net savings in material costs only, again in 1974 dollars, which can be expected if the standard approach is used.
Percent Savings in Material Costs	"Net Material Cost Reduction" expressed as a percentage of total material cost for the specific standard.
Percent Savings in Total Costs	The sum of "Net Wage Reduction" and "Net Material Cost Reduction" expressed as a percentage of the total cost for the specific standard.

5. 2..2.2. General Assumptions

The basic assumptions made to facilitate the economic analyses, and generally applicable to all candidates, are the following:

a. For labor and material costs, constant 1974 dollars are used. No costs are inflated past July 1974.

b. All direct yard labor man-hours are valued at $4.8o plus 25% for fringe benefits which adds up to a total of $6.oo per hour. The 25% fringe benefit allowance is made up as follows:

Vacation:	4.99%
Holidays:	3. 28%
Hospital ization,.-Health & Life Insurance:	8.5%
Pension:	6.9%
Shift Bonus:	1. 02%
Death Days:	. 47%
Total	25.10%
	use: 25%

These figures are based on published data on fringe benefits paid by 25 yards.

c. All indirect yard labor hours will also be valued at $6.oo per hour including fringe benefits.

d. All engineering and management services will be valued at $9.00 per hour including fringe benefits.

5.2.2.3 <u>Criteria</u>

The following criteria, applicable to all standards candidates, were established for use and guidance in performing the economic analyses:

a. Analyses were limited to items associated with the main propulsion plant and its ancillary equipment.

b. Analyses were performed in such a manner that they will be universal and not dependent upon costs. from a specific yard, owner, designer or vendor.

c. Estimates for direct labor man-hours and schedule times used in the analysis is were based on any one of the following source data:

i. Historical Data: This often is the only data existing, but it is the most difficult source to use for comparison of method changes.

ii. Work Sampling: These data are established by calculating the Standard deviation and determining the level of confidence. When these data are available, judgment should be used in selecting the statistical accuracy desired.

III. Engineered Time. Data: Standard time data applicable to shipbuilding, when available, are an acceptable source in cases where new methods are to be compared.

The sources for all data used in the analyses were identified as to which of the above three types they are. Any sources which are confidential, or of a proprietary nature, were identified in general terms only: e.g. "shipyard source." If for any cost items none of the above sources were available, then costs were estimated using in-house pool of experience.

d. Only those savings which are real and which can reasonably be achieved by appropriate management action were considered. Inflating the savings .by using unrealistic . or unsupportable claims was avoided.

e. Overtime premium was not included in the cost analyses.

f. Overhead, as will be remembered from *its* definition in 5.2.2.1, normally incorporates such. items as property taxes, depreciation, insurance and other items which are not altered by incremental changes in the man-hour expenditures. Overhead savings, therefore, were not claimed in cost comparisons.

g. The cost items were arranged to exhibit expenditures, and therefore cost savings when subjected to a comparison, at one point in time; as such, they did not adequately reflect the on-going impact of project expenses. For this reason, cost items were identified as recurring or non-recurring costs.

h. Latent savings are the second or third generation savings or earnings which are secondary results of a method or system change. They do not include the contribution of the original method or system change. They do include, however, the savings from putting a “freed resource” to a new use. Areas of prime concern for latent impact studies include those where a freed resource is made available either by a method change or by increased through-put. Latent savings were not included in the quantitative analysis since they would depend largely on the facilities available in a specific shipyard and as such would constitute a deviation from the objective of this study. Nevertheless, latent savings will exist, and they are a distinct advantage of the standards alternative.

5.2.3 Method of Generalization

In order to predict the labor and material savings for potential Standards on which economic analyses were not performed, a method for generalization of results obtained from the analyses performed on selected candidates was devised.

A brief description of the method and a sample application are given below. Individual generalizations for all standards are to be found at the end of analyses for each group.

5.2.3.1. Approach

a. Identify each standard with the most nearly simiiar standard for which an econcmic analysis was performed.

b. Assign a "size rating" in percentage to each standard as compared to the similar standard. .

c. Assign a "complexity rating" to each candidate in the same manner.

d. For the selected "similar" standard estimate the contributions of its size and complexity to the overall savings.

e. Multiply size rating from (b) by size contribution from (d) to get estimated % reduction in costs for the subject standard based on size comparison with the similar standard.

f. In the same manner, calculate estimated (%) cost reduction based on complexity comparison.

g. Add the two estimated % *cost* reductions *to* get the overall % *cost* reduction attainable for the subject standard.

h. Multiply percentage obtained in (g) by the calculated total savings for the similar standard to get the estimated total savings for the subject standard.

5.2.3.2 Sample Generalization

a. Candidate for Generalization: Main Condenser
Similar Candidate: Main Boiler

b. For the Main Boiler: (From 5.6.2.4)
Total Savings = s18,570 (for Hardware Standards)

Size Contribution for Boiler: Estimated 40% of total

Complexity Contr~bution for Boiler: Assume 60% of total

c. For the Main Condenser:

Estimate Size Rating: 30%
Complexity Rating: 60%
As compared to Main Boiler

d. Calculate Related Savings:

Contribution	% for Candidate Std	% Similar Std	Estimated % Savings
si ze	.30	.40	.12
Compl exity	.60	.60	.36
Total			.48

Total Savings for Condenser: .48 x 18,570 = $ 8,9oo

5.2.3.3 Results of Generalization

The above process was repeated for all the Candidates in Groups 11, Ill and IV, and the predicted total savings for Candidates in each group were listed at the end of economic analysis for that group. (Refer to5,,4.3, 5.5.3 and 5.6.3).

Table 5-2 is a compilation of the data in above-mentioned sections as applicable to the propulsion Machinery Components of a 26,000 SHP Steam Turbine plant which may be installed on an 80,000 DWT Oil Tanker.

NAME OF CANDIDATE STANDARD	GROUP	TOTAL SAVINGS $	SOURCE REF.
MAIN CONDENSER	IV-H	8,900	TABLE 5-26
MAIN TURBINE	IV-H	26,000	TABLE 5-26
FORCED DRAFT FAN	IV-H	6,500	TABLE 5-26
MAIN CIRCULATING PUMP	III	5,124	TABLE 5-21
LUBE OIL COOLER	IV-H	1,900	TABLE 5-26
FIRST STAGE HEATER	II	20,090	TABLE 5-16
DEAERATING FD. HTR.	III	5,175	TABLE 5-21
LUBE OIL SERVICE PUMP	IV-H	3,600	TABLE 5-26

TABLE : 5-2 "GENERALIZED" SAVINGS FOR COMPONENTS OF A 26,000 SHP STEAM TURBINE PLANT

5.2.4 Synthesizing Savings from Individual Standards into Overall Savings on the Total Construction Cost of a "PARENT" Ship*

After estimating the total cost savings for all standards in all groups, following the "method of generalization" described in 5.2.3, a method of incorporating these individual savings into the total construction cost of a sample ship was developed. The standard formats developed for a steam turbine and a medium-speed diesel propulsion plant (Group I -- total propulsion plant standards) were used as a basic reference.

As a "parent" ship for the steam turbine propulsion plant analysis, one that would use the24-26,000 SHP plant was selected. Referring to Table O of the standard format, enclosed in Appendix C.1.l., the number of standards and the "group" each standard belongs to were selected as shown in Table 5.3, which is a filled-out copy of the above-mentioned Table D.

For the diesel propulsion plant analysis, a ship that would use the 14,000 SHP medium speed diesel installation was selected as the parent ship. Table A of the standard total diesel plant format in Appendix C.I.2 is filled out for the parent ship by assuming the use of specific groups and types of standards. Table 5-4 is the result of these assumptions.

LIST I NG OF PROPULS I0N PLANT COMPONENTS

FOR A PERENT SHIP

WITH 26, 000 SHP STEAM PLANT

Equipment/Component	Quantity	Standard Group	Remarks.
Main Steam Boiler	2	III	
Main Turbine (Set)	1	Iv	Hardware Std.
Main Condenser	1	Iv	Hardware Std.
Reduction Gear (Set)	1		Non-Std.
Main Lube Oil Pump	2	Iv	Hardware Std.
Forced Draft Fan	2	Iv	.Hardware Std.
Main Feed Pump	1	II	Ma-in Feed Pump Module
Fuel Oil Service Pump	1	II	Fuel Oil Service Sys. Module .
Main Circulating Pump	2	111	
Main Condensate Pump	2	IV	Hardware Std.
Fuel Oil Heater	1	II	F.O. Service Sys.Module
Lube Oil Cooler	2	IV	Hardware Std.
First-Stage Feed Heater	1	II	First Stg. Fd. Htr. Module
Gland Exhauster		II	First Stg. Fd. Htr. Module
Drain Cooler		II	First Stg. Fd. Htr. Module
De-aerating Feed Heater	1	III	
3rd Stage Heater			N.A.
4th Stage Heater			N.A.
Automation System	1		Non-Std.

TABLE 5 - 3

LISTING OF PROPULSION PLANT COMPONENTS
for a PARENT SHIP
with 14,000 SHP MEDIUM SPEED DIESEL PLANT

Equipment/Component	Standard Group	Quantity	Remarks
MAIN DIESEL ENGINE	IV	2	Hardware
AUTOMATION SYSTEM	—	1	Non-Std.
REDUCTION GEAR	—	1	Non-Std.
STARTING AIR COMPRESSOR	IV	2	Hardware
EXHAUST GAS BOILER	III	2	
FRESH WATER COOLERS	IV	3	Hardware
LUBE OIL COOLERS	—	—	Included in Accessory Rack
DIESEL ACCESSORY RACK	II	2	
FUEL OIL SERVICE SYSTEM	II	2	
FUEL OIL PURIFIER	IV	1	Hardware
LUBE OIL PURIFIER	IV	1	Hardware
LUBE OIL SERVICE PUMP	IV	4	Hardware
REDUCTION GEAR LUBE OIL BOOSTER PUMP	IV	1	Hardware

TABLE 5-4

For each of the standards used in the "parent" ship's propulsion plant, the predicted total unit savings in dollars were obtained from 5.4.3, 5.5.3, and 5.6.3, and listed in Tables 5 - 5 and 5 - 6. Multiplying the unit savings by the number of units of each standard to be installed on the ship, the total amount of savings attainable by using each standard was obtained. A summation of these savings resulted in the composite savings possible for the parent ships if the Group II, III and IV Standards, as indicated in Tables 5 - 3 and 5 - 4, are used. Referring to Table 5 - 5, the "composite" savings mentions above is $176,494 for the parent steam propelled ship. For the parent Diesel propelled ship, the savings is $182,402 as read from Table 5 - 6. The savings possible due to implementation and use of Group I total plant Standards is additional to these amounts. These are as estimated in 5.,3.2.3 and 5.3.3.3, for ships of the size and power ranges similar to the parent ships, savings are $87,84o on total shipbuilding costs for the steam plants, and $56,340 for the diesel plants.

Therefore, the overall savings attainable through the use of Groups II, III and IV Standards , for the parent ships become:

$176,494 +87,840= $264,334 for a steam plant of 26,000 SHP

and

$182,402 +56,340= s238,742 for a diesel plant of-14,000 SHP.

Equipment – Component	Selected Standard Group	Unit Savings for the Standard $	Number of Units	Total Savings	Reference
Main Boiler	III	17,124	2	34,248	5.5.2.1
Main Turbine	IV-H	26,000	1	26,000	5.6.3
Main Condenser	IV-H	8,900	1	8,900	5.6.3
L.O. Purifier	III	4,461	2	8,922	5.5.2.2
Forced Draft Fan	IV-H	6,500	2	13,000	5.6.3
Main Feed Pump	II	11,757	1	11,757	5.4.2.2
Fuel Oil System	II	17,470	1	17,470	5.4.2.1
Main Circ. Pump	III	5,124	2	10,248	5.5.3
Main Condensate Pump	IV-H	4,842	2	9,684	5.6.2.2
L.O. Cooler	IV-H	1,900	2	3,800	5.6.3
L.O. Service Pump	IV-H	3,600	2	7,200	5.6.3
First Stage Feed Htr.	II	20,090	1	20,090	5.4.3
Deaerating Feed Htr.	III	5,175	1	5,175	5.5.3
	Total Savings – Groups II, III & IV			176,494	

Table: 5-5

EQUIPMENT – COMPONENT	SELECTED STANDARD GROUP	UNIT SAVINGS FOR THE STANDARD $	NUMBER OF UNITS	TOTAL SAVINGS	REFERENCE
DIESEL ENGINE	IV-H	18,200	2	36,400	5.6.3
STARTING AIR COMPR.	IV-H	4,698	2	9,396	5.6.2:3
EXHAUST GAS BOILER	III	3,767	2	7,534	5.5.3
FRESH WATER COOLER	IV-H	1,857	3	5,571	5.6.3
ACCESSORY RACK	II	31,607	2	63,214	5.4.2.3
F.O. SERVICE SYST.	II	17,470	2	34,940	5.4.2.1
F.O. PURIFIER	IV-H	3,900	1	3,900	5.6.3
L.O. PURIFIER	IV-H	3,900	1	3,900	5.6.3
L.O. SERVICE PUMP	IV-H	3,600	4	14,400	5.6.3
REDUCTION GEAR L.O. BOOSTER PUMP	IV-H	3,147	1	3,147	5.6.3
TOTAL SAVINGS – GROUPS II, III & IV				182,402	

5.2.5 Prediction of Savings for Other Ships in the Forecast

In order to predict the probable savings (due to use of propulsion plant stahdards) in the construction cost of any ship without going through an extensive analysis of all the propulsion plant standards used on the vessel, the relative acquisition costs of the propulsion plants were utilized as a basis for comparison; and it was assumed that the savings attainable will be directly related to the acquisition cost for all plants of the same working medium. In other words, it is estimated that all steam turbine plants will yield a constant percentage of the total acquisition costs as savings due to standardization. Similarly all diesel plants will yield a savings which is a constant percentage of its total acquisition cost.

The percentage savings for steam and diesel plants were estimated using the previously estimated total savings for the respective sample plants (See 5.7). It is recognized that in order to obtain truly meaningful comparisons, the respective ships should be considered in much more extensive detail, including such characteristics as the propulsion shafting and propellers, non-propulsion machinery, deck machinery and other shipboard installations. However when all of these are considered, unless a specific ship design is at hand, the results obtained will not, in any sense, be exact. For purposes of this feasibility study, the specific ship designs are naturally not available. . Yet the need foresee-the effects (benefits or penalties) the proposed standardization might have upon shipbuilding costs is a prerequisite of the program. Therefore, in order to predict not the exact magnitudes of the savings but the general trend for various applications, the following method of comparison is adopted:

Given the constant percentage savings, the approximate overall savings for any propulsion plant can be calculated . by estimating the total acquisition cost of the plant and multiplying this cost by the percentage savings.

Example

For the "parent' ship with 26,000 SHP, 2 Boilers, 2 Stage feed heating, the percentage savings is: 3.82% (from 5.7.1).

For a sample ship with 30,000 SHP, 2 Boilers and 2 Stage feed heating, the total acquisition cost is estimated by the formula:

$$A= 42855.7\ (SHP)^{0"5}$$

and found to be $A = \$7,42 \times 10^6$

Therefore the savings is:

$$s= .0382 \times 7.42 \times 10^6 = \$283,000$$

Refer to Section 5.7.2 and Table 5-27 for estimation of savings for all other steam plants. Diesel plant savings are summarized in Section 5.7.2

5.3 ANALYSIS OF TOTAL PLANT STANDARDS - GROUP I

5.3.1 General

5.3.1.1 Brief Description of Group 1 Standards

The proposed total plant standards were described as to contents and extent in the standard formats developed in the course of Sub-task 2 efforts. More detailed copies of these formats are included in Appendix-C.

As established in Sub-task 2, Paragraph 4.5.4.1, the total plant standard is considered a "top level reference document which can be utilized in defining and designing the total propulsion plant", and it contains the performance parameters and operating characteristics on which the design of major systems for the total plant is based.

5.1.2 Candidates Selected for Economic Analysis

The results of the forecast showed that within the forecast period, 239 ships with geared steam turbine propulsion plants would be contracted for. Ships with gas turbine propulsion plants *were* next with a number to be contracted of 119, and medium-speed diesel propelled ships followed with a predicted number of 90.

It appears reasonable and logical that economic analyses should be performed for each of these three propulsion plants. However, as discussed in Sub-task 2, paragraph 4.6.3, gas turbine propulsion plants have been essentially standardized at the total package level by the manufacturers in such a manner that there would be little if any difference between the existing approach and the standards approach. It was therefore deemed premature to attempt an economic analysis of the gas turbine propulsion plant.

- --

The following two total plants were selected for quantitative analysis:

1. For Steam Plants: a 26,000 SHP Two Boiler two-stage feed heating cycle geared steam turbine installation.
2. For diesel plants: a 14,000 SHP medium-speed, geared diesel installation.

5.3.1.3 Limitations of Analyses

In performing the economic analyses, the basic guidelines" established in 5.2.2 were followed. As will be recalled, these guidelines consisted of certain assumptions and criteria. The accuracy of the analyses naturally depends largely on the validity of these guidelines. Additionally, the specific assumptions made in connection with each analysis and the actual numerical data used in estimating costs for cost items involved limit the accuracy of the results obtained. It can be concluded, therefore, that the precise amount of savings estimated - in terms of numerical evaluations - may be subject to some uncertainty. However, the comparative evaluations are useful and it can be deduced with confidence that if the standards in question are implemented, there will be a definite trend toward savings, and that it is feasible to initiate a program toward implementation of total plant standards.

5.3.2 26,000 SHP Steam Propulsion Plant Analysis

In the following pages analysis of the steam propulsion plant is presented. The selected standard's SHP range is 26,000. Group I format of Appendix C.I.I describes the possible contents of a total plant standard for this horsepower range as well as all other ratings.

The anal yses, as described in greater detail in 5.3.2.1 and 5.3.2.2, are based on the assumption that a complete standard had been developed and implemented for use by shipyards, design agents, manufacturers, and owners, and that it contains, as a minimum, the extent of information outlined in the format.

5.3.2.1 Definition of Existing Approach

The economic analyses are based on a comparison of the existing method of production in the U.S. Shipbuilding Industry for the design of a total propulsion plant with the method of production that would be used if the proposed total plant standards were implemented and made available to the shipyards and ship designers.

The present method, or the "existing approach" is defined as follows.:

a. The design of the propulsion plant is not available.

b. Starting with the owner's requirements, a complete preliminary design is developed following normal procedures.

c. Contract and detail designs are developed after finalizing the preliminary design parameters.

.The breakdown of cost items for the existing approach will be as listed on the analysis formats in 5.3.2.3 and 5.3.3.3, for steam and diesel propulsion plants respective'ly*

5.3.2.2 Definition of Standards Approach

With the standards approach, the following specific assumptions apply:

a. A formal "Total Plant Standard" for the SHP and type of propulsion plant in question is available to the shipyard and the ship designer;

b. This standard document contains all the information, listed in the standard format of Appendix C.I.l;

c. For the shaft horsepower range in question, the standard heat balances contained .in the formal document will be useable with little or no modifications for all possible ship types and variations.

The breakdown of cost items for the standards approach is as shown below. (This breakdown was the basis for the analysis forms used in 5.3.2.3.)

a. For Contract Design:

1. Study owner's requirements and decide *on* the type of power plant and drive system for the SHP range. Select a standard power plant from the available total plant standards which most nearly fulfills the requirements. Review the standard heat balances and generator sizing.
2. Review and finalize the standard pump and heat exchanger sizing calculations.
3. Review and finalize the standard electrical load analysis.
4. Review Standard schematic engine room arrangements and add ship-plant interface.
5. Review and finalize standard piping systems schematics.
6. Develop engine room arrangements.

7. Review and finalize standard piping diagrammatic arrangements.
8. Review standard line shaft and bearing arrangements and add interface with the ship.
9. Develop set of secondary contract drawings.
10. Amplify standard and compile information developed into a contract specifications.
11. Finalize conditional ABS and USCG approvals.

b. For Detail Design:

1. Prepare equipment and material specifications.
2. Perform bidding and procurement operations.
3. Produce final heat balance diagram.
4. Produce final electrical load analysis.
5. Finalize shafting & bearings calculations.
6. Perform piping system stress analysis
7. Finalize piping system diagrammatic arrangement drawings.
8. Develop complete set of detail working drawings.
9. Complete detail specifications for propulsion machinery.
10. Prepare test & trial memoranda
11. Obtain ABS, USCG and Owner's approvals.

5.3.2.3 Cost Analyses

Based on the breakdown of cost items for the .existing and standards approaches for the 26,000 SHP steam turbine propulsion plant, the cost analyses *were* performed on analysis forms included in following pages.

The costs were estimated separately for the contract design and detail design phases. The source for labor manhours entered for. the existing method is MR&S data compiled from previous experience. For the standards approach, the labor expenditures are estimated values.

The results can be summarized as follows:

Design Phase	Savings in Labor Manhours	Savings *In $*	Schedule Time Savings Months
Contract Design	6740	$60,660	4
Detail Design	3020	27,180	3
Total Savings	9760	87,840	7

Therefore a total savings of 9760 manhours is possible in labor expenditures and this may correspond to a scheduling time savings of up to seven months. The dollar value of the savings, based on the $9/manhour rate, is $87,84o. As will be recalled from 5.2.2.2, the rate used here contains the fringe benefits but has not allowance for overhead. It follows that, depending on the overhead rate, the actual savings will probably be considerably greater than the $87,84o estimated.

Group I - Economic Analysis

26,000 SHP Steam Turbine Plant

Contract Design

COST ITEMS		EXISTING APPROACH				STANDARDS APPROACH				NOTES
NO.	DESCRIPTION	DIRECT LABOR MH	INDIRECT LABOR MH	LABOR COST $	SCHEDULE MONTHS	DIRECT LABOR MH	INDIRECT LABOR MH	LABOR COST $	SCHEDULE MONTHS	
1	Prelim. Heat Balance	1200			3.0	40			.2	
2	Pump & Heat Xchg. Sizing	2000			4.3	80			.5	
3	Prelim. Elect. Load. Anal.	800			5.0	40			.6	
4	Schem. E.R. Arrg't.	200			5.0	80			1.0	
5	Prelim Piping Schematics	600			5.3	60			1.2	
6	Engine Room Arrangements	800			5.9	800			1.8	
7	Piping Systems Diagrammatic Arrg'ts	1500			6.0	40			1.8	
8	Lineshaft & Bearings Diag. Arrg't. & Calcs.	400			6.0	80			1.8	
9	Set of Secondary Contract Dwgs.	500			6.0	200			2.0	
10	Contract Specs	1000			6.0	1000			2.5	
11	ABS & USCG Approvals	200			6.5	40			2.5	
12										
13										
14										
15										
16										
	TOTALS	9200		82,800	6.5	2460		22,140	2.5	
	(LESS STDS. APPR.)			22,140	2.5					
	SAVINGS $			60,660	4.0					

MR&S-2650.C
DEC-74

TABLE 5-7

GROUP I – ECONOMIC ANALYSIS
26,000 SHP STEAM TURBINE PLANT
DETAIL DESIGN

COST ITEMS		EXISTING APPROACH				STANDARDS APPROACH				
NO.	DESCRIPTION	DIRECT LABOR MH	INDIRECT LABOR MH	LABOR COST $	SCHEDULE MONTHS	DIRECT LABOR MH	INDIRECT LABOR MH	LABOR COST $	SCHEDULE MONTHS	NOTES
1	SPECS. FOR EQUIP. & MAT'L.	1500			5	750			2	
2	BIDDING & PROCUREMENT	600			7	300			4	
3	FINAL HEAT BALANCE	300			8	40			3	
4	FINAL ELEC. LOAD ANAL.	300			9	40			3	
5	SHAFTING CALCS.	500			9	400			7	
6	PIPING STRESS ANAL.	1000			9	800			8	
7	PIPING DIAG. ARR'GTS.	300			9	150			8	
8	DETAIL WORKING DWGS	10,000			14	10,000			12	
9	DETAIL SPECS.	1,000			8	200			2	
10	TEST & TRIAL MEMOS	600			15	600			12	
11	APPROVALS	800			16	600			13	
12										
13										
14										
15										
16										
	TOTALS	16,900		152,100	16	13,880		124,920	13	

MR&S-2650.C
DEC. 74

(LESS STDS. APPR.)	124,920	13
SAVINGS	27,180	3

TABLE 5-8

5.3.3 14,000 SHP Medium Speed Diesel Plant Analysis

In the following pages, analysis of the medium speed diesel propulsion plant is presented. The selected candate's SHP range is 14,000. Group 1 format of Appendix C.1.2 describes the contents of a typical total plant standard for this horsepower range as well as all other atings.

The analyses, as described in greater detail in 5.3.3,1 and 5.3.3.2, are based on the assumption that a complete standard had been developed and implemented for use by shipyards, design agents, manufacturers and owners, and that if contains, as a minimum, the extent of information outlined in the—format.

5.3.3.1 Definition of Existing Approach

The present, or the "existing" approach, in connection with diesel propulsion plants, is defined in the same manner as with the steam propulsion plant:

a. A design for the plant is not available.

b. Starting with the owner's requirements, a complete preliminary design is developed following normal procedures.

c. Contract and detail designs are developed after finalizing the preliminary design parameters.

The breakdown of cost items for the existing approach will be as shown on the analysis formats of 5.3.3.3.

5.3.3.2 Definition of Standards Approach

The following specific assumptions are applicable for the analysis of the standards approach:

a. A formal "Total Plant Standard" for the SHP and type of propulsion plant desired is available to the shipyard and the ship designer.

b. This standard document contains all the information listed in the standard format of Appendix C.1.2.

The breakdown of cost items for the standards approach is as shown below. (This breakdown was the basis for analysis forms used in 5.3.3.3)

a. <u>For Contract Design</u>:

1. Study owner's requirements and decide on the type of power plant and drive system for the SHP range. Select a standard power plant from the available total plant standards which most nearly fulfills the requirements.
2. Review and finalize the auxiliary and support systems for the main propulsion plant.
3. Review and finalize the standard sizing of equipment and materials.
4. Review and finalize standard piping system schematics.
5. Review and finalize the standard electrical load analysis.
6. Review standard lineshaft and bearing calculations and diagrammatic arrangements, finalize, and add interface with the ship.
7. Review standard schematic engine room arrangements and add ship-plant interface.
8. Develop engine room contract arrangement plans.
9. Develop contract diagrammatic arrangements for piping systems.
10. Develop set of secondary contract drawings.
11. Develop contract specifications.
12. Obtain standard ABS and USCG approvals.

b. <u>For Detai l Design</u>:

1. Prepare technical and procurement specifications for equipment and materials for the total propulsion plant.
2. Conduct bidding and procurement operations.
3. Perform final shafting calculations, finalize shafting and bearings arrangements, obtain torsional vibration analysis for the engine and shafting system.
4. Finalize diagrammatic arrangement of propulsion piping systems, add interface with ship and other non-propulsion piping systems.
5. Conduct final electrical load analysis required for electrical one-line diagram.
6. Develop complete set of working drawings related to the main propulsion systems.
7. Perform stress analys'is for the piping systems.
8. Develop detail specifications for the main propulsion Sys terns .
9. Prepare test and trial memoranda.
10. Obtain USCG, ABS, Owner's, and U.S. Public Health Service approvals as required.

5.3.3.3 Cost Analysis

The contract design phase and the detai l design phase were anal yzed separately.

The labor manhour expenditures for both the existing and the standards approaches were estimated by MR&S since no engineered time data or work sampling data were available.

A summary of the results follows:

Design Phase	Savings in Manhours	Savings In $	Schedule Time Savings - Months
Contract Design	4200	$37,800 .	3.3
Detail Design	2060	18,540	3.0
Total. Savings	6260	56,340	6.3

A total savings of 6260 manhours can be realized in labor expenditures. This may correspond to a scheduling time savings of up to 6.3 months. The dollar value of the savings, based on the established $9/Manhour rate (see 5.2.2.2), is $56,340. Since the rate used does not contain overhead expenses, which depend on the actual overhead rate, the net total savings will probably be considerably more than the estimated value of $56,340.

GROUP I – ECONOMIC ANALYSIS 5.3.3.3

14,000 SHP MEDIUM SPEED DIESEL PLANT

CONTRACT DESIGN

COST ITEMS,		EXISTING APPROACH				STANDARDS APPROACH				NOTES
No.	DESCRIPTION	DIRECT LABOR MH	INDIRECT LABOR MH	LABOR COST $	SCHEDULE MONTHS	DIRECT LABOR MH	INDIRECT LABOR MH	LABOR COST $	SCHEDULE MONTHS	
1	PRELIMINARY DESIGN	400			1	40			Z	
2	DESIGN OF AUXILIARY & SUPPORT SYSTEMS	1000			2	160			1.0	
3	SIZING OF EQUIPMENT & MAT'LS.				3	80			1.2	
4	PIPING SCHEMATICS	COO			3.5	120			1.5	
5	PRELIMINARY ELECT. LOAD ANALYSIS	=			14	80			1.8	
6	LINESHAFT & BEARINGS DIAG. ARR'GT. & CALCS.	400			4.5	80			2.0	
7	ENGINE ROOM SCHEMATIC ARR'GT.	200			4.7	40			2.1	
8	ENGINE ROOM – CONTRACT ARRANGEMENT DWGS.	600			5.3	600			2.4	
9	PIPING SYSTEMS – CONTRAC DIAG. – ARRANGEMENTS	800			5.7	200			2.6	
10	SET OF SECONDARY CONTRACT DWGS.	1000			6.0	400			3.0	
11	CONTRACT SPECIFICATIONS	800			6.0	800			3.0	
12	ABS & USCG APPROVALS	200			6.5	40			3.2	
13										
14										
15										
16										
	TOTALS	6800		61,200	6.5	2600		23,400	3.2	
	(LESS STDS. APPR.)			23,400	3.2					
	SAVINGS			37,800	3.3					

MR&S-2250.C DEC. 74

TABLE 5-9

GROUP I – ECONOMIC ANALYSIS

5.3.3.3

14,000 SHP MEDIUM SPEED DIESEL PLANT

DETAIL DESIGN

COST ITEMS		EXISTING APPROACH				STANDARDS APPROACH			
NO.	DESCRIPTION	DIRECT LABOR MH	INDIRECT LABOR MH	LABOR COST $	SCHEDULE MONTHS	DIRECT LABOR MH	INDIRECT LABOR MH	LABOR COST $	SCHEDULE MONTHS
1	EQUIPMENT & MATERIAL SPECS	1200			4	700			2
2	BIDDING & PROCUREMENT	500			5	250			2.5
3	FINAL SHAFTING CALCS. & VIBRATION ANALYSIS	500			6	400			3
4.	PIPING SYSTEMS DIAGRAMMATIC ARR'GT	400			7	200			3
5	FINAL ELECTRICAL LOAD ANALYSIS	200			7	40			3
6	DETAIL WORKING DRAWINGS	6,400			11	5,400			9
7	PIPING SYSTEMS STRESS ANALYSIS	400			11	350			9.5
8	DETAIL SPECS	800			8	200			10
9	TEST & TRIAL MEMORANDA	600			12	600			10
10	APPROVALS	700			13	500			10
11									
12									
13									
14									
15									
16									
	TOTALS	11,700		105,300		9,640		86,760	10
	(LESS STDS. APPR.)			86,760	10				
	SAVINGS			18,540	3				

MR&S-2650.C
DEC. 74

TABLE 5-10

5.3.4 Generalization of Results for Group I Standards

5.3.4.1 For Steam Turbine Plants

The results of economic analysis fora 26,000 SHP Geared Steam Turbine Propulsion plant total package standard showed that the total savings that can be expected is $87,840 in labor cost and seven months in scheduling time. It will be remembered that the steam plant in question was a "two boiler - two stage feed heating" , cycle.

In subtask-1 report, "Forecast for Propulsion Plant Standards," it was predicted that the ships to be contracted for during the forecast period would require, in addition to the "2 Boiler - 2 Heater" cycle plant mentioned above, the following different plant cycles:

- Two boiler, 4 heater cycle
- One boiler, 2 heater cycle
- One boiler, 4 heater cycle
- Reheat cycle.

Subjecting each one of these cycles to a comparison against the basic cycle of 2 boilers and 2 heaters, the probable total savings can be estimated by assuming that the savings will be a constant percentage of the total acquisition cost of the propulsion plant.

Table 5 - 11 Summarizes the results of calculations performed in this manner. The total acquisition costs shown in column A of this table are taken from Table 5-27 in Section 5.7.

The constant "percentage value applied in calculating savings for each cycle is derived as follows from the parent 26,000 SHP, 2 boiler, 2 heater cycle propulsion plant savings:

Savings for parent plant = $87,840

Total acquisition cost of parent plant =

$\$6.78 \times 10^{6}$

Percentage Savings = $\frac{87{,}840}{\text{[illegible]}} \times 100 = 1.296\%$

The predicted savings listed in Column B for different cycle types are then obtained by multiplying this constant percentage value by the total acquisition costs in column A.

STEAM PLANT			Ⓐ ACQUISITION COST $ · 10⁻⁶	Ⓑ SAVINGS WITH GR.I STDS. $
CYCLE	SHP	SYMBOL		
TWO BOILERS TWO HEATERS	16,000	A-16	5.42	70,243
" "	26,000	A-26	6.78	87,840
" "	30,000	A-30	7.42	96,163
TWO BOILERS FOUR HEATERS	37,000	B-37	8.48	109,900
" "	44,000	B-44	9.24	119,750
" "	50,000	B-50	9.85	127,656
ONE BOILER TWO HEATERS	25,000	C-25	6.82	88,387
" "	30,000	C-30	7.49	97,070
ONE BOILER FOUR HEATERS	37,000	D-37	8.61	111,586
REHEAT CYCLE	44,000	E-44	9.48	122,861
" "	50,000	E-50	10.09	130,766

TABLE 5-11

5.3.4.2 For Diesel Plants

The savings due to implementation and use of total plant standards for the 14,000 SHP Medium-Speed Diesel Propulsion Plant was estimated in 5.3.3.3 and found to be $56,34o.

The forecast includes ships with medium-speed diesel engine propulsion plants of 7,000 and 28,000 SHP as well. Following the same logic as for the steam turbine plants, and assuming that the percentage savings on the basis of total acquisition cost is constant, the individual savings for each varying SHP range can be predicted as follows:

For the parent plant of 14,000 SHP, total acquisition cost, from 5.7, is $4.32x 10^6$.

The percentage savings:

$$\frac{\quad}{4.32 \times 10^6} \times 100 = 1.304\%$$

Applying this constant percentage value *to* other SHP ranges:

For 7,000 SHP Plant:

Savings = .01304 x2.78 x 19^6 = $36,251

For 28,000 SHP Plant:

Savings = .01304x 7.05 X.10^6= $91,932

5.4 Analysis of Module Standa*rds - Group II

5.4.1 General

5.4.1.1 Brief Description of Group II Standards

The module standards were defined in subtask-2 (4.5.3.2) as documents "which contain the technical data and information to define and describe a complete sub-system or group of like equipment" mounted together on a common base. A format was developed for this standard and is included in Appendix c.2. An option is open to the shipyard with the module standards. to either purchase a vendor-assembled module ("BUY" decision) or to buy the individual equipment from Vendors and assemble them in accordance with the requirements of the Standard in the shipyard ("MAKE" decision).

5.4.1.2 Candidates Selected for Economic Analysis

As a representative sampling of potential candidates for module standards, the following were selected, as discussed in 4.6.2, for economic analysis in the present subtask:

1. Fuel Oil Service System Module
2. Main Feed Pump Module
3. Diesel Accessory Rack Module

5.4.1.3 Limitations of Analysis

In connection with each individual module, assumptions additional to those established in 5.2.2 were made regarding various cost items. In economically analyzing the module standards, it was recognized that the basic funtion involved was the assembling of individual equipment comprising the module on a common foundation and making necessary connections. As such, it was more readily adaptable to shipyard procedures, and it was therefore possible to follow the Bath Iron Works Corporation suggested "Cost Analysis Guide!' " of Table 5-1. As a result of this approach, however, the analyses were further dependent on the validity of estimates made for cost items such as crane time, set-up time, inventory, maintenance and repairs, etc. it is quite clear that these cost items will require differing expenditures in different shipyards. The estimates presented here, naturally are subjective in this sense. Nevertheless, they results in finite savings with standard modules over non-standard modules, be it shipyard-assembled or vendor-assembled. .

5.4.1.4 "Make-or-Buy" Decision

Once the module standards are developed and implemented, the shipyards will have a genuine opportunity to investigate the advantages and/or disadvantages of assembling the module themselves. If an economic gain is foreseen in shipyard-assembled modules and if the production work force of the shipyard necessary to do this assembling, without disrupting the normal ship construction and installation. wor.k, is available, then the decision will be "make". If, however, the reverse happens, the only choice will be to "buy" the vendor-supplied module. There may be special cases when due to availability of slack work force, a "make" decision can be adopted despite the fact that buying the module may cost less.

In the analyses reported upon in 5.4.2, the "make-or-buy" decision, strictly in terms of dollar values, is apparent. The cost savings estimated for each of the three selected candidates show that Alternative l, which assumes a vendor-supplied standard module, is economically advantageous over Alternative 2 which is the case for a shipyard-assembled standard module. An additional factor which is not accounted for in this report is the probable lower overhead rate of a module builder as compared to the shipyard. However, as pointed out above, the actual "make-or-buy" decision will have to be resolved by the individual shipyards for the time frame at hand. This decision may have to be made after considering some or all of the following factors:

1. Responsibility
2. Proficiency of procurement
3. Proficiency of assembly
4. Quantity buys
5. Profits or mark-ups
6. Delays
7. Delivery times
8. Work for personnel at slack times
9. Module design costs
10. Module design control
11. Overhead comparison

5.4.1.5 Definition of Existing Approach

The existing or "Present" approach, which is assumed to be the method of production "used in U.S. Shipyards today, is defined as fol lows:

a. 'Individual components of the module are purchased separately and arrive at the shipyard on separate foundations. Shipyard must design the module.

b. The shipyard must store and protect equipment until it is ready for assembly.

c. The shipyard has no preformed pipe ready.

d. Assembling of the non-standard module will be done by the shipyard prior to installation on the ship.

The breakdown of cost items for the *existing* approach will be as listed on the analysis formats in 5.4.2.

5.4.1.6 Definition of Standards Approach

The economic analyses of modules for the standards approach is performed for two distinctly different alternatives. The first alternative is the purchasing of a vendor-assembled standard module by the shipyard, and the second is the assembling of the standard module by the shipyard. Each of these alternatives will be traded off against the present method.

The breakdown of *cost* items for the standards approach is as shown below (This breakdown was used as the basis for analysis forms used in 5.4.2):

- .

a. Procurement Phase

1. Technical department direct labor

2. Contracts department direct labor

3. Planning and estimating department direct labor

4. Bid and response

5. Equipment costs.

b. Installation Phase

1. Direct labor in shop

2. Direct labor on ship

3. Crane time

4. Engineering interface

5. Set up time

6. Delays and spool pieces

7. Inventory

8. Maintenance and repairs

c. Test and Check Out Phase:

These costs are assumed to be equal for the Present and Standards approaches.

5.4.2 Cost Analysis

The cost analyses for the module standard were based on the breakdown of cost itmes for the existing and standards approaches as described in 5.4.1.5 and 5.4.1.6.

For the existing approach, engineered time data for various operations such as planning and estimating department direct labor, contract department direct labor and technical department direct labor were used as supplied by Bath Iron Works Corporation. All other cost items for which engineered time data or work sampling data were not available were estimated by MR&S.

Two different alternatives were investigated for the standards approach as can be seen in the analysis forms on the following pages. The first alternative is the "vendor supplied standard module', and the second is a "shipyard assembled standard module". For both of these alternatives, the method of production was carefully considered and cost items were estimated one by one. Since no precedent existed for a standards approach of the type in question, all cost values were necessarily estimated by MR&S.

in the analysis forms that follow, the recurring cost items are identified with the symbol (R). The savings for these cost items will repeat themselves even in the case of multiple ship orders.

The analyses show that for the candidate standards analyzed, the following savings are possible when using module standards compared to the non-standard module approach.

	Vendor Supplied Std. Module	Yard Assembled Std. Module
Fuel Oil Service System Module	$17,470	$12,835
Main Feed Pump Module	11,757	7,407
Diesel Accessory Rack	31,607	20,804

GROUP II ECONOMIC ANALYSIS

5.4.2.1 FUEL OIL SERVICE SYSTEM MODULE

	COST ITEM	EXISTING APPROACH	STANDARDS APPROACH	
			ALT 1	ALT 2
		SHIPYARD ASSEMBLED NON-STANDARD MODULE	VENDOR SUPPLIED STANDARD MODULE	SHIPYARD ASSEMBLED STANDARD MODULE
PROCUREMENT	TECH. DEPT. DIRECT LABOR	5,976	1,476	1,728
	CONTRACTS DEPT. DIR. LAB.	(R) 3,024	936	1,872
	P & E DEPT. DIR. LAB.	2,727	2,275	3,159
	BID & RESPONSE	1,620	450	675
	EQUIPMENT COST	(R) 1,310	568	568
	SUB-TOTAL	14,657	5,725	8,002
INSTALLATION	DIRECT LABOR - SHOP	(R) 2,832	1,134	1,224
	DIRECT LABOR - SHIP	(R) 1,230	318	438
	CRANE SERVICE	240	96	96
	ENGINEERING INTERFACE	1,350	426	1,248
	SET-UP TIME	534	48	78
	DELAYS & SPOOL PIECE	(R) 4,800	1,200	2,100
	INVENTORY	(R) 702	114	396
	MAINT. & REPAIRS	(R) 246	60	174
	SUB-TOTAL	11,934	3,396	5,754
TEST & CHECK-OUT		(R) ~E	~E	~E
TOTAL		26,591	9,121	13,756
SAVINGS			17,470	12,835

(R) RECURRING COST

TABLE 5-12

GROUP II ECONOMIC ANLYLYSIS

5.4.2.2 MAIN FEED PUMP MODULE

	COST TEM	EXISTING APPROACH	STANDARDS APPROACH	
			ALT 1	ALT 2
		SHIPYARD ASSEMBLED NON-STANDARD MODULE	VENDOR SUPPLIED STANDARD MODULE	SHIPYARD ASSEMBLED STANDARD MODULE
	TECH. DEPT. DIRECT LABOR	5,994	1,818	1,989
PROCUREMENT	CONTRACTS DEPT. DIR. LAB.	(R) 2,016	783	1,278
PROCUREMENT	P & E DEPT. DIR. LAB.	2,052	1,269	3,780
PROCUREMENT	BID & RESPONSE	1,080	540	432
PROCUREMENT	EQUIPMENT COST	(R) 1,210	640	640
PROCUREMENT	SUB-TOTAL	12,352	5,050	8,119
INSTALLATION	DIRECT LABOR - SHOP	(R) 1,494	726	978
INSTALLATION	DIRECT LABOR - SHIP	(R) 1,440	252	354
INSTALLATION	CRANE SERVICE	(R) 180	84	84
INSTALLATION	ENGINEERING INTERFACE	900	213	768
INSTALLATION	SET-UP TIME	480	66	54.
INSTALLATION	DELAYS & SPOOL PIECE	(R) 2,040	1,200	1,296
INSTALLATION	INVENTORY	(R) 468	90	228
INSTALLATION	MAINT. & REPAIRS	(R) 114	30	120
INSTALLATION	SUB-TOTAL	7,116	2,66	3,882
	TEST & CHECK-OUT	(R) ~E	~E	~E
	TOTAL	19,468	7,711	12,001
	SAVINGS		11,757	7,467

(R) RECURRING COST

TABLE 5-13

GROUP II ECONOMIC ANALYSIS

5.4.2.3 DIESEL ACCESSORY RACK MODULE

COST ITEM	EXISTING APPROACH	STANDARDS APPROACH ALT 1	STANDARDS APPROACH ALT 2
	SHIPYARD ASSEMBLED NON-STANDARD MODULE	VENDOR SUPPLIED STANDARD MODULE	SHIPYARD ASSEMBLED STANDARD MODULE
TECH. DEPT. DIRECT LABOR	7,200	2,088	1,746
CONTRACTS DEPT. DIR. LAB.	(R) 5,760	783	4,914
P & E DEPT. DIR. LAB.	2,736	1,260	3,300
BID & RESPONSE	2,880	540	1,728
EQUIPMENT COST	(R) 2,500	680	680
SUB-TOTAL	21,076	5,351	12,368
DIRECT LABOR – SHOP	(R) 5,208	2,328	3,072
DIRECT LABOR – SHIP	(R) 2,496	648	696
CRANE SERVICE	(R) 570	156	156
ENGINEERING INTERFACE	3,600	942	2,784.
SET-UP TIME	1,236	102	78
DELAYS & SPOOL PIECE	(R) 7,800	3,000	3,192
INVENTORY	(R) 1,872	114	912
MAINT. & REPAIRS	(R) 480	90	276
SUB-TOTAL	23,262	7,380	11,166
TEST & CHECK-OUT	(R) ~E	~E	~E
TOTAL	44,338	12,731	23,534
SAVINGS		31,607	20,804

(R) RECURRING COST

TABLE 5-14

5.4.3 Generalization of Results for Group II Standards

Table 5-15 is-a summary of results for the economic analyses performed in 5.4.2. Following the procedure outlined in 5.2.3, *these* results' can be used in estimating the "generalized" savings for all other possible standards in Group II. Table 5-16 lists all the module standards considered in Subtask - 2, identifies each of these with a similar standard from Table 5-15, and calculates the predicted overall savings obtainable through *its use.*

The following size and complexity contributions are assumed for each of the economically analyzed module standards for use when adopting them for comparison as a similar standard:

Fuel Oil Service System Module:	Size:	45%
	Complexity:	55%
Main Feed Pump Module:	Size:	35%
	Complexity:	65%
Diesel Accessory Rack Module:	Size:	40%
	Complexity:	.60%

STANDARD MODULE	OVERALL SAVINGS $	REF.
FUEL OIL SERVICE SYSTEM	17,470	5.4.2.1
MAIN FEED PUMP	11,757	5.4.2.2
DIESEL ACCESSORY RACK	31,607	5.4.2.3

TABLE 5-15

GENERALIZED SAVINGS FOR GROUP II MODULE STANDARDS

NAME OF CANDIDATE STANDARD	% RATINGS SIZE	% RATINGS COMPLEX	NAME OF SIMILAR STANDARD	% REDUCTIONS SIZE	% REDUCTIONS COMPL.	% REDUCTIONS TOTAL	NET TOTAL SAVINGS $
LUBE OIL PURIFIER MODULE	140	120	F.O. SYST. MODULE	63	66	129	22,536
CONDENSATE PUMP MODULE	120	90	MAIN FEED PUMP MOD.	42	58	100	11,757
HIGH PRESSURE FEED HEATER MODULE	60	70	F.O. SYST. MOD.	27	38	65	11,356
POWER UNIT MODULE	1000	600	MAIN FEED PUMP MOD.	350	390	740	87,000
LUBE OIL SERVICE SYSTEM MODULE	90	70	F.O. SERV. SYST. MOD.	40	38	78	13,627
LOW PRESSURE FEED HEATER MODULE	110	120	F.O. SERV. SYST. MOD.	49	66	115	20,090
DIESEL AIR STARTING PACKAGE	140	110	DIESEL ACCESSORY RACK	56	66	122	38,560

TABLE: 5-16

5.5 Analysis of Envelope Standards - Group III

5.5.1 General

5.5.1.1' Brief Description of Group III Standards

The envelope standard is a document which contains the technical data and information "required to define and describe the interface characteristics"of the equipment." As it" was discussed In 4.5.2.1 and 4.5.3.3, this standard concept is based on an imaginary cube envelope around the equipment. All mechanical connections are brought to the surfaces of this envelope, and the shipyard brings services to these surfaces.

It will. be remembered that space limitations may restrict the use of envelope standards, but that as a major advantage they effectively establish equipment standards without interfering with the independence of individual equipment manufacturers. In Appendix C.3. . a standard envelope format is included to indicate the content and extent of this standard concept.

5.5.1.2 Candidates Selected for Economic Analysis

Selected for economic analysis in Subtask-3 were the following envelope standards candidates:

1. Boiler Envelope
2. Lube Oil Purifier Envelope
3. Main Feed Pump Envelope

Each of these envelopes will be economically analyzed for the existing method, and the standards aporoach and results will be compared to estimate the savings due to using envelope standards.

5.5.1.3 Limitations of Analyses

The accuracy of the results are dependent upon specific assumptions made in analyzing the cost items for each Candidate Standard. Especially such cost items as crane time, set-up time, inventory, maintenance and repairs, etc., may vary considerably from one shipyard to another. Therefore the estimates presented here are necessarily subjective in this sense. However, the overall effect obtained is realistic, and even though the absolute values of savings may be subject to variations, the direction of gains is firm and finite with envelope standards as compared to no standards.

A "make-or-buy" decision may be thought of in relation to the envelope standards. However, especially for smaller pieces of equipment which are likely candidates for envelope standards, the number and extent of external connections to the equipment are so few that little, if any, difference can be expected between the "make" or "buy" alternatives.

5.5.1.4 Definition of Existing Approach

The present or existing approach used in the U.S. Shipyards today for those equipment which are candidates for envelope standards can be summarized as follows:

a. The equipment is purchased through normal channels and following usual procurement procedures.

b. The equipment is stored and protected in the shipyard until it is ready for installation on board ship.

c. All mechanical, electrical and other external connections to the equipment are made after installation.

d. Foundations, if required, are manufactured by the shipyard after final approved drawings from the vendor are received.

The breakdown of cost items for the present approach will be the same as those for the module standards and as shown on analysis formats in 5.5.2.

5.5.1.5 Definition of Standards Approach

The standards approach for the case with envelope standards can be defined as follows:

a. The equipment can be purchased directly from the manufacturers complete with its base and external connections to the interface points on the envelope surface.

b. The shipyard will be able to manufacture preformed piping and prepare connections until the interface points on the envelope surface.

c. The envelope "incl udes the standard base and the shipyard can prepare ship's foundation to match using the drawings in the standard document without waiting for vendor's plans.

The breakdown of cost items are the same as for module standards as shown in 5.4.1. and on analysis formats as well.

5.5.2 Cost Analyses

The breakdown of cost items for the existing and standards approaches as described in 5.5.1.4 and 5.5.1.5 were used as a basis for the cost analyses of envelope standards.

For the existing approach, Bath Iron Works Corporation 's engineered time data were used in establishing expenditures for various procurement operations such as planning and estimating department direct labor, contracts department direct labor and tehcnical department direct labor. No engineered time data nor work sampling data were available for the remaining cost items, and accordingly the values used for these are MR&S estimates.

There was no precedent for a "Standards Approach" from which source data could be drawn. For this reason, all cost items for the standards approach were estimated by MR&S.

The recurring cost items are identified with the symbol (R) in the analysis forms that follow. The savings for these cost items will repeat themselves even if multiple ships are being built.

The results of the analyses indicate that for the candidate standards in question the following savings are attainable when using envelope standards as compared with the present approach:

Main Boiler Envelope = $17,124

Lube Oil Purifier Envelope = $ 4,461

Main Feed Pump Envelope = $5,394

GROUP III - ECONOMIC ANALYSIS

5.5.2.1 MAIN BOILER ENVELOPE

	COST ITEM		EXISTING APPROACH	STANDARDS APPROACH
PROCUREMENT	TECH. DEPT. DIRECT LABOR		4,356	1,800
	CONTRACTS DEPT. D. LABOR	(R)	1,008	783
	P & E DEPT. D. LABOR		1,728	1,161
	BID & RESPONSE		1,620	270
	MATERIAL COSTS	(R)	750	1,500
	SUB-TOTAL		9,462	5,514
INSTALLATION PHASE	DIRECT LABOR - SHOP	(R)	10,200	9,408
	DIRECT LABOR - SHIP	(R)	9,180	7,020
	CRANE TIME	(R)	624	624
	ENGINEERING INTERFACE		2,280	432
	SET-UP TIME		1,440	720
	DELAYS & SPOOL PIECE	(R)	7,200	240
	INVENTORY	(R)	936	240
	MAINT. & REPAIRS	(R)	288	288
	SUB-TOTAL		32,148	18,972
TEST & CHECK-OUT PHASE		(R)	~ E	~ E
TOTAL			41,610	24,486
SAVINGS				17,124

(R) RECURRING COST

TABLE 5-17

GROUP III - ECONOMIC ANALYSIS

5.5.2.2 LUBE OIL PURIFIER ENVELOPE

	COST ITEM	EXISTING APPROACH	STANDARDS APPROACH
PROCUREMENT	TECH. DEPT. DIRECT LABOR	2,574	1,458
	CONTRACTS DEPT. D. LABOR	(R) 1,008	.657
	P & E DEPT. D. LABOR	702	810
	BID & RESPONSE	720	252
	MATERIAL COSTS	(R) 40	100
	SUB-TOTAL	5,044	3,277
INSTALLATION PHASE	DIRECT LABOR - SHOP	(R) 1,392	576
	DIRECT LABOR - SHIP	(R) 1,572	918
	CRANE TIME	(R) 156	156
	ENGINEERING INTERFACE	474	216
	SET-UP TIME	432	ZIG
	DELAYS & SPOOL PIECE	(R) 900	240
	INVENTORY	(R) 216	126
	MAINT. & REPAIRS	(R) 42	42
	SUB - TOTAL	5,184	2,490
TEST & CHECK-OUT PHASE		(R) ~ E	~ E
TOTAL		10,228	5.767
SAVINGS			.4,461

(R) RECURRING COST

TABLE 5-18

GROUP III - ECONOMIC ANALYSIS

5.5.2.3 MAIN FEED PUMP ENVELOPE

	COST ITEM		EXISTING APPROACH	STANDARDS APPROACH
PROCUREMENT	TECH. DEPT. DIRECT LABOR		3,528	1,620
	CONTRACTS DEPT. D. LABOR	(R)	1,008	1,008
	P & E DEPT. D. LABOR		1,134	1,107
	BID & RESPONSE		540	252
	MATERIAL COSTS	(R)	225	450
	SUB-TOTAL		6,435	4,437
INSTALLATION PHASE	DIRECT LABOR - SHOP	(R)	1,608	624
	DIRECT LABOR - SHIP	(R)	1,956	1,188
	CRANE TIME	(R)	156	156
	ENGINEERING INTERFACE		474	228
	SET-UP TIME		768	264
	DELAYS & SPOOL PIECE	(R)	960	240
	INVENTORY	(R)	258	126
	MAINT. & REPAIRS	(R)	84	42
	SUB-TOTAL		6,264	2,868
TEST & CHECK-OUT PHASE		(R)	~E	~E
TOTAL			12,699	7,305
SAVINGS				5,394

(R) RECURRING COST

TABLE 5-19

5.5.3 Generalization of Results for Group III Standards

Table 5-20 cotains a summary of results of the economic analyses performed in 5.5.2. Following the procedure outlined in 5.2.3, these results can be used in estimating the "generalized" savings for all other standards in Group III. Table 5-21 lists all the envelope standards considered in Subtask 2, identifies each of these with a similar standard from Table 5-20, and calculates the predicted overall savings obtainable through its use.

The following size and complexity contributions are assumed for each of the economically analyzed envelope standards for use when adopting them for comparison as a similar standard:

Main Boiler Envelope:

Size : 40%

Complexity : 60%

Lube Oil Purifier Envelope:

Size : 60%

Complexity : 40%1

Main Feed Pump Envelope :

Size : 50%

Complexity : 50%

STANDARD ENVELOPE	OVERALL SAVINGS $	REF.
MAIN BOILER	17,124	5.5.2.1
LUBE OIL PURIFIER	4,461	5.5.2.2
MAIN FEED PUMP	5,394	5.5.2.3

TABLE 5-20

NAME OF CANDIDATE STANDARD	% RATINGS		NAME OF SIMILAR STANDARD	% REDUCTIONS			NET TOTAL SAVINGS $
	SIZE	COMPLEX		SIZE	COMPL.	TOTAL	
MAIN STEAM TURBINE ENVELOPE	80	140	BOILER ENVELOPE	32	84	116	19,864
MAIN CONDENSER ENVELOPE	40	50	BOILER ENVELOPE	16	30	46	7,877
MAIN DIESEL ENGINE ENVELOPE	80	100	BOILER ENVELOPE	32	60	92	15,754
MAIN REDUCTION GEAR ENVELOPE	50	70	BOILER ENVELOPE	20	42	62	10,617
MAIN CONDENSATE PUMP ENVELOPE	120	90	FEED PUMP ENVELOPE	60	45	105	5,664
MAIN CIRCULATING PUMP ENVELOPE	130	60	FEED PUMP ENVELOPE	65	30	95	5,124
LUBE OIL SERVICE PUMP ENVELOPE	60	60	FEED PUMP ENVELOPE	30	30	60	3,236
FUEL OIL SERVICE PUMP ENVELOPE	60	60	FEED PUMP ENVELOPE	30	30	60	3,236
DEAERATING FEED HEATER ENVELOPE	120	110	L.O. PURIF. ENV.	72	44	116	5,175
LOW PRESSURE FEED HEATER ENVELOPE	80	90	L.O. PURIF. ENV.	48	36	84	3,747
FUEL OIL HEATER ENVELOPE	70	90	L.O. PURIF. ENV.	42	36	78	3,480

TABLE: 5-21 SHEET 1 OF 2

NAME OF CANDIDATE STANDARD	% RATINGS		NAME OF SIMILAR STANDARD	% REDUCTIONS			NET TOTAL SAVINGS $
	SIZE	COMPLX.		SIZE	COMPL.	TOTAL	
BRIDGE CONTROLS ENVELOPE	150	150	FEED PUMP ENVELOPE	75	75	150	8 091
ENGINE ROOM CONTROLS ENVELOPE	150	160	FEED PUMP ENVELOPE	75	80	155	8,361
AIR PREHEATER ENVELOPE	120	80	L.O. PURIF. ENVELOPE	72	32	104	4,639
ECONOMIZER ENVELOPE	200	80	L.O. PURIF. ENVELOPE	120	32	152	6,781
AIR EJECTOR ENVELOPE	50	120	L.O. PURIF. ENVELOPE	30	48	78	3,480
EXHAUST GAS BOILER	10	30	BOILER ENVELOPE	4	18	22	3,767

TABLE: 5-21 SHEET 2 OF 2

5.6 ECONOMIC ANALYSIS OF-INDIVIDUAL EQUIPMENT STANDARDS - GROUP IV

5.6.1 General ,

5.6.1.1 Brief Description of Group IV Standards

The Group IV Standards should be implemented by means of a "phasing-in" process. The order of development of standards for individual equipment and/or components will be

1. Data Standards
2. Procurements Standards
3. Hardware Standards

Detailed descriptions—of each one of these three different standard concepts, as well as sample formats, are to be found in Appendix C.4. The economic analsyses reported upon in this section are based on the sample formats and as such assume that all information mentioned in the formats is available.

In general, the scope of Group IV Standards can be summarized as follows:

<u>Data Standard</u>: Includes technical information which is necessary for ship designers to perform proplusion plant designs at any level without requiring additional information from vendors.

<u>Procurements Standard</u>: Contains both the technical and the legal documentation to purchase vendor equipment.

<u>Hardware Standard</u>: Contains the technical information necessary to define and describe the hardware which is interchangeable among all vendors as to interface.

5.6.1.2 candidates selected for Economic Analysis

As a-result of technical analyses performed in Subtask - 2, the foldowing Group IV standards candidates were selected for economic analysis (See Section 4.6.2):

Main Condensate Pump

Starting Air Compressor

Main Boiler

Each of these candidates will be economically . analyzed for each of the three different concepts of standards. Analyses will be based on a comparison of the "present" approach (with no standard available) with the "standards''a aproach (where it will be assumed that standards are available). The "present" . and "standards" approaches are more clearly developed in 5.6.1.4 and 5.6.1.5 respectively.

5.6.1.3 Limitations of Analyses

The analyses performed in 5.6.2.2, 5.6.2.3 and 5.6.2.4 are based on the general guidelines discussed in 5.2.2 which make certain assumptions and set certain criteria. Furthermore, in performing the individual analyses, certain additional specific assumptions were made due to a lack of concrete source information on many of the cost items involved. As a result, analyses are best estimates. However,they show a trend toward labor savings for individual equipment standards; so that even though they are limited . in absolute values of savings, they are instrumental in assessing the advantage of implementing Group IV Standards.

5.6.1.4. Definition of Existing Approach

A. For Data Standards

1. Shipyard has a catalog library which isnot complete nor standardized.
2. Cost items not listed as variable are assumed constant for this study.
3. A certain amount of revision to the heat balance calculation, arrangement drawings, weight estimates, piping schematics and electrical load analysis will be necessary after Vendor's actual data *on* the component is received by the Shipyard.
4. It is assumed that a search of the in-house catalog library will enable the shipyard to select a sufficient number of manufacturers whose products will meet the basic design requirements.

B. For Procurement Standards

1. Shipyard has a catalog library which is not complete nor standardized.
2. Cost items not listed as variable are assumed constant for this study.
3. A certain amount of revision to the heat balance calculations, arrangement drawings, weight estimates, piping schematics and electrical load analysis will be necessary after Vendor's actual data on the component is received by the Shipyard.
4. it is assumed that a search of the in-house catalog library will enable the shipyard to select a sufficient number of manufacturers whose products will meet the basic design requirements.

C. <u>For Hardware Standards</u>

1. Shipyard has a catalog library which is not complete nor standardized,.
2. Cost items not listed as variable are assumed constant for this study.
3. A certain amount of revision to the heat balance calculations, arrangement drawings, weight estimates, piping schematics and electrical load analysis will be necessary after Vendor's actual data on the component is received by the Shipyard.
4. It is assumed that a search of the in-house catalog library will enable the shipyard to select a sufficient number of manufacturers whose products will meet the basic design requirements.
5. It is assumed that a new design or a modification of an existing design will be required for the component in question, by the manufacturer.
6. As a source for man-hours required to develop purchase specs and carry out the planning and contract department operation, engineered time data supplied by Bath Iron Works Corporation is used. -

5.6.1.5 Definition of Standards Approach

A. For Data Standards

1. Shipyard has e "Data Standard" available for the subject component.
2. Data Standard contains all technical information at the Vendor plan level.
3. Data Standard does not contain any legal and sales information that can substitute-for a purchase specification.
4. Technical info available in the data standard will reduce the"procurement effort by ~ 25%.
5. Due to more accurate data available in the standard in the initial stages of design, the revisions to various contract design work will be reduced by 25%.

B. For Procurement Standards

1. The shipyard has a "procurement standard" available for the subject component.
2. Procurement standard contains all technical arid legal information needed to incorporate the subject component into the ship design and also to procure, install and test the same. As such, it will eliminate the need to write purchase specifications and it will reduce the procurement effort by ~ 50%.
3. Revisions to contract design calculations and diagrams will be reduced by ~ 25%.

C. For Hardware Standards

1. The shipyard has a "Hardware Standard" available for the subject component.

2. The Standard contains all technical and legal information, including:

   a. Performance characteristics

   b. Operating characteristics

   c. Interface requirements

   d. Packaging information

   e. Installation drawings and procedure

   f. Critical materials specifications

   g. Regulatory body approvals

   h. Test memoranda & quality control requirements

   i. Purchase specifications

3. It is assumed that based on the information available in the Standard,. the Manufacturers will have developed complete machine designs for manufacture and set-up for manufacture on the component in question.

4. It is further assumed that with the completely accurate technical data available in the Standard, no revisions to the contract design calculations and diagrams will be necessary.

5. Additional savings-which may be possible to attain in the scheduling the due to elimination of delays in arrangement drawings and due to reduced delivery time for the manufacture of “Standard” equipment are neglected in this study (since they are difficult to assess due to large variations).

5.6.2 Cost Analyses

The Group IV, Individual Equipment/Component Standards, were analyzed for each of the three different types of standards. In the following pages, the basis of analyses are listed in the form of a detailed breakdown of cost items. The cost items for each type of standard, namely the data, the procurement and the hardware standard, are presented in an analysis form in the same sequence as the breakdowns in 5.6.2.1.2 through 5.6.2.1.4.

The engineered time data as furnished by Bath Iron Works Corrporation are used for estimating the procurement phase cost items for the existing approach. The remaining cost items and the standards approach analysis figures were estimated by MR&S.

The recurring costs are identified in the analysis forms by a (+) sign under the proper *column.* As it was pointed out earlier, in connection with the mdule and envelope standards cost analyses, the savings for these cost items will repeat themselves even if a contract for multiple ships were awarded. All other cost items are non-recurring; and as such, they are applicable *to* the first ship of a type or class to be built in any one shipyard.

The analysis results indicate that the following over-all savings are attainable when using Group IV standards as compared to the present approach of no standards:

	Data Std	Procurement Std	Hardware Std
Main Condensate Pump	1,350	2,124	4,842
Starting Air Compressor	1,242	1,980	4.698
Main Boiler	3,510	6,3oo	18,570

5.6.2.1 Detailed Breakdown of Cost Items

5.6.2.1.1 Data Standard

Cost Item # l : Establish Design Requirements

a) Review preliminary heat balance & establish

Performance characteristics

Operational characteristics

b) Review ship specs - determine space & weight relation if any.

cost Item #2: Review Industry Availability

a) Use in-house catalogues/brochures or information files

1 - Determine if any mfrs have products that fulfill requirements

2 - Select a sufficient number of mfrs whose products general requirements

3 - Write technical specs for the component endeavoring not *to* stifle competition.

b) For the Standards Approach, use "Data Standard"

1 - Select components from the data standard

2 - Write technical specs for the components selected.

Cost Item # 3: Prepare Purchase Specs:

a) Based on Technical specs of cost item #2, write procurement specs.

b) Incorporate legal and sales information into the procurement specs.

Cost Item #4: Procure

Procure item following normal shipyard procedure.

Cost 1 tem # 5: Incorporate Component into Ship Design

a) For Existing Approach, obtain vendor's data from the mfr. and:

1 - Revise heat balance to reflect changes in component data as compared to those assumed for preliminary heat balance.

2 - Using size info., develop contract arrangement dwgs.

3 - Use weight info. re ship's weight estimate.

4 - Use piping & valve size info. to develop related piping system schematics.

5 - Use prime mover power characteristics info. to revise preliminary electrical load analysis.

b) For Standards Approach, use data std to do the same work as pr (a) above.

5.2.1.2 Procurement Standard

Cost Item # 1: Establish Design Requirements

a) Review preliminary heat balance & establish

Performance characteristics

Operational characteristics

b) Reveiw ship specs - determine space & weight relation if any.

Cost Item # 2: Review industry Availability

a) Use in-house catalogues/brochures or information files

1 - Determine if any mfrs have products that fulfill requirements

2 - Select a sufficient number of mfrs whose products meet general requirements

3 - Write technical specs for the component endeacring not to stifle competition.

b)

1 - Select component from the "data' section of procurement standard

2 - *Select* technical specs from the "specs" section of procurement standard.

Cost Item #3: Purchase Specs

a) Prepare purchase specs & Legal & Sales info

b) Select Std. Purchase Specs.

Cost Item #4: Procure

Following normal shipyard procedure (using std. procurement specs.)

cost Item #5: Contract Design

a) For Existing Approach, obtain vendor's data from the mfr. and:

1- Revise heat balance to reflect changes in component data as compared to those assumed for preliminary heat balance.

2 - Using size info., develop contract arrangement dwgs.

3 - Use weight info. re ship’s weight estimate

4 - Use piping & valve size info. te develop related piping system schematics.

5 - Use prime mover power characteristics info. to revise preliminary electrical load analysis. -

b) For Standards Approach, use data std to do the same work as pr (a) above.

5.6.2.1.3 Hardware Standard

Cost Item #1: Establish Design Requirements

a) Review prelirninary.heat balance & establish

Performance characteristics

Operational characteristics

b) Review ship specs - determine space & *weight* relation if any.

Cost Item #2: Review Industry Availability

a) Use in-house catalogues/brochures or information files to screen components available to industry:

1 - Determine if any mfrs have products that fulfill requirements

2 - Select a-sufficient number of mfrs whose products meet general requirements

3 - Write technical specs for the component endeavoring not to stifel competition.

b) For the Standards Approach, use "Hardware STandards"

- Select standard hardware which most nearly fulfills requirements of design

Cost Item #3: Procurement

a) Prepare Purchase Specs.

b) Procure item following normal shipyard procedure (using tech. specs from 2.a or 2.b)

c) Select STd Purchase Specs from hardware Std.

d) Procure item following normal shipyard procedure (using procurement specs from hardware standard) - for the standards approach.

cost Item #4: Incorporate Component into Ship Design

For Existing Approach, obtain vendor's data from the mfr. and:

a) Revise heat balance to reflect changes in component data as compared to those assumed for preliminary heat balance.

b) Using size info., develop contract arrangement dwgs.

d) Use piping & valve size info. to develop related piping system schematics.

e) Use prime mover power characteristics info. to revise preliminary electrical load analysis.

NOTES :

1. For existing approach, preliminary calculation, diagrams, estimates and arrangement will have to be revised after obtaining vendor's data for the component. In the standards approach, all data needed to finalize the preliminary work is contained in the hardware standard - so that no revision is necessary.

Cost Item #5: Manufacture

a) Prepare Design

b) Set-up for Manufacture

c) Production

NOTES :

1. With the standards approach, set-up for manufacture may require less time in the long run since changes from one set-up to another will have been established and therefore can be effected in a minimum of time.

2. With the standards approach,_the manufacturers will not have to develop repeated learning curves. The learning curve will be there except for the very first time a standard hardware is produced. Special machinery, tools, dies, molds, etc. will have been bought, manufactured or otherwise mad a part of the facility. "Since the materials will have been specified in the standards, the manufacturer will be in a better position to stock some critical materials.

Cost item #6: installation

1. Make mechanical (piping, etc.) Conn's.
2. Make electrical connections
3. Provide quality control

NOTES :

1. Since physical dimensions and bolting and/or other fastening requirements will be available in the hardware standard, these work items can be accomplished earlier in the construction schedule of the ship.
2. Since all pipe and valve/fitting sizes and specs will be contained in the hardware standard, it will be possible to prepare pre-formed piping sections and obtain time (& labor) savings in actual construction work.
3. Since shipyard quality control personnel will have become familiarized with Quality Assurance procedures, they will be in a position to provice more efficient control work and thereby effect considerable savings.

cost Item #7: Testing & Checkout

a) In-place tests after instalIation

NOTES :

1. There may be some savings in this cost item 9 with the standards approach) due to standardization of test procedures as delineated in the hardware Standard.
2. No savings can be expected in dock trials and sea trials since operation of all systems is very much inter-reIated.

GROUP IV – ECONOMIC ANALYSIS

5.6.2.2 MAIN CONDENSATE PUMP

TYPE STANDARD: DATA

COST ITEM		RECURRING	EXISTING APPROACH DIRECT LABOR MH	EXISTING APPROACH DIRECT LABOR $	EXISTING APPROACH SCH. DAYS	STANDARDS APPROACH DIRECT LABOR MH	STANDARDS APPROACH DIRECT LABOR $	STANDARDS APPROACH SCH DAYS
PROCUREMENT	ESTABLISH DESIGN REQ'MTS.		E		E	E		E
	REVIEW INDUSTRY AVAILABILITY		144		10	56		5
	PREPARE PURCHASE SPECIFICATIONS		E		E	E		E
	PROCURE	+	88		6	66		5
	INCORPORATE INTO SHIP DESIGN		172		12	132		9
MANUFACTURE	DESIGN							
	SET UP							
	PRODUCTION							
INSTALLATION								
TEST & CHECK-OUT								
TOTALS			404		28	254		19
SAVINGS						150	1,350	9

TABLE 5.22

SWEET 1 OF 3

GROUP IV - ECONOMIC ANALYSIS

5.6.2.2 MAIN CONDENSATE PUMP

TYPE: STANDARD : PROCUREMENT

COST ITEM		RECURRING	EXISTING APPROACH DIRECT LABOR MH	EXISTING APPROACH DIRECT LABOR $	EXISTING APPROACH SCH. DAYS	STANANDARDS APPROACH DIRECT LABOR MH	STANANDARDS APPROACH DIRECT LABOR $	STANANDARDS APPROACH SCH. DAYS
PROCUREMENT	ESTABLISH DESIGN REQ'MTS.		E		E	E		E
	REVIEW INDUSTRY AVAILABILITY		144		10	32		2
	PREPARE PURCHASE SPECIFICATIONS		48		3	8		1
	PROCURE	+	88		6	44		3
	INCORPORATE SHIP DESIGN		172		12	132		9
MANUFACTURE	DESIGN							
	SET UP							
	PRODUCTION							
INSTALLATION								
TEST & CHECK-OUT								
TOTALS			452		31	216		15
SAVING						236	z, 124	16

TABLE 5-22

SHEET 2 of 3

GROUP IV - ECONOMIC ANALYSIS

5.6.2.2 MAIN CONDENSATE **PUMP**

TYPE STANDARD : *HARDWARE*

COST ITEM		RECURRING	EXISTING APPROACH			STANDARDS APPROACH		
			DIRECT LABOR MH	DIRECT LABOR $	SCH. DAYS	DIRECT LABOR MH	DIRECT LABOR $	SCH. DAYS
PROCUREMENT	ESTABLISH DESIGN REQ'MTS.		E		E	E		E
	REVIEW INDUSTRY AVAILABILITY		144	1,296	10	16	144	2
	PREPARE PURCHASE SPECIFICATIONS		48	432	5	8	72	1.
	PROCURE	+	88	792	6	18	162	1
	INCORPORATE INTO SHIP DESIGN		172	1,548	12	-		-
MANUFACTURE	DESIGN		180	1,620	6	160	1,440	5
	SET UP	+	48	288	2	44	264	2
	PRODUCTION	+	840	5,040	26	760	4,560	25
INSTALLATION		+	248	1,488	10	194	1,164	7
TEST & CHECK-OUT		+	48	432	2	32	288	1
TOTALS			1,316	12,936	79	1,232	8,094	43
SAVINGS						584	4,842	36

TABLE 5-22

SWEET 3 of 3

GROUP IV – ECONOMIC ANALYSIS

5.6.2.3 STARTING AIR COMPRESSOR

TYPE STANDARD: DATA

	Cost Item	Recurring	Existing Approach: Direct Labor MH	Existing Approach: Direct Labor $	Existing Approach: Sch. Days	Standards Approach: Direct Labor MH	Standards Approach: Direct Labor $	Standards Approach: Sch. Days
PROCUREMENT	ESTABLISH DESIGN REQ'MTS.		E		E	E		E
	REVIEW INDUSTRY AVAILABILITY		120		9	48		4
	PREPARE PURCHASE SPECIFICATIONS		E		E	E		E
	PROCURE	+	88		6	66		5
	INCORPORATE INTO SHIP DESIGN		160		11	116		8
MANUFACTURE	DESIGN							
	SET UP							
	PRODUCTION							
INSTALLATION								
TEST & CHECK-OUT								
TOTALS			368		26	230		17
SAVINGS						138	1,242	9

TABLE 5-23

Sheet 1 of 3

GROUP IV - ECONOMIC ANALYSIS

5.6.2.3 STARTING AIR COMPRESSOR

TYPE: STANDARD : PROCUREMENT

COST ITEM		RECURRING	EXISTING APPROACH			STANDARDS APPROACH		
			DIRECT LABOR MH	DIRECT LABOR $	SCH. DAYS	DIRECT LABOR MH	DIRECT LABOR $	SCH. DAYS
PROCUREMENT	ESTABLISH DESIGN REQ'MTS.		E		E	E		E
	REVIEW INDUSTRY AVAILABILITY		120		9	28		2
	PREPARE PURCHASE SPECIFICATIONS		48		3	8		1
	PROCURE	+	88		6	44		3
	INCORPORATE INTO SHIP DESIGN		160		11	116		8
MANUFACTURE	DESIGN							
	SET UP							
	PRODUCTION							
INSTALLATION								
TEST & CHECK-OUT								
TOTALS			416		29	196		14
SAVINGS						220	1,980	15

TABLE 5-23

Sheet 2 of 3

GROUP IV - ECONOMIC ANALYSIS

5.6.2.3 STARTING AIR COMPRESSOR

TYPE: STANDARD : HARDWARE

COST ITEM		RECURRING	EXISTING APPROACH DIRECT LABOR MH	EXISTING APPROACH DIRECT LABOR $	EXISTING APPROACH SCH. DAYS	STANDARDS APPROACH DIRECT LABOR MH	STANDARDS APPROACH DIRECT LABOR $	STANDARDS APPROACH SCH. DAYS
PROCUREMENT	ESTABLISH DESIGN REQ'MTS.		E		E	E		E
PROCUREMENT	REVIEW INDUSTRY AVAILABILITY		120	1,080	9	16	144	2
PROCUREMENT	PREPARE PURCHASE SPECIFICATIONS		48	432	3	8	72	1
PROCUREMENT	PROCURE	+	88	792	6	18	162	1
PROCUREMENT	INCORPORATE INTO SHIP DESIGN		160	1440	11	—		—
MANUFACTURE	DESIGN		240	2,160	7	216	1,944	6
MANUFACTURE	SET UP	+	60	360	2	54	324	2
MANUFACTURE	PRODUCTION	+	960	5,760	26	864	5,184	24
INSTALLATION		+	248	1,488	10	194	1,164	7
TEST & CHECK-OUT		+	60	540	3	40	360	2
TOTALS			1,984	14,052	77	1,408	9,354	45
SAVINGS						576	4,698	32

TABLE 5-23

Sheet 3 of 3

GROUP IV - ECONOMIC ANALYSIS

MAIN BOILER

TYPE 5TANDARD: DATA

COST ITEM		RECURRING	EXISTING APPROACH: DIRECT LABOR MH	EXISTING APPROACH: DIRECT LABOR $	EXISTING APPROACH: SCH. DAYS	STANDARDS APPROACH: DIRECT LABOR MH	STANDARDS APPROACH: DIRECT LABOR $	STANDARDS APPROACH: SCH. DAYS
PROCUREMENT	ESTABLISH DESIGN REQ'MTS.		E		E	E		E
PROCUREMENT	REVIEW INDUSTRY AVAILABILITY		288		16	128		9
PROCUREMENT	PREPARE PURCHASE SPECIFICATIONS		E		E	E		E
PROCUREMENT	PROCURE	+	280		8	210		6
PROCUREMENT	INCORPORATE INTO SHIP DESIGN		624		38	464		28
MANUFACTURE	DESIGN							
MANUFACTURE	SET UP							
MANUFACTURE	PRODUCTION							
INSTALLATION								
TEST & CHECK-OUT								
TOTALS			1192		62	802		43
SAVINGS						390	3,510	19

TABLE 5-24

sheet 1 of 3

GROUP IV - ECONOMIC ANALYSIS

5.6.2.4 MAIN BOILER

TYPE: STANDARD : PROCUREMENT

	COST ITEM	RECURRING	EXISTING APPROACH			STANDARDS APPROACH		
			DIRECT LABOR MH	DIRECT LABOR $	SCH. DAYS	DIRECT LABOR MH	DIRECT LABOR $	SCH. DAYS
PROCUREMENT	ESTABLISH DESIGN REQ'MTS.		E		E	E		E
	REVIEW INDUSTRY AVAILABILITY		288		16	32		2
	PREPARE PURCHASE SPECIFICATIONS		160		10	16		1
	PROCURE	+	280		15	140		8
	INCORPORATE INTO SHIP DESIGN		624		38	464		30
MANUFACTURE	DESIGN							
	SET UP							
	PRODUCTION							
INSTALLATION								
TEST & CHECK-OUT								
TOTALS			1352		79	652		41
SAVINGS						700	6,300	38

TABLE 5-24

Sheet 2 of 3

GROUP IV - ECONOMIC ANALYSIS

5.6.2.4 MAIN BOILER

TYPE STANDARD : HARDWARE

COST ITEM		RECURRING	EXISTING APPROACH			STANDARDS APPROACH		
			DIRECT LABOR MH	DIRECT LABOR $	SCH. DAYS	DIRECT LABOR MH	DIRECT LABOR $	SCH. DAYS
PROCUREMENT	ESTABLISH DESIGN REQ'MTS.		E		E	E		E
	REVIEW INDUSTRY AVAILABILITY		288	2,592	16	8	72	1
	PREPARE PURCHASE SPECIFICATIONS		160	1,440	10	16	144	1
	PROCURE	+	280	2,520	18	38	342	3
	INCORPORATE INTO SHIP DESIGN		624	5,616	38	-	-	-
MANUFACTURE	DESIGN		2400	21,600	56	2,160	19,440	50
	SET UP	+	400	2,400	8	360	2,160	7
	PRODUCTION	+	6,000	36,000	146	5,400	32,400	133
INSTALLATION		+	1,020	6,120	60	920	5,520	54
TEST & CHECK-OUT		+	400	3,600	15	360	3,240	14
TOTALS			11,572	81,888	367	9,256	63,318	263
SAVINGS						2,316	18,570	104

TABLE 5-24

Sheet 3 of 3

5.6.3 Generalization of Results for Group IV Standards

Table 5-25 is a summary of results for the economic analyses performed in 5.6.2. Following the procedure outlined in 5.2.3, these results can be used in estimating the "generalized" savings for all other possible standards candidates in Group IV.

Table 5-26 lists all of the individual equipment standards considered in Subtask 2, identifies each of these with a similar. standard from Table 5-25, and calculates the predicted overall savings obtainable through its use.

The following size and complexity contributions are assumed for each of the economically analyzed standards for *use when* adopting them for comparison as a similar standard:

Main Condensate Pump:

Size : 50%

Complexity: 50%

Starting Air Compressors:

Size : 70%

Complexity: 30%

Main Boiler:

Size : 40%

Complexity: 60%

INDIVIDUAL EQUIPMENT	TYPE OF STANDARD	OVERALL SAVINGS $	REF.
MAIN CONDENSATE PUMP	DATA	1,350	Table 5-22
	PROCUREMENT	2,124	″
	HARDWARE	4,842	″
STARTING AIR COMPRESSOR	DATA	1,242	Table 5-23
	PROCUREMENT	1,980	″
	HARDWARE	4,698	″
MAIN BOILER	DATA	3,510	Table 5-24
	PROCUREMENT	6,300	″
	HARDWARE	18,570	″

TABLE 5-25

Name of Candidate Standard	% Ratings		Name of Similar Standard	% Reductions			Net Total Savings $
	Size	Complex		Size	Compl.	Total	
Main Steam Turbine	80	180	Main Boiler	32	108	140	26,000
Main Diesel Engine	90	120	Main Boiler	36	72	98	18,200
Main Condenser	30	60	Main Boiler	12	36	48	8,900
Boiler Controls	20	110	Main Boiler	8	66	74	13,700
Engine Controls	15	90	Main Boiler	6	54	60	11,100
Reduction Gear	40	60	Main Boiler	16	36	52	9,700
Main Feed Pump	80	130	Main Condensate Pump	40	65	105	5,100
Forced Draft Fan	120	150	Main Condensate Pump	60	75	135	6,500
First Stage Feed Htr	10	10	Main Boiler	4	6	10	1,900
D.A. Feed Heater	20	20	Main Boiler	8	12	20	3,700
F.O. Service Pump	60	70	Main Condensate Pump	30	35	65	3,100

NAME OF CANDIDATE STANDARD	% RATINGS		NAME OF SIMILAR STANDARD	% REDUCTIONS			NET TOTAL SAVINGS $
	SIZE	COMPLEX'		SIZE	COMPL.	TOTAL	
L.O. SERVICE PUMP	80	70	MAIN CONDENSATE PUMP	40	35	75	3 600
L.O. PURIFIER	90	80	STARTING AIR COMPRESSOR	27	56	83	3,900
F.O. PURIFIER	90	80	STARTING AIR COMPRESSOR	27	56	83	3,900
L.O. HEATER	8	10	MAIN BOILER	3	6	9	1,700
L.O. COOLER	10	10	MAIN BOILER	4	6	10	1,900
F.O. HEATER	8	10	MAIN BOILER	3	6	9	1,700
AIR EJECTOR	40	60	MAIN CONDENSATE PUMP	20	30	50	2,400
AIR PREHEATER	15	15	MAIN BOILER	6	9	15	2,800
THRUST BEARING	10	15	MAIN BOILER	4	9	13	2,400
F.W. COOLER	10	10	MAIN BOILER	4	6	10	1,857
REDUCTION GEAR L.O. BOOSTER PUMP	60	70	MAIN CONDENSATE PUMP	30	35	65	3,147

5.7 Synthesis of Economic Analyses and Application of Savings to Forecast-Ships

5.7.1 Percentage Savings for the Parent Ships

The total savings available through implementation of standards in all of the four groups (as shown in Table 5-3) for the parent steam-propelled ship was estimated to be approximately $264,ooo (see 5.2.4). It will be recalled that the parent ship had a steam turbine propulsion, plant of 26,000 SHP with 2 main boilers and 2 stage feed heating.

The machinery acquisition cost for this plant can be estimated by using the cost equations developed from Jose Femenia's paper "Economic comparison of various Marine power plants" (1) by escalating the constants to correspond to 1974 dollars. The equations were listed

that exist in the forecast.

1. Two Boiler, 2 Heater Cycle:

$$A = 42855.7 \times (SHP)^{0.5}$$

2. Two Boiler, 4 Heater Cycle:

$$A = 44067.6\ (SHP)^{0.5}$$

3. Single Boiler, 2 Heater Cycle:

$$A = 38589\ (SHP)^{0.511}$$

4. Single Boiler, 4 Heater Cycle:

$$A = 42936\ (SHp)^{0.504}$$

5. Reheat Cycle:

$$A = 51928\ (SHP)^{0.487}$$

---

(1) SNAME Transactions, Volume 81, 1973, page 79

For the parent ship, the applicable cost equation is 1. Therefore:

Acquisition Cost:

$$A = 42855.7 \times (26,000))0^{"}5 = \$6.9I \times 10^{6}$$

and Percentage Savings:

$$a = \frac{264,000}{6.91 \times lo^{o}} \times 100 = 3.82\%$$

For the parent diesel-propelled ship, the total savings available through implementation of standards in all four groups was predicted to be $238,7oo in 5.2.4.

The machinery acquisition costs for medium-speed diesel propulsion plants can be estimated by the equation:

$$A = 11,374 \times (SHP)^{0.6222}$$

For the 14,000 SHP Parent plant:

Acquisition Cost $A - 11,374\ (14,000)^{0.622} = \$4.31 \times 10^{6}$

and percentage savings:

$$a = \frac{238,700}{4.31 \times 10^{6}} \times 100 = 5.538\%$$

5.7.2 Predicted Savings for Other Ships

It is assumed, for the purposes of this feasibility study, that for all steam plants of varying cycle types, the savings due to Standards as proposed will be a constant fraction of the total acquisition cost of the propulsion plant. It therefore becomes possible *to* predict the savings for any and all ships in the forecast if the propulsion plant costs can be estimated. Using Femenia's equations listed above in 5.7.1, the acquisition costs for each of the cycles are calculated; then the percentage savings calculated in 5.7.1 is applied to each of these total costs to get individual savings in terms of 1974 dollars. Table 5-27 lists all plants, and results of calculations.

The diesel propulsion plant savings as percentage of acquis it ion costs . was estimated to be 5. 538%. -Applying this percentage factor to the - acquisition costs. of each diesel plant, the savings become:

For 7,000 SHP Diesel Plant:

$$11{,}374 \times (7{,}000)^{0.622} \times .05538 = \$155{,}209$$

For 14,000 SHP Diesel Plant:

$238,700 (from 5.2.4)

For 28,000 SHP Diesel Plant:

$$11{,}374 \times (28{,}000)^{0622} \times .05538 = \$367{,}619$$

Steam Propulsion Plant			Total Acquisition Cost $\$ \times 10^{-6}$	Total Savings $\$ \times 10^{-3}$
Cycle Type	Symbol	SHP $\times 10^{-3}$		
Two Boiler Two Heater	A-16	16	5.42	207
"	A-25	25	6.78	259
"	A-30	30	7.42	283
Two Boiler Four Heater	B-37	37	8.48	324
"	B-44	44	9.24	353
"	B-50	50	9.85	376
One Boiler Two Heater	C-25	25	6.82	261
"	C-30	30	7.49	286
One Boiler Four Heater	D-37	37	8.61	329
Reheat	E-44	44	9.48	362
"	E-50	50	10.09	385

TABLE : 5-27

5.8 A PROJECTION OF INDUSTRY-WIDE BENEFITS

The benefits to be expected from the implementation of proposed standards will be in the form of labor, material and scheduling time savings. The savings in labor and material costs, in the present analysis, were combined into one total and given the name "total savings."

The total savings were estimated:

a. For several selected candidates in each group of standards, by economically analyzing the *cost* items in accordance with the methodology of 5.2 and comparing the present method of approach with the Standards approach.

b. For remaining standards in each group, by extrapolating the results of analyzed standards following the method of generalization described in 5.2.3.

c. For parent steam and diesel propulsion plants, by summing up savings from all standards incorporated into the parent plant, as described in 5.2.4.

d. For other steam and diesel propulsion plants, and therefore for other ships that are included in the forecast, by assuming a constant percentage savings based on the total acquisition cost of the plant in question (5.2.5).

The scheduling time savings were also estimated wherever applicable and possible. But is it considered unrealistic to generalize on these. Therefore in investigating industry-wide benefits we will limit ourselves to labor and material savings only.

The results obtained are used to estimate the over-all industry-wide benefits which are to be expected for each year of the forecast period as well as for its total duration.

5.8.1 For Each Year of the Forecast Period

Referring to the Sub-task 1 Report, "Forecast for Propulsion Plant Standards," Table 3-4.2 Ilsts steam plants by cycle type and shows quantities of ships, for each year of theforecast period, which will have propulsion plants of the type listed. Table 3-6 is a similar compilation for diesel plants.

Tables 5-28 and 5-29 list the total savings for each plant for each year of the forecast period for the total number of ships to be contracted for in that year with that propulsion plant. In estimating the total savings for the first year of implementation, 1975, it was assumed that each of the ships to be contracted would result in unit savings corresponding to the type of plant and the SHP range. For succeeding years of standards implementation, however, several of the ships were assumed to be part of a series construction and therefore they were assumed to provide no additional savings.

To clarify the approach, let us consider the following example:

In the year 1976, 10 ships will be contracted for with a B-37 propulsion plant. (The symbol B-37 corresponds to a "Two Boiler-Four Stage Feed Heating" cycle of 37,000 SHP power range.) It was assumed that 4 out of 10 of these ships will be part of a series construction belonging to the remaining six contracts. Therefore, out of a total number of 10,ships, only 6 are assumed to offer the unit savings.

In tables 5-28 and 5-29, the number of series ships and the number of ships which will provide savings are identified for each year.

5.8.2 For the Total Forecast Period

In order to estimate the total savings for the complete forecast period, the influence of escalation in labor and material costs would have to be taken into consideration. All costs and cost savings reported up to this point in this report are in constant 1974 dollars - as assumed in 5.2.2.2 for uniformity in economic analyses. None of the costs are inflated past July 1974. As an initial approach, these costs will be subjected to a 9% per year escalation rate and the total estimated savings will be determined.

Table 5-30 shows the result of escalating combined total savings attainable by using standard diesel and steam plants for each year reported in Tables 5-28 and 5-29 by an inflation rate of 9% per year. it is assumed that gas turbines will provide no additional savings for the purposes of this study.

The projected industry-wide benefits escalated as described above appear to be in the order of $81,353,000 - for the total forecast period. The uninflated industry-wide benefits are approximately $51.S million It must be remembered that the numerical results obtained here depend on the assumptions made and criteria adopted, and therefore their accuracy is limited to the extent discussed in 5.3.1.3, 5.4.1.3, 5.5.1.3 and 5.6.1.3,

Steam Plant Symbol	Unit Savings $ x10^-3	1975 (1)		'76		'77		'78	
		No. of Plants	Total Savings $ x10^-3	No. of Plants	Total Savings $ x10^-3	No. of Plants	Total Savings $ x10^-3	No. of Plants	Total Savings $ x10^-3
A-16	207	2	414	1-S	0	1-S (2) 1-N (3)	207	1-S	0
A-25	259	7	1,813	3-S 5-N	1,295	3-S 4-N	1,036	3-S 5-N	1,295
A-30	283	2	566	1-S 2-N	566	1-S 2-N	566	1-S 1-N	283
B-37	324	14	4,536	4-S 6-N	1,944	3-S 6-N	1,944	3-S 5-N	1,620
B-44	353	2	706	1-S 3-N	1,059	1-S 1-N	353	1-S 1-N	353
B-50	376	1	376	1-S 1-N	376	—	—	1-S	0
C-25	261	—		—		—		—	
C-30	286	—		—		—		—	
D-37	329	—		—		—		—	
E-44	362	—		—		—		—	
E-50	385	—		—		—		—	
			8,411		5,240		4,106		3,551

(1) First Year of Implementation
(2) Series Construction
(3) New Contract

Table: 5-28

Sheet 1 of 3

Steam Plant Symbol	Unit Savings $\$ \times 10^{-3}$	1979 No. of Plants	1979 Total Savings $\$ \times 10^{-2}$	'80 No. of Plants	'80 Total Savings $\$ \times 10^{-3}$	'81 No. of Plants	'81 Total Savings $\$ \times 10^{-3}$	'82 No. of Plants	'82 Total Savings $\$ \times 10^{-3}$
A-16	207	–		1-N	207	–		1-S	0
A-25	259	3-S 6-N	1,554	2-S 4-N	1,036	2-S 4-N	1,036	1-S 2-N	518
A-30	283	1-S 1-N	283	1-N	283	1-N	283	1-N	283
B-37	324	2-S 4-N	1,296	2-S 2-N	648	2-S 4-N	1,296	2-S 4-N	1,296
B-44	353	1-S	0	1-N	353	–		1-S	0
B-50	376	1-N	376	–		1-S	0	–	
C-25	261	–		1-N	261	1-S	0	1-S	0
C-30	286	–		1-N	286	1-N	286	1-S	0
D-37	329	–		1-N	329	1-S	0	1-N	329
E-44	362	–		1-N	362	1-S	0	–	
E-50	385	–		–		–		1-N	385
			3,509		2,239		2,901		2,811

TABLE: 5-28

SHEET 2 OF 3

MEDIUM SPEED DIESEL PLANT SHP×10⁻³	UNIT SAVINGS $×10⁻³	1975		'76		'77		'78	
		No.	TOTAL SAVINGS $×10⁻³	No.	TOTAL SAVINGS $×10⁻³	No.	TOTAL SAVINGS $×10⁻³	No.	TOTAL SAVINGS $×10⁻³
7	155	2	310	1-S 1-N	155	1-S 1-N	155	1-S 1-N	155
14	239	5	1195	2-S 3-N	717	2-S 1-N	239	2-S 1-N	239
28	368	–	–	–	–	1-N	368	–	–
TOTAL SAVINGS FOR YEAR		1,505		872		762		394	

YEAR / SHP×10⁻³	'79		'80		'81		'82	
7	1-S 1-N	155	1-S 1-N	155	1-S 1-N	155	1-S 1-N	155
14	2-S 2-N	478	1-S 3-N	717	1-S 3-N	717	2-S 2-N	478
28	–	–	2	736	1-S 1-N	368	1-S 1-N	368
TOTAL SAVINGS FOR YEAR	1,633		1,608		1,240		1,001	

YEAR / SHP×10⁻³	'83		'84		'85	
7	1-S 1-N	155	1-S 1-N	155	1-S 1-N	155
14	2-S 2-N	478	2-S 2-N	478	1-S 3-N	717
28	1-S 1-N	368	1-S 1-N	368	1-S 1-N	368
TOTAL SAVINGS FOR YEAR	1,001		1,001		1,240	

S – SERIES
N – NEW

TABLE : 5-29

TABLE : 5-30

Forecast Year	$ Savings $\times 10^{-3}$ Steam Plants	Diesel Plants	Combined	Escalation Factor	Savings Inflated @ 9% Per Year $ $\times 10^{-6}$
1975	8411	1505	9916	1.09	10,808
76	5,240	872	6,112	1.1881	7.262
77	4,106	762	4,868	1.295	6.304
78	3,551	394	3,945	1.4116	5.569
79	3,509	633	4,142	1.5386	6.373
1980	2,239	1,608	3,847	1.6771	6.452
81	2,901	1,240	4,141	1.828	7.570
82	2,811	1,001	3,812	1.9926	7.596
83	2,955	1,001	3,056	2.1719	6.637
84	2,394	1,001	3,395	2.3674	8.037
1985	2,149	1,240	3,339	2.5804	8.745
Total for Forecast Period	40,266	11,257	51,523		81.353

5.9 Summary and Conclusions

5.9.1 General

The technical analysis, subtask-2, resulted in the selection of certain systems, sub-systems and components of different types of propulsion plants as potential candidates for which standards may be developed. The selection was based on technical feasibility, industry acceptance and a qualitative consideration of economic advantages.

Table 5-31 lists all the candidates under the four proposed primary standards groups.

In the course of subtask-3, economic analyses were performed of the potential candidates in order to determine the magnitude of *cost* and schedule savings of an installed propulsion plant. The method used was conducting specific detailed economic analyses on a representative sampling of potential candidates and then generalizing to obtain cost and schedule savings for all remaining potential standards.

As a representative sampling, the following candidate standards (from Table 5-31) were selected for quantitative treatment in the context of an economic analysis:

Group I - Total Plant Standards:

- 26,000 SHP Steam Turbine Propulsion Plant
- 14,000 SHP Medium-Speed Diesel Propulsion Plant

Group II - Module Standards

- Fuel Oil Service System Module
- Main Feed Pump Module
- Diesel Accessory Rack Module

POTENTIAL CANDIDATES FOR STANDARDS

FROM SUBTASK - 2

GROUP - TOTAL PLANT STANDARDS	GROUP II - MODULE STANDARDS
Steam Turbine Propulsion'Plants	Main Condensate Pump
15,000-17,500 SHP	Main Feed Pump
24,000 - 26,000 SHP	Fuel Oil Service System
28,500 - 32,000 SHP	High Pressure Feed Heater
36,000 - 40,00 SHP	power Unit
43,000 -45,000 SHP	Lube Oil Purifier
5o,000 + SHP	Lube Oil Service System
	Low Pressure Feed Heater
Diesel Propulsion Plants	Diesel Accessory Rack
7,000 SHP	Diesel Air Starting Package
14,000 SHP	
28,000 SHP	

GROUP Ill - ENVELOPE STANDARDS	GROUP IV - INDIVIDUAL EQUIPMENT/ COMPONENT STANDARDS
Main Boiler	Main Boiler
Main Turbine	Main Turbine
Main Diesel Engine	Main Diesel Engine
Main Condenser	Main Condenser
Main Reduction Gear	Main Reduction Gear
Main Feed Pump	Main Feed Pump
Main Condensate Pump	Main Condensate Pump
Main Circulating Pump	Lube Oil Service Pump
Lube Oil Purifier	First Stage Feed Heater
Lube Oil Service Pump	Boiler Controls
Fuel Oil Service Pump	Engine Controls
Deaerating Feed Heater	Forced Draft Fan
Low Pressure Feed Heater	Deaerating Feed Heater
Fuel Oil Heater	Fuel Oil Service Pump
Bridge Controls	Lube Oil Purifier
Engine Room Controls	Fuel Oil Purifier
Air Preheater	Lube Oil Heater
Economizer	Lube Oil. Cooler
Air Ejector	Fuel Oil Heater
Exhaust Gas Boiler	Air Ejector
	Air Preheater
	Thrust Bearing
	Fresh Water Cooler
	Red. Gear L.O. Booster Pump

TABLE 5 - 31

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Group III - Envelope Standards

- Main Boiler Envelope
- Lube Oil Purifier Envelope
- Main Feed Pump Envelope

Group IV - Individual Component/Equipment Standards

- Main Condensate Pump
- Starting Air Compressor
- Main Boiler

Each candidate standard in each group was then economically analyzed and savings to be expected by the adoption of the subject standard as compared to the existing non-standard approach was estimated.

Table 5-32 summarizes the results of economic analyses.

TABLE 5 - 32: ANALYSIS OF SAVINGS

GROUP OF STANDARD	TYPE OF STANDARD	NAME OF CANDIDATE STANDARD	LABOR + YARD MAT'L COST * $ ①	TOTAL COST $ ②	SAVINGS				REF.
					NET TOTAL $ ③	% OF YARD COST ④	% OF TOTAL COST ⑤	% OF MACH'Y ACQ. COST ⑥	
I TOTAL PLANT	SOFTWARE	26,000 SHP STEAM	234,900	258,400	87,840	37.4	34.0	1.29	Note ⑦
		14,000 SHP DIESEL	166,500	183,200	56,340	33.8	30.8	1.30	Note ⑧
II MODULE	SOFTWARE	F.O. SERVICE SYST.	27,600	99,600	17,470	63.3	17.5	0.26	Note ⑨
		MAIN FEED PUMP	20,700	108,700	11,757	56.8	10.8	0.17	
		DIESEL ACCES. RACK	46,900	144,900	31,607	67.4	21.8	0.73	
III ENVELOPE	SOFTWARE	MAIN BOILER	49,000	690,000	17,124	34.9	2.5	0.25	Note ⑩
		L.O. PURIFIER	11,000	20,000	4,461	40.6	22.6	0.07	
		MAIN FEED PUMP	13,700	46,700	5,394	39.4	11.5	0.08	
IV INDIVID'L EQUIPMENT / COMPONENT	DATA	MAIN CONDENSATE P.	7,800	21,000	1,350	17.3	6.4	0.02	Note ⑪
		STARTING AIR COMP.	7,800	24,800	1,242	15.9	5.0	0.02	
		MAIN BOILER	42,500	682,000	3,510	8.3	0.5	0.05	
	PROCUREMENT	MAIN COND. P.	7,800	21,000	2,124	27.2	10.1	0.03	
		ST. AIR COMP.	7,800	24,800	1,980	25.4	8.0	0.05	
		MAIN BOILER	42,500	682,000	6,300	14.8	0.9	0.09	
	HARDWARE	MAIN COND. P.	7,800	21,000	4,842	62.1	23.1	0.07	
		ST. AIR COMP.	7,800	24,800	4,698	60.2	18.9	0.11	
		MAIN BOILER	42,500	682,000	18,570	43.7	2.7	0.27	

Notes for TabIe 5-32

1. Under this column,, the costs of accomplishing the specified work" in the shipyard in connection with the Candidate equipment or services are listed. The costs for each group are estimated in different ways, and each is explained in Notes 7, 8, 9. 10 and 11 below. These represent the costs for existing approach.

2. Total cost is defined as the shipyard cost as listed in Column l. plus the purchase price of the equipment(s) that may go into the Standard. These are also existing costs.

3. Net total savings are taken directly from analysis results of Tables 5-15, 5-20, and 5-25.

4. Savings as a percentage of yard cost is obtained simply by dividing numbers in column 3 by numbers in column 1.

5. The numbers under this column denote the savings attainable through the utilization of a candidate standard as a percentage of the total cost for the existing approach for the same quantity of equipment and/or components.

6. The numbers in this column indicate for each candidate standard the expected savings as a percentage of the total machinery acquisition cost. The acquisition costs for the 26,000 SHP steam and 14,000 SHP diesel plants are taken directly as calculated from section 5.7.1, and the percentage values are obtained by dividing column 3 by the acquisition cost for the propulsion plant into which the candidate standard in question belongs. For the diesel accessory rack and starting air compressor, the diesel plant acquisition *cost is* used and for all other standards, the steam plant acquisition cost is taken as a basis.

7. The total cost for Group I candidate standards is obtained by adding approximately 10% allowance-for indirect labor and material to the *cost* estimated in the analysis.

8. The total cost for modules are calculated separately by using source data for "individual components, when available, and by contacting some Manufacturers.

9. The total costs for envelopes are calculated separately by using available source data (Shipyard Source).

10. The total *costs* for hardware standards are obtained by adding purchase *cost* of the equipment in question to the "labor + yard material" *cost* estimated in column 1.

5.9.2 Analysis of Results

In Table 5-32, the savings are tabulated in four different ways:

a. Under the column "Net Total $", the savings are reported, as the heading implies, in terms of net dollars to be gained when the standard in question is implemented and utilized. It is evident that greatest dollar savings are possible by utilizing the following standards:

1.	total Steam Plant Standard	$87,840
2.	Total Diesel Plant Standard	$56,34o
3.	Diesel Accessory Module	$31, 607
4.	Main Boiler Hardware Standard	$18,570
5.	F.O. System Module Standard	$17,470
6.	Main Boiler Envelope	$17,124
7.	Main Feed Pump Module	$11,757
8.	Main Boiler Procurement Standard	$6,300
9.	Main Feed Pump Envelope	$5,394
10.	Main Condensate Pump Hardware Standard	$4,842
11.	Starting Air Compressor Hardware Standard	$4,698

b. Under the column "% of Yard Cost," the savings are reported as a percentage of the shipyard expenses in connection with the subject equipment exclusive of its purchase cost. The candidates showing greatest promise of savings in this sense are:

1.	Diesel Accessory Module Standard	67.4%
2.	F.O. Service System Module	63.3%
3.	Mai n Condensate Pump Hardware Standard	62. 1%
4.	Starting Air Compressor Hardware Standard	60. 2%
5.	Main Feed Pump Module Standard	56. 8%
6.	Main Boiler Hardware Standard	43. 7%
7.	1.0. Purifier Envelope Standard	40. 6%
8.	Mai n Feed Pump Envelope Standard	39. 4%
9.	Total Steam Plant Standard	37.4%
10.	Main Boiler Envelope Standard	34. 9%
11.	Total Diesel Plant Standard	33. 8%

c. Under the column “% of total cost,” the savings are reported as a percentage of the total rests relating to the subject equipment, including its purchase cost. The order of savings for this case is as follows:

1.	Total Steam Plant Standard	34.0%
2.	Total Diesel Plant Standard	30. 8%
3.	Main Condensate Pump Hardware Standard	23. 1%
4.	L.0, Purifier Envelope Standard	22.62
5.	Diesel Accessory Rack Module Standard	21. 8%

6. Starting Air Compressor Hardware Standard — 18.9%
7. F.O. Service System Module Standard — 17.5%
8. Main Feed Pump Envelope Standard — 11.5%
9. Main Feed Pump Module Standard — 10.%%
10. Main Condensate Pump Procurement Standard — 10I%
11. Starting Air Compressor Procurement Standard — 8.0%

d. It is also possible to investigate what the savings are as a , percentage of the total machinery acquisition cost of a ship's propulsion plant. The next column lists these percentages, and the order of savings is as shown below:

1. Total Diesel Plant Standard — 1.30%
2. Total Steam Plant Standard — 1. 29%
3. Diesel Accessory Module Standard — 0.73%
4. Main Boiler Hardware Standard — 0.27%
5. F.O. Service *System* Module Standard — 0. 26%
6. Main Boiler Envelope Standard — 0.25%
7. Main Feed Pump Module Standard — 0. 17%
8. Starting Air Compressor Hardware Standard — 0.11%
9. Main Boiler Procurement Standard — 0.09%
10. Main Feed Pump Envelope Standard — 0.08%
11. Main Condensate Pump Hardware Standard — 0. 07%

It must be pointed-out here, that all of the above classifications are based on the net dollar savings estimated for each candidate standard as a result of the analyses performed, and therefore the magnitudes and priorities they indicate are accordingly dependent upon the accuracy of and the justification for the assumptions and criteria established during the analyses. As discussed earlier, however, in sections 5.3.1.3., 5.4.1.3, 5.5.1.3 and 5.6.1.3, the trend towards savings due to utilization of standards is definite. And it is possible to study these trends and arrive at the comparative benefits of any one group of standards over the others.

Again in connection with the estimated or predicted savings, the following should be remembered:

a) The savings are calculated on the basis of a direct labor rate of 9 %/hr for engineering manhours and 6 $/hr for yard labor manhours, including fringe benefits but excluding overhead. The actual savings will be greater than reported in proportion to the prevalent overhead rate.

b) Additional savings may be attainable by using lower level standards in a higher level standard -- for example,.by using two main feed pump hardware standards in a standard main feed pump module.

c) Additional savings will be attainable due to putting into a new use the resources freed through the utilization of standards (latent savings).

d) The savings as reported here do not reflect the influence of the cost of developing and instituting the Standards. The net advantage of the standards program may be reduced when this factor is taken into account.

e) All savings are reported in terms of 1974 dollars. No escalation is applied past July 1974.

f) The savings as reported include effects of 'recurring as well as non-recurring costs.

5.9.3 Conclusions

The savings for total plant Standards occupy the first and second places in the priority classifications on the basis of net dollar savings, percentage total cost, and percentage acquisition *costs.* The net dollar savings of $87,84o, percentage total savings of 34% and percentage acquisition cost savings of 1.29% for the total steam plant are the highest savings obtainable among all candidates. The savings for total diesel plant are also high for the three different classifications. The reason for the low priority obtained with the total plant standards when classified on the basis of percentage yard cost is that the total plant standard basically covers the design efforts, and as such no important purchase costs are involved.

It is evident that, even within the limited extent of total plant standards as used in this analysis, the savings are tangibie. When and if a more extensive total plant standard, including a greater portion of detail design and possibly all of contract design, is adopted and implemented, then the savings wiil be much greater. In the course of preliminary work for this subtask, MRGS had studied this possibility and found out that the savings for the total steam plant might be in the order of $160,000, and this might correspond to a scheduling time savings of approximately 13 months; corresponding savings for the total diesel plant is in the vicinity of $115,000, and 12.5 months of scheduling time.

Effectively, these standards would rank highest in cost effectiveness, and it is recommended that they be further investigated for utilization in the implementation of the standards program.

In terms of net dollar savings and also in terms of savings as a percentage of yard costs and acquisition costs, module standards and hardware standards offer very good possibilities. The diesel accessory rack module standard promises a net savings of $31,607, and the Fuel Oil Service System Module Standard promises $17,470. These correspond, respectively, to 67.4% and 63.3% of the yard costs for the subject equipment/components. The savings reported for Modules in Table 5-32 are those attainable with Alternative 1 Standard approach. This is to say that the shipyards would buy a Vendor-assembled standard module and simply install it on board. The respective savings for Alternative 2 standards approach, which calls for the standard modules to be assembled by the shipyard, would be $20,804 and $12,835 in net dollar values, and 44.4% afid 46.5% in percentage of yard costs.

It is evident from the four different priority classificatior that the module standards always enter the "best savings" listing. The three module standards that were economically analyzed, occupy 3rd, 5th and 7th places in the "net dollar savings"; Ist, 2nd and 5th places in the "percentage of yard cost" savings; 5th, 7th and 9th places in the 'percentage of total cost" savings; and 3rd, 5th and 7th places in the "percentage of acquisition cost" savings.

These results reinforce greatly the qualitative conclusions reached during Subtask-2 technical analysis efforts that modules are the most viable candidates to write standards for. It might be well to point out at this junction that the shipyards, almost invariably, indicated a desire to design their own standard modules to suit the space requirements in their specific ship constructions. However, it is believed strongly that when the "nationally developed module standards" are implemented and made available to designers, shipyards and vendors in the early stages of ship design and construction efforts, all concerned parties will be in a position to specify, install and manufacture these standard modules without any disadvantageous space problems, but with all the ensuing benefits in the form of savings.

AS pointed out above, the hardware standards also offer *very* good savings possibilities. The three hardware standards, which were economically analyzed, occupy the following ranks in savings classifications.:

In Net Dollar Savings = 4th, 10th and Ilth

In % Yard Costs = 3rd, 4th and 6th

In % Total Costs = 3rd and 6th

In % Acquisition Costs= 4th, 8th and llth

The candidate which ranks 4th in Net Savings, 6th in % Yard costs and 4th in % acquisition costs is the Main Boiler Hardware Standard.

Even though the Main Boiler was selected as a candidate for economic analysis (of individual equipment standards), it is a well known fact that the boiler manufacturers, much like the gas turbine manufacturers, have already standardized their product lines quite extensively. In this sense, it is highly probable that very strong resistance will be met from Vendors when a different set of hardware standards are attempted. It follows that, from a practical standpoint, the main boiler should not be selected as a final candidate to write hardware standards for.

One may argue that the above reasoning would hold true for other equipment such as pumps, heat exchangers, compressors and the like. And it would, indeed, in most casesl However, the size and complexity of these equipment are small compared to the main boilers; and the number of qualified Vendors for them are many times that for boiIers. It is therefore considered possible that the vendors of these equipments may yield to nationally implemented standards, since by doing so they also will eventually experience savings in their production costs.

A close study of the results reported in Table 5-32, and also in Table 5-25, shows that no important savings should be expected through the use of data standards and procurement standards for individual equipment. Even though one particular procurement standard shows up in the priority classification of net dollar savings in the 8th place (and 9th place in % acquisition cost classification), this happens to be the one for the main boiler again, and is subject to the same reasoning as for the boiler hardware standard. The two other procurement standards which appear in the listing for percentage total *cost* savings are those for the main condensate pump and the starting air compressor. The net savings for these two are $2,124 and $1,980 respectively. The meager savings leads one into doubts as to the justification of writing procurement standards for these equipment. However, it will be recalled from 5.6. that the underlying thought. in investigating data and procurement standards was to provide a step-by-step approach to eventual hardware standards. In this context, the implementation of hardware standards being desirable, so are the data and procurement standards. One word of caution may be added here that for large equipment such as main turbines and main diesel engines for which manufacturers already have standardized product lines, the individual equipment standards may not be beneficial at this point in time.

The envelope standards seem to offer the least savings as a group. The priority classification is as follows:

In Net Dollars Savings	= 6th and 9th places
In % Yard costs	= 7th, 8th and 10th
in % Total costs	= 4th and 8th
In %Acqu'isition *Costs*	= 6th and 10th places

Again, the main arguments for envelope standards, as discussed in 5.5.1, should be borne in mind. It will be remembered that space requirements were a major factor in using envelopes. For this reason, it was concluded that larger equipment in congested areas of engine rooms would probably not Iend themselves to economically feasible envelope applications. The main boiler envelope, for example, even though it promises the 6th ranking net dollar savings, of $17,124, may not be feasible since it would require additional space in an area where space is already at a premium. If we exclude the main boiler envelope from the priority listings for this reason, we will be left with only the main feed pump envelope that makes the priority list with $5,394 net savings and ranks 9th.

The main advantage of the envelope standard, of course, is the interchangeability of various manufacturers' equipment without interfering with their specific and different designs. In this sense, the smaller equipment like pumps, purifiers, heat exchangers, control consoles, etc., can be recommended for envelope standards. Furthermore, when the most of developing and instituting standards are considered, the envelope standards, as far as smaller equipment are concerned,"may prove to be more advantageous than the hardware Standards since the envelope standards would require no changes in the Manufacturers' product lines. The manufacturers would simply have to add a few connections and bring these to the interface points on the surface of the envelope. In addition to the advantage of lower development costs for the envelope standards, the resistance from the vendors against implementing these standards would be very small, if any, as compared to their understandable and already stated strong resistance against instituting hardware standards.

In summarizing the findings, it can be said that the order of priority for development of national standards for different groups and types of standards should be as follows:

1. Total Plant Standards
   (For Steam and Diesel Plants)
2. Module Standards
3. Hardware Standards
   (Starting with data and procurement standards)
4. Envelope Standards

The savings to be expected when using a total plant standard is about 1.3% of the total plant acquisition cost. When using suitable Group II, III and IV standards in addition to the total plant standards, the cost savings approach 3.8% of the total plant acquisition cost for the steam plants and 5.5% for the diesel plants.

These are appreciable savings to be experienced for each new contract for a number of ships of the same design to be constructed in any one shipyard. It is believed that the savings ‘reported are conservative and that the actual gains will be greater, so that even after amortizing the standards development costs, there will still be considerable savings to justify developing and instituting national standards for ship’s propulsion plant design, systems, equipment and/or components.

APPENDIX C.I.I

Format for Group I Standards -

Title - Standard Total Propulsion Plant
No. - TP-SG-etc.

1. Definition: This standard is a document which contains the technical information in standard format which is necessary *to* define and describe a ________ to ________ SHP steam turbine ________ feed heater propulsion plant. Standards are available for each of the following propulsion plants.

15,000 - 17,500 SHP .(2 Feed Heaters)

24,000 - 26,000 SHP (2 Feed Heaters)

28,500 - 32,000 SHP (4 Feed Heaters)

36,000- 40,000 SHP (4 Feed Heaters)

43,000- 45,000 SHP (4 Feed Heaters)

50,000 SHP (4 Feed Heaters)

Standardized Parameters (for-Total Steam Plant)

Steam Conditions @ Boiler Superheater Outlet

P: psig

T: °F

Main Condenser Vacuum: ________ "HG

Sea Water Temperature: °F

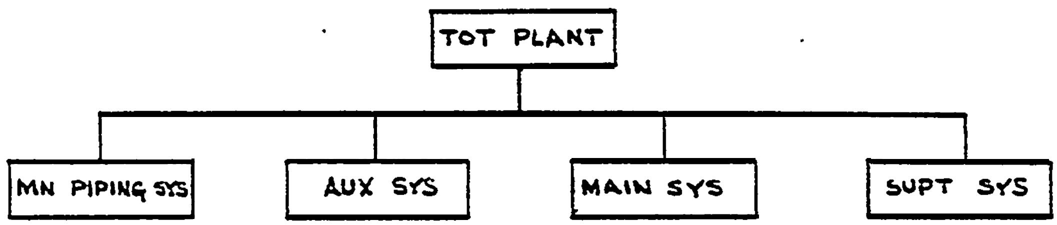
Outside Air Temperature: °F

Outside Air Relative Humidity: %

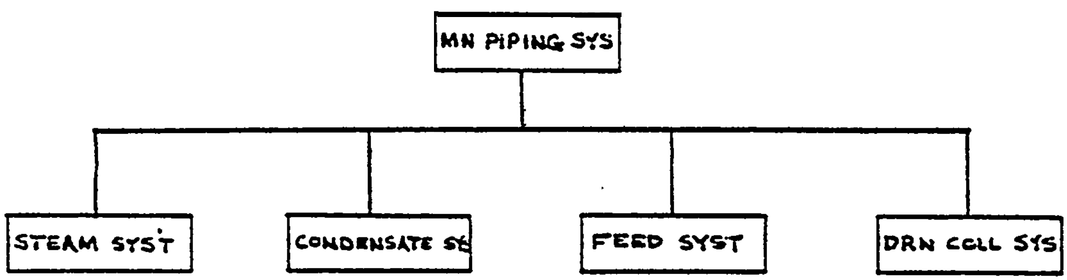
Machinery Space Air Temperature: °F

Machinery Space Air Relative Humidity: %

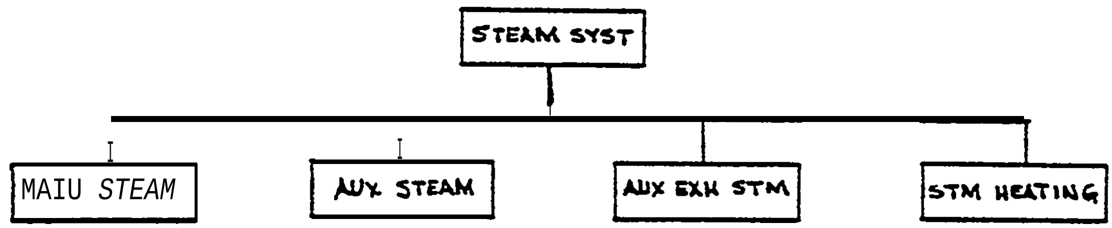
2. System Block Diagrams. The total plant for purposes of this Standard wi11 consist of the following eIements:



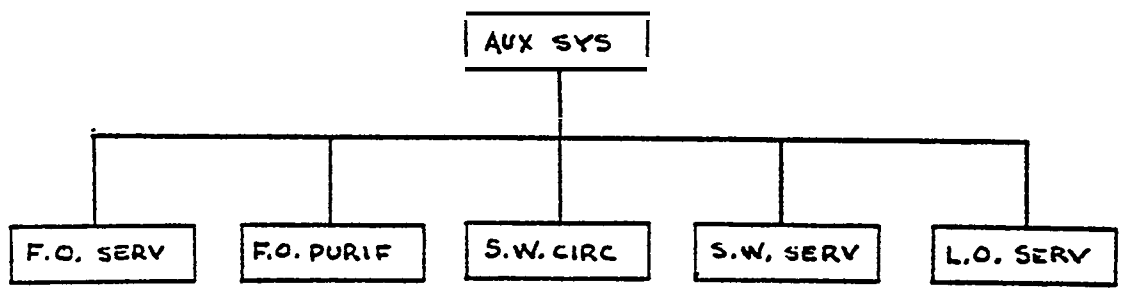
2.1 The Main Piping systems as pertain to this standard contain the following systems:



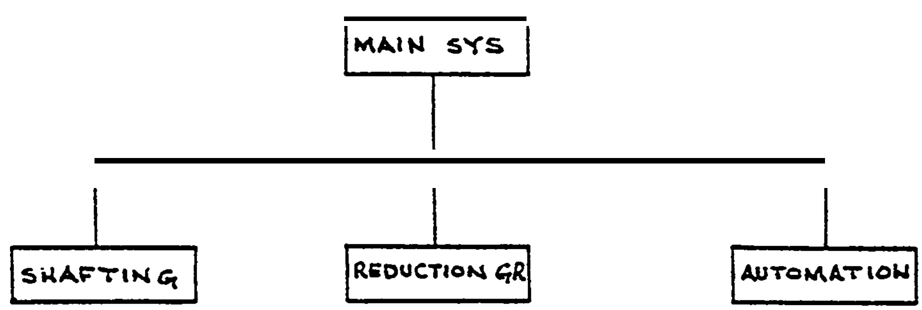
2.1.1 The steam systems segment of the main piping *systems* are further subdivided into the following main and auxiliary steam systems.



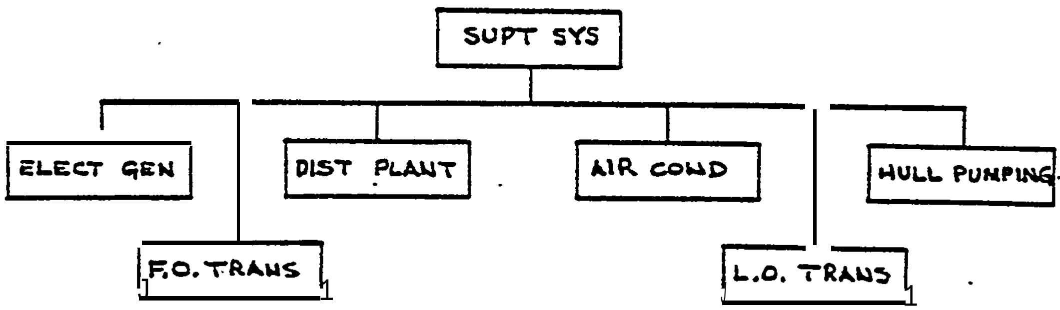
2.2 The Auxiliary Systems-contain the following sub-systems which are required for operation of the propulsion system.



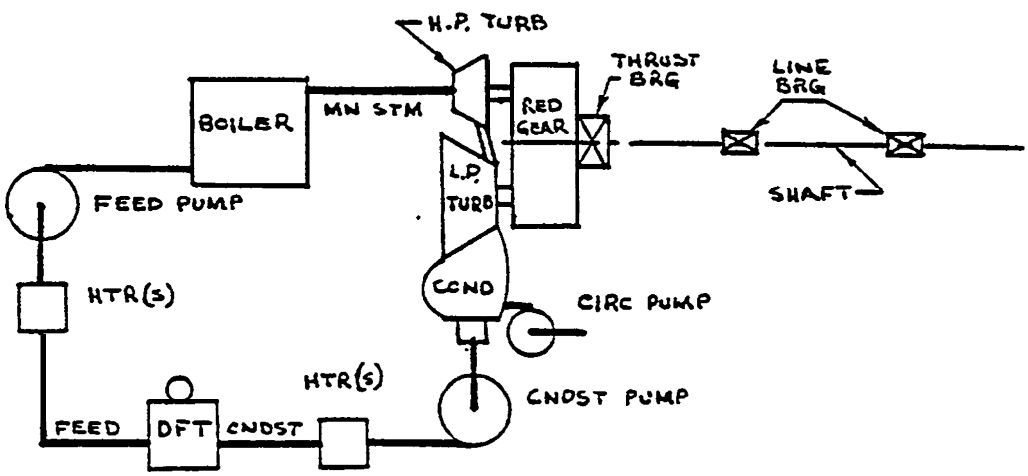
2.3 The main systems which are required for propulsion plants are contained in the following:



2.4 The Supporting Systems are those systems which are required for accomplishment of the ship’s mission and which interface with and affect the propulsion system.



3. Propulsion Plant Block Diagram



4. Heat Balance Diagrams

Infonnation required is compatible with that required for each system in paragraph 5, "System Diagrams." Heat Balance diagrams are prepared for the following conditions:

- Maximum Continuous Service
- Port Condition
- Operational Missions

A typical heat balance diagram is *shown* in figure "A."

4.1 Required data for heat balance diagrams

Refer to SNAME Technical & Research Bulletin 3-11

Steam Conditions (Press, Temperature, Enthalpy, FIow)

Water Conditions (Press, Temperature, Enthalpy, F1ow) at inlets and outlets of all equipment in the propulsion plant loop

Condenser Vacuum

Ambient Air and Water Conditions (Press, Temperature, Humidity)

Boiler Efficiency

Boiler Fuel Rate

Turbine Steam Rate

Fuel Oil Conditions (Higher Heating Value)

Auxiliary Loads

- Distilling Plant (Quantity and Efficiency)
- Electric Load
- Heating, Hot Water Loads
- Air Conditioning Load

Equipment Operating Conditions (Working Pressures, Relief Pressures, System Losses, etc.)

Mission Requirements

Cargo Pump l (Quantity, Type, Pressure, Temperature)

Crane Requirements (Electric, Fuel, etc.)

Tank Cleaning Requirements (Steam, Electric)

5. Systems Diagrams

Generally systems diagrams will be prepared for the following listed systerns. Typically, each diagram consists of a one-line piping diagram showing the subject piping system with symbolic representations of all relevant equipment, valves, fittings, flanges, and instrumentation. Diameters of piping and sizes of fittings, and valves are indicated *on* the diagram. Included are Tables which list materials and specifications, maximum allowable fluid velocities, and equipment (pump) types, sizes and capabilities. Tables "A", "B" and "C" are typical of information on a piping diagram. Typical piping diagrams are included for information in figures "B" through"l" inclusive.

5.1 Steam Systems

- Main Steam (Figure B)
- Auxiliary Steam (Figure C)
- Auxiliary Exhaust (Figure D)
- Steam Heating

5.2 Condensate System (Figure E)

5.3 Feed System (Figure E)

5.4 Drain Collecting System(s) (Figure E)

- H.P. drains
- L.P. drains

5.5 Auxiliary Systems - These include all auxiliaries required for operation of the propulsion plant.

- Fuel Oil Service System (Figure F)
- Fuel Oil Purifier System
- S.W. Circulating System (Figure G)
- Auxiliary Condenser & S.W. Service Systems (Figure G)
- Lubricating Oil Service System(s) (Figure H)

5.6 Main systems - These include the systems for major equipment allied with the main propulsion plant which is required for operation of the ship.

- Shafting System
  Dimensional Diagram
  Material Requirements
  Bearing Type & Locations
  Thrust Bearing (may be with Red Gr.)
  Weight & Force Diagram

- Reduction Gear System
  - Type
  - Load Factors
  - K Factors
  - Gear Diagram
- Automation System
  - Type System
  - System Block Diagram
  - One-Line Diagram
  - Service Requirements

5.7 Supporting Systems -- These *systems* requirements are those which are required for proper sizing of components In the propulsion plant.

- Electric Generation
  - Hotel Load
  - Auxiliary Load
  - Machinery Support Load
- Distilling Plant
  - Required Load
  - Efficiency
- Air Conditioning, Ventilation
  - Required Load

l Hull Pumping Systems

Bilge Pumping Diagram (FIGURE)

(Interfaces with Propulsion Systems)

Ballast System Interface (FIGURE 1)

Fire - fighting System Interface

Cargo Pumping Requirements (if applicable) (FIGURES J & K)

. Fuel oil Transfer System (Figure L)

. Lubricating Oil Transfer System (FIGURE H)

6. A listing of available standards for equipment components and modules which may be used in the composition of this standard propulsion plant is included in Table D.

TABL

SYSTEM	1F
BUTTERWORTH SEAWATER SYSTEM	2" AB 1½" BE
BUTTERWORTH HOSE VALVES	2½
BOILER PRESS. DESUPERHEATED STEAM 100 PSI DESUPERHEATED STEAM- SEE NOTE BELOW:	2" AB 1½" BE

MAXIMUM VELOCITIES

WATER:

SYMBOL	FLOW GPM	TEMP. °F	IPS	VELOCITY FT/MIN
A	852	77	6"	568
B	850	60	6"	566
C	451	77	6"	301
D	451	77	5"	434
E	852	77	6"	568
F	881	200	6"	587
G	101	140	2"	577
H	101	140	2½"	405

STEAM:

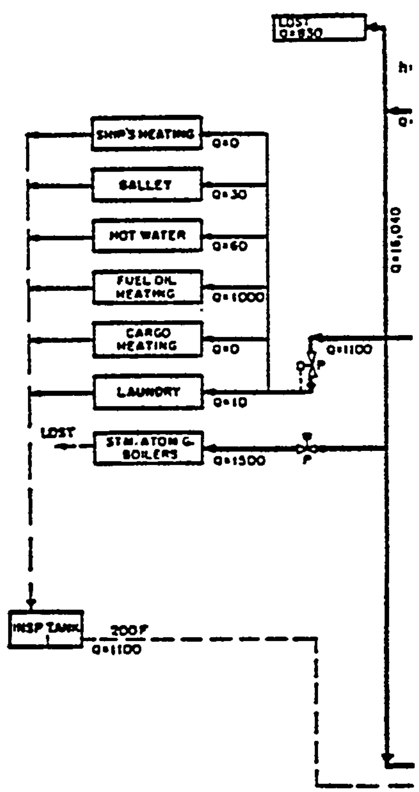
SYMBOL	FLOW LB/HR	TEMP °F	IPS	VELOCITY FT/MIN
J	50,000	540	5"	4,081
K	50,000	440	8"	11,054

TABLE B

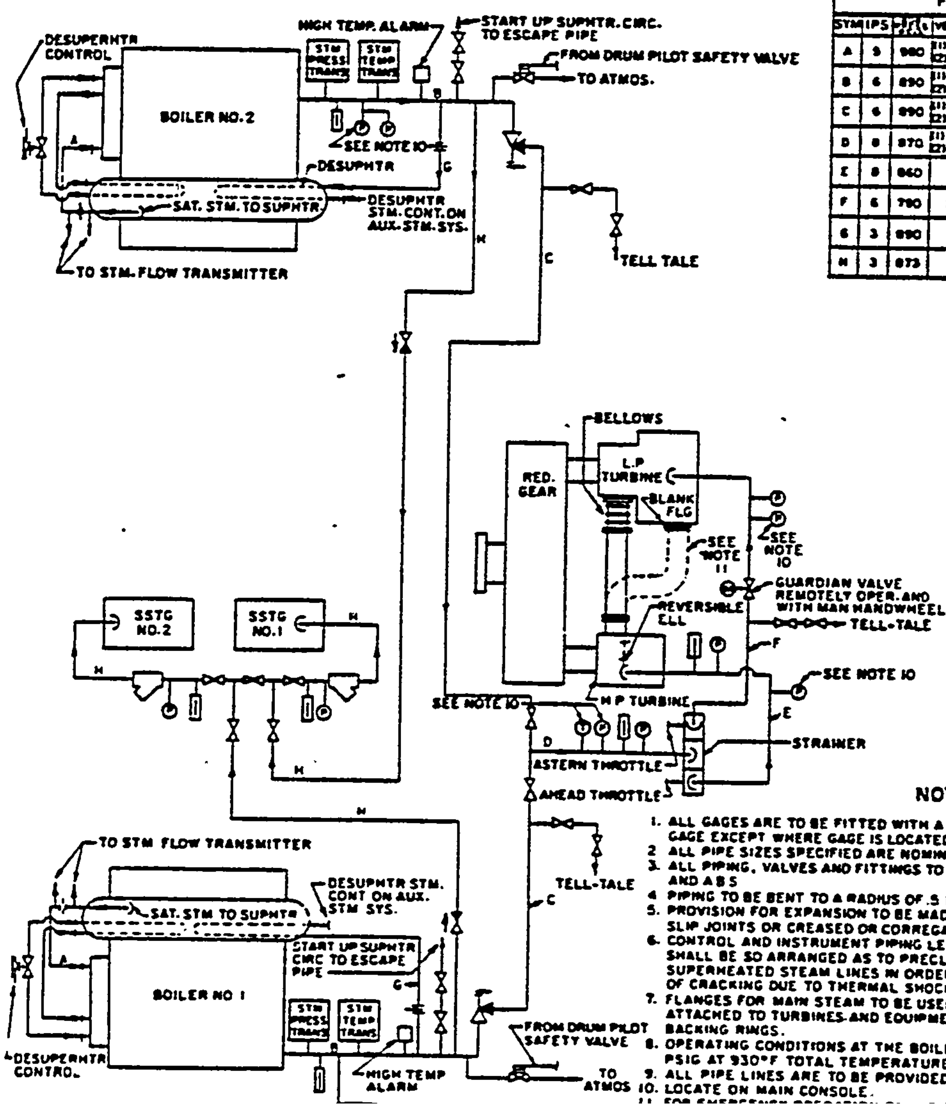
PUMP TABLE						
Nº OF UNITS	DESCRIPTION	TYPE	DRIVE	CAPACITY GPM	SUCTION LIFT	TOTAL HEAD FT
1	FIRE & BUTTERWORTH PUMP (EXISTING).	HORIZ CENTRIF	STEAM TURB.	450	FLOODED	456
1	BUTTERWORTH PUMP (NEW).	HORIZ CENTRIF	MOTOR	450 *	FLOODED	450 *
1	GENERAL SERVICE & FIRE PUMP (EXIST.) LOCATED IN SHAFT ALLEY.	HORIZ CENTRIF	MOTOR	350	FLOODED	285

% 400 GPM AT 470 FT HEAD

TABLE C



LOST
Q=830
SHIP'S HEATING
Q=0
GALLEY
Q=30
HOT WATER
Q=60
FUEL OIL HEATING
Q=1000
CARGO HEATING
Q=0
LAUNDRY
Q=10
Q=1100
P
LOST
STM. ATOM G. BOILERS
Q=1500
P
Q=16,010
INSP TANK
200F
Q=1100

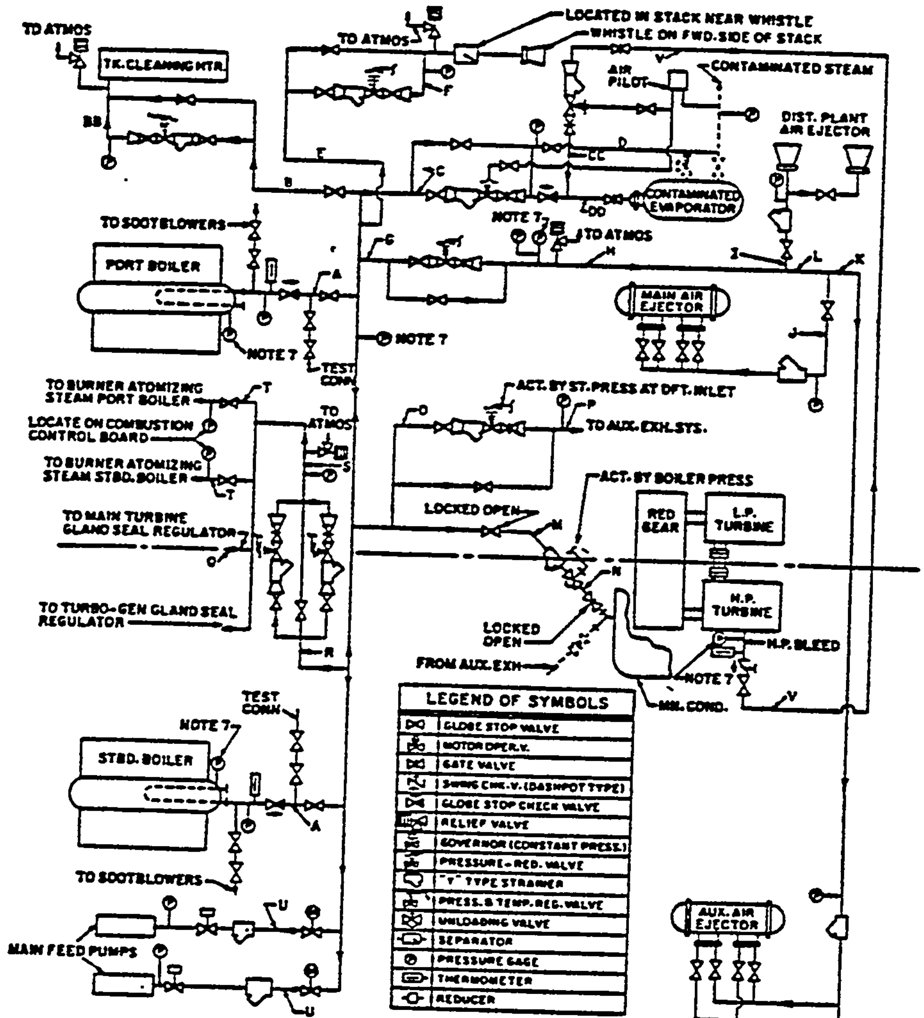


FLOWS AND VELOCITIES						
SYM	IPS	°F	VEL.	FLOW	CONDITION	SERVICE
A	5	980	(1) 93.4 (2) 107	(1) 83600 (2) 96150	(1) ABS POWER (2) 115% OVLD	DRUM TO SUPHTR INLET
B	6	890	(1) 118 (2) 135	(1) 83600 (2) 96150	(1) ABS POWER (2) 115% OVLD	SUPHTR OUTLET TO JUNCTION OF SSTG
C	6	890	(1) 109 (2) 116	(1) 77300 (2) 82530	(1) ABS POWER (2) 115% OVLD	SSTG JUNCTION TO JUNCT OF 2 BOILERS
D	8	870	(1) 123 (2) 68.8	(1) 148225 (2) 82530	(1) ABS POWER (2) 115% OVLD	MN STM. HEADER TO MN TURB THROTTLE
E	8	860	125	146225	ABS POWER	MN. TURB THROTTLE TO H P TURB CHEST
F	6	780	210	135360	ABS POWER	MN TURB THROTTLE TO ASTERN TURBINE
G	3	890	103	19000	ABS ASTERN	SUPHTR OUTLET TO DESUPHTR INLET
H	3	873	72.0	13800	ONE SSTG AT RATING	MAIN STEAM TO SSTG

LEGEND OF SYMBOLS	
	GLOBE STOP VALVE (MOTOR OPER)
	GLOBE STOP VALVE
	GLOBE STOP CHECK VALVE
	SUPHTR SAFETY VALVE PILOT ACT
	STM TEMP CONT V AIR PILOT ACT
	ANGLE STOP-CHECK VALVE
	RING & BLIND FLANGE
(T)	REMOTE READING THERMOMETER
(P)	PRESSURE GAGE
	ORIFICE
	THERMOMETER
	"Y" TYPE STRAINER

NOTES

1. ALL GAGES ARE TO BE FITTED WITH A VALVE AT THE MAIN AND ONE AT THE GAGE EXCEPT WHERE GAGE IS LOCATED ON MAIN, THEN ONE VALVE WILL BE USED.
2. ALL PIPE SIZES SPECIFIED ARE NOMINAL, WITH I.P.S OUTSIDE DIAMETERS.
3. ALL PIPING, VALVES AND FITTINGS TO MEET THE REQUIREMENTS OF THE USCG AND ABS
4. PIPING TO BE BENT TO A RADIUS OF 5 DIAMETERS
5. PROVISION FOR EXPANSION TO BE MADE IN ALL PIPES WITHOUT THE USE OF SLIP JOINTS OR CREASED OR CORREGATED PIPE BENDS
6. CONTROL AND INSTRUMENT PIPING LED FROM SUPERHEATED STEAM LINES SHALL BE SO ARRANGED AS TO PRECLUDE CONDENSATE FROM ENTERING THE SUPERHEATED STEAM LINES IN ORDER TO GUARD AGAINST THE POSSIBILITY OF CRACKING DUE TO THERMAL SHOCK
7. FLANGES FOR MAIN STEAM TO BE USED ONLY AS REQUIRED AND WHERE ATTACHED TO TURBINES AND EQUIPMENT. LINE JOINTS TO BE WELDED USING BACKING RINGS.
8. OPERATING CONDITIONS AT THE BOILER SUPERHEATER OUTLET ARE 875 PSIG AT 930°F TOTAL TEMPERATURE
9. ALL PIPE LINES ARE TO BE PROVIDED WITH DRAINS WHERE NECESSARY
10. LOCATE ON MAIN CONSOLE.
11. FOR EMERGENCY OPERATION [illegible]



LEGEND OF SYMBOLS	
	GLOBE STOP VALVE
	MOTOR OPER. V.
	GATE VALVE
	SWING CHK. V. (DASHPOT TYPE)
	GLOBE STOP CHECK VALVE
	RELIEF VALVE
	GOVERNOR (CONSTANT PRESS.)
	PRESSURE-RED. VALVE
	"Y" TYPE STRAINER
	PRESS. & TEMP. REG. VALVE
	UNLOADING VALVE
	SEPARATOR
	PRESSURE GAGE
	THERMOMETER
	REDUCER

FLOWS AND VELOCITIES						
STM	IPS	PRESS PSIG	VEL FT/SEC	FLOW LB/HR	CONDITION	SERVICE
A	4	775	43.7	20000	MAXIMUM	DESUPHTR STM LOOP
B	2½	850	64.1	12000	RATED	850/130 RED STA.
BB	5	130	81.6	12000	RATED	850/130 RED STA TO TK CLEANING HEATER
C	2½	850	53.4	10000	RATED	[illegible]
CC	4	185	42.0	4190	FULL POWER	HP TURBINE BLEED TO CONTAM EVAP
D	4	130	91.3	8500	RATED	CONTAM EVAP BY-PASS
DD	4	350	42.5	10000	RATED	RED.V. TO CONTAM EVAP
E	1	850	47.2	1500	RATED	850/140 RED STA
F	2	140	57.0	1500	RATED	850/140 RED. VALVE TO WHISTLE
G	1½	850	16.2	1260	RATED	850/143 RED STA
H	2	143	47.0	1260	RATED	850/143 RED VALVE TO ALL AIR EJECTORS
I	1¼	143	47.6	570	RATED	143 PSIG TO D.S. PLANT AIR EJECTOR
J	1½	143	41.0	490	RATED	143 PSIG TO MN AIR EJECTOR
K	1	143	28.9	200	RATED	143 PSIG TO AUX AIR EJECTOR
L	1½	143	42.4	690	RATED	143 PSIG TO MN & AUX AIR EJECTORS
M	2	850	202	20000	RATED	850 PSIG TO UNLOADING VALVE
N	4	7.8	1302	20000	RATED	UNLOADING VALVE TO [illegible]
O	3	850	72.0	21000	ASTERN	850/32 RED. STA.
P	8	32	176	21000	ASTERN	850/32 RED VALVE TO [illegible]
Q	1¼	143	78.2	935	RATED	143 PSIG TO GLAND SEAL REGULATOR
R	1½	850	17.4	1335	FULL POWER	850/143 RED STA
S	2	143	50.5	1335	FULL POWER	850/143 RED V TO GL SEAL & B. ATOMIZATION
T	1¼	143	35.1	420	FULL POWER	143 PSIG TO BURNER ATOM STM
U	2½	850	36.8	11000	RATED	850 PSIG TO MN FEED PUMP
V	2½	205	101	4190	RATED	HP TURBINE BLEED

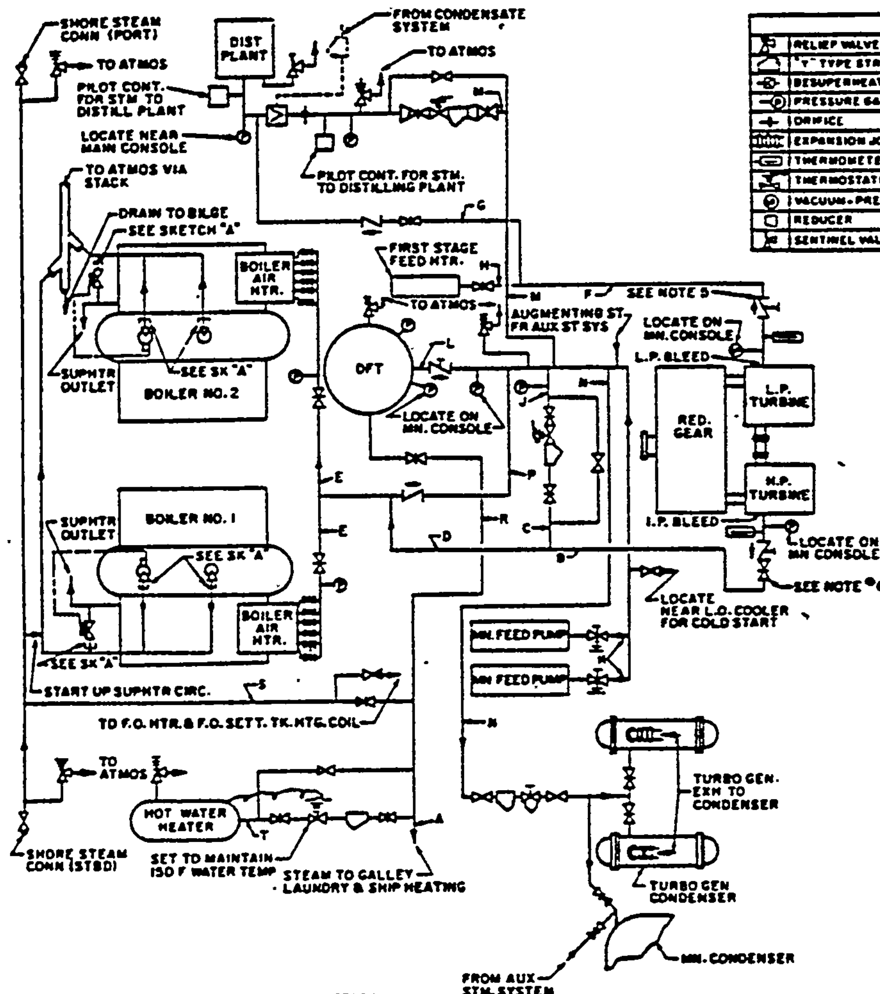
NOTES

1. ALL PIPING, VALVES AND FITTINGS TO MEET REQUIREMENTS OF THE USCG AND ABS.
2. PIPING ARRANGEMENTS SHALL BE DESIGNED WITH DUE REGARD FOR THERMAL EXPANSION AND ALLOWABLE LOADS ON PUMPS AND OTHER EQUIPMENT.
3. FLANGES FOR AUXILIARY STEAM ARE TO BE USED ONLY WERE ATTACHED TO VALVES, FITTINGS OR EQUIPMENT. LINE JOINTS ARE TO BE WELDED USING BACKING RINGS.
4. PIPING TO BE BENT TO A RADIUS OF 5 DIAMETERS.
5. ALL PIPE LINES ARE TO BE PROVIDED WITH DRAINS WERE NECESSARY.
6. ALL STEAM PIPING TO THE CONTAMINATED EVAPORATOR AND H.P. BLEED STEAM PIPING DOWNSTREAM OF, AND INCLUDING, THE CHECK VALVE AT THE H.P. TURBINE ARE DESIGNED FOR FULL DESUPERHEATED STEAM PRESSURE OF 965 PSIG.
7. LOCATE ON MAIN CONSOLE.

Diagram of auxiliary and high-pressure bleed steam

FIGURE "C"

PIPING SYSTEMS



LEGEND OF SYMBOLS	
RELIEF VALVE (SPRING LOADED)	GLOBE STOP VALVE
"Y" TYPE STRAINER	GATE VALVE
DESUPERHEATER	SWING CHECK VALVE
PRESSURE GAGE	SWING CHECK VALVE (DASHPOT TYPE)
ORIFICE	UNLOADING V. AIR PILOT OPER.
EXPANSION JOINT	PRESSURE RED. V. AIR PILOT OPER.
THERMOMETER	SUPHTR SAFETY V PILOT ACT.
THERMOSTATIC CONTROL VALVE	GLOBE HOSE VALVE
VACUUM-PRESSURE GAGE	COMB. EXH RELIEF & BACK PRESS RES V.
REDUCER	BOILER SAFETY VALVE
SENTINEL VALVE	

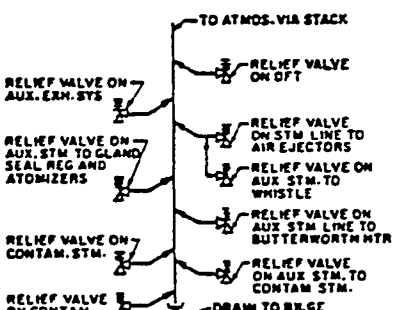
FLOWS AND VELOCITIES

SYM	SIZE IN	NOM PRESS	VEL. [illegible]	FLOW [illegible]	CONDITION	SERVICE
A	3	35	78.2	1700	[illegible]	STM TO GALLEY, LAV. & SHIP HEATING
B	6	67	203	22610	MAXIMUM	I P TURBINE BLEED
C	4	67	257	13070	MAXIMUM	I P BLEED TO EXH MN.
D	5	67	124	9940	[illegible]	2 BOILER-AIR HEATERS
E	3½	67	125	4770	[illegible]	1 BOILER-AIR HEATER
F	12	[illegible]	190	19420	RATED	L.P TURBINE BLEED
G	8	[illegible]	160	7220	RATED	[illegible]
H	10	[illegible]	171	12200	RATED	[illegible]
J	4	35	416	13070	MAXIMUM	I P BLEED TO EXH. MN.
K	6	35	130	11000	RATED	EXH - 1 MN. FD. PUMP
L	8	35	106	14230	[illegible]	EXH TO DFT
M	5	35	128	7220	RATED	EXH TO DISTL. PLANT
N	4	35	103	4309	STAND-BY	[illegible]
P	5	35	130	7297	ASTERN	[illegible]
R	3	35	92.2	2000	[illegible]	[illegible]
S	3	35	92.2	2000	[illegible]	[illegible]
T	1½	35	67.2	300	RATED	STM. TO H.W. HEATER

@ PSIG EXCEPT AS NOTED

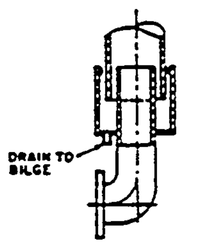
NOTES

1. ALL PIPING, VALVES AND FITTINGS ARE TO MEET THE REQUIREMENTS OF THE U.S.C.G. AND ABS.
2. ALL PIPE SIZES SPECIFIED ARE NOMINAL WITH IPS OUTSIDE DIAMETER.
3. PIPING ARRANGEMENTS SHALL BE DESIGNED WITH DUE REGARD FOR THERMAL EXPANSION AND ALLOWABLE LOADS ON PUMPS AND OTHER EQUIPMENT.
4. PIPING IS TO BE BENT TO A RADIUS OF 3 DIAMETERS.
5. THE L.P. TURBINE BLEED STEAM SWING CHECK VALVE IS TO BE OPERABLE FROM THE FLAT AND SHALL BE FITTED WITH AN INDICATOR.
6. THE GATE VALVE AT THE H.P. TURBINE I.P. BLEED SHALL BE ARRANGED TO PERMIT OPERATION FROM THE TURBINE OPERATING PLATFORM.



SKETCH "B"

SCHEMATIC OF MISC. RELIEF VALVES TO ATMOS



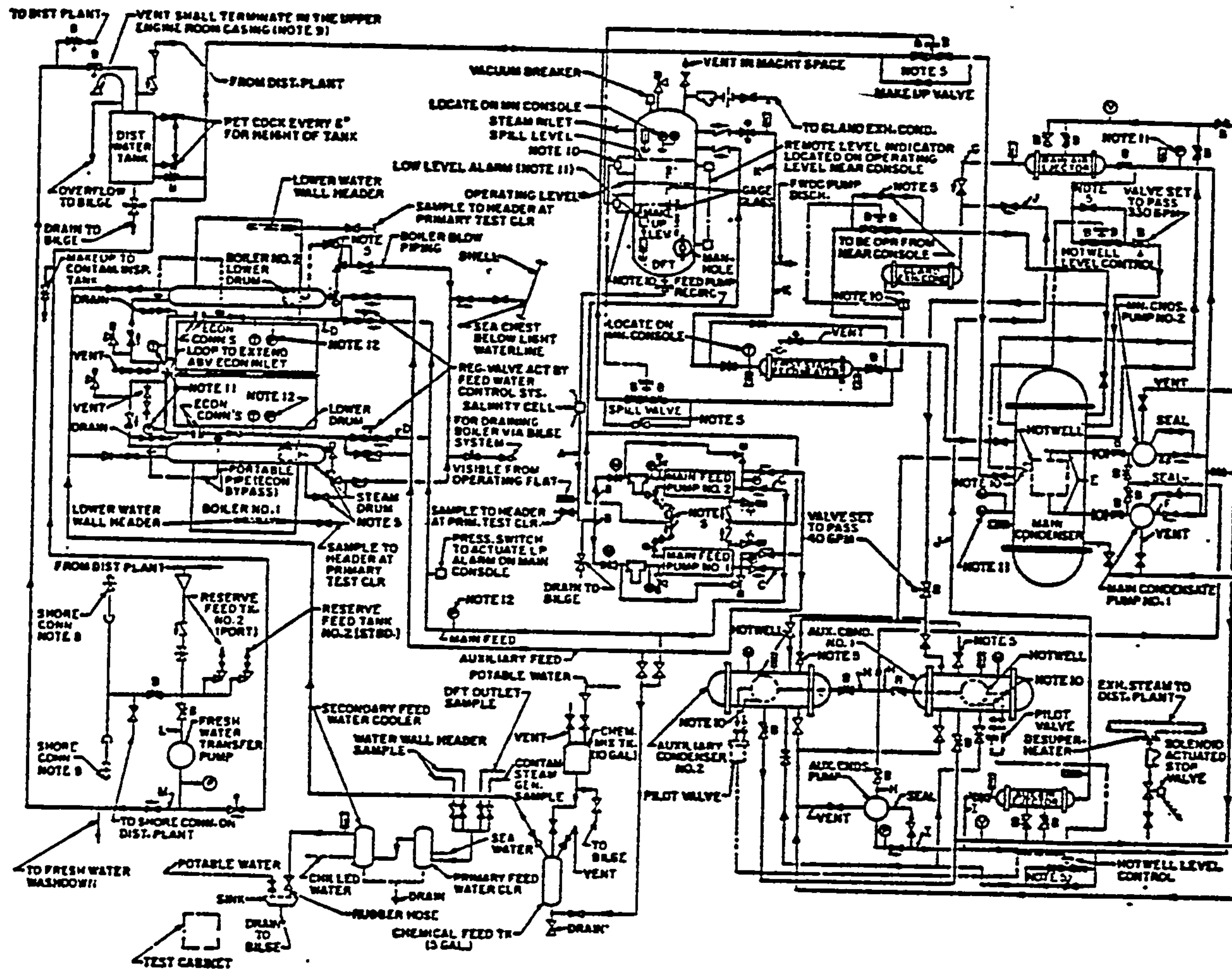
SKETCH "A"

SLIP JOINTS FOR SAFETY VALVE ESCAPE PIPING

Diagram for auxiliary exhaust, intermediate- and low-pressure bleed steam, and escape piping

FIGURE "D"

PIPING SYSTEMS



FLOWS AND VELOCITIES				
SYMBOL	[illegible]	[illegible]	[illegible]	SERVICE
A	8	450	2.80	MAIN FEED PUMP COMBINED SUCTION
B	6	450	4.99	MAIN FEED PUMP SUCTION
C	5	450	8.67	MAIN FEED PUMP DISCHARGE
D	4	225	6.98	FEED TO EACH BOILER
E	8	320	2.05	MAIN CONDENSATE PUMP SUCTION
F	4	320	8.04	MAIN CONDENSATE PUMP DISCHARGE
G	5	365	5.84	MAIN CONDENSATE
H	2½	45	3.00	SSTG CONDENSATE PUMP SUCTION
I	2	45	4.29	SSTG CONDENSATE PUMP DISCHARGE
J	2	45	4.29	SSTG CONDENSATE
K	5	475	6.80	CONDENSATE TO DFT
L	5	250	4.00	F.W. TRANSFER PUMP SUCTION
M	3	250	10.00	F.W. TRANSFER PUMP DISCHARGE

NOTES

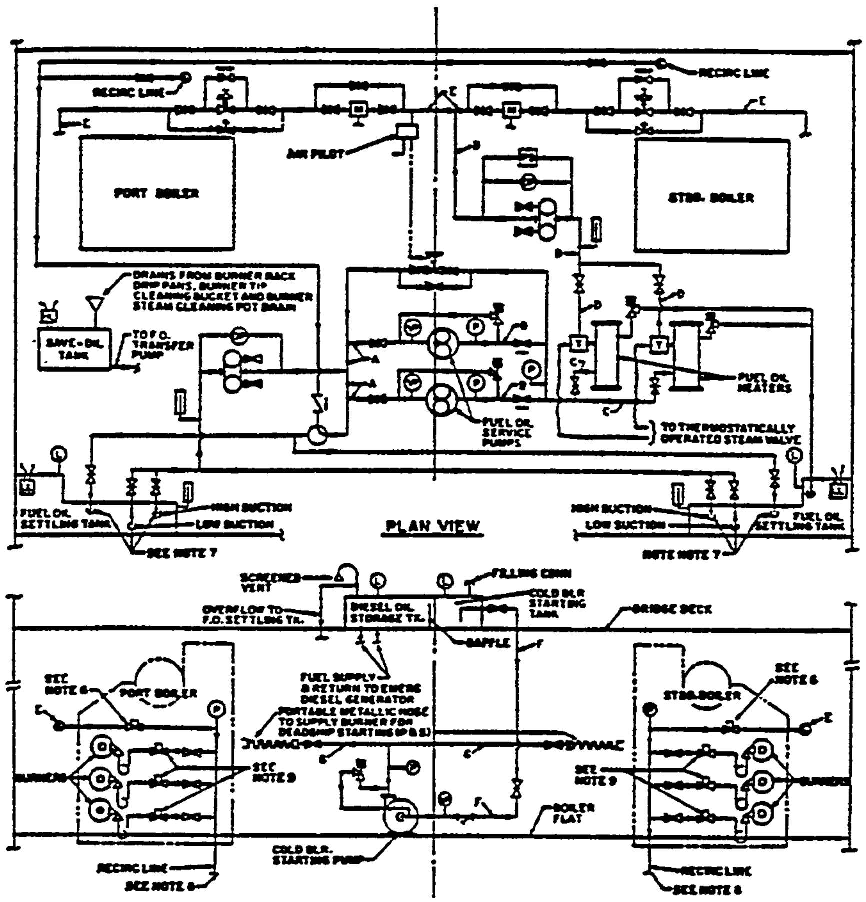
1. ALL PIPING, VALVES AND FITTINGS ARE TO MEET THE REQUIREMENTS OF THE USCG AND ABS.
2. ALL PIPE SIZES SPECIFIED ARE NOMINAL WITH IPS OUTSIDE DIAMETERS
3. PIPING IS TO BE BENT TO A RADIUS OF 5 DIAMETERS.
4. ALL JOINTS SUBJECT TO CONDENSER VACUUM ARE TO BE GENERALLY FLANGED OR BRAZED. WHERE SCREWED JOINTS ARE USED, THESE JOINTS ARE TO BE TINNED OR HEAVILY DOPED
5. VALVES REFERRING TO THIS NOTE SHALL BE LOCATED ON OR OPERATED FROM THE MACHINERY FLAT.
6. THE MOTOR OPERATED VALVE AT THE MAIN FEED PUMP SUCTION IS CONTROLLED FROM THE MAIN CONSOLE.
7. STOP VALVES SUBJECT TO VACUUM SHALL BE INSTALLED WITH THE VACUUM UNDER THE VALVE SEAT.
8. EACH DECK FILLING CONNECTION SHALL BE FITTED WITH HOSE CONNECTIONS AND PROVIDED WITH LOCK CAP AND CHAIN. EACH CONNECTION SHALL BE MARKED WITH AN ENGRAVED LABEL PLATE INDICATING THE SERVICE.
9. VENT PIPE TERMINALS SHALL BE FITTED WITH DOUBLE SCREENS WHICH SHALL BE REMOVABLE FOR CLEANING. THE INNER SCREEN SHALL HAVE 1/32" SQUARE OPENINGS. THE OUTER SCREEN SHALL BE FITTED 1/2" FROM THE INNER SCREEN AND SHALL BE OF STAINLESS STEEL WIRE WITH 1/4" SQUARE OPENINGS
10. CONTROL VALVE SENSING LINES SHALL BE AS SHORT AS POSSIBLE.
11. LOCATE ON MAIN CONSOLE.
12. LOCATE GAGE TO BE READ AT COMBUSTION CONTROL CONSOLE.

PUMP TABLE				
QTY	SERVICE	TYPE	CAPACITY GPM	TOTAL HD. PSI
2	MAIN CONDENSATE	VERT.-CENT. MOTOR DRIVEN	320	112.5
1	SSTG CONDENSATE	VERT.-CENT. MOTOR DRIVEN	45	112.5
2	MAIN FEED	HORIZ.-CENT. TURBINE DRIVEN	450	1100
1	F.W. TRANSFER	HORIZ.-CENT. MOTOR DRIVEN	250	100

LEGEND OF SYMBOLS
GATE VALVE
STOP VALVE
BUTTERFLY VALVE
DIAPHRAGM CONTROL VALVE
STOP CHECK VALVE
STOP VALVE (LOCKED CLOSED)
GATE VALVE (MOTOR OPER.)
HOSE VALVE
RELIEF VALVE
[illegible]
SALINITY CELL
THERMOSTAT
MULTIPLE ORIFICE
THERMOMETER
PRESSURE GAGE
VACUUM GAGE
VACUUM/PRESSURE GAGE
DIAL THERMOMETER-REMOTE
NEEDLE VALVE
LIFT CHECK VALVE
GATE VALVE (LOCKED CLOSED)
GATE VALVE (LOCKED OPEN)
ANGLE STOP VALVE
"Y" STRAINER
STOP VALVE (LOCKED OPEN)
STRAINER
BUTTERFLY VALVE (LKD. OPEN)
STOP CK. VALVE (LOCKED SHUT)
ANGLE STOP VALVE (LKD OPEN)
BUTTERFLY VALVE (LKD. SHUT)
SWING CHECK VALVE
ORIFICE
FUNNEL

Diagram—feed, condensate, boiler blow, and boiler water sampling

FIGURE "E"



SECTION VIEW

SHOWING BURNER FUEL OIL AND
DIESEL OIL COLD BOILER START PIPING

LEGEND OF SYMBOLS	
	GATE VALVE
	GLOBE STOP VALVE
	ANGLE STOP VALVE
	GLOBE STOP CHECK VALVE
	SWING CHECK VALVE
	HOSE GLOBE VALVE
	MICRO VALVE
	SOLENOID VALVE
	MINIMUM F.O. PRESSURE VALVE
	CONTROL VALVE
	PRESSURE REGULATING VALVE
	ANGLE RELIEF VALVE
	PLUG COCK VALVE - 2 WAY - 3 PORT
	STRAINER "Y" TYPE
	DUPLEX STRAINER
	SCREEN COVERED FUNNEL
	THERMOMETER
	PRESSURE GAGE
	VACUUM-PRESSURE GAGE
	DUPLEX PRESSURE GAGE
	TANK LEVEL GAGE
	HIGH LEVEL ALARM
	LOW LEVEL ALARM
	PRESSURE SWITCH
	THERMOSTAT
	OIL FLOW TRANSMITTER & METER, SPRING LOADED, PNEUMATICALLY OPERATED

FLOW DATA					
CODE	SIZE	CONDITION	FLOW G P M	SERVICE	VELOCITY F P S
A	4"	PUMP RATING	32	FUEL OIL SERVICE PUMP SUCTION	0.81
B	3"	PUMP RATING	32	FUEL OIL SERVICE PUMP DISCHARGE	1.36
C	3"	ABS POWER RATING	27	FUEL OIL HEATER INLET 100°F	1.22
D	2"	ABS POWER RATING	27	FUEL OIL HEATER OUTLET 230°F	2.73
E	1½"	ABS POWER RATING	13.5	FUEL OIL HEADER	2.20
F	[illegible]	PUMP RATING	2.0	COLD BOILER START PUMP SUCTION	1.40
G	[illegible]	PUMP RATING	2.0	COLD BOILER START PUMP DISCHARGE	2.74

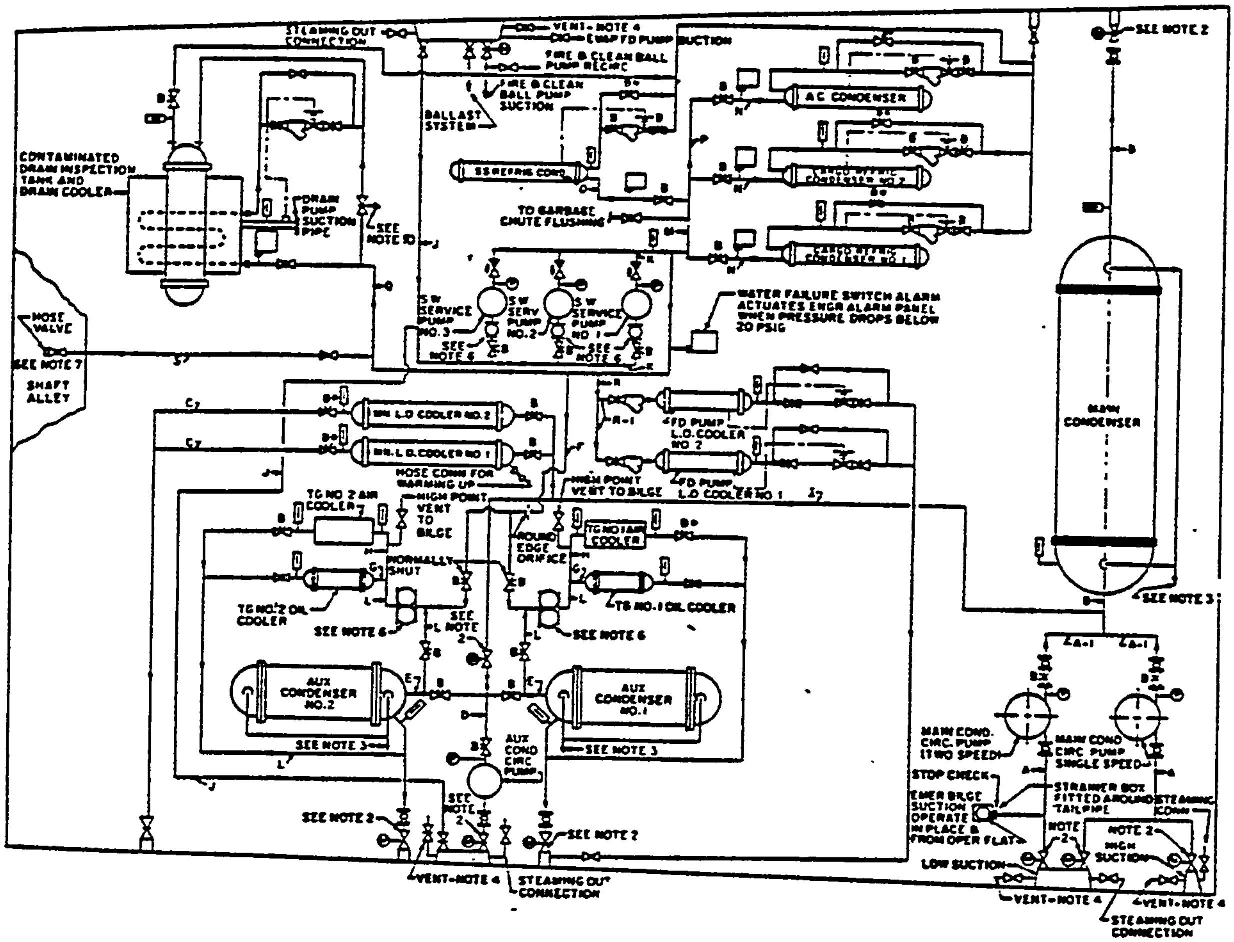
PUMP TABLE				
QTY.	NAME	TYPE	CAP G P M	DISCH HEAD
2	FUEL OIL SERVICE TWO SPEED	ROTARY MOTOR DRIVEN	16/32	350
1	COLD BOILER START	ROTARY MOTOR DRIVEN	2	150

NOTES

1. ALL PIPING, VALVES AND FITTINGS ARE TO MEET THE REQUIREMENTS OF THE U.S. COAST GUARD AND ABS.
2. ALL PIPE SIZES SPECIFIED ARE NOMINAL WITH IPS OUTSIDE DIAMETERS.
3. COAMINGS, DRIP PANS, ETC. SHALL BE FITTED UNDER FUEL OIL SERVICE PUMPS, HEATERS, ETC. WHERE NECESSARY TO PREVENT OIL DRAINAGE TO BILGE.
4. ALL FUEL OIL PIPING TO BE INSTALLED REMOTELY AS POSSIBLE FROM HIGH TEMPERATURE STEAM LINES.
5. FUEL OIL SERVICE PUMPS SHALL BE CONTROLLED FROM THE AUXILIARY BOARD, ALSO THE PUMPS SHALL HAVE PROVISIONS OUTSIDE THE MACHINERY SPACE FOR EMERGENCY SHUT DOWN
6. THE MAIN SOLENOID VALVE IS TO CLOSE IN EVENT OF LOSS OF POWER TO THE FORCED DRAFT BLOWER, LOW WATER OR TOTAL FLAME FAILURE WITHIN THE BOILER. A MANUAL TRIP SHALL BE PROVIDED ON THE VALVE
7. HIGH SUCTION PIPE SHALL TERMINATE 18" ABOVE TANK BOTTOM, LOW SUCTION PIPES SHALL TERMINATE BELOW THE LEVEL OF THE BOTTOM OF THE TANK IN A DRAIN WELL.
8. FUEL OIL RECIRCULATING LINE IS TO ENTER NEAR TOP OF FUEL OIL SETTLING TANK AND TERMINATE NEAR THE BOTTOM OF TANK IN A "U" BEND.
9. THE BURNER SOLENOID VALVE IS TO CLOSE IN EVENT OF BURNER FLAME FAILURE. A MANUAL TRIP SHALL BE PROVIDED ON THE VALVE.

Diagram of fuel-oil service system

FIGURE "F"



FLOWS AND VELOCITIES					
SYM	SIZE IN	FLOW GALS/MIN	VELOCITY FT/SEC	OPERATING CONDITION	SERVICE
A	28	17720	9.22	MAXIMUM PUMPED	MAIN S W CIRC. PUMP SUCTION
A-1	26	17720	10.7	MAXIMUM PUMPED	MAIN S W CIRC. PUMP DISCHARGE
B	34	33100	10.4	MAIN COND RATING	MAIN CONDENSER CIRC. WATER OVERBOARD
C	6	685	6.92	L.O COOLER RATING	MAIN L.O. COOLER S W.
D	8	1850	9.73	PUMP RATING	AUX. COND CIRC. PUMP
E	10	1375	5.96	AUX. COND	AUX. CONDENSER S W
F	3	80	2.90	L O & AIR CLR RATING	TG L.O & AIR COOLER S.W.
G	2	30	2.51	L.O COOLER RATING	TG L.O. COOLER S W.
H	2½	50	2.82	AIR COOLER RATING	TG AIR COOLER S.W.
I	12	2125	5.76	—	MN S W CIRC P TO AUX COND & MN L.O CLR THRU X CONN
J	10	1500	5.87	3-SERVICE PUMP RATING	COMBINED S W SERVICE PUMP SUCTION
K	5	500	7.25	1-SERVICE PUMP RATING	S W SERVICE PUMP SUCTION AND DISCHARGE
L	3½	80	2.26	L O & AIR CLR RATING	TG L.O & AIR COOLER S W
M	6	1835	18.49	—	SUPPLY TO REFRIG. EQUIP.
N	3½	300	8.42	CONDENSER RATING	CARGO REFRIG COND. S W.
O	2½	95	5.32	CONDENSER RATING	SS REFRIG. CONDENSER S W
P	3½	340	9.55	CONDENSER RATING	AC CONDENSER S.W.
Q	4	190	4.22	RATING	CONTAM INSPECTION TANK COOL COIL & ATMOS COND
R	1	10	2.91	2 COOLERS	FD PUMP L.O. COOLER
R-1	¾	5	2.42	1 COOLER	FD PUMP L.O. COOLER
S	1	25	7.29	RATING	EMER SHAFT BEARING COOLING VIA HOSE

PUMP TABLE				
QTY	SERVICE	TYPE	CAP GPM	TOTAL HD FT
2	MN.CIRC	VERT CENT SINGLE STG	17800	18
1	AUX.CIRC	VERT CENT SINGLE STG	1850	22
3	SEAWTR SERVICE	VERT CENT SINGLE STG	500	86

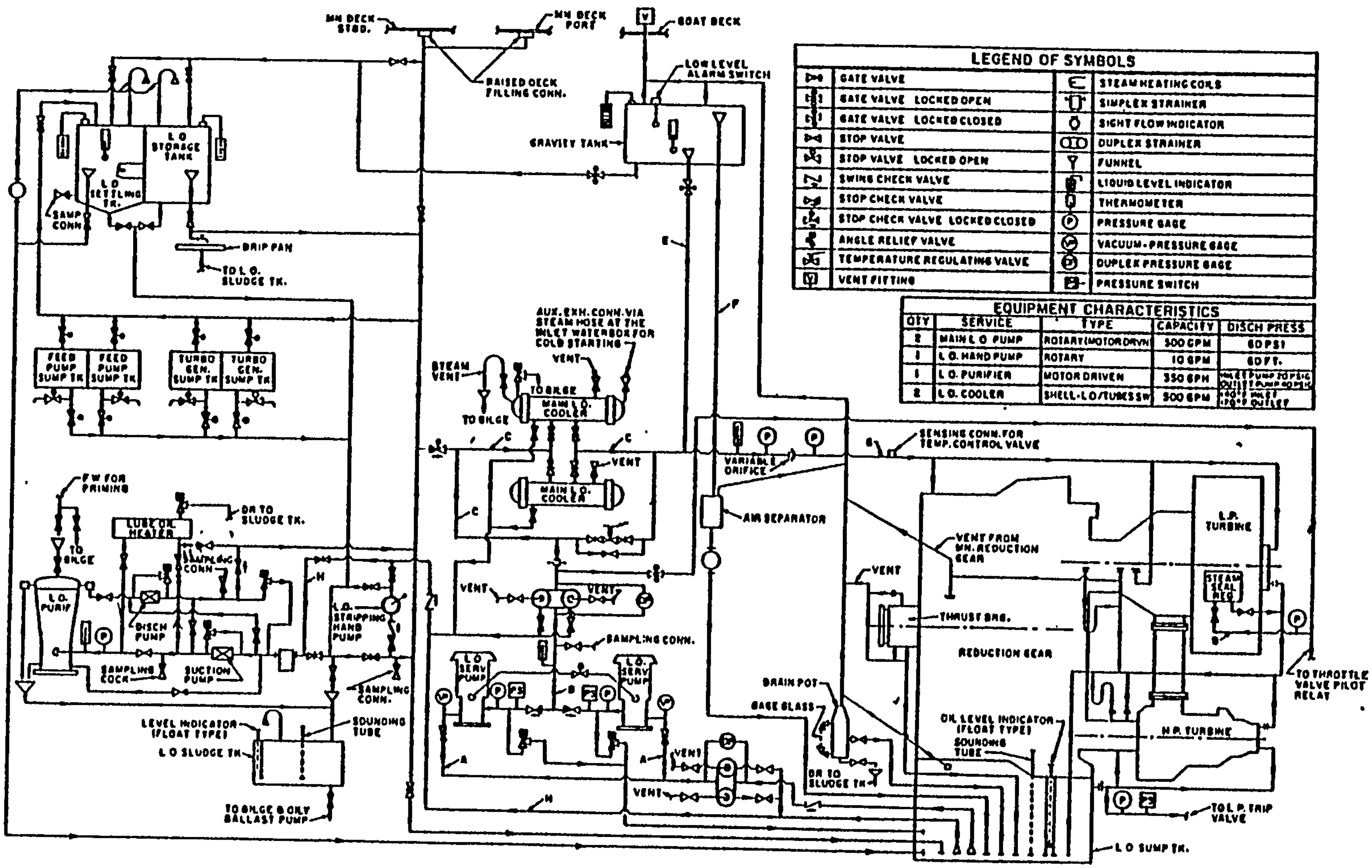
LEGEND OF SYMBOLS	
	GATE VALVE
	STOP VALVE
	SWING CHECK VALVE
	BUTTERFLY VALVE
	TEMP REGULATING VALVE
	STOP CHECK VALVE
	RUBBER EXPANSION JOINT
	PRESSURE GAGE
	THERMOMETER
	SWITCH, WATER FAILURE
	STRAINER "Y" TYPE
	STRAINER, DUPLEX
	SEA CHEST SUCTION
	SEA CHEST DISCHARGE
	GATE VALVE - MOTOR OPERATED
	BUTTERFLY VALVE FITTED WITH NOTCHED PLATE FOR THROTTLING
	STRAINER, SIMPLEX
	NEEDLE VALVE
	ANGLE RELIEF VALVE

NOTES

1. ALL PIPING, VALVES AND FITTINGS ARE TO MEET THE REQUIREMENTS OF THE USCG AND ABS
2. ALL MOTOR OPERATED VALVES ARE TO HAVE CONTROLS ADJACENT TO UNIT AND ALSO AT THE ENGINE ROOM OPERATING CONSOLE.
3. CONDENSER HEAD VENTS SHALL SLOPE UP TO THE SEA CHEST VENT.
4. THE SEA CHEST VENT SHALL TERMINATE ON THE WEATHER DECK
5. SWING CHECK VALVES SHALL BE INSTALLED IN THE FORE AND AFT DIRECTION
6. STRAINERS ARE TO HAVE PERFORATIONS SMALLER THAN SEA WATER PASSAGES IN EQUIPMENT BEING SERVED UNLESS THAT EQUIPMENT IS SERVED BY ADDITIONAL STRAINERS
7. ONE HOSE VALVE LOCATED MIDWAY IN SHAFT ALLEY, FOR EMERGENCY COOLING OF LINE SHAFT BEARINGS, SHALL BE PROVIDED WITH A HOSE OF SUFFICIENT LENGTH TO REACH THE MOST REMOTE BEARING.
8. PIPING IS TO BE BENT TO A RADIUS OF 3 DIAMETERS
9. ALL SEA CHEST CONNECTIONS SHALL BE INSTALLED ON THE SIDE OF THE SEA CHEST EXCEPT VENTS WHICH ARE MOUNTED ON THE TOP OF THE CHEST
10. NEEDLE VALVE MUST BE OPENED WHEN THE GENERAL SERVICE PUMP IS IN OPERATION AND REGULATED SUCH THAT THE TEMPERATURE OF THE CONTAMINATED DRAIN PUMP SUCTION DOES NOT EXCEED 180°F.

Diagram of seawater systems in machinery space

FIGURE "G"



LEGEND OF SYMBOLS			
(symbol)	GATE VALVE	(symbol)	STEAM HEATING COILS
(symbol)	GATE VALVE LOCKED OPEN	(symbol)	SIMPLEX STRAINER
(symbol)	GATE VALVE LOCKED CLOSED	(symbol)	SIGHT FLOW INDICATOR
(symbol)	STOP VALVE	(symbol)	DUPLEX STRAINER
(symbol)	STOP VALVE LOCKED OPEN	(symbol)	FUNNEL
(symbol)	SWING CHECK VALVE	(symbol)	LIQUID LEVEL INDICATOR
(symbol)	STOP CHECK VALVE	(symbol)	THERMOMETER
(symbol)	STOP CHECK VALVE LOCKED CLOSED	(symbol)	PRESSURE GAGE
(symbol)	ANGLE RELIEF VALVE	(symbol)	VACUUM-PRESSURE GAGE
(symbol)	TEMPERATURE REGULATING VALVE	(symbol)	DUPLEX PRESSURE GAGE
(symbol)	VENT FITTING	(symbol)	PRESSURE SWITCH

EQUIPMENT CHARACTERISTICS

QTY	SERVICE	TYPE	CAPACITY	DISCH PRESS
2	MAIN L O PUMP	ROTARY(MOTOR DRVN)	500 GPM	60 PSI
1	L O. HAND PUMP	ROTARY	10 GPM	60 FT.
1	L O. PURIFIER	MOTOR DRIVEN	350 GPH	INLET PUMP 20 PSIG OUTLET PUMP 60 PSIG
2	L O. COOLER	SHELL-L O/TUBES SW	500 GPM	140°F INLET 120°F OUTLET

FLOW DATA

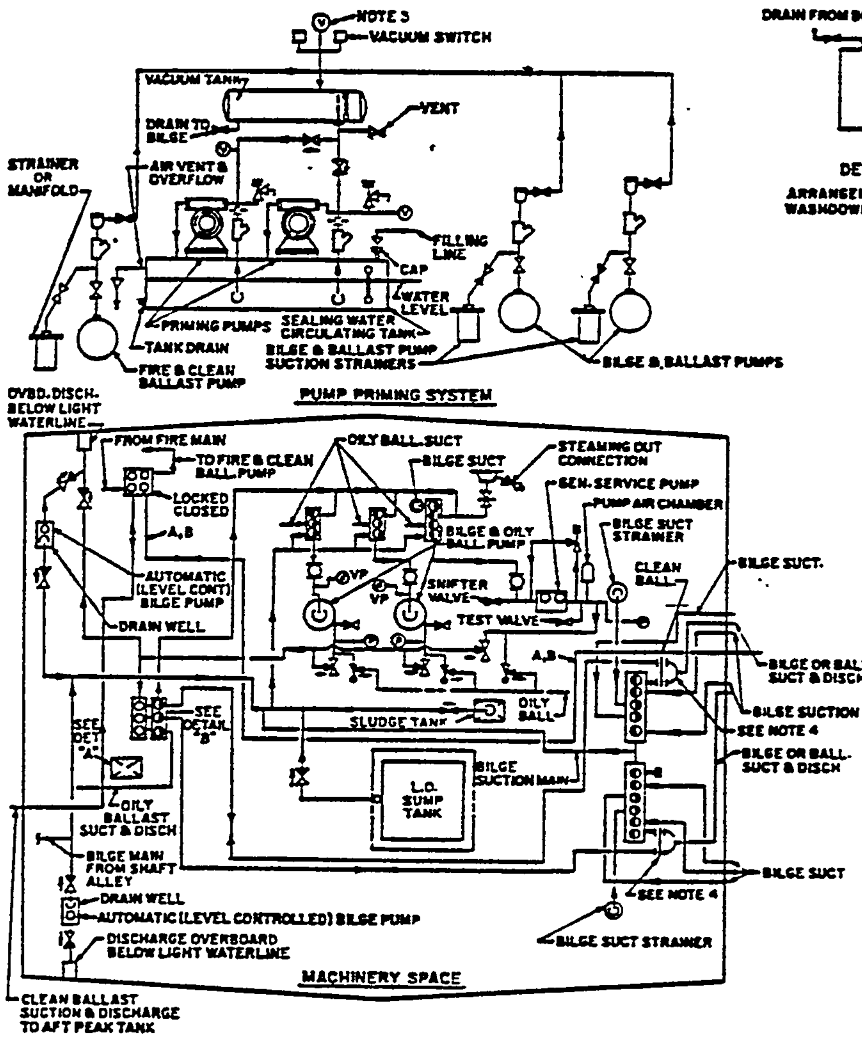
CODE	SIZE	FLOW GPM	SERVICE	VELOCITY FPM.
A	6"	500	L O SERVICE PUMP SUCTION	3 20
B	6"	500	L O SERVICE PUMP DISCHARGE	3 94.
C	6"	500	L O HDR. TO & FROM COOLER	5.54
D	3/4"	2 5	CONT OIL TO STEAM SEAL REG.	1.50
E	6"	340 1	L O FROM GRAVITY TK TO BRGS.	3 88
F	6"	151.9	GRAVITY TK OVERFLOW TO SUMP	1.68
G	6"	340 1	MN. HDR. TO BEARINGS	3 86
H	2"	13.40	PURIFIER PUMP IN PARALLEL WITH TRANSFER PUMP	1.27

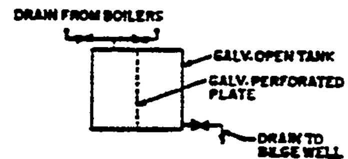
NOTES

1. ALL PIPING, VALVES AND FITTINGS ARE TO MEET THE REQUIREMENTS OF THE U S COAST GUARD AND ABS.
2. ALL PIPE SIZES SPECIFIED ARE NOMINAL WITH IPS OUTSIDE DIAMETERS.
3. ALL DRAINS TO SUMP SHALL TERMINATE BELOW WORKING LEVEL AND AS REMOTE FROM PUMP SUCTIONS AS PRACTICABLE.
4. KEEP ALL OIL PIPING AT SAFE DISTANCE FROM HOT SURFACES AND IN NO CASE CLOSER THAN 18" WHERE THE TEMPERATURE EXCEEDS 650°F IN ORDER TO MINIMIZE FIRE HAZARDS.
5. THE MAIN TURBINE SUPPLY PIPING SHALL BE FITTED WITH A VARIABLE ORIFICE TO OBTAIN 10-15 PSIG PRESSURE AT THE REDUCTION GEAR HEADER INLET.
6. SPECIAL CARE MUST BE TAKEN IN DESIGN AND INSTALLATION SO THAT THE ENTIRE LUBE OIL SYSTEM WILL BE ACCESSIBLE FOR THOROUGH CLEANING.
7. ALL BEARING DRAINS MUST HAVE AN EASY FLOW PATH WITHOUT POCKETS, HORIZONTAL RUNS, OR SHARP BENDS.

Diagram of lubricating-oil system

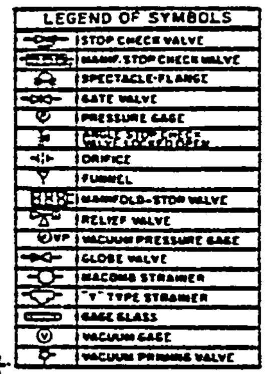
FIGURE "H"



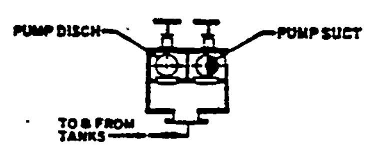


DETAIL "A"

ARRANGEMENT OF BOILER WASHDOWN TANK (60 GAL.)



FLOWS AND VELOCITIES						
SYM	OPERATING CONDITION	SIZE INCH	FLOW, GPM	VEL, FT/SEC	PRESS DROP PSI	REMARKS
A	BALLASTING FORE PEAK TANK	6	700	7.76	10.	FIRE BILGE AND CLEAN BALLAST PUMP AT RATED CAPACITY
B	DEBALLASTING FORE PEAK TANK	6	700	7.76	10.	FIRE BILGE AND CLEAN BALLAST AT MAX. PUMP SUCTION AVAILABLE



DETAIL "B"

TYPICAL SECTION THROUGH BALLAST MANIFOLD

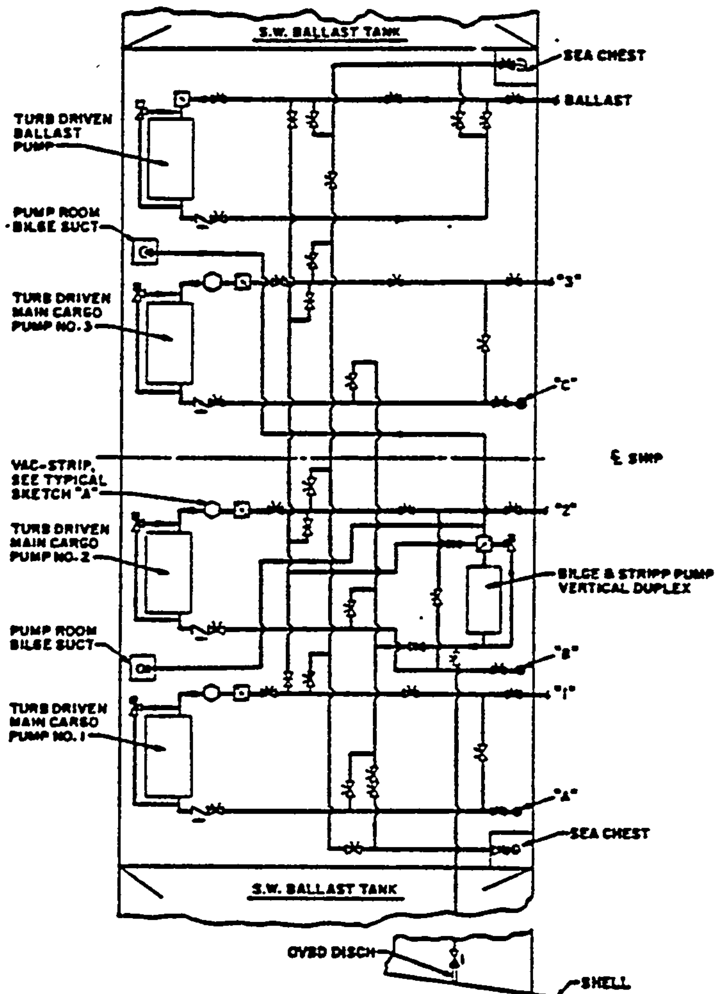
PUMP TABLE				
NAME	NO	TYPE	CAPACITY	TOTAL HEAD
BILGE & BALL.	2	VERTICAL CENTRIF.	700 GPM	40 PSIG
GEN SERVICE	1	VERTICAL DUPLEX DOUBLE ACTING	700 GPM	125 PSIG
BILGE PUMP	2	VERTICAL CENTRIF.	30 GPM	30 PSIG
PRIMING PUMP	2	HORIZ. ROTARY	30 CFM	15" Hg VAC.

NOTES

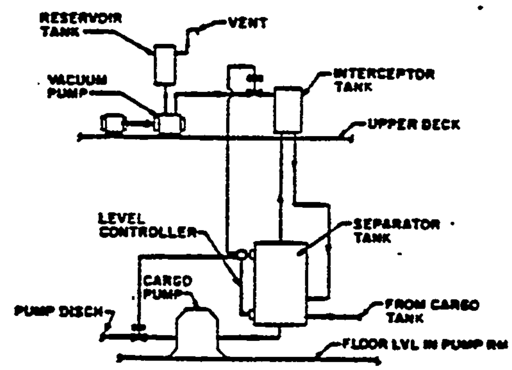
1. ALL PIPING, VALVES AND FITTINGS ARE TO MEET THE REQUIREMENTS OF USCG AND ABS.
2. ALL PIPE SIZES SPECIFIED ARE NOMINAL, WITH IPS OUTSIDE DIAMETERS.
3. VACUUM SWITCH STARTS ONE PUMP WHEN THE VACUUM DROPS TO 15" Hg. STARTS A SECOND PUMP WHEN IT REACHES 12" Hg. AND STOPS THE PUMPS WHEN THE VACUUM REACHES 20" Hg. THE SWITCH CONTAINS A MANUAL OPERATING FEATURE.
4. SPECTACLE FLANGE TO BE POSITIONED TO ALLOW ONLY THE BILGE SUCTION TO BE USED WHEN CARRYING DRY CARGO IN THE DEEP TANKS FORWARD.

Diagram of bilge, clean ballast, and priming system in machinery space

FIGURE 1



PLAN VIEW - PUMP ROOM



SKETCH "A"

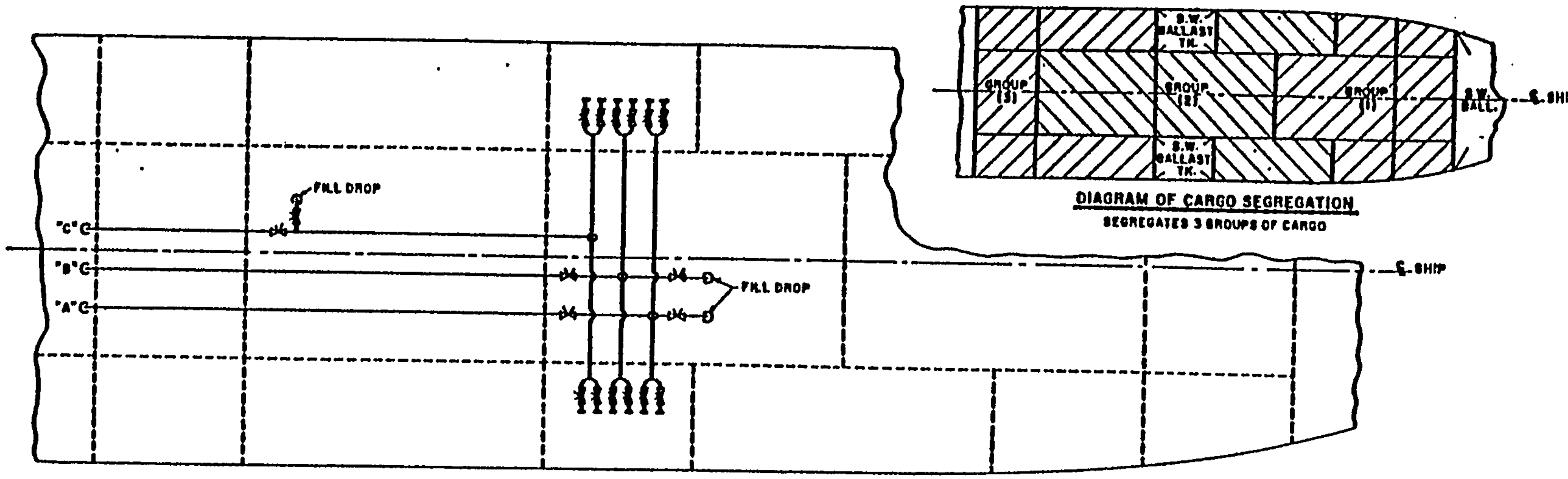
TYPICAL DIAGRAMMATIC ARR OF STRIPPING SYSTEM FOR CARGO OIL PUMPS

PUMP TABLE				
QTY.	SERVICE	TYPE	RATED CAP GPM	TOTAL HEAD PSI
3	CARGO OIL	HORZ CENT	40000	220
1	BALLAST	HORZ CENT	40000	80
1	BILGE	VERT DUPLEX	1940	200

LIST OF SYMBOLS	
	GATE VALVE
	STOP CHECK VALVE
	BUTTERFLY VALVE (HYD. OPERATED)
	SWING CHECK VALVE
	ANGLE RELIEF VALVE
	REGULATING VALVE
	BELLMOUTH
	STRAINER
	VACUUM STRIPPER

Diagram of cargo-oil piping in pump room

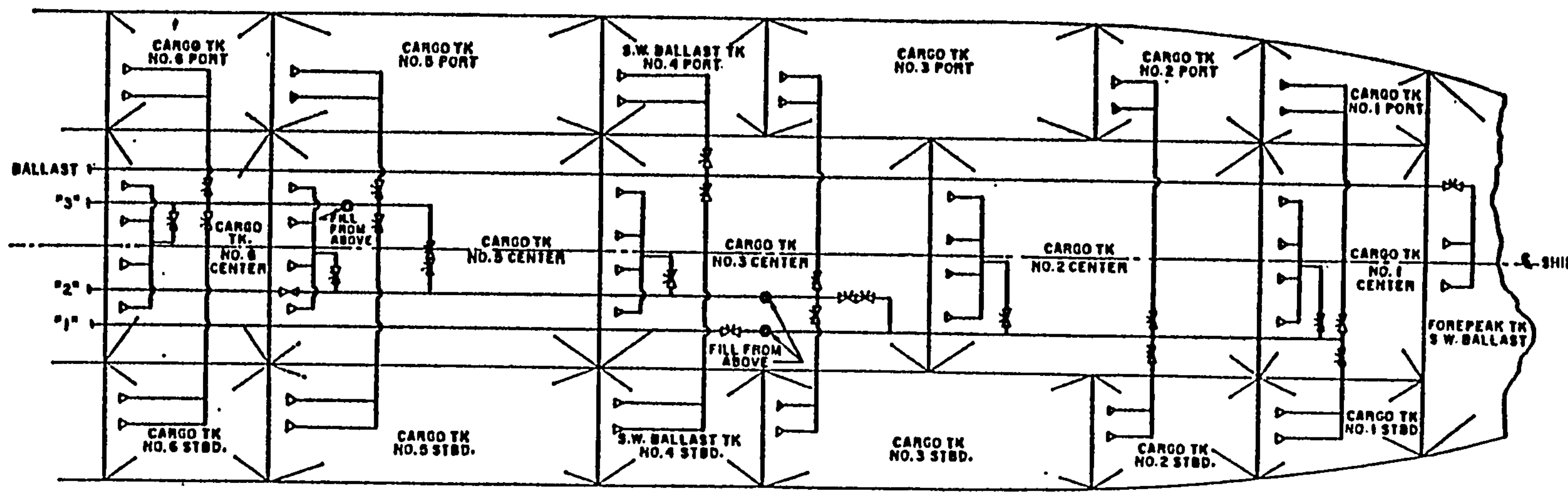
FIGURE J



PLAN VIEW - UPPER DECK

FWD

Fig. 19 Diagram of cargo-oil piping on deck

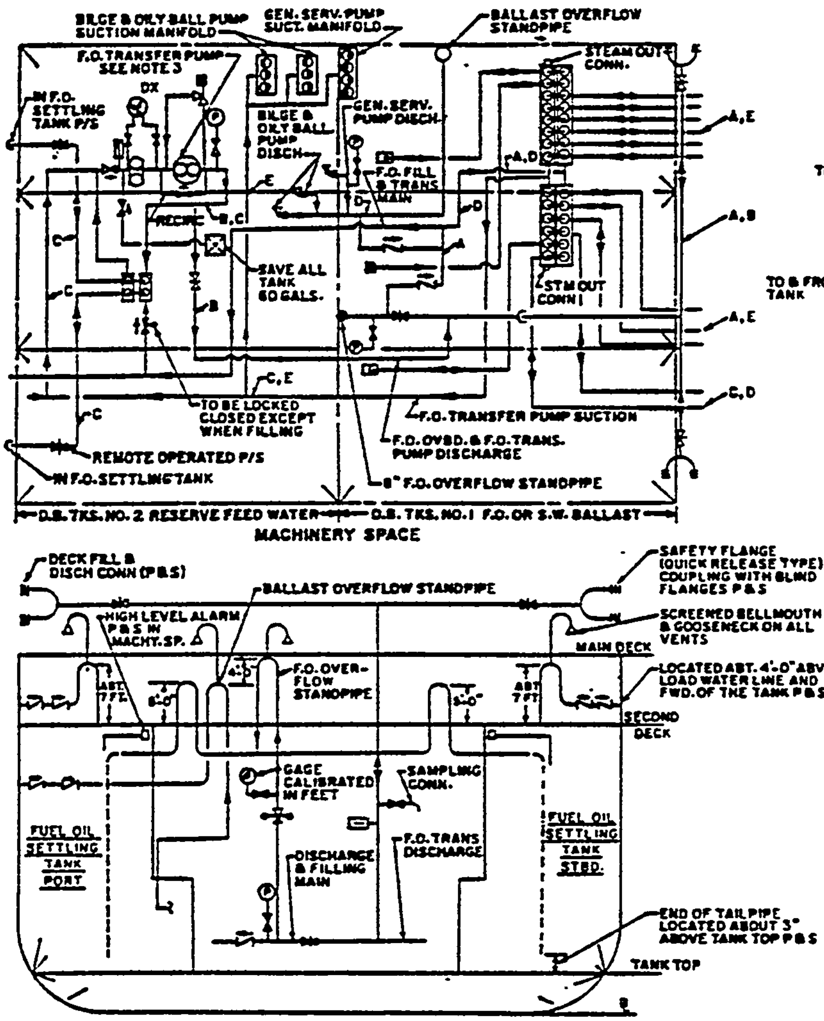


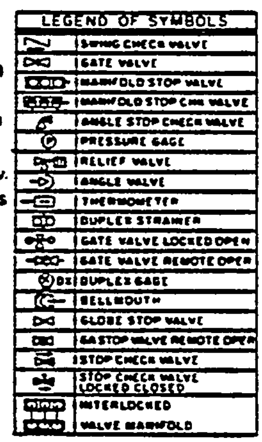
PLAN VIEW TANKS

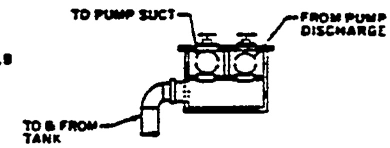
FWD

Diagram of cargo-oil piping in tanks

FIGURE K







SKETCH "A"

TYPICAL SECTION THROUGH FUEL OIL TRANSFER AND BALLAST MANIFOLD.

SECTION-OVERFLOW PIPING IN MACHINERY SPACE

FLOW DATA[1]						
SYMBOL	SERVICE	SIZE	VELOCITY FT/SEC	FLOW	PRESS DROP	REMARKS
A	F.O. FILL	[illegible]	[illegible]	2200 BBLS/HR[2]	50 PSI	TO NO. 1 D.B. TK.
B	F.O. DISCH	[illegible]	[illegible]	300 GPM	30 PSI	TO FILL CONN ON DK
C	F.O. TRANS	[illegible]	[illegible]	300 GPM	30 PSI	FROM NO. 1 D.B. TK.
D	BALLASTING	[illegible]	[illegible]	700 GPM	25 PSI	TO NO. 1 DEEP TK.
E	DEBALLASTING	[illegible]	[illegible]	700 GPM	30 PSI	FROM NO. 1 D.B. TK.

NOTES

1. FLOW DATA BASED ON FUEL OIL VISCOSITY 3000 SSU
2. TOTAL FLOW OF 2200 BBLS/HR TO ALL TANKS INCLUDES FLOW OF 360 BBLS/HR TO NO. 1 DOUBLE BOTTOM TANK
3. THE FUEL OIL TRANSFER PUMP IS A VERTICAL TWO-SPEED PUMP WHICH DEVELOPS A TOTAL HEAD OF 100 PSI AT 300 GPM.

Diagram of fuel-oil filling, transfer, oily ballast, and overflows in machinery space

FIGURE L

Table D

Equipment/Component	Standard No.	Standard Group	Remarks
Main Steam Boiler			
Main Turbine (Set)			
Main Condenser			
Reduction Gear {Set)			
Main Lube Oil Pump			
Forced Draft Fan			
Main Feed Pump			
Fuel Oil Service Pump			
Main Circulating Pump			
Main Condensate Pump			
Fuel Oil Heater			
Lube Oil Cooler			
First-Stage Feed Heater			
Gland Exhauster			
Drain Cooler			
De-aerating Feed Heater			
3rd Stage Heater			
4th Stage Heater			
Automation System			

APPENDIX C.1.2

Format for Group 1 Standards

Title: Standard Total* Propulsion Plant

No. : TP-DG-etc.

1. Definition: This standard is a document which contains in a standard format, the technical information necessary to define and describe a ________ to ________ SHP medium-speed diesel engine propulsion plant. Standards are available for each of the following propulsion plants:

   8,000- 10,000 SHP, Medium-Speed Diesel

   12,000 - 14,000 SHP, Medium-Speed Diesel

   24,000 - 28,000 SHP, Medium-Speed Diesel

Standardized Parameters (for Total Diesel Plant)

Medium Speed Diesel Engine Rating:

_____ BHP @ _____ ERPM (Maximum Continuous Rating)

_____ BHP @ _____ ERPM for Hrs operation (Maximum Intermittent Rating)

BMEP _____ psi

Maximum Fuel Rate #/BHP/HR

Sea Water Temperature ____ °F

Outside Air Temperature ____ °F

Outside Air Relative Humidity ___ %

Machinery Space Air Temperature ____ °F

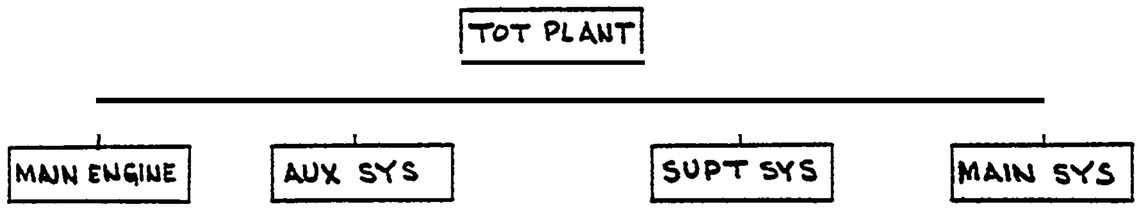
Machinery Space Air Relative Humidity ____%

Exhaust System maximum pressure drop ____ inches H_2O

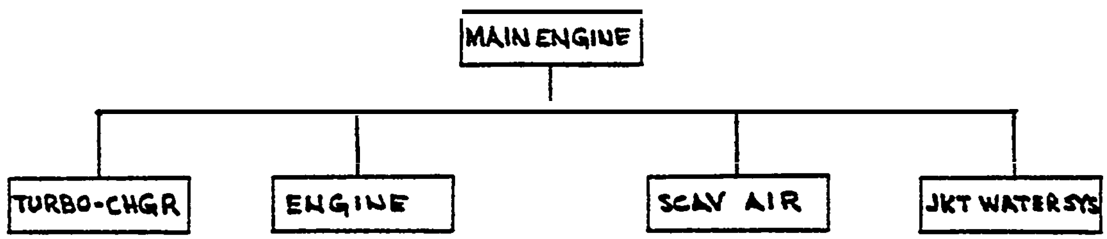
inlet Air System maximum pressure drop ____ Inches H_2O

2. System Block Diagrams

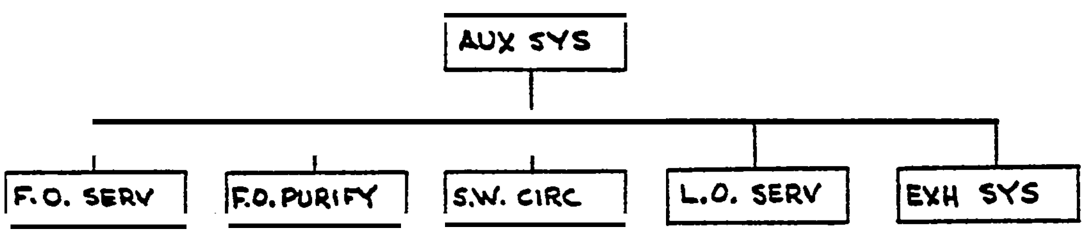
The total plant will consist of the following **elements:**



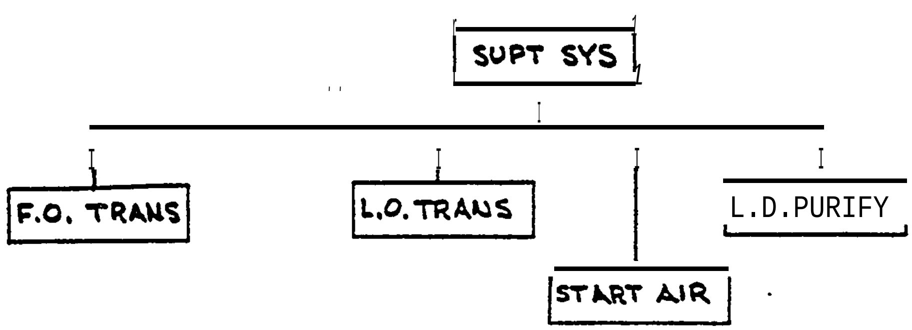
2.1 The main engine and piping systems contain the following sub-systems:



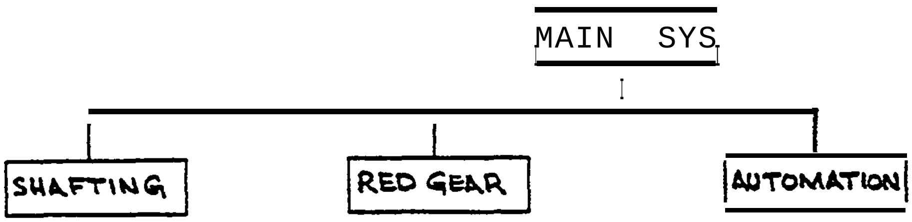
2.2 The auxiliary systems contain the following sub-systems which are required for operation of the propulsion systems:



2.3 The supporting systems are those systems which are required for the accomplishment of the ship's mission and which interface with and affect the propulsion system.



2.4 The main systems which are required for propulsion plants are contained in the following:



3. Propulsion Plant Arrangement

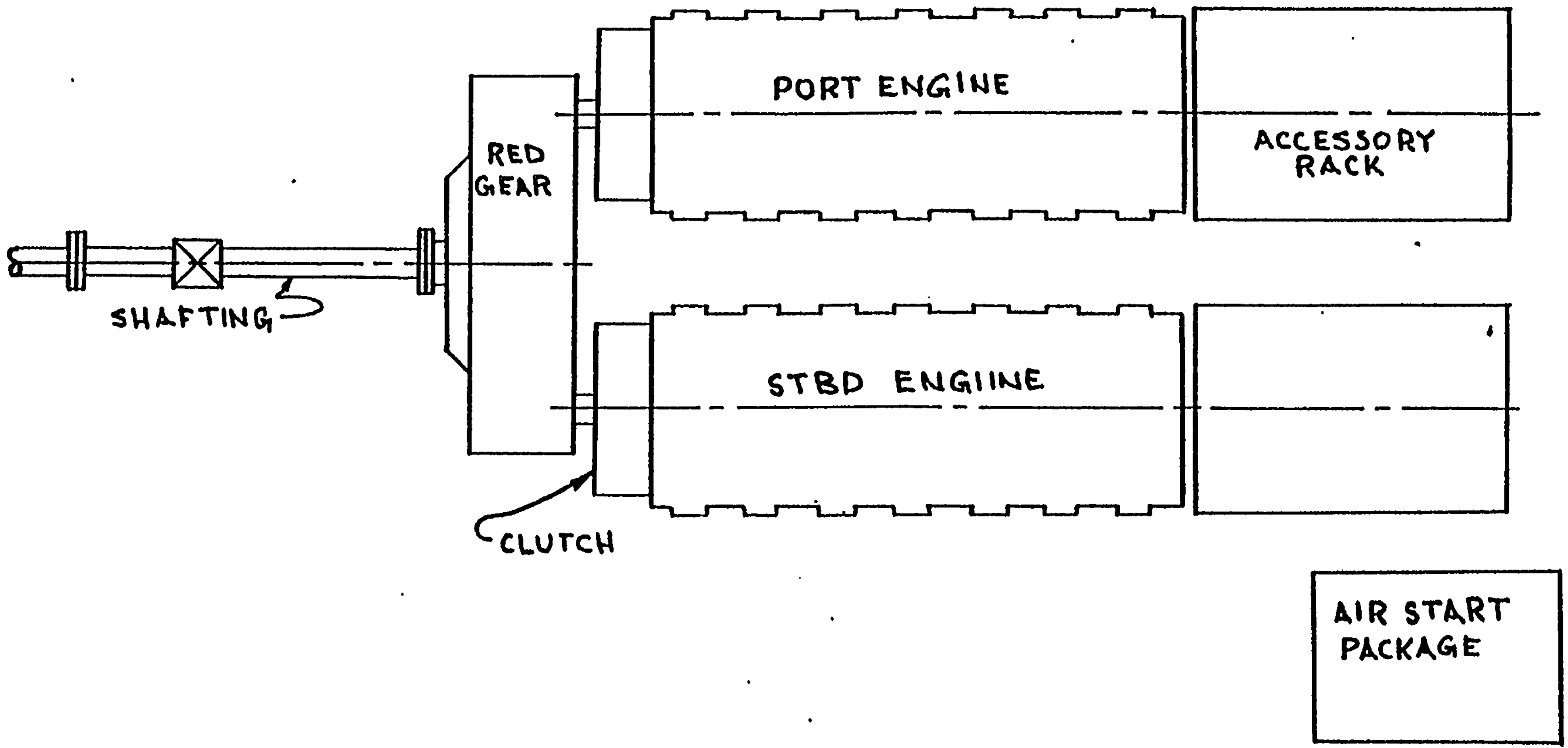
The schematic arrangement of the main propulsion machinery will be as shown in Figure M.

4. Systems Diagrams

For the systems Iisted below, systems diagrams are included to provide guidelines for developing the actual systems for a vessel. Typically, each diagram Consists of a one-line piping schematic showing the subject piping system with symbolic representations of all relevant equipment, valves, fittings, flanges and instrumentation.

Diameters of piping and sizes of fittings and valves are indicated on the diagrams. Also included in this group are tables which list materials and specifications. the maximum allowable fluid velocities, and pump tables which show pump types, sizes and capacities.

Under each of the systems shown below, those parameters are included which will be needed for the preparation of *systems* diagrams as defined above.



DIESEL SCHEMATIC ARRGT

FIG. M

4.1 Main Engine

- Air intake system (Must be integrated with specific ship arrangement)
- Jacket Cooling Water System (Figure O)

4.2 Auxiliary Systems

- Fuel Oil Service System (Figure Q)
- Fuel Oil Purifying System
- Salt Water Circulating System (Figure O)
- Lube Oil Service System (Figure R)
- Exhaust System (Figure N)

4.3 Support Systems

- Fuel Oil Transfer System
- Lube Oil Transfer System
- Lube Oil Purifying
- Starting Air System (Figure P)

4.4 Main Systems

Included here are those systems for major equipment allied with the main propulsion plant and requried for the operations of the ship.

4.4.1 Shafting System

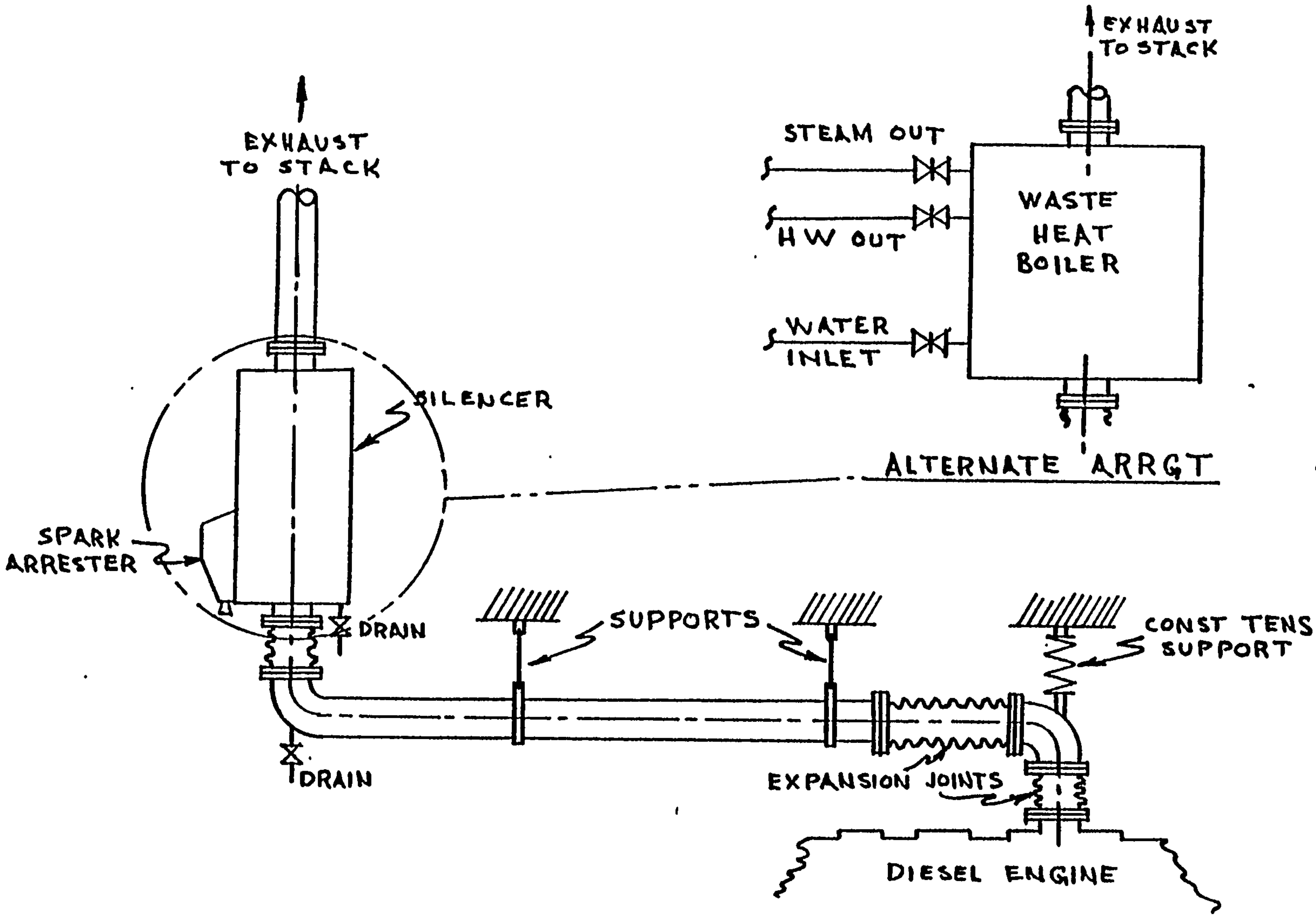
Dimensional Diagram

Material Requirements

Bearing Type and Locations

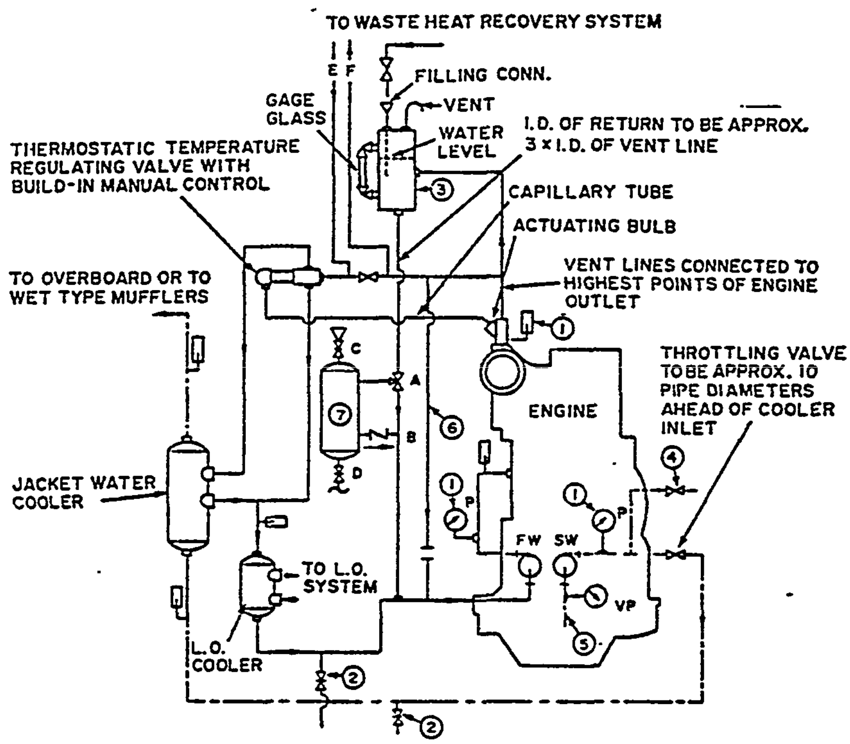
Thrust Bearing Type and Location (May be included in Reduction Gear)

Weight and Force Diagram



DIESEL EXHAUST DIAGRAM

FIG. N



NOTES

1 TO BE INSTALLED ON ENGINE GAGE BOARD.

2 DRAINS TO BE INSTALLED IN LOWEST POINT IN JACKET WATER AND SEA WATER SYSTEMS. USE GATE VALVES.

3 EXPANSION TANK SHALL BE LOCATED IN THE SAME COMPARTMENT WITH ENGINE.

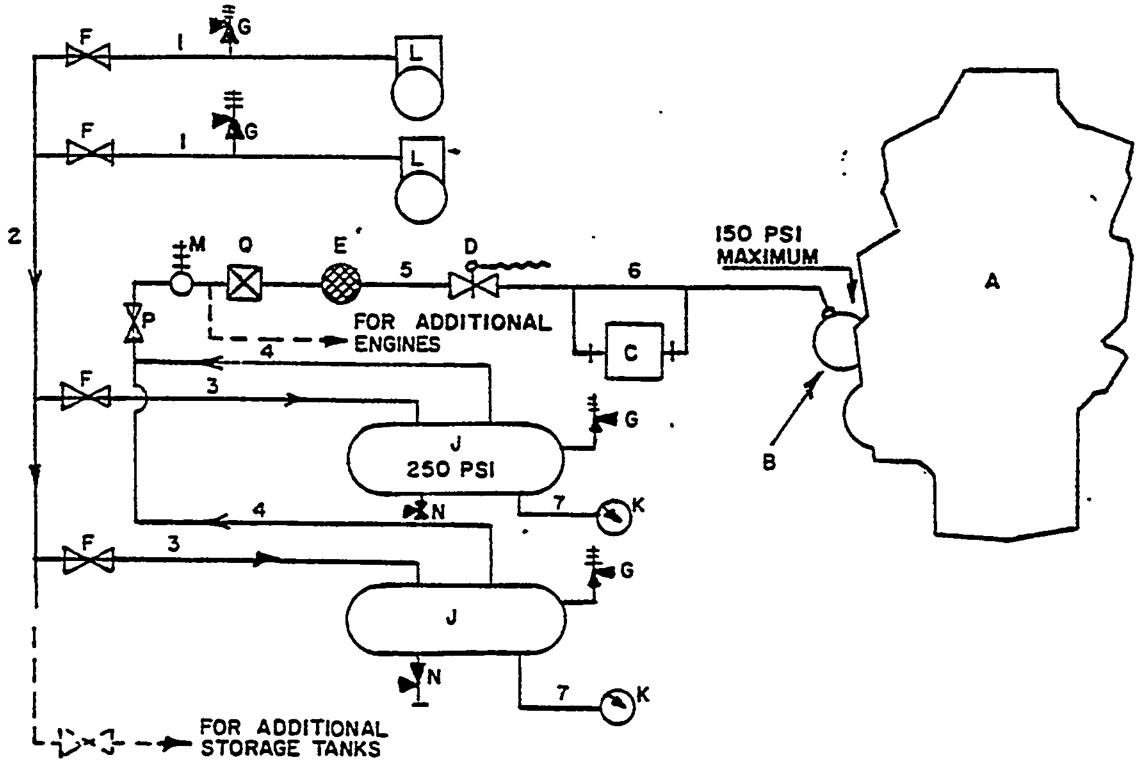
4 SEA WATER SUPPLY FOR GENERATOR AIR COOLERS WITH THROTTLING VALVE TO BE PROVIDED ONLY WHEN REQUIRED.

5 SEA WATER PUMP SUCTION PIPING TO BE OF SUFFICIENT SIZE, AND ARRANGED TO LIMIT VACUUM AT PUMP SUCTION TO 6" HG AT RATED RPM.

6 JACKET WATER BY-PASS ACROSS BOTH COOLERS SHALL BE PROVIDED WHEN REQUIRED TO OBTAIN SPECIFIED OPERATING TEMPERATURES

7 TANK FOR INITIATING AND MAINTAINING JACKET WATER TREATMENT. CAPACITY TO BE 1 1/2 GALLONS FOR EACH 100 GALLONS IN ENGINE SYSTEM. TO USE, CLOSE VALVE "A" TO TANK AND OPEN VALVES "C" & "D" TO DRAIN TANK. CLOSE "D", FILL TANK WITH CORRECT AMOUNT OF SOLUTION. CLOSE "C", OPEN "A". CIRCULATION OF JACKET WATER WILL FEED SOLUTION INTO SYSTEM. TEST SAMPLE FOR CORRECT CONCENTRATION.

Fig. ○ —Diagram of typical cooling water system



NOTE: Quick opening valve "D" to be opened only for starting engine.

Letter	Name
A	Engine
B	Air Motor-on Eng.
C	Lubricator-on Eng.
D	Starting Valve
E	Strainer
F	Shut-off Valve-3/4 IPS
G	Relief Valve
J	Air Tank
K	Pressure Gage
L	Air Compressor
M	Pressure Reducing Valve
N	Drain Cock
P	Shut-off Valve 1-1/2 IPS
Q	Conn. to Eng. Sys. 1-1/2 IPS

Pipe No.	Pipe Size IPS
1	3/4
2	3/4
3	3/4
4	1-1/2
5	1-1/2
6	1-1/2
7	1/4

FIG. P: STARTING AIR SYSTEM DIAGRAM

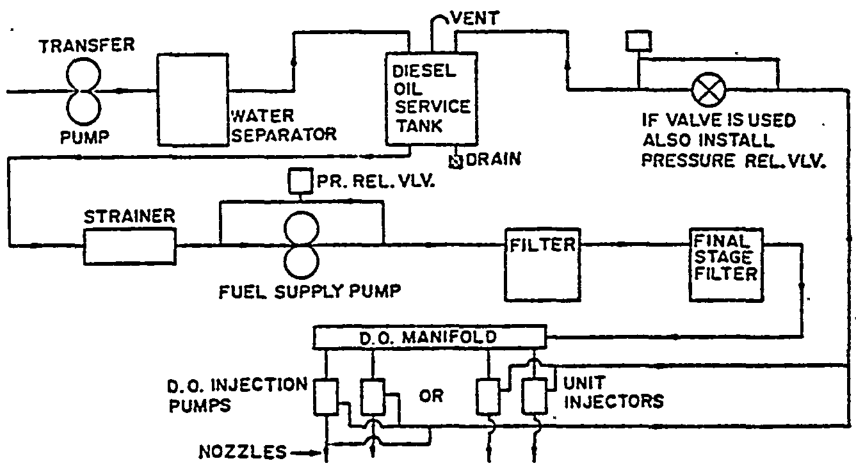


Fig. Q —Diagram of a typical fuel system

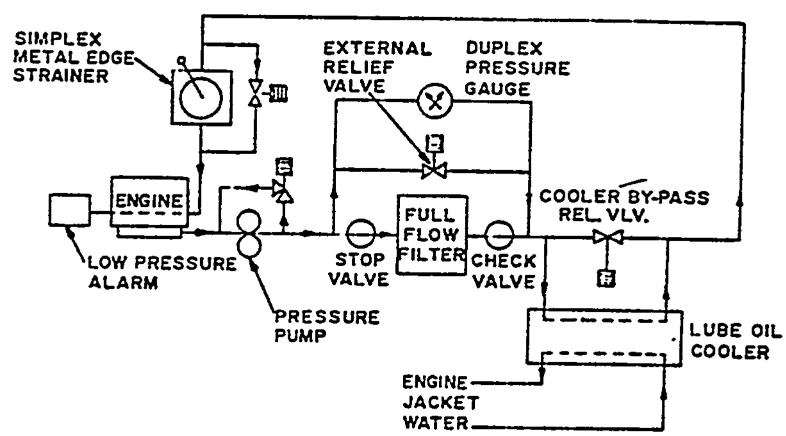


Fig. R – Lube Oil Service System Diagram

4.4.2 Reduction Gear

Type

Load Factors

K-Factors

Gear Diagram

4.4.3 Automation System

Type and Degree

System Block Diagram

One-Line Diagram

Service Requirements

5. Standards for Equipment/Components

A listing of available standards for equipment and/or Components which may be used in the composition of this standard propulsion plant is included in Table E.

Equipment/Component	Standard Group	Quantity	Remarks
Main Diesel Engine			
Automation System			
Reduction Gear			
Starting Air Compressor			
Exhaust Gas Boiler			
Fresh Water Cooler			
Lube Oil Cooler			
Diesel Accessory Rack			
Fuel Oil Service System			
Fuel Oil Purifier			
Lube Oil Purifier			
Lube Oil Service Pump			
Reduction Gear L.O. Booster Pump			

Table E - Equipment/Component Standards

APPENDIX C-2

Equipment/System Module Standard - Group II

Definition:

This standard is a document which. contains the-technical data and in formation required to define and describe a complete sub-system or group of like equipment which is mounted together on a common base. This module has defined and located interfaces and limiting size dimensions and weights, which make the moduels (but not the components) interchangeable from all sources. The equipment which is included in the module may *or* may not be standard.

This standard affords the benefits of standard equipment without limitations being imposed on equipment vendors.

Standard Format:

In order to illustrate this standard, an example of a fuel oil service system module format follows:

Example: First Page

Title: Description of system or Equipment utilization.

Identification: Alpha-numerical standard identification with encoded type and size.

Application: General data with reference to the scope of this standard as to sizes, temperatures, pressures, and medium characteristics.

Next Page(s)

Performance Data Matrix: Chart showing capacity, pressure, temperature and viscosity characteristics for each module.

Next Page(s)

Outline Drawings(s): Drawings plus dimension chart giving interface sizes and locations, mounting information and overall size and weight limitations for each module.

Next Page(s)

Design Characteristics: Contains listing of components required with technical data requirements of each component. Includes block and/or schematic diagram of system.

Approvals: Includes regulatory agency approvals of module designs.

Equipment Suppliers: Includes the following lists with approvals noted if applicable.

1. Module manufacturers
2. Individual component manufacturers

Other Documents: Reference to other standars and specifications which are applicable.

APPENDIX C-3

Equipment Envelopes Standard - Group III

Definition:

This standard is a document which contains the technical data and information in standard format which is required to define and describe the interface characteristics of equipment so that separate vendors equipment of like characteristics may be used interchangeably. The envelope standard concept limits overall size and weight of the envelope and determines interface and installation requirement sizes and locations for that particular equipment independent of vendor source. These data will be such that all eligible vendors will be able to meet the requirements of the standard by using a sub-base and adding interconnections between the equipment and the interface locations.

Standard Format:

An example of a format which may be utilized for this equipment envelope standard follows. More than one format may be needed to satisfy the requirements of the many different types of equipment which fall into this category. The example depicts that for a Condenser Circulating Pump.

Example: First Page

Title: Description of equipment utilization. ,

Identification: Alpha-numerical standard identification with encoded type and size.

Application: General data with reference to the scope of this standard as to sizes, temperatures, pressures, and medium characteristics.

Next Page(s)

Performance Data Matrix: Chart showing capacity, pressure, temperature, and viscosity characteristics for each envelope size.

Pump Selection Charts: Capacity, Total Dynamic Head and Horsepower and model number of the vendor's available pumps for this service.

Next Page(s)

Pump Characteristic curves: for each model listed containing curves of Capacity versus Head, Horsepower, and Suction pressure

Next Page(s)

Outline drawings: with key dimensions of each model. Included are all interface dimensions, overall sizes, weights and bolting information for each module size.

Approvals: Includes regulatory agency approvals of module designs.

Equipment Suppliers: Includes the following lists with approvals noted if applicable.

1. Envelope manufacturers
2. Individual component manufacturers

Other Documents: Reference to other standards and specifications which are applicable.

APPENDIX C.4.1

Data Standard   Group IV

Definition: This standard is a document which contains technical information in standard format which pertains to vendor equipment required for propulsion machinery. The technical information included is that which is necessary for ship designers to perform propulsion plant designs at any level (preliminary design, contract design or detail design) without requiring additional information from vendors such as contract drawing and specification approval.

Standard Format: One standard format will be utilized for all like equipment. One example of a format which applies to pumps follows:

EXAMPLE: First Page

Title: Describes pump service and type of pump

Performance Chart: A matrix of comparative performance data of the available pumps by vendor which satisfy the service requirements. Information included in the chart is Standard identification number, Vendor Identity, Type of casing, capacity range, pressure range, required services, driving means, and a reference page number within the standard which contains the remaining data.

Referenced Page

Vendor Identity, Address; and phone numbers:

Also included are contacts for standard data maintenance.

Standard Identification Number:

Specifications and Other Standards: which these pumps comply with

Next Page(s)

Pump Selection Charts:

Capacity, Total Dynamic Head and Horsepower and model number of the vendor's available pumps for this service,

Next Page(s)

Pump Characteristic curves: for each model listed containing curves of Capacity versus Head, Horsepower, and Suction pressure

Next Page(s)

Outline drawings: with key dimensions of each model. Included are all interface dimensions, overall sizes, weights and bolting information.

Next Page

Operating Data: Includes such items as temperature and pressure limitations of casings, bearings and seals

Materials: This contains a listing of the major components materials utilized in each model as required for compatibility with the intended utilization.

Approvals: Regulatory Agency approvals, if applicable to the particular hardware.

Next Page

Design Features and Specifications: This section contains general information regarding the design of the pump components which might be required by a ship designer. Included are items such as Casing description, Impeller data, maintenance features of bearings and seals, lubrication and alignment requirements, etc., and any special features which are desired.

S.W. CIRCULATING PUMPS

Centrifugal Split Casing Types

Horizontal and Vertical

MANUFACTURER	CAPACITY GPM	PRESSURE FT H_2O	ELECTRIC LOAD	STANDARD NO.	PAGE NO.
Worthington	0-6000	0-300	1½-250 HP	TP-3C-W1	2
Weil	0-5000	0-400	1-300 HP	TP-3C-W2	15
Goulds	0-5500	0-550	1-350 HP	TP-3C-G	
Aurora	0-6000	0-350	1-250 HP	TP-3C-A	

Worthington Sales Company
270 Sheffield Street
Mountain side, New Jersey 07092

Tele. (201) 654-3300

Technical Contact: Mr. Kenneth C. Hill, Engineer
Marine & Government Department

Standard Identification No. TP-3C-WI

Applicable Standards:

pump Standard P-3C-WI-43 through P-3C-WI-57

Total Package Standard TP-2C-18 through TP-2C-36

Applicable Specifications:

Material specs ______________

Screw Threads ______________

types LR, ~~LLR~~, LRV

selection tables

TYPES LR-~~LLR~~ PUMPS, 3500 R.P.M.

G.P.M.	TOTAL HEAD FEET 75	100	125	150	175	200	250	300	350	400	450	500	550	600	650	700	750	800
50					1½ LLR 7 7½ HP	1½ LLR 7 7½ HP	1½ LLR 7 10 HP	1½ LLR 7 10 HP	1½ LLR 7 15 HP	1½ LLR 7 15 HP	1½ LLR 10 20 HP	1½ LLR 10 20 HP	1½ LLR 10 25 HP	1½ LLR 10 25 HP	1½ LLR 10 30 HP.	1½ LLR 10 30 HP.	1½ LLR 10 40 HP.	1½ LLR 10 40 HP.
100			1½ LLR 7 7½ HP	1½ LLR 7 7½ HP	1½ LLR 7 10 HP	1½ LLR 7 10 HP	1½ LLR 7 15 HP	1½ LLR 7 15 HP	1½ LLR 7 20 HP	2 LLR 9 20 HP	2 LLR 9 25 HP	2 LLR 9 25 HP	1½ LLR 10 30 HP	1½ LLR 10 40 HP	1½ LLR 10 40 HP.	1½ LLR 10 50 HP.	1½ LLR 10 50 HP	
150		1½ LLR 7 15 HP	1½ LLR 7 15 HP	1½ LLR 7 15 HP	1½ LLR 7 15 HP	1½ LLR 7 15 HP	1½ LLR 7 20 HP	1½ LLR 7 20 HP	2 LLR 9 25 HP	2½ LR 10 30 HP.	2 LLR 9 30 HP	2 LLR 9 40 HP	2 LLR 9 40 HP	1½ LLR 10 50 HP	1½ LLR 10 60 HP.	1½ LLR 10 60 HP.		
200				3 LR 9 20 HP	3 LR 9 20 HP.	2½ LR 10 20 HP	2½ LR 10 20 HP	2 LLR 9 25 HP	2½ LR 10 30 HP.	2½ LR 10 40 HP	2 LLR 9 40 HP.	2 LLR 9 40 HP	2 LLR 9 50 HP.	1½ LLR 10 60 HP.				
250		4 LR 10 20 HP	4 LR 10 25 HP	3 LR 9 20 HP	2½ LR 10 20 HP	2½ LR 10 20 HP	2½ LR 10 25 HP	2½ LR 10 30 HP	2½ LR 10 40 HP	2½ LR 10 40 HP	2 LLR 9 50 HP	2 LLR 9 50 HP.						
300		4 LR 10 20 HP	4 LR 10 25 HP	4 LR 10 25 HP	2½ LR 10 20 HP	2½ LR 10 20 HP	2½ LR 10 30 HP	2½ LR 10 30 HP	2½ LR 10 40 HP	2½ LR 10 50 HP	2 LLR 9 50 HP							
350		4 LR 10 20 HP	4 LR 10 20 HP	2½ LR 10 25 HP	2½ LR 10 20 HP	2½ LR 10 25 HP	2½ LR 10 30 HP	2½ LR 10 40 HP	2½ LR 10 40 HP	2½ LR 10 50 HP	2 LLR 9 60 HP							
400		4 LR 10 20 HP	4 LR 10 20 HP	3 LR 9 25 HP	3 LR 9 25 HP	3 LR 9 30 HP	3 LR 9 40 HP	2½ LR 10 40 HP	2½ LR 10 50 HP	4 LR 11 75 HP.	4 LR 11 100 HP.							
500		4 LR 10 20 HP	4 LR 10 15 HP	3 LR 9 30 HP	3 LR 9 30 HP	3 LR 9 40 HP	3 LR 9 40 HP	3 LR 9 50 HP	4 LR 11 75 HP.	4 LR 11 75 HP	4 LR 11 100 HP.							
600	4 LR 10 20 HP	4 LR 10 25 HP	4 LR 10 30 HP	4 LR 10 40 HP	3 LR 9 40 HP	3 LR 9 40 HP.	3 LR 9 50 HP	3 LR 9 60 HP	4 LR 11 75 HP	4 LR 11 100 HP	4 LR 11 100 HP							
700	4 LR 10 25 HP	4 LR 11 25 HP	4 LR 11 30 HP	4 LR 10 30 HP	4 LR 10 50 HP	3 LR 9* 50 HP	3 LR 9* 60 HP	4 LR 11 75 HP	4 LR 11 100 HP	4 LR 11 100 HP								
800	4 LR 10 25 HP	4 LR 10 30 HP	4 LR 10 30 HP	4 LR 10 40 HP.	4 LR 10 50 HP	3 LR 9* 50 HP	3 LR 9* 60 HP	4 LR 11 75 HP	4 LR 11 100 HP.	4 LR 11 100 HP								
900	4 LR 10 25 HP	4 LR 10 30 HP	[illegible]	4 LR 10 50 HP	4 LR 10 50 HP	4 LR 11 60 HP	4 LR 11 75 HP	4 LR 11 100 HP	4 LR 11 100 HP	4 LR 11 125 HP								
1000	4 LR 11 25 HP	4 LR 10 40 HP	[illegible]	4 LR 10 50 HP	4 LR 11 50 HP	4 LR 11 75 HP	4 LR 11 100 HP	4 LR 11 100 HP	4 LR 11 125 HP	4 LR 11 125 HP								
1200		4 LR 10* 40 HP	4 LR 10* 50 HP	4 LR 10* 50 HP	4 LR 10* 75 HP	4 LR 11 100 HP	4 LR 11 100 HP	4 LR 11 125 HP	4 LR 11 150 HP									
1400			4 LR 10* 60 HP	4 LR 10* 125 HP	4 LR 11* 100 HP	4 LR 11* 100 HP	4 LR 11* 125 HP	4 LR 11* 150 HP										

types LR, ~~LLR~~, LRV

selection tables, cont'd.

..PES LR-LLR PUMPS, 1750-1150 R.P.M.

G.P.M.	TOTAL HEAD 20	30	40	50	60	70	80	90	100	120	140	160	180	200	225	250	275	300
20					1½ LLR 7 1 HP	1½ LLR 7 1 HP	1½ LLR 7 1½ HP	1½ LLR 7 1½ HP	1½ LLR 7 2 HP	1½ LLR 10 3 HP	1½ LLR 10 3 HP	1½ LLR 10 3 HP	1½ LLR 10 3 H.P.	1½ LLR 10 3 HP				
30				1½ LLR 7 1 HP	1½ LLR 7 1 HP	1½ LLR 7 1½ H.P.	1½ LLR 7 1½ HP	1½ LLR 7 2 HP	1½ LLR 7 2 HP	1½ LLR 10 3 HP	2 LLR 9 3 H.P.	1½ LLR 10 3 HP	1½ LLR 10 3 H.P.	1½ LLR 10 7½ H.P.				
40			1½ LLR 7 1 HP	1½ LLR 7 1 HP	1½ LLR 7 1½ HP	1½ LLR 7 1½ HP	1½ LLR 7 2 HP	1½ LLR 7 2 HP	1½ LLR 7 3 HP	1½ LLR 10 3 HP	1½ LLR 10 3 HP	1½ LLR 10 3 H.P.	1½ LLR 10 3 H.P.	1½ LLR 10 7½ H.P.				
50		1½ LLR 7 1 HP	1½ LLR 7 1 HP	1½ LLR 7 1½ HP	1½ LLR 7 1½ HP	1½ LLR 7 2 HP	1½ LLR 7 2 HP	1½ LLR 7 3 HP	1½ LLR 10 3 HP	1½ LLR 10 3 HP	1½ LLR 10 3 HP	1½ LLR 10 3 HP	1½ LLR 10 7½					
60		1½ LLR 7 1 HP	1½ LLR 7 1½ HP	2½ LR 10 1½ HP	1½ LLR 7 2 HP	1½ LLR 7 2 HP	1½ LLR 7 1 HP	1½ LLR 7 3 HP.	1½ LLR 10 3 HP	1½ LLR 10 3 H.P.	1½ LLR 10 3 HP	1½ LLR 10 7½ H.P.	1½ LLR 10 7½ HP					
80		1½ LLR 7 1½ HP	1½ LLR 7 2 HP	2½ LR 10 2 HP.	2½ LR 10 3 HP	2½ LR 10 3 HP	2½ LR 10 3 HP	2½ LR 10 5 HP	2½ LR 10 5 HP.	1½ LLR 10 7½ H.P.	1½ LLR 10 7½ H.P.	1½ LLR 10 7½ H.P.	2½ LR 13 10 H.P.	2½ LR 13 15 HP				
100		2½ LR 13 2 HP	2½ LR 10 3 HP	2½ LR 10 2 HP	2½ LR 10 3 HP	2½ LR 10 3 HP	2½ LR 10 5 HP	2½ LR 10 5 HP	2½ LR 10 5 HP	2½ LR 13 7½ HP	2½ LR 13 7½ H.P.	2½ LR 13 10 HP	2½ LR 13 10 HP	2½ LR 13 15 H.P.				
150		2½ LR 13 3 HP	2½ LR 10 3 HP	2½ LR 10 3 HP	2½ LR 10 3 HP	2½ LR 10 5 HP	2½ LR 10 5 HP	2½ LR 10 5 HP	2½ LR 10 7½ H.P.	2½ LR 13 7½ H.P.	2½ LR 13 10 HP	2½ LR 13 10 H.P.	2½ LR 13 15 H.P.					
200		2½ LR 13 3 HP	2½ LR 10 3 HP	2½ LR 10 5 HP	2½ LR 10 5 HP	2½ LR 10 5 HP	2½ LR 10 7½ H.P.	2½ LR 10 7½ HP	2½ LR 10 7½ HP	2½ LR 13 15 HP	2½ LR 13 15 HP	2½ LR 13 15 H.P.	2½ LR 13 15 H.P.					
250	4 LR 10 3 HP	3 LR 7 3 HP	3 LR 7 3 HP	3 LR 9 5 HP	3 LR 9 5 HP	3 LR 9 7½ HP	3 LR 9 7½ H.P.	2½ LR 10 10 HP	2½ LR 10 10 H.P.	2½ LR 13 15 HP	2½ LR 13 15 H.P.	2½ LR 13 15 H.P.	2½ LR 13 20 H.P.					
300	4 LR 10 3 HP	3 LR 7 3 HP	3 LR 7 5 HP	3 LR 9 5 HP	3 LR 9 7½ HP	3 LR 9 7½ HP	3 LR 9 7½ HP	2½ LR 10 10 H.P.	2½ LR 10 15 H.P.	2½ LR 13 15 HP	2½ LR 13 20 HP	2½ LR 13 20 H.P.	4 LR 14 25 H.P.					
350	4 LR 10 3 HP	4 LR 10 5 HP	3 LR 9 5 HP	3 LR 9 7½ HP	3 LR 9 7½ HP	3 LR 9 7½ HP	3 LR 9 10 HP	2½ LR 13 15 H.P.	2½ LR 13 15 H.P.	2½ LR 13 20 HP	2½ LR 13 20 HP	2½ LR 13 20 HP	4 LR 14 25 HP	4 LR 14 30 HP				
400	4 LR 10 3 HP	4 LR 10 5 HP	4 LR 13 7½ HP	3 LR 9 7½ HP	3 LR 9 7½ H.P.	3 LR 9 10 HP	3 LR 9 10 HP	4 LR 10 15 HP	2½ LR 13 20 H.P.	2½ LR 13 20 HP	3 LR 12 20 H.P.	4 LR 14 25 HP	4 LR 14 25 H.P.	4 LR 14 30 HP				
450	4 LR 10 3 HP	4 LR 13 5 HP	4 LR 13 7½ HP	3 LR 9 7½ HP	3 LR 9 10 HP	3 LR 9 10 HP	4 LR 13 15 HP	3 LR 12 15 HP	3 LR 12 15 HP	3 LR 12 20 HP	3 LR 12 20 H.P.	4 LR 14 25 H.P.	4 LR 14 30 HP	4 LR 14 30 HP				
500	4 LR 10 5 HP.	4 LR 10 5 HP	4 LR 10 7½ H.P.	4 LR 10 10 HP	4 LR 10 10 HP	4 LR 10 15 HP	4 LR 10 15 HP	3 LR 12 15 HP	3 LR 12 20 HP	3 LR 12 20 HP	3 LR 12 25 H.P.	4 LR 14 30 H.P.	4 LR 14 30 HP	4 LR 14 40 H.P.		5 LR 15 50 H.P.		
600	4 LR 10 5 HP	4 LR 13 7½ HP	4 LR 13 7½ HP	4 LR 10 10 HP	4 LR 10 15 HP	4 LR 10 15 HP	4 LR 10 20 H.P.	3 LR 12 20 H.P.	3 LR 12 20 H.P.	3 LR 12 25 H.P.	3 LR 12 30 H.P.	4 LR 14 30 H.P.	4 LR 14 40 H.P.	4 LR 14 40 H.P.	5 LR 15 50 HP	5 LR 15 50 H.P.		
700	5 LR 10 3 HP	4 LR 13 7½ HP	4 LR 10 10 HP	4 LR 10 15 HP	4 LR 10 15 H.P.	4 LR 10 15 HP	3 LR 12 20 HP	3 LR 12 25 HP	3 LR 12 25 HP	3 LR 12 30 H.P.	4 LR 14 40 HP	4 LR 14 40 HP	4 LR 14 40 HP	4 LR 14 50 HP	5 LR 15 50 HP	5 LR 15 60 HP	6 LR 19 100 HP	6 LR 14 100 HP
800	5 LR 10 5 HP	5 LR 10 10 HP	4 LR 13 10 H.P.	4 LR 10 15 H.P.	4 LR 10 15 HP	4 LR 10 20 HP	4 LR 12 20 HP	4 LR 12 25 HP	4 LR 12 25 H.P.	4 LR 12 30 H.P.	4 LR 14 40 H.P.	4 LR 14 40 H.P.	4 LR 14 50 H.P.	4 LR 14 50 H.P.	5 LR 15 60 HP	5 LR 15 65 H.P.	6 LR 15 75 HP	6 LR 14 100 HP
900	5 LR 10 7½ HP	5 LR 13 10 HP	5 LR 13 15 HP	4 LR 10 15 HP	4 LR 10 20 HP	4 LR 12 25 HP	4 LR 12 25 HP	4 LR 12 25 HP	4 LR 12 30 HP	4 LR 12 40 HP	4 LR 11 40 H.P.	4 LR 14 50 HP	4 LR 11 50 H.P.	5 LR 15 60 H.P.	5 LR 15 60 HP	5 LR 15 75 HP	6 LR 16 100 H.P.	6 LR 18 125 HP
1000	5 LR 10 7½ HP	5 LR 10 [illegible]	5 LR 10 15 HP	5 LR 10 15 HP	5 LR 10 20 H.P.	4 LR 12 25 HP	4 LR 12 30 HP	4 LR 12 30 H.P.	4 LR 12 30 H.P.	4 LR 12 40 HP	5 LR 13 40 HP	5 LR 13 50 HP	5 LR 15 60 H.P.	5 LR 15 60 H.P.	5 LR 15 75 HP	5 LR 15 75 HP	6 LR 16 100 H.P.	6 LR 19 125 HP
1200	6 LR 10 7½ HP	6 LR 13 15 HP	5 LR 13 15 HP	5 LR 10 20 H.P.	5 LR 10 25 HP	6 LR 10 25 HP	4 LR 12 30 HP	4 LR 12 40 HP	5 LR 13 40 HP	5 LR 13 40 HP	5 LR 13 50 H.P.	6 LR 13 60 H.P.	5 LR 15 75 H.P.	5 LR 15 75 H.P.	5 LR 15 100 HP	6 LR 15 100 H.P.	6 LR 15 100 H.P.	6 LR 19 125 HP
1400	6 LR 13 10 HP	6 LR 13 15 HP	5 LR 13 20 HP	6 LR 10 20 H.P.	6 LR 10 25 HP	6 LR 10 30 HP	5 LR 13 40 HP	5 LR 13 40 HP	5 LR 13 50 HP	5 LR 13 50 HP	6 LR 13 60 H.P.	6 LR 13 75 HP	5 LR 15 100 H.P.	5 LR 15 100 H.P.	6 LR 16 100 HP	6 LR 16 100 H.P.	6 LR 4 125 H.P.	6 LR 4 150 HP
1600	8 LR 13 10 HP	8 LR 13 15 HP	4 LR 13 10 HP	6 LR 10 25 HP	6 LR 10 30 HP	6 LR 10 40 HP	5 LR 13 40 HP	5 LR 13 50 H.P.	5 LR 13 50 HP	6 LR 13 60 H.P.	6 LR 13 75 HP	6 LR 13 75 HP	6 LR 16 100 H.P.	6 LR 16 100 H.P.	6 LR 15 100 HP	6 LR 16 125 H.P.	6 LR 14 150 HP	6 LR 18 150 HP
1800	8 LR 13 15 HP	8 LR 13 [illegible]	5 LR 10 25 HP	6 LR 10 30 HP	6 LR 13 40 HP	6 LR 13 40 HP	5 LR 13 50 HP	5 LR 13 50 H.P.	6 LR 13 60 HP	6 LR 13 75 HP	6 LR 13 75 H.P.	6 LR 14 100 HP	6 LR 15 100 H.P.	6 LR 15 125 HP	6 LR 16 125 HP	6 LR 14 125 HP	6 LR 19 150 HP	6 LR 18 200 HP
2000	8 LR 13 15 HP	[illegible]	6 LR 13 30 HP	6 LR 10 40 HP	6 LR 10 40 HP	6 LR 10 60 HP	6 LR 13 50 HP	6 LR 13 60 HP	6 LR 13 75 HP	6 LR 13 75 HP	8 LR 13 100 HP	8 LR 13 100 HP	6 LR 16 125 H.P.	5 LR 16 125 HP	6 LR 16 125 HP	6 LR 14 150 H.P.	6 LR 18 200 H.P.	6 LR 14 200 HP
2500		4 LR 13 10 HP	4 LR 13 40 HP	8 LR 13 40 HP	8 LR 13 50 HP	9 LR 13 50 HP	9 LR 13 40 HP	9 LR 13 75 HP	8 LR 13 75 HP	9 LR 13 [illegible] HP	4 LR 13 100 H.P.	8 LR 13 125 HP	8 LR 13 150 HP	6 LR 19 150 H.P.	6 LR 18 200 HP	6 LR 18 200 HP	6 LR 19 250 HP	
3000			10 LR 15 40 HP	4 LR 13 50 HP	4 LR 13 60 HP	8 LR 13 75 HP	8 LR 13 75 HP	8 LR 13 100 HP	9 LR 13 100 HP	9 LR 13 125 HP	8 LR 13 125 HP	8 LR 13 150 HP	*6 LR 19 200 H.P.	*6 LR 18 200 HP	*6 LR 19 250 HP	*6 LR 19 250 HP		
3500			10 LR 15 40 HP	10 LR 15 60 HP	10 LR 15 75 HP	10 LR 15 75 HP	10 LR 15 100 H.P.	9 LR 13 100 HP	8 LR 13 125 HP	8 LR 13 125 HP	8 LR 13 150 HP	10 LR 15 150 HP	10 LR 15 200 H.P.	10 LR 15 200 HP				
4000			10 LR 15 60 HP	10 LR 15 75 HP	10 LR 15 75 HP	10 LR 15 100 HP	10 LR 15 100 H.P.	10 LR 15 125 HP	10 LR 15 125 HP	10 LR 15 150 H.P.	10 LR 15 150 HP	10 LR 15 200 HP	10 LR 15 200 HP					
4500				10 LR 15 75 HP	10 LR 15 100 HP	10 LR 15 100 HP	10 LR 15 125 HP	10 LR 15 125 H.P.	10 LR 15 150 HP	10 LR 15 150 H.P.	10 LR 15 200 HP	10 LR 15 200 H.P.	10 LR 15 250 HP					
5000					10 LR 15.	10 LR 15 125 HP	10 LR 15 125 HP	10 LR 15 150 HP	10 LR 15 150 H.P.	10 LR 15 200 HP	10 LR 15 200 H.P.	10 LR 15 250 H.P.						
5500						*10 LR 15 150 HP	*10 LR 15 150 HP	*10 LR 15 150 HP	*10 LR 15 200 HP	*10 LR 15 200 HP	*10 LR 15 250 HP	*10 LR 15 250 HP						
6000							*10 LR 15 200 HP	*10 LR 15 200 H.P.	*10 LR 15 200 HP	*10 LR 15 250 HP	*10 LR 15 250 H.P.							

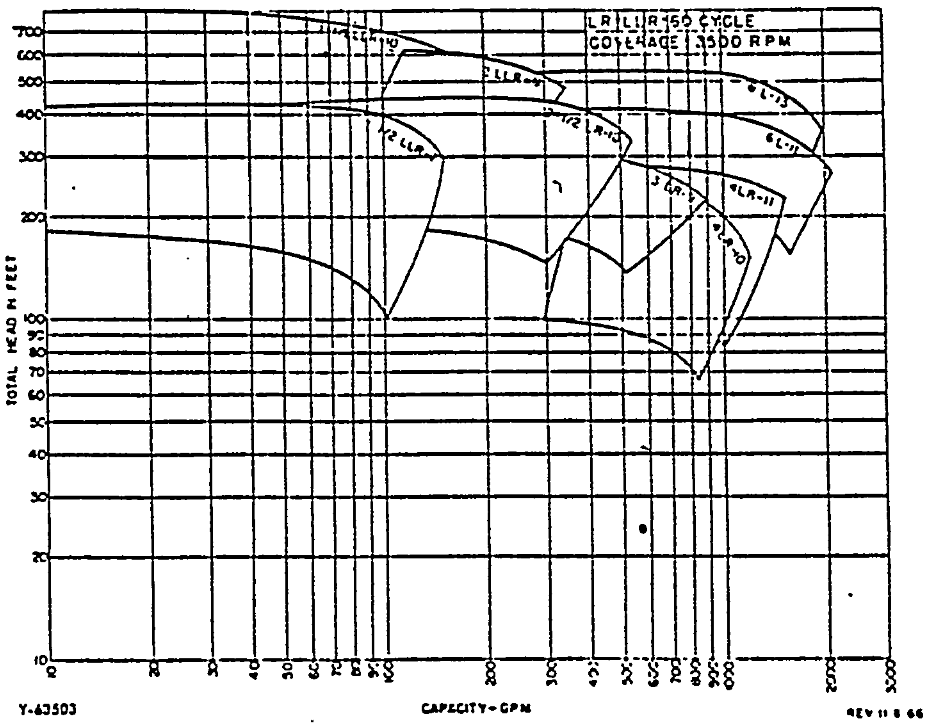
NOTES:
Except as noted by asterisk, these selections require N P S H. available of no more than 30 feet. For systems providing less than 30 feet N P S H, check individual rating curves. Selections marked by asterisk require more than 30 feet N P S.H. and individual rating curves should be consulted.
Horsepowers listed are nominal motor horsepowers for the open dripproof motors required to power the pump at the conditions listed when pumping a liquid of 1.0 specific gravity and viscosity equal to water. Standard service factors of open dripproof motors are used. If a different motor enclosure, specific gravity, or viscosity is employed, refer to the individual rating curves.

Pump selection within bold lines denotes 1150 R.P.M. Operation.

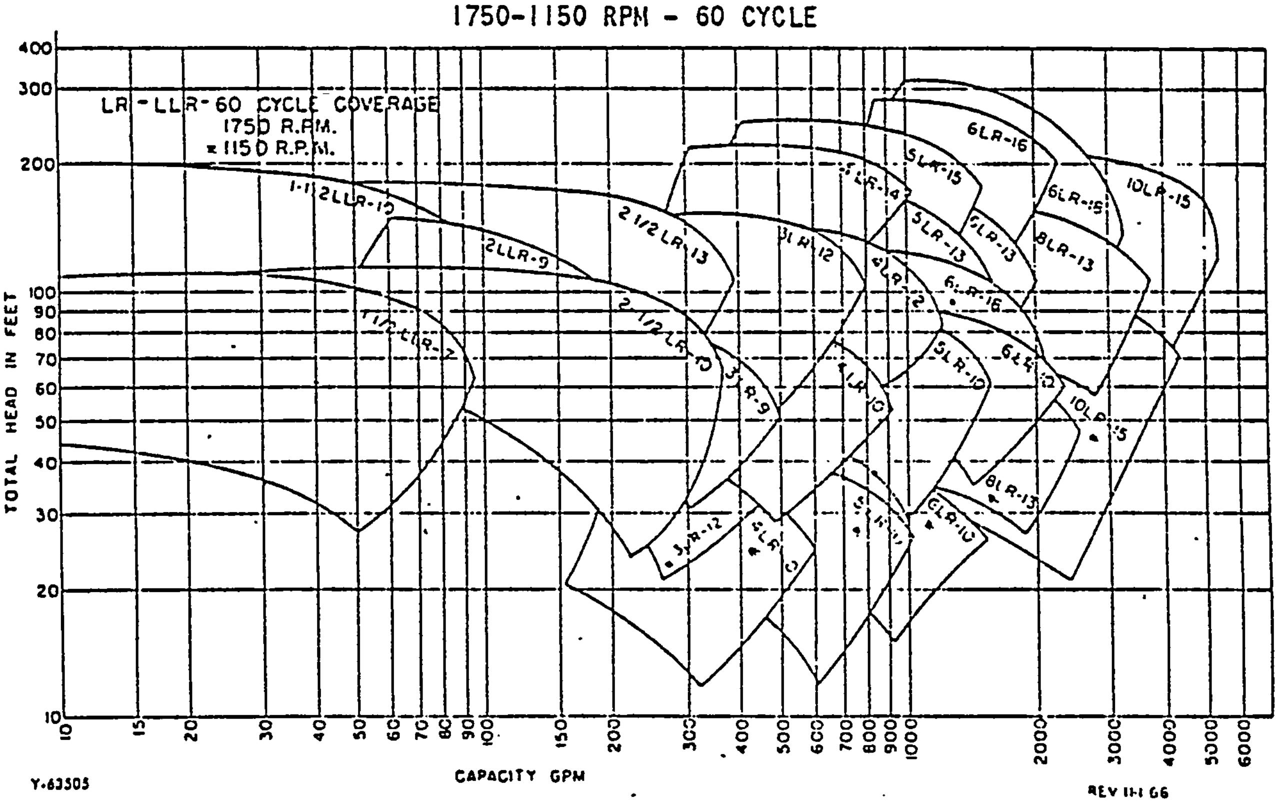
types LR, ~~LLR~~ LRV

composite coverage charts

COMPOSITE CHARTS FOR TYPE LR, ~~LLR~~ PUMPS 3500 RPM - 60 CYCLE

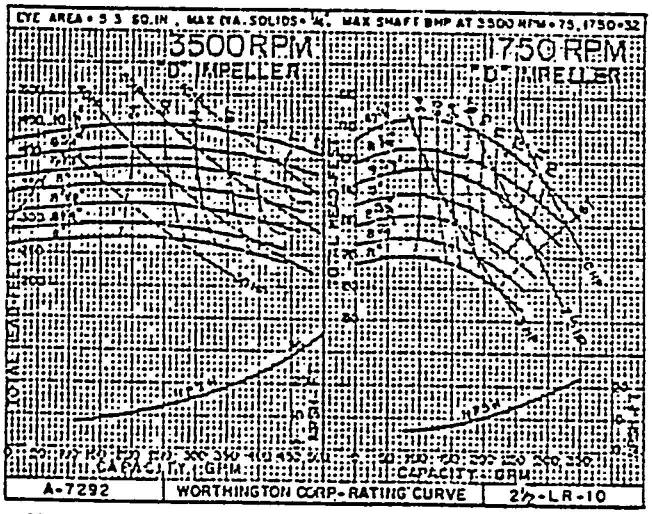


1750-1150 RPM - 60 CYCLE

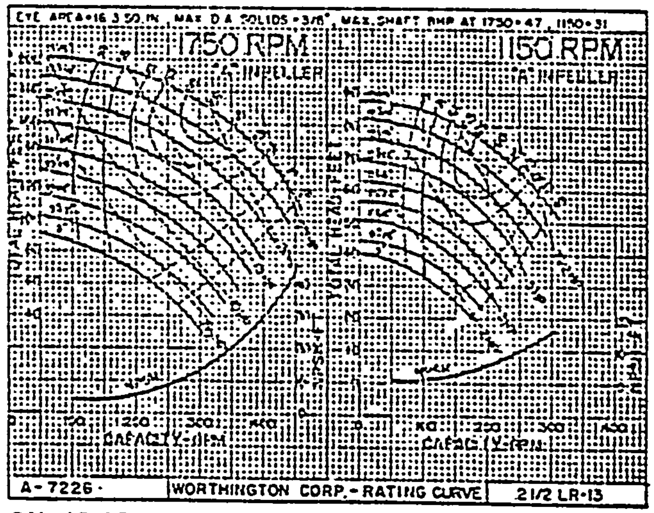


types LR, LRV

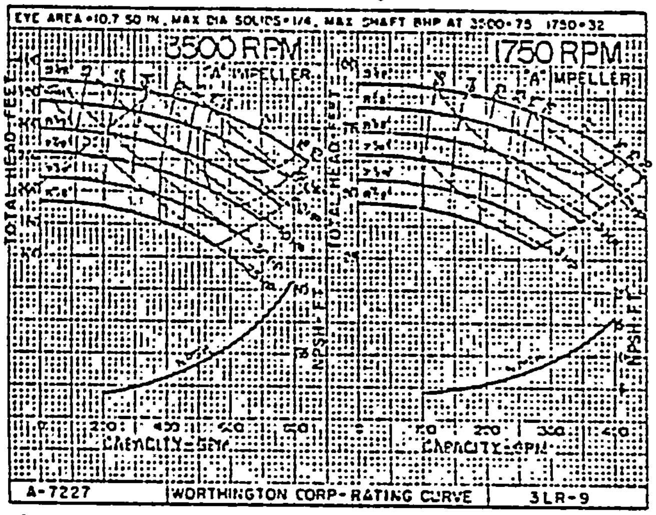
rating curves



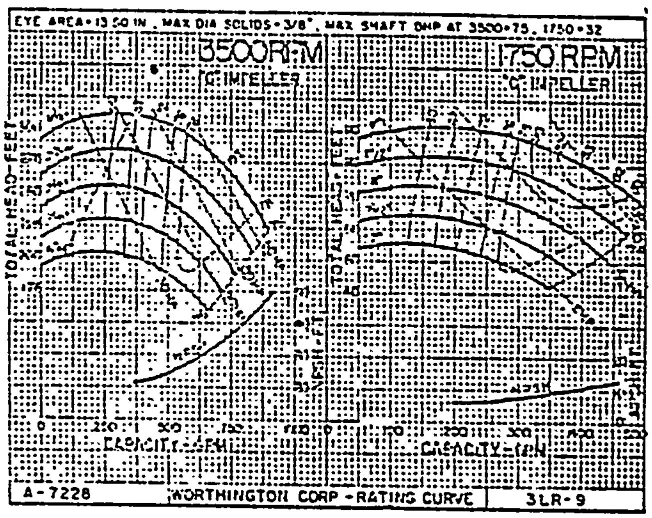
2½ LR-10



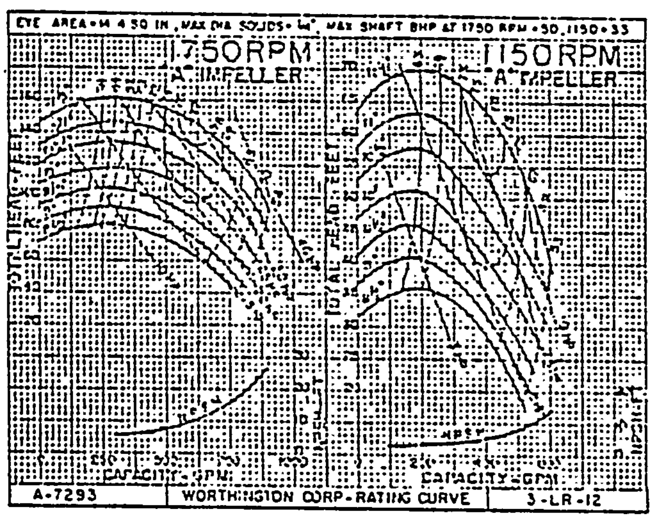
2½ LR-13



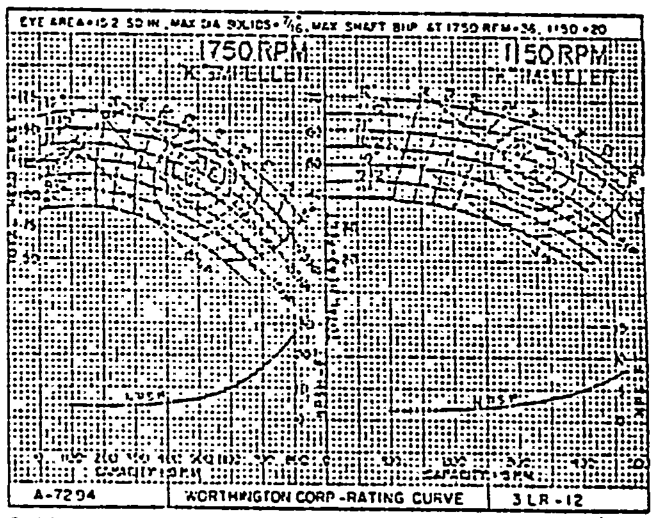
3 LR-9



3 LR-9



3 LR-12

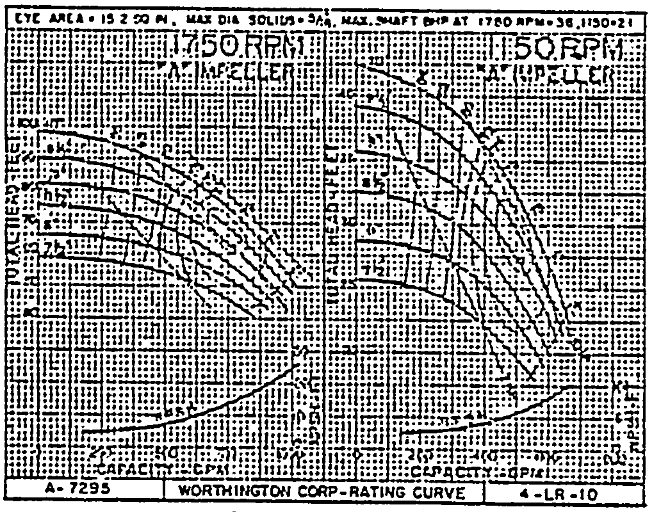


3 LR-12

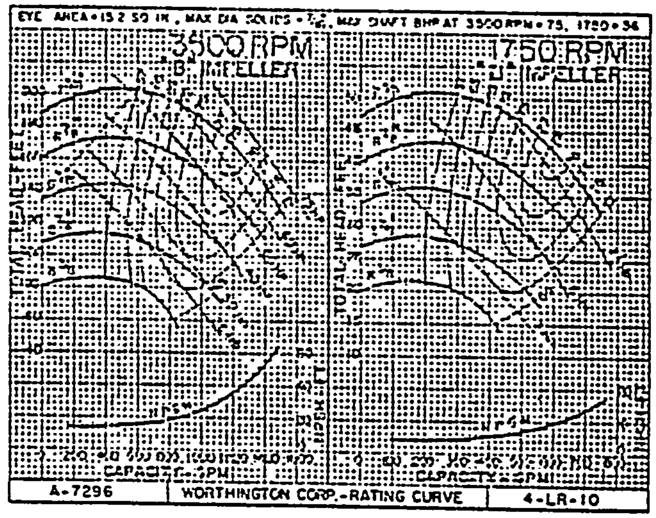
horizontal split case centrifugal pumps

types LR, LRV

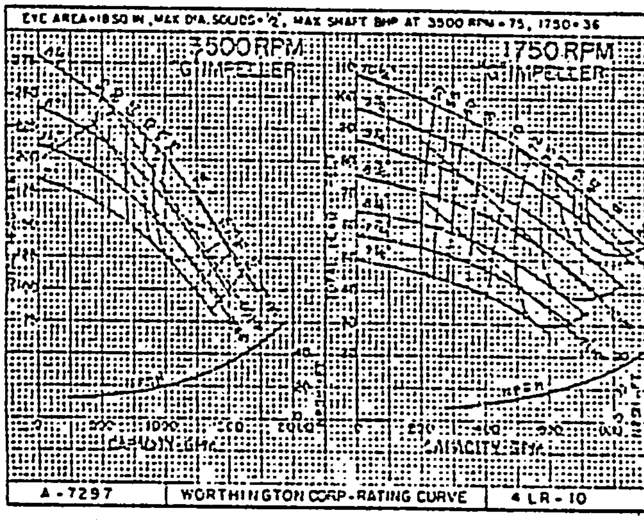
rating curves



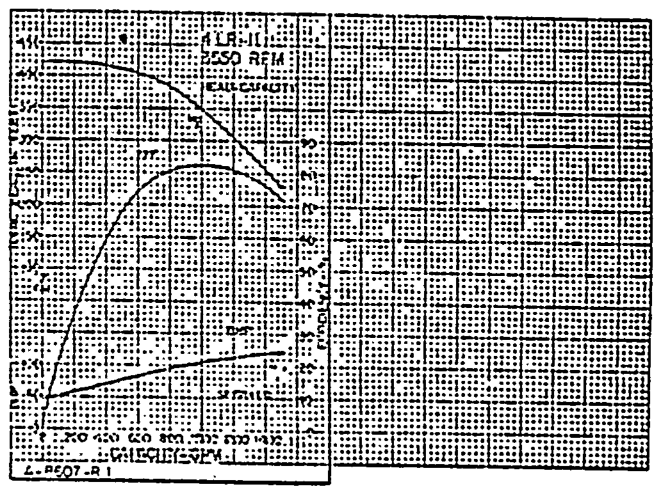
4 LR-10



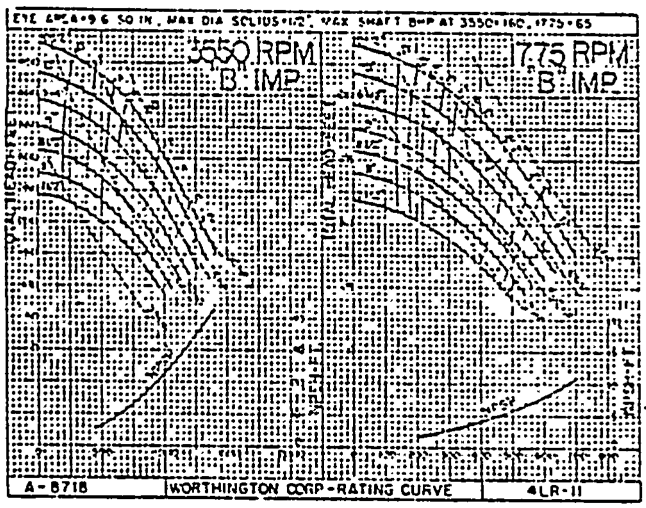
4 LR-10



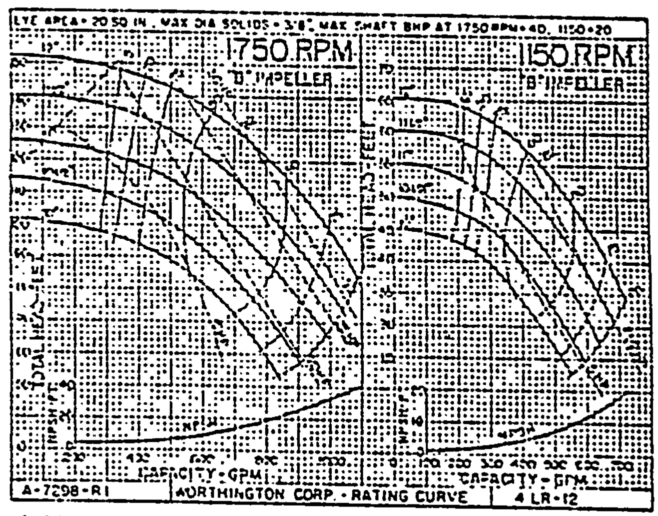
4 LR-10



4 LR-11



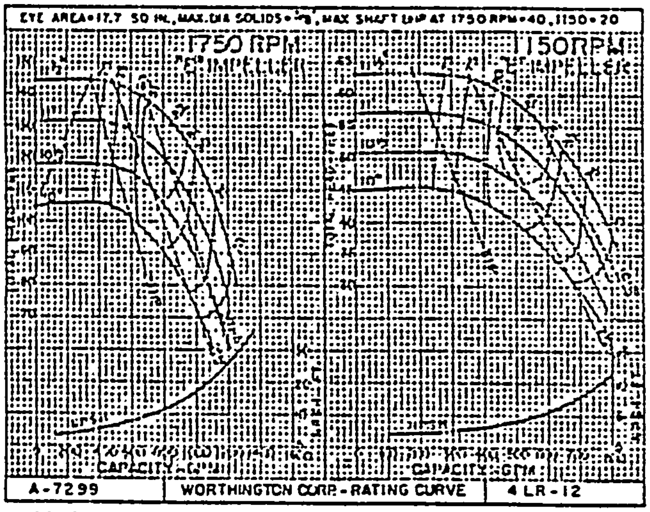
4 LR-11



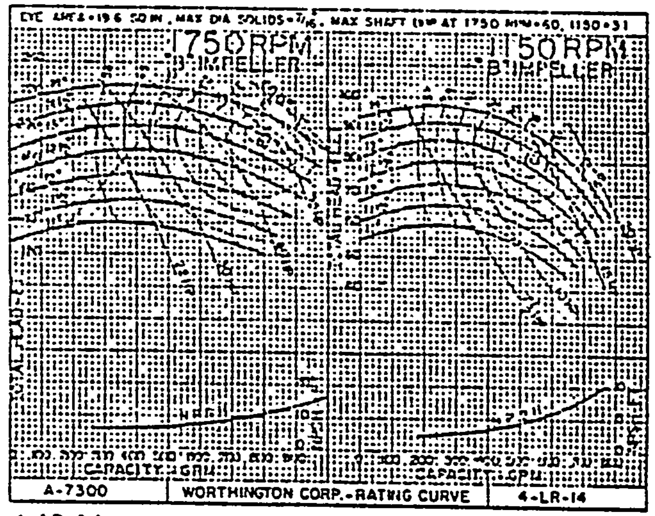
4 LR-12

types LR, LRV

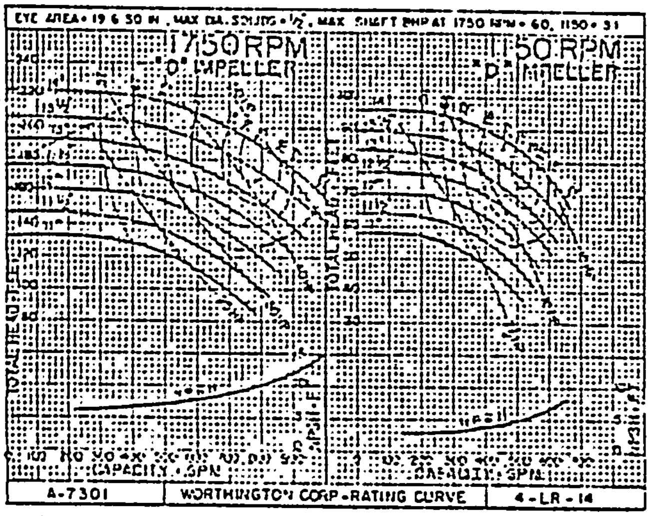
rating curves



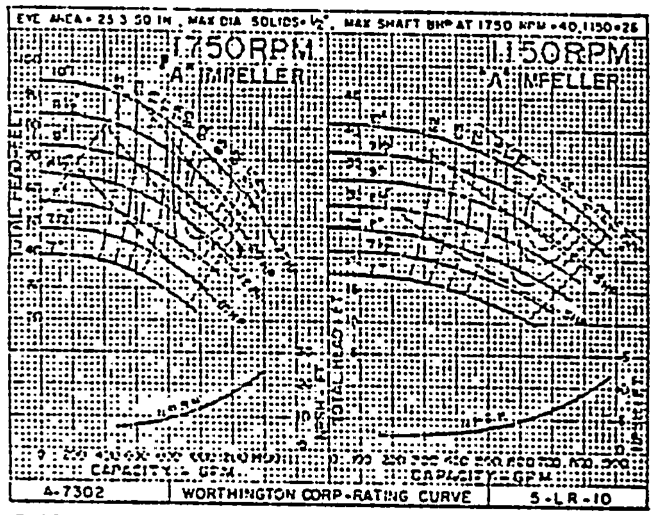
4 LR-12



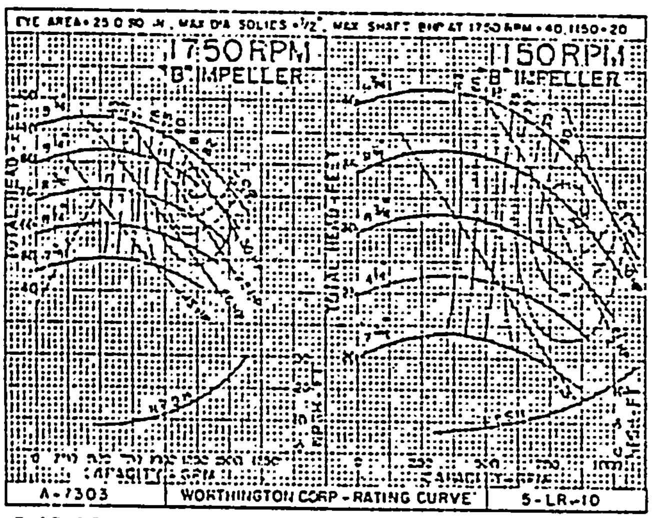
4 LR-14



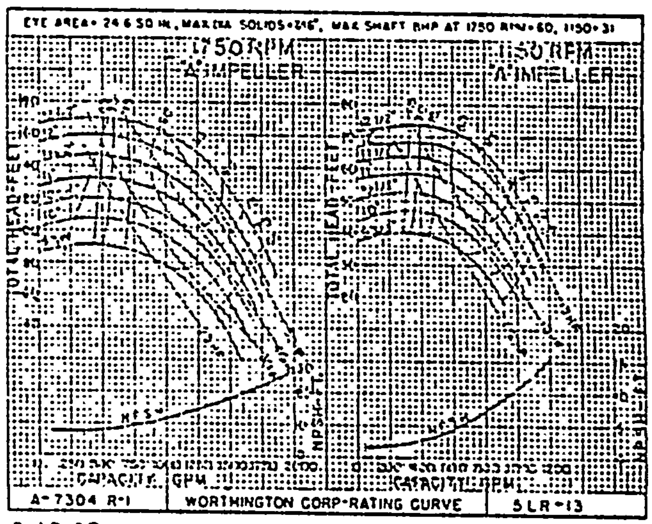
4 LR-14



5 LR-10



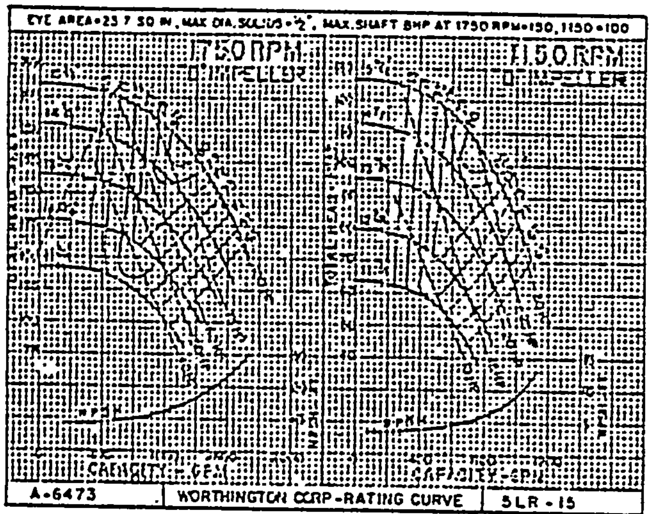
5 LR-10



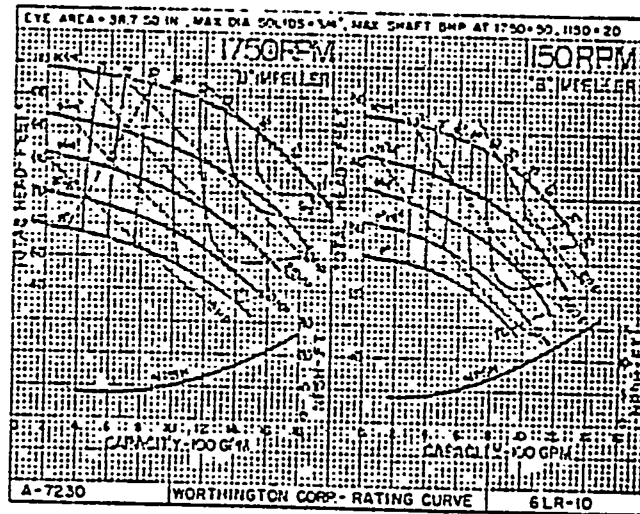
5 LR-13

types LR, LRV

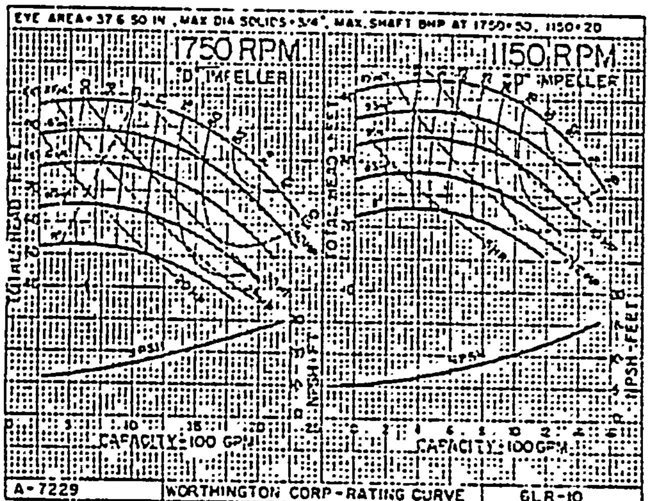
rating curves



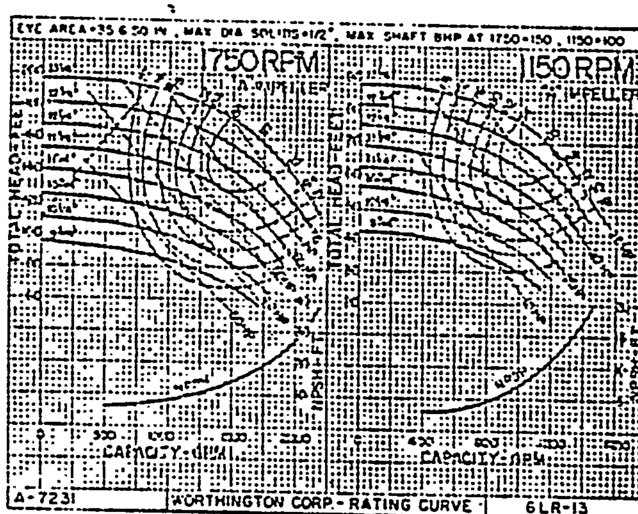
5 LR-15



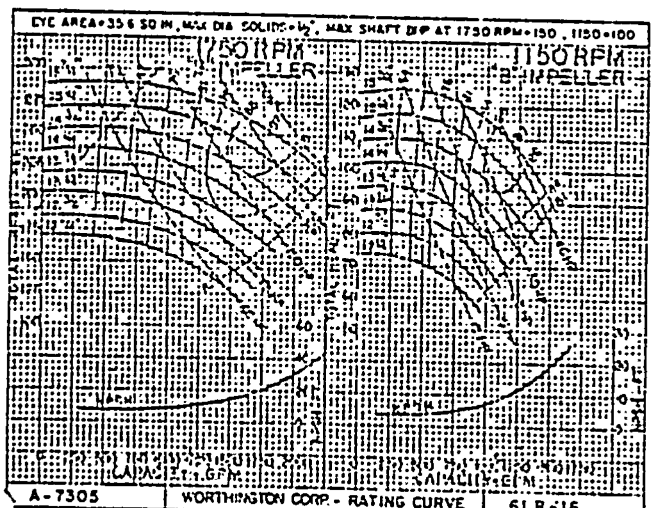
6 LR-10



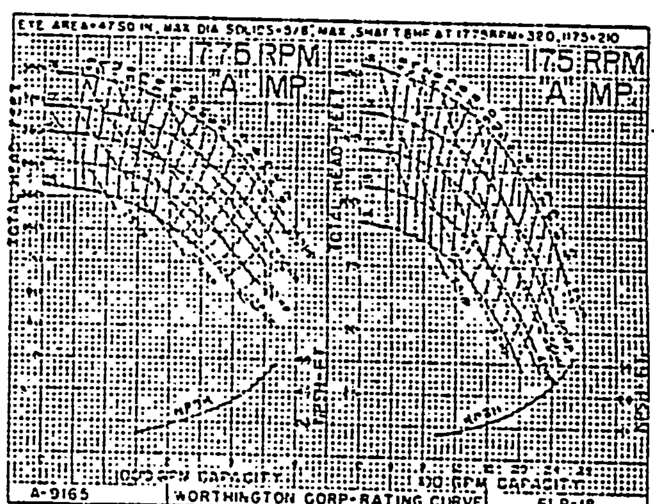
6 LR-10



6 LR-13

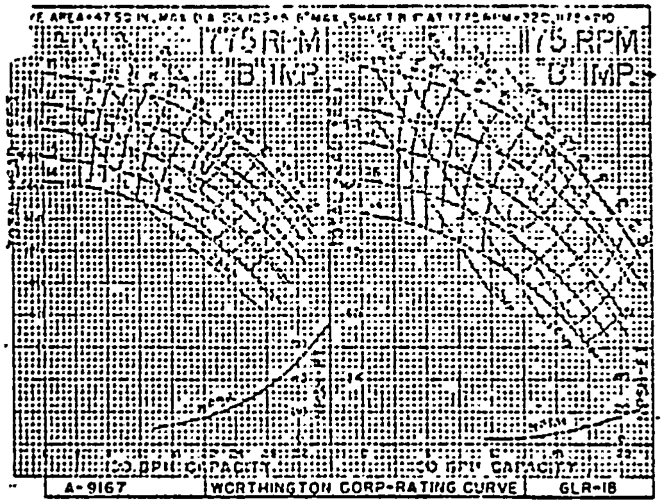


6 LR-16

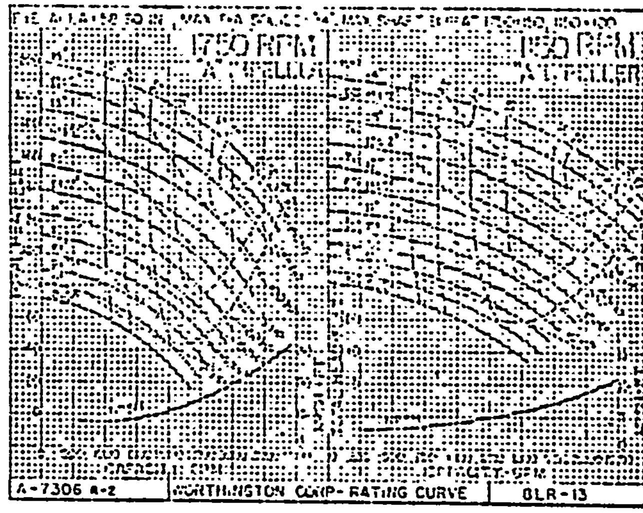


6 LR-18

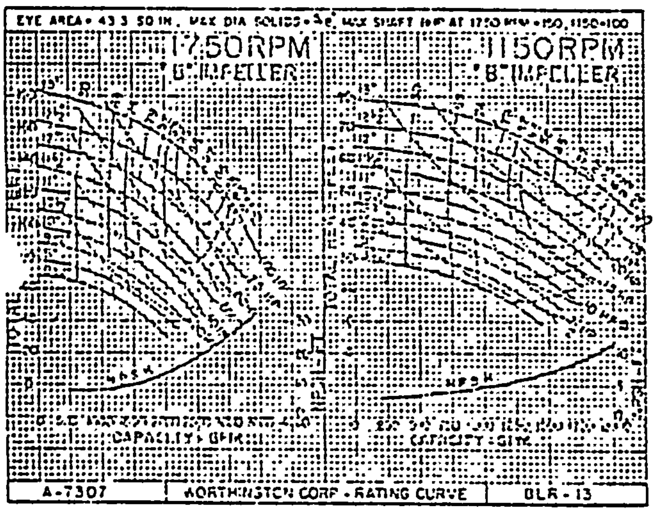
types LR, and LRV rating curves



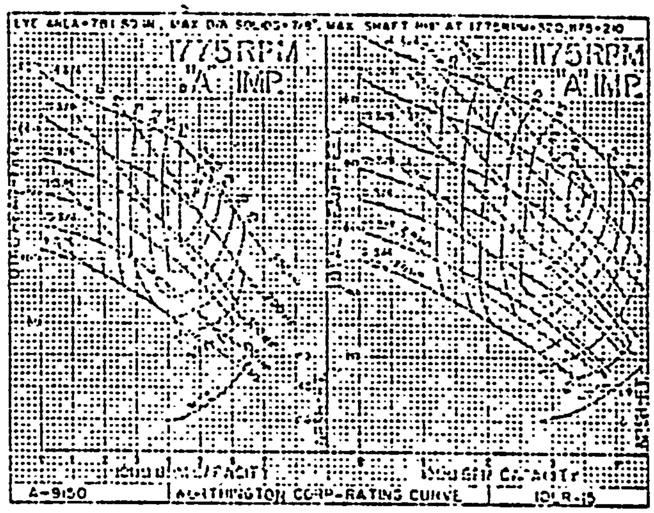
6 LR-18



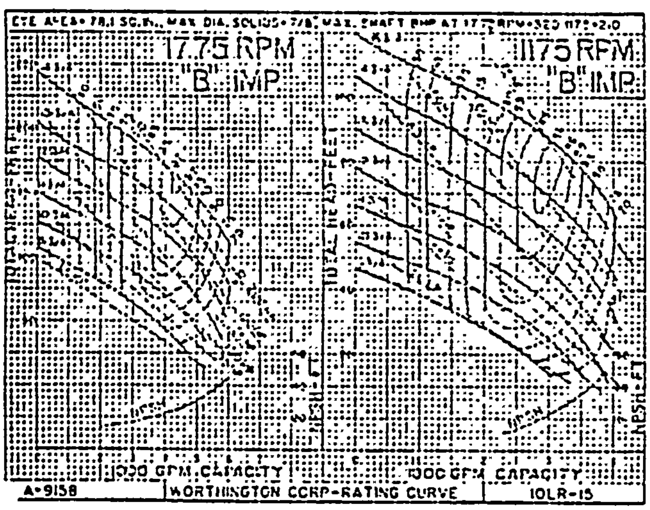
8 LR-13



8 LR-13



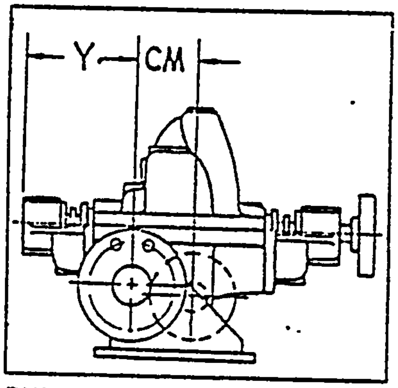
10 LR-15

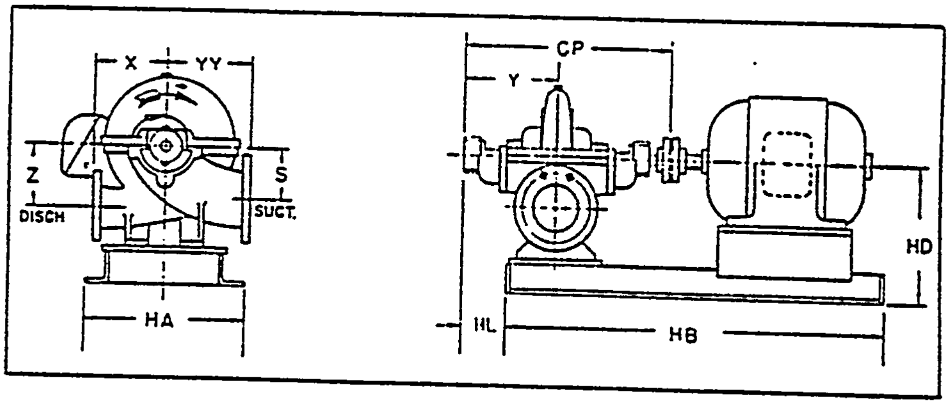


10 LR-15

types LR, ~~LLR~~

dimensions





PUMP DIMENSIONS

pump size	suct.	disch.	S	X	Y	Z	CP	CM	YY	HD	HL	WT	base
~~1½ LLR-7~~	~~2~~	~~1½~~	~~3½~~	~~6¾~~	~~9¾~~	~~4¼~~	~~26¼~~	~~3¼~~	~~6¼~~	~~12½~~	~~4~~	~~200~~	~~1~~
~~1½ LLR-10~~	~~3~~	~~1½~~	~~4½~~	~~8½~~	~~10½~~	~~5½~~	~~26¼~~	~~4~~	~~8½~~	~~13¼~~	~~4~~	~~360~~	~~1~~
~~2 LLR-9~~	~~3~~	~~2~~	~~4½~~	~~8~~	~~10⅞~~	~~5~~	~~26¼~~	~~4½~~	~~8⅞~~	~~13¼~~	~~4~~	~~290~~	~~1~~
2½ LR-10	3	2½	5	8	10¼	6½	23	1½	8¾	15	6	220	1
2½ LR-13	4	2½	5¾	9½	11⅛	7½	24⅜	1½	10	16	7	250	1
3 LR-9	4	3	5¼	7½	12	5¾	26¾	—	9	15	6¼	220	1
3 LR-12	5	3	5¾	8⅜	12	7¼	26¾	—	10½	16	6¼	280	1
4 LR-10	5	4	5¾	9	12	6¼	26¾	—	11	16	6¼	280	1
4 LR-11	6	4	6⅜	10	13	6½	30	—	12½	17½	6	320	2
4 LR-12	6	4	6⅜	9	12¼	7¾	27	—	11	17½	6	400	1
4 LR-14	6	4	6⅛	12	13	7⅜	30	—	12½	17½	6	385	2
5 LR-10	6	5	6½	9½	12¼	7	27	—	13	17½	6	370	2
5 LR-13	6	5	6½	10½	13	7¼	30	—	13	17½	6	425	2
5 LR-15	6	5	6½	13	14¾	7¼	34	—	13½	17½	7¾	600	1
6 LR-10	8	6	7¾	10	13	7½	28⅛	—	14	20	6	425	2
6 LR-13	8	6	7½	11	14¾	9	34	—	14	20	7¾	610	1
6 LR-16	8	6	7⅜	14	14¾	8½	34	—	15	20	7¾	680	1
6 LR-18	10	6	9	12½	14¾	10½	39	—	17	24¾	12	1000	3
8 LR-13	10	8	8⅞	11½	17¼	10	34	—	17	24¼	7¾	780	1
10 LR-15	12	10	10½	14	17¼	10½	39	—	18	27¾	12	1185	3

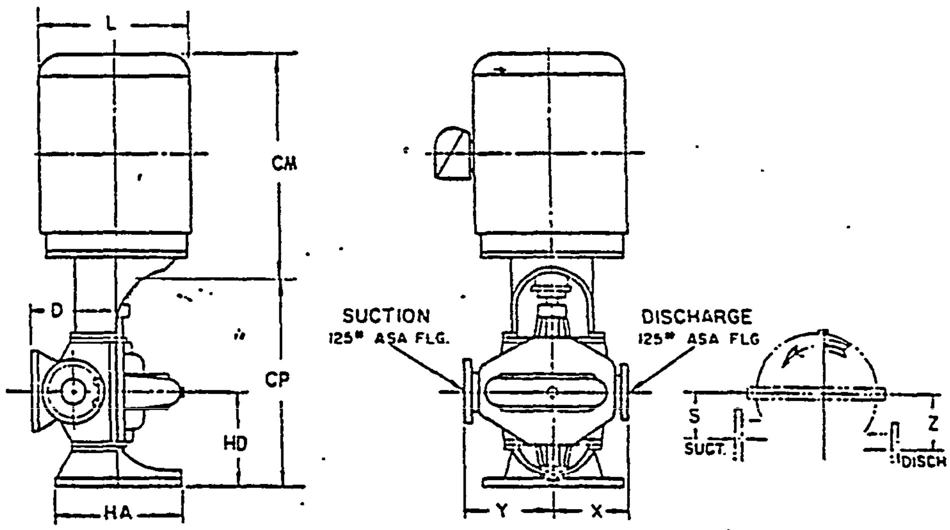
BASE DIMENSIONS

nema frame motor	base 1			base 2			base 3		
	HA	HB	WT* pump & base	HA	HB	WT* pump & base	HA	HB	WT* pump & base
182 T	24	41¾	250	24	41¾	280	—	—	—
184 T	24	41¾	260	24	41¾	290	—	—	—
213 T	24	41¾	305	24	41¾	335	—	—	—
215 T	24	41¾	310	24	41¾	340	—	—	—
254 T	24	41¾	360	24	54½	390	—	—	—
256 T	24	41¾	390	24	54½	420	—	—	—
284 T	24	54½	455	24	54½	485	—	—	—
286 T	24	54½	570	24	54½	600	28	60	920
324 T	24	54½	605	24	54½	635	28	60	955
326 T	24	54½	660	24	54½	690	28	60	1010
364 T	24	54½	790	24	54½	820	28	60	1150
365 T	24	54½	845	24	54½	875	28	60	1210
404 T	24	64¼	1015	24	54½	1045	32	66	1270
405 T	24	64¼	1095	24	54½	1125	32	66	1440
444 T	24	64¼	1490	24	64¼	1490	32	66	1870
445 T	24	64¼	1655	24	64¼	1655	32	66	2030

*Approximate Weight Of Base And ODP Motor — Add 10% for TEFC or Ex Prf.

type LRV

dimensions



PUMP DIMENSIONS

LRV											
pump	suct.	disch.	D	X	Y	CP	HA	HD	S	Z	WT
3 LRV-9	4	3	10½	7½	9	27⅝	18	13	5¼	5¾	395
3 LRV-12	5	3	11½	8⅝	10½	27⅝	18	13	5¼	7¼	455
4 LRV-10	5	4	11½	9	11	27⅝	18	13	5¼	6¼	455
4 LRV-11	6	4	13	10	12½	30⅞	18	13⅞	6⅜	6½	495
4 LRV-12	6	4	13	9	11	27⅞	18	13⅛	6⅛	7¾	585
4 LRV-14	6	4	13	12	12½	30⅞	18	13⅞	6⅛	7⅝	570
5 LRV-10	6	5	13	9½	13	27⅞	18	13⅛	6½	7	545
5 LRV-13	6	5	13	10½	13	30⅞	18	13⅞	6½	7¼	610
5 LRV-15	6	5	13	13	13½	34½	20	15¼	6½	7¼	780
6 LRV-10	8	6	15½	10	14	29	18	13¾	7¾	7½	600
6 LRV-13	8	6	15½	11	14	34½	20	15¼	7½	9	790
6 LRV-16	8	6	15½	14	15	34½	20	15¼	7⅝	8½	900
8 LRV-13	10	8	18	11½	17	35¼	20	16	8⅞	10	1065
10 LRV-15	12	10	21	14	18	39	25	18¼	10½	10½	1510

MOTOR DATA

Motor Frame	CM	L	WT
213 TP	20¼	10⅞	165
215 TP	20¾	10⅞	180
254 TP	24½	13	205
256 TP	24¾	13	270
284 TP	25⅝	13	330
286 TP	25⅝	13	355
324 TP	27⅛	14¼	400
326 TP	27⅛	14¼	450
364 TP	29⅛	16¼	520
365 TP	29⅛	16¼	580
404 TP	38⅞	18½	690
405 TP	38⅞	18½	990
444 TP	44¾	20½	1180
445 TP	44¾	20½	1330

All dimensions are in inches -

OPERATING DATA

MAXIMUM SUCTION PRESSURES

2-1/2" LR	75 psi
3" to 10" LR, LRV	150 psi

TEMPERATURE RATINGS

STANDARD MECHANICAL SEALS	212°F
STANDARD PACKED STUFFING BOX	250°F

(SEALS AND PACKING AVAILABLE FOR HIGHER TEMPERATURES)

materials of construction

PART	STANDARD FITTED PUMP	ALL IRON PUMP	ALL BRONZE PUMPS
	MATERIALS	MATERIALS	MATERIALS
Casing	Cast Iron	Cast Iron	Bronze
Bearing Bracket	Cast Iron	Cast Iron	Cast Iron
Bearing Cover	Cast Iron	Cast Iron	Cast Iron
Impeller	Bronze	Cast Iron	Bronze
Casing Ring	Bronze	Cast Iron	Bronze
Shaft	11% Chrome Steel	11% Chrome Steel	Monel
Impeller Nut	Bronze	Steel	Bronze
Stuffing Box Bushing	Bronze	Steel	Bronze
Gland	Cast Iron	Cast Iron	Bronze
Seal Cages	Teflon*	Teflon	Teflon

Type LR, single stage, single suction size 2½"

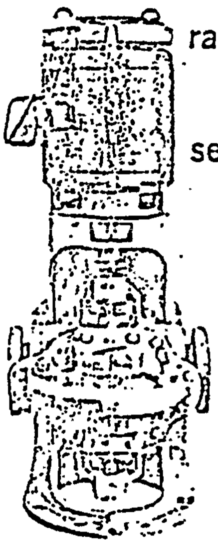
PART	STANDARD FITTED PUMP	ALL IRON PUMP	ALL BRONZE PUMPS
	MATERIALS	MATERIALS	MATERIALS
Casing	Cast Iron	Cast Iron	Bronze
Bearing Bracket	Cast Iron	Cast Iron	Cast Iron
Bearing Cover	Cast Iron	Cast Iron	Cast Iron
Impeller	Bronze	Cast Iron	Bronze
Casing Ring	Bronze	Cast Iron	Bronze
Shaft Sleeve	Bronze	Steel	Bronze
Shaft	Steel	Steel	Steel
Shaft Nut	Bronze	Steel	Bronze
Stuffing Box Bushing	Bronze	Steel	Bronze
Gland	Cast Iron	Cast Iron	Bronze
Seal Cage	Teflon	Teflon	Teflon

Type LR, single stage, double suction size 3" to 10"

PART	STANDARD FITTED PUMP	ALL IRON PUMP	ALL BRONZE PUMPS
	MATERIALS	MATERIALS	MATERIALS
Casing	Cast Iron	Cast Iron	Bronze
Bearing Bracket	Cast Iron	Cast Iron	Cast Iron
Bearing Cover	Cast Iron	Cast Iron	Cast Iron
Impeller	Bronze	Cast Iron	Bronze
Casing Ring	Bronze	Cast Iron	Bronze
Shaft Sleeve	Bronze	Steel	Bronze
Shaft	Steel	Steel	Steel
Shaft Nut	Bronze	Steel	Bronze
Stuffing Box Bushing	Bronze	Steel	Bronze
Gland	Cast Iron	Cast Iron	Bronze
Seal Cage	Teflon	Teflon	Teflon
Pump Base	Cast Iron	Cast Iron	Cast Iron
Motor Base	Fab. Steel	Fab. Steel	Fab. Steel

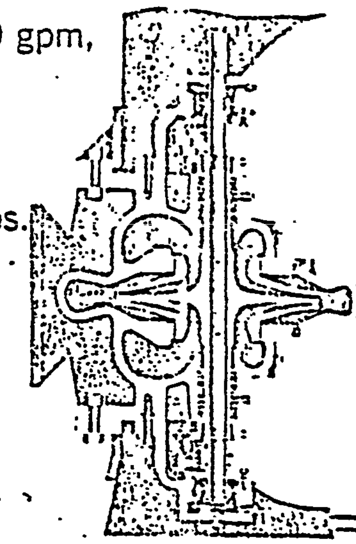
Type LRV, single stage, double suction, vertically mounted sizes 3" to 10"

type LRV—single stage, double suction vertically mounted, sizes 3" to 10" construction features



ratings: capaeities to 6000 gpm, heads to 300 ft.

services: general service, water supply, circulating pumps.



Type LRV vertical pump

Typical section, type LRV

Incorporates all of the outstanding features of the LR pump plus the added advantage of being used in the space saving vertical position. Accurate motor alignment is achieved by precision machining. Fluid is blocked from the bottom bearing by a positive sealing device.

SPECIFICATIONS

Casing The casing is of the volule type and is designed to produce a smooth flow with gradual velocity changes. It is designed for vertical mounting with heavy-duty flanges for base and motor mounting brackets. It is split on the shaft centerline for ease of Inspection or removal of interior parts. This may be done without disturbing piping connection or pump alignment. The casing halves are scaled by a pre-cut gasket. Casing halves are accurately located by the use of straight dowel pins. This eliminates the pos - sibility of a mismatch between halves which would impair both hydraulic and mechanical performance.

Impeller The impeller is a double-suction encloscd type. It is hydraulically balanced by its inherent design. The impeller is firmly secured to the shaft by a key and by external shaft nuts.

Renewable case rings Renewable case rings are locked in place and protected against rotation by 2 Model pins.
Impeller rings. Securely held Impeller rings can be supplied as an option.

Stuffing box bushing A renewable stuffing box bushings provided which insures freedom from packing trouble.

Shaft sleeve Renewable shaft sleeves are provided which extend through the stuffing box. They are securely keyed and held in place with shaft nuts incorporating nylon Inserts for locking purposes.

Shaft The shaft is of heat-treated steel, ground to accurate dimensions and polished to a smooth surface. The shaft sleeves protect the shaft at the stuffing boxes. The sleeves are secured in lateral position by external shaft nuts. The impeller keys are extended into the hub of the shaft sleeve to prevent slippage between the shaft and the sleeves. Scaling to protect against leakage under the shaft sleeve is accomplished by the use of "O" ring type seals, localcd between the sleeve and the shaft. It is adequately sized and designed to minimize deflection. The maximum runout of the shaft, at the stuffing box face, will not exceed .002".

Dearings The hearings are single-row, deep-groove type ball bearings. They arc designed and sized for at least 100,000 hours minimum rated bearing life. Each bearing is capable of carrying both line and thrust type loads. They are securely held to the shaft by an easily installed snap ring. Special flinger, shaft scaling o-ring and labyrinth all protect lower bearing from waler seepage.

Bearing Brackets The hearing brackets are separate from the pump casing and are accurately machined, and doweled to the casing. Perfect alignment between housing and casing results in accurate alignment between rotor and casing. Removal of dowels permits removal of complete rotor assembly without disturbing piping, base or motor.

Packing - mechanical seals As a standard, stuffing boxes will be packed with the best quality graphited asbestos packing. Die-moulded packing is supplied, as a standard, insuring both a perfect seal and an easy installation. Mechanical seals are available, if desired, and are easily interchangeable with packing

APPENDIX C.4.2

Procurement Standard Group IV

Definition: This standard is a document which contains the information in standard format which is required for a shipyard to purchase vendor equipment required for Propulsion machinery. This document contains both the technical documentation and the legal documentation (Eor the purpose of this study, only the technical requirements will be considered).

Standard Format:

For information the legal portion of this standard will contain standard statements of Warranty, Price Adjustments, Terms of payments, Liability Limitations, Loss Risks, Shipping, Delays, Changes, Drawing Approval Terms, Cancellation, and Taxes.

One standard technical format applicable to a pump purchase is described as follows:

EXAMPLE: First Page

Title: Brief Description of item by service

Identification: Standard identification number

Applicable Documents: Reference to requirements such as other standards, Regulatory agency specifications and requirements, etc.

Quantity of Purchase

Intended Service

Next Page(s)

Drawing Requirements: Included are information drawings, approval drawings and schedule of delivery

Instruction & Maintenance Manuals:

Physical Description: In chart form

Performance Data: In chart form

Materials Data: List

Weights

Spares

Inspection Requirements: Includes at vendors' sites and at delivery point requirements

Outline Drawing: This is an envelope or limit type drawing with information required for interface and to limit the vendor.

Performance Curves: Includes capacity versus head, horsepower and suction

Special Design Considerations: Contains any special considerations with which vendor must comply. Includes physical and chemical properties of recommended materials, special handling, heat treating, ambient conditions, etc.

Test Requirements: Specifies tests which must be performed by the vendor such as hydrostatic pressure tests and load run tests.

TITLE: TANK WASHING CENTRIFUGAL PUMP PROCUREMENT STANDARD

STANDARD NO: P-TW-4 B

APPLICABLE DOCUMENTS:

Pump Standard HP-TW-4B 63

Installation Drawing N 51-2362

LEGAL STD.

TERMS OF PAYMENT

These are __________ standard terms of payment for domestic orders. If other terms are acceptable, or when export terms are required; they are listed elsewhere in this proposal.

On all orders under $100,000 regardless of manufacturing schedule; and those orders over $100,000 with a manufacturing schedule less than six (6) months:

Net cash within thirty (30) days after shipment, or after notification that __________ is ready to ship. These terms apply to partial as well as complete shipments

On orders over $100,000 with a manufacturing schedule of six (6) months or longer:

10%—with Purchaser's Order, Letter of Intent, or written authorization, whichever bears the earliest date.

80%—in approximately equal payments every sixty (60) days, to commence sixty (60) days after date of Purchaser's order and to continue through the balance of the proposed manufacturing schedule, excepting that the last payment in this group shall become due upon shipment or notification that __________ is ready to ship.

10%—when shipment is made; or upon completion of erection and test, but not later than ninety (90) days after shipment or notification that __________ is ready to ship.

PRICE ADJUSTMENT

The following clauses are applicable to the extent they are referred to elsewhere in this proposal. Selection of price adjustment clause is based upon the proposed shipping date for the equipment offered. Any purchased material whose price will be adjusted to reflect the vendors' price in effect at time of shipment is listed as an exception.

Clause 9 The prices named herein for __________ equipment will be adjusted to the prices in effect at the time of shipment, such adjustment, if any, not to exceed 10% of the contract price.

Clause 10 The prices named herein for __________ equipment are not subject to any change from the prices in effect on the date the order is accepted.

Clause 11 The prices named herein for __________ equipment will be adjusted to the prices in effect at the time of shipment, such adjustment, if any, not to exceed 15% of the contract price.

Clause 12 The prices named herein for __________ equipment will be adjusted to the prices in effect at the time of shipment, such adjustment, if any, not to exceed 20% of the contract price.

• • • • • • • • • •

1. Warranty, Remedy, Disclaimer

__________ warrants for a period of one year from the date of shipment the equipment of its own manufacture to be delivered hereunder against defects in material and workmanship, under normal use and service when used and maintained in accordance with instructions supplied by __________. This is __________ sole and exclusive warranty. It applies only to equipment manufactured by __________ and specifically excludes equipment manufactured by others. Such other equipment is warranted only by its manufacturer. If such a defect appears within one year from the date of shipment and Purchaser has given __________ immediate written notice of same, __________ will repair the part, or at its option replace the part, by shipping a similar part F.O.B. shipping point, or at its option refund an equitable portion of the purchase price. __________ may require the return of the defective part, transportation prepaid, to establish the claim. No allowance will be made for repairs without __________ written consent or approval. Any descriptions of the equipment, any specifications, and any samples, models, bulletins, or similar material, used in connection with this sale are for the sole

OF ANY KIND WHATSOEVER, EXPRESSED OR IMPLIED; AND ALL WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE HEREBY DISCLAIMED BY WORTHINGTON AND EXCLUDED FROM THESE TERMS OF SALE. The Purchaser's sole and exclusive remedy, whether based upon warranty, contract or tort, including negligence, will be to proceed under this warranty. All liability of ________ shall terminate one year from the date of shipment of the equipment. All references to one year in this paragraph shall be limited to thirty (30) days for mounted demolition tools and parts and ninety (90) days for hand held contractor's tools, crawler drills and parts.

2. Limitation of Liability

__________ shall not in any event be liable for special, indirect, incidental or consequential damages. __________ liability on any claim of any kind, including negligence, for any loss or damage arising out of, connected with, or resulting from this contract, or the performance or breach thereof, or the design, manufacture, sale, delivery, resale, installation, technical direction of installation, inspection, repair, operation or use of any equipment covered by or furnished under this contract shall in no case exceed the price paid by the Purchaser for the equipment. ________ also disclaims all liability, whether in contract, tort, warranty, or otherwise, to any party other than Purchaser.

3. Shipping Dates

The time for shipment given herein is approximate and is estimated from the date of receipt of order with complete manufacturing information and approval of drawings as may be necessary. ________ shall not be liable for any loss or damage for delay or non-delivery due to the acts of civil or military authority, acts of the Purchaser or by reason of 'force majeure', which shall be deemed to mean all causes whatsoever not reasonably within the control of ________ including, but not limited to acts of God, war, riot or insurrection, blockades, embargoes, sabotage, epidemics, fires, strikes, lockouts, or other industrial disturbances, delays of carriers, and inability to secure materials, labor or manufacturing facilities.

4. Payments

The prices specified are in U.S. currency, payable in New York exchange free of all expense to ________ for collection charges. Pro rata payments shall be made for partial shipments. If delivery is prevented or postponed at the Purchaser's request, or by reason of any other cause set forth specifically or by implication in paragraph 3 above, then all dates of payment related to delivery shall relate instead to the date of completion of manufacture. Letters of credit or other credit instruments established to provide payment for the equipment specified in this proposal shall make provision for payment as set forth above where delivery is prevented or postponed under such circumstances. Storage of such equipment will be at the Purchaser's expense and risk. When in the opinion of ________

5. Changes and Drawings

________ reserves the right to change or modify the design and construction of equipment and to substitute other suitable material. If drawings are furnished, they are submitted to show general style and arrangement of the equipment offered.

6. Cancellation

The Purchaser may cancel his order only upon written notice and payment to ________ of reasonable cancellation charges specified by

7. Suspension

If ________ performance of the work is delayed for a period of more than six (6) months either by reason of the request or acts of the Purchaser, acts of civil or military authority, or by reason of "force majeure", upon removal of the cause of any such delay performance shall be resumed, delivery will be rescheduled, and the purchase price shall be adjusted to that in effect at the time of resumption of performance subject to such price adjustment clause as may then be applicable or notified by ________ to Purchaser. If Purchaser is unwilling to accept the adjustment price and projected delivery date, he may cancel his order by giving written notice thereof to ________ at any time within thirty (30) days after he has been informed of ________ adjusted price and projected delivery date and upon payment of reasonable cancellation charges specified by ________.

LEGAL STD

8. Risk of Loss, Security

The Purchaser shall bear all risk of loss of or damage to the equipment after delivery to transportation facility at shipping point. Purchaser agrees that ________ shall retain a security interest in the equipment only until the purchase price has been paid and Purchaser agrees to perform all acts necessary to perfect and assure ________ security interest.

9. Taxes

The Purchaser shall pay to ________, in addition to the purchase price, the amount of all Sales, Use, Privilege, Occupation, Excise, or other taxes, Federal, state, local or foreign which ________ may be required to pay in connection with furnishing goods or services to the Purchaser.

10. Freight

Purchaser shall pay to ________, in addition to the purchase price, any amount by which transportation charges may be increased, by reason of increased transportation rates, between the dates of this proposal and the time of shipment.

11. Seller

For purposes of this proposal, ________ shall mean the ________ Corporation subsidiary which delivers and invoices the equipment.

12. Service Supervisor (Marine-Government)

a. The machinery shall be installed and put in operation by and at the expense of the Purchaser. Upon request of the Purchaser, . . will furnish the services of a Service Supervisor to advise and assist the Purchaser in the installation of the machinery. Purchaser shall furnish safe and proper working conditions, and safe storage for any special tools. The Purchaser shall furnish all necessary help, labor, cranes, cribbing, oil, supplies, station operating force, steam, electricity, water and other material and supplies required to install and operate the machinery and shall furnish free available crane and switching service and the services of operators and other employees that may be necessary in connection therewith.

b. ______ shall not be responsible for materials furnished by the Purchaser or for acts or failures to act of personnel furnished by the Purchaser, nor shall ______ be responsible for the construction of foundations or in the case of land installation, for the nature of the soil upon which they are built.

c. Unless otherwise stipulated, the Purchaser shall pay for these services at the following rates:

(1) All services except shipboard trial trips:

(i) At the rate of $ ___ for each normal eight hour day worked or spent in travel to and from the job site, plus all travel expenses of the Service Supervisor from the time of leaving base location until return and all shipping charges for any special tools and materials at actual cost.

(ii) Hours worked in excess of the normal eight hour day, Monday through Friday and hours worked on Saturday, Sunday and Holidays, will be billed at the rate of $ ___ per hour.

(iii) The minimum billing for less than four hours worked or spent in travel will be 50% of the daily rate. The minimum billing for more than four hours but less than eight hours worked or spent in travel will be the full daily rate.

(iv) The time when the Supervisor is ready, willing and able to work at the job site even though his services are not in fact utilized shall be considered to be time worked for the purposes of this paragraph.

(2) Shipboard trial trips only:

(i) At the rate of $ ___ for each twenty-four hour period or part thereof, on shipboard during a normal work week.

(ii) At the rate of $ ___ for each twenty-four hour period or part thereof on shipboard on Saturday, Sunday and Holidays.

(iii) Travel time from the time of leaving base location until return will be charged at the rate in 12 c (1) above; all travel expenses will be charged at actual cost from time of leaving base location until return.

(3) The rates specified in the 12c (1) and (2) above are not subject to change provided the Supervisor begins to perform these services within 90 days after the equipment is shipped.

d. ______ shall not in any event be held liable for any special, indirect or consequential damages.

LEGAL STD

PUMPS PER SHIP: 1		SERVICE: Tank Washing	
DESCRIPTION		**PERFORMANCE**	
SIZE	3x2x13 D-1011	CAPACITY—GPM	450
TYPE/STAGES	Centrifugal/Single	TDH—FT.	471
MOUNTING	Horizontal	LIQUID PUMPED	Sea Water
CASING SPLIT	Radial (Back Pull Out)	SP. GR./TEMP./VISC.	1.03
SUCTION SIZE	3" 150# F.F. Flange	SUCTION CONDITIONS	Flooded
DISCHARGE SIZE	2" 150# F.F. Flange	NPSH REQ'D/AVAIL.	20'/Advise
ROTATION	CCW (Suction End)	EFFICIENCY—%	69
ELEVATION	RW-16056R-6	BHP	81
SECTION	-	PUMP SPEED—RPM	3550
CURVE	A-12968	DRIVER HP (RECOMMENDED)	100
MATERIALS		**SPARE PARTS**	
CASING	Worthite 20	THRUST BEARING	
CASE WEAR RING	-	LINE BEARING	
IMPELLER	Worthite 20	CASE WEAR RINGS	
IMPELLER WEAR RING	-	IMPELLER WEAR RINGS	
SHAFT	Worthite 20	SHAFT SLEEVES	TECH
SHAFT SLEEVE	-	IMPELLER	STD
STUFFING BOX	Packed (Blue Asbestos)	PACKING & GASKETS	
THRUST BEARING	Ball		
LINE BEARING	Ball		
BEARING HOUSING	Cast Iron		
PUMP BASE	Channel Steel		
~~Coupling~~	~~Falk T Spacer~~		
WEIGHTS		**DRIVER**	
PUMP, BASE, COUPLING	495#	100 HP @ 3600, 3/60/440, IEEE #45, Marine	
DRIVER (IF FURNISHED)	650#	ODP, 365T Frame	
TOTAL	1145#		

SHIPMENT OF THE ABOVE DESCRIBED UNIT CAN BE MADE IN 42 weeks AFTER APPROVAL OF DRAWINGS AND RELEASE TO MANUFACTURE.

DRAWINGS FOR APPROVAL CAN BE SUBMITTED WITHIN 4-6 WEEKS AFTER RECEIPT OF ORDER WITH ENGINEERING DETAILS.

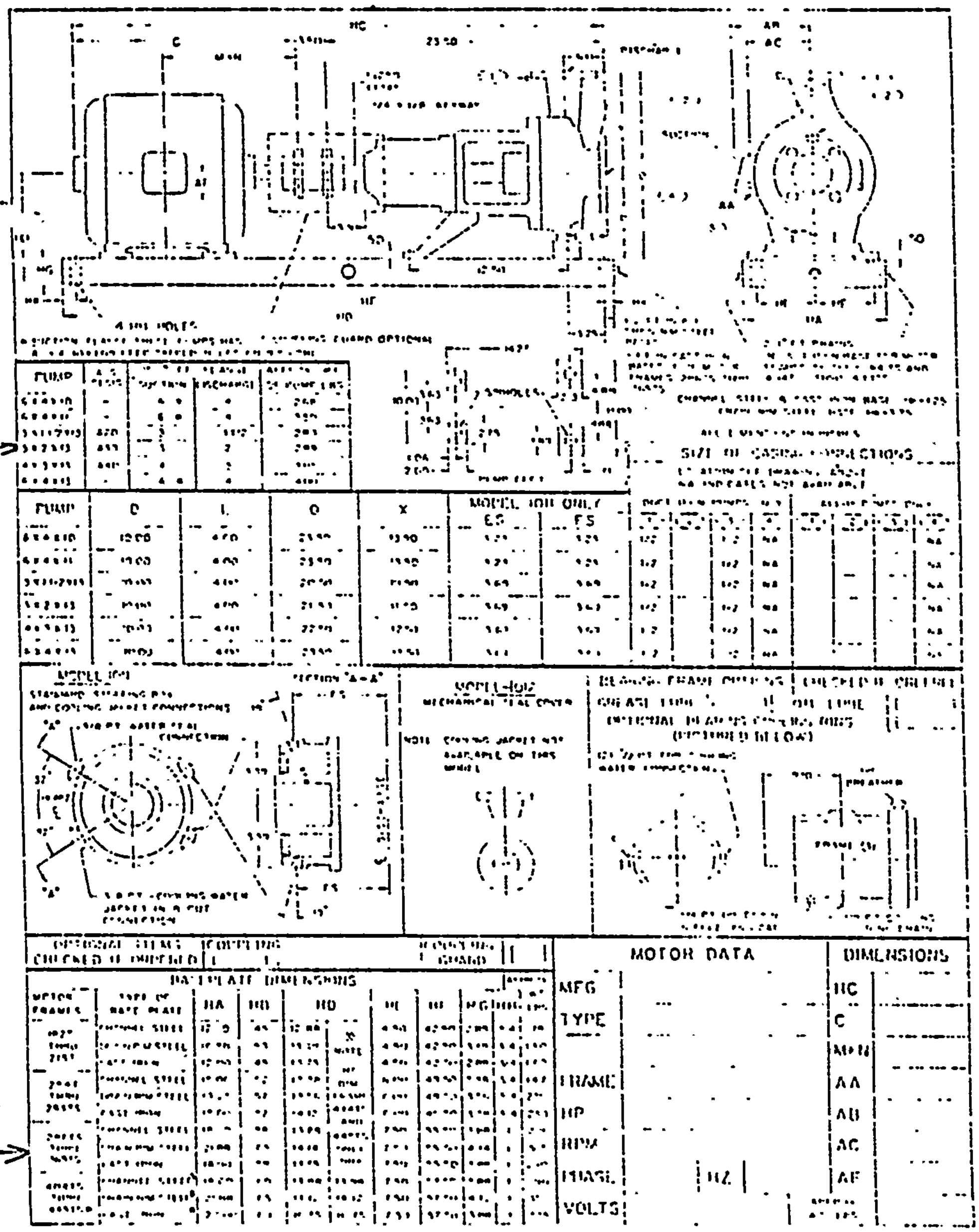
COMMENTS:

TECH STD

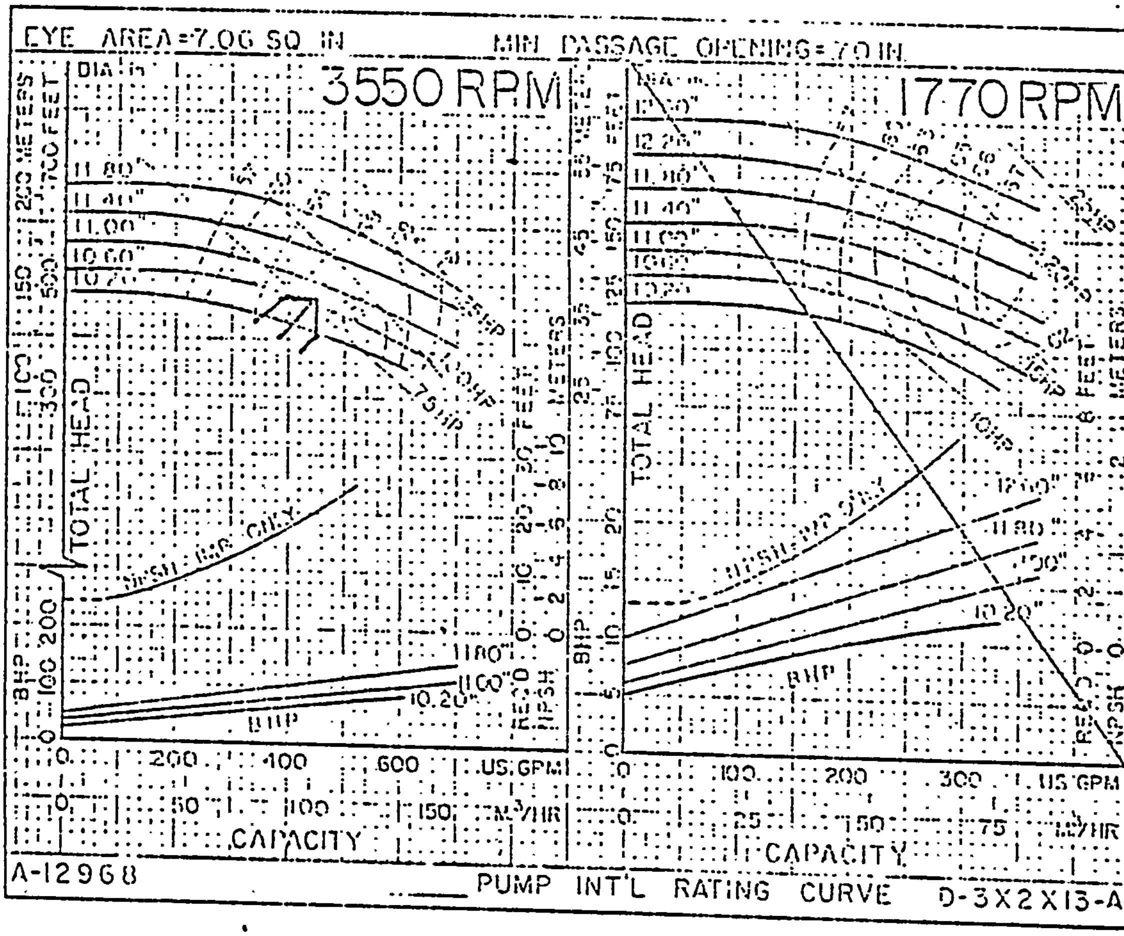
TYPE D-1011 & D-1012
FRAME 3

6 x 4 x 10	3 x 2 x 13
6 x 4 x 11	4 x 3 x 13
3 x 1½ x 13	6 x 4 x 13

FOR USE WITH CHANNEL STEEL, CHANNEL STEEL W/DRIP RIM, OR CAST IRON BASEPLATES



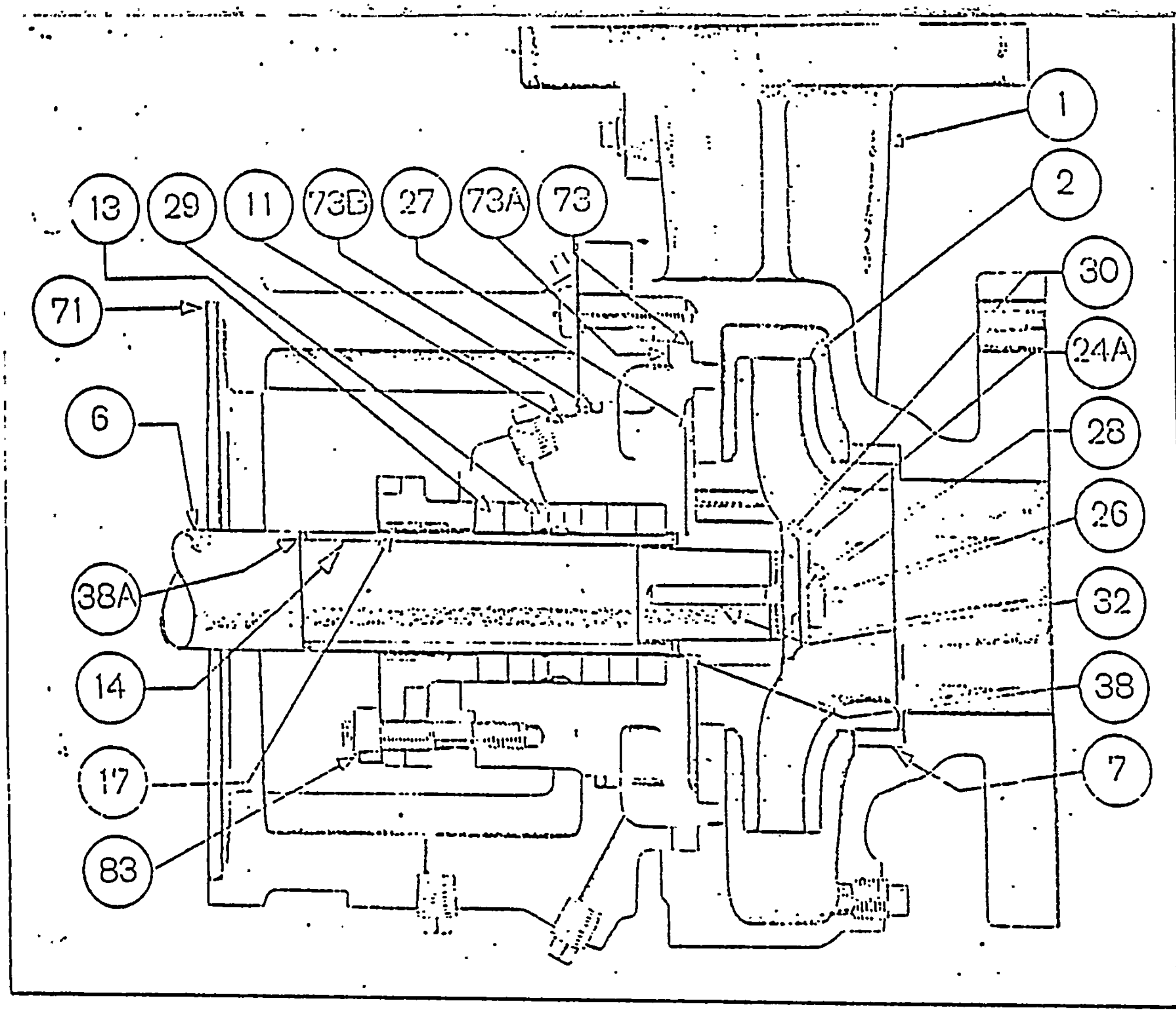
MOTOR DATA	TYPE ______	FRAME ______	H.P. ______
R.P.M. ______	PHASE ______	CYCLES ______	VOLTS ______



CLOSED IMPELLER
3 x 2 x 13 FRAME SELECTION

IMPELLER DIAMETER	MAXIMUM SPECIFIC GRAVITY			
	3550 RPM		1770 RPM	
	FRAME 2	FRAME 3	FRAME 2	FRAME 3
12.6	N/R	N/R	1.58	2.00
12.1		.76	1.78	2.00
11.6		.86	2.00	2.00
11.1		.97	2.00	2.00
10.6		1.12	2.00	2.00

N/R - Not Recommended.



	Item No.	Name of Part
	1	Casing
x	2	Impeller
	6	Shaft (an integral part of the motor)
x	7	Ring, Casing
	11	Cover, Stuffing Box
	11B	Cap, Cooling
o	13	Packing
o	14	Sleeve, Shaft
	17	Gland, Packing
	17A	Gland, Mechanical Seal
x	24A	Lockwasher, Impeller
x	26	Screw, Impeller
x	27	Ring, Adapter and cover
o	28	Gasket, Impeller Screw

	Item No.	Name of Part
o	29	Ring, Lantern
o	30	Gasket, Impeller Lockwasher
x	32	Key, Impeller
o	38	Gasket, Sleeve (Outer)
o	38A	Ring 'O', Shaft Sleeve
o	65	Seal (Mechanical Seal)
	71	Adapter
o	73	Gasket, Casing
o	73A	Gasket, Stuffing Box Cover
o	73B	Ring 'O', Cooling Cap (Outer)
o	73C	Ring 'O', Cooling Cap (Inner)
o	73E	Gasket, Gland M.S.
o	80	Rotor, Mechanical Seal
	83	Stud, Gland
o	211	Ring, Retaining (Mech. Seal Rotor)

o These parts recommended as spare parts to be carried by user.
x Spare parts in addition to above—for export only.

TECH [illegible] D

ORDER NO. | PG | OF

TO

Model D-1021 | UNITS REQ'D | GP NO | S N

PART NO.	NO REQD.	NO ONE UNIT	CLASS AND DESCRIPTION	MATERIAL		NO OF UNIT	PATTERN NO CUT NO OF PUR REF	ASTM No
			Casing	M-3171	(W-20)			A-296
			Casing Gasket	Asb.				
			Impeller	M-3171	(W-20)			A-296
			Impeller Key	M-3171	(W-20)			A-296
			Shaft (In Motor)	M-4171	(C-20)			B-473
			Shaft Sleeve	M-4171	(C-20)			B-473
			Mach. Seal (BP-MCM)	Carbon vs Ceramic Faces				A-296 Grade C
			Gland	M-3265	(316)			A-296
			Adaptor Cover Ring	M-3171				B-473
			Casing Cap Screws	M-4171				
			Gland, Cap Screws	M-4270	(Bar)			A-479
			Adaptor, Motor Bracket	M-3126				A-395
			Impeller (Cap) Screw	M-4171	(C-20 Bar)			B-473
			Impeller Screw Washer	Nyltite				
			Impeller Screw Lockwasher	M-3171				A-296
			Lockwasher Gasket	Asb.				A-296
			Stuffing Box Cover	M-3171	(W-20)			B-473

8

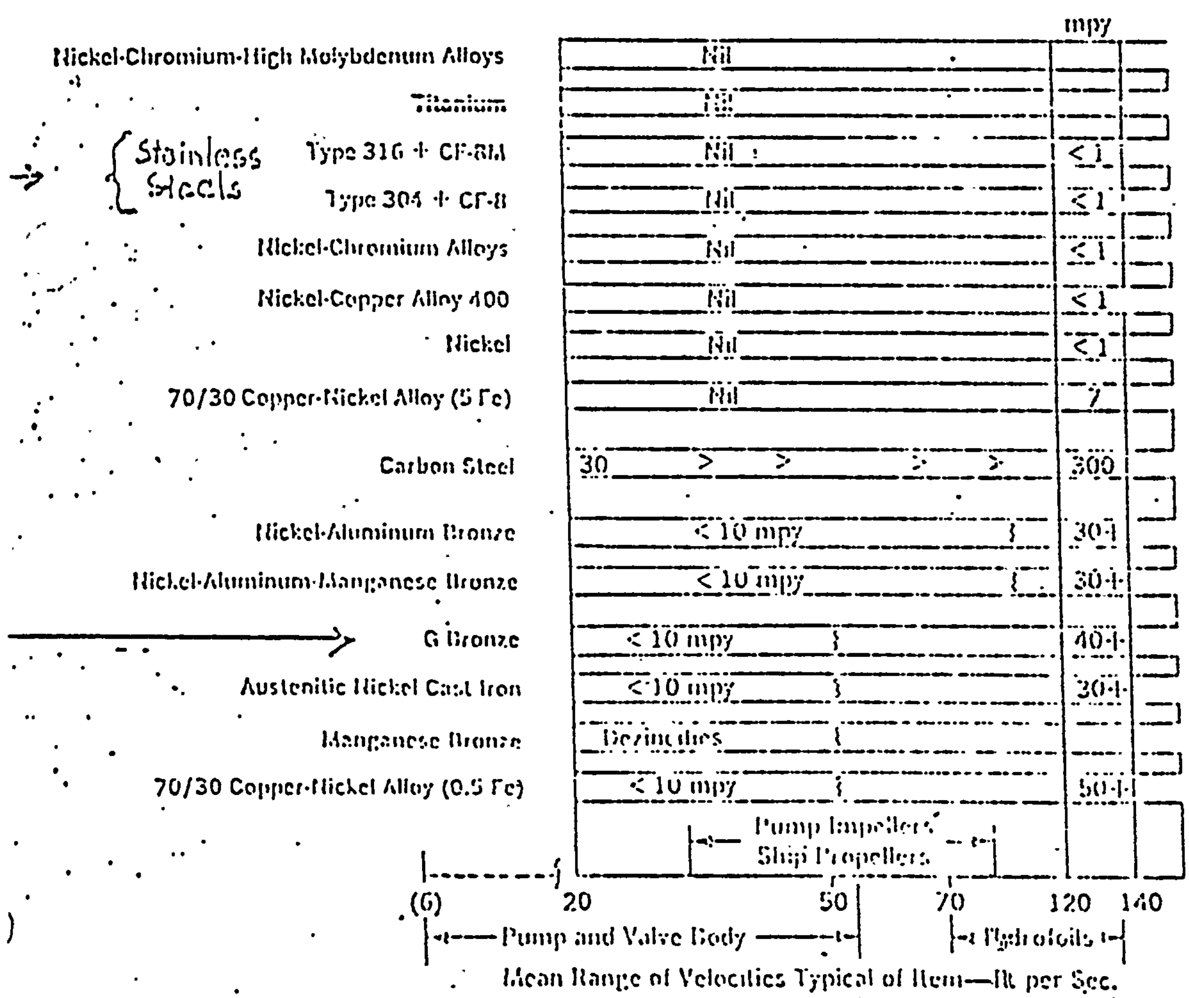
ORDER NO.

BILL OF MATERIAL

6. TEST REPORT

The vendor shall furnish 3 copies of the report specified in ASTM A-479. The report shall show the date, purchase order number, specification number (M-4270), heat number and name of vendor.

Materials



SEAWATER VELOCITY (PUMP TO HYDROFOIL RANGES)

APPENDIX C.4.3

Hardware Standard   Group IV

Definition: This standard is a document which contains the technical information in standard format which is necessary to define and describe hardware which is interchangeable from all vendors as to interface. Interchangeable, as applicable to this standard, means like equipment of a given capacity will have identical -- within limits -- performance characteristics, interface dimensions, size limitations, weight, mounting dimensions, and compatibility of materials.

Standard Format:

An example of a format which would serve as a pump standard follows: It is obvious that several formats are required for the various types of equipment utilized in propulsion plants. For example, the format for a heat exchanger would of necessity be quite different in the required technical data area than a pump.

EXAMPLE: First Page

Title: Describes pump by Type and service

Standard Identification: Alpha-numerical identification with encoded indicators

Applicable Documents: Other standards, specifications, and regulatory agency requirements which apply either partially or wholly or which this standard is in compliance with

Approvals: Regulatory agency applicable approvals of the standard

Next Page(s)

Description of Application: Design requirements which include liquids handled and their descriptive conditions. Pump ratings are included in chart form with identification number, capacity, pressure, required services, prime mover type and size.

Next Page(s)

Pump Characteristic Curves: Curves indicating pump capacity, discharge head, horsepower, suction head and speed.

Pump Selection Chart: Gives capacity, head, horsepower and applicable standard number.

Next Page(s)

Outline Drawings: These include dimensional charts showing key installation and overall dimensions, limiting envelope, weights and space required for service of units.

Next Page(s)

Operating Data: Includes important design factors such as limits applicable to bearings, seals, casing, shafting, etc.

Materials: Includes a listing of allowable materials for the major components for compatibility with the intended utilization.

Maintenance Requirements: Includes design information required for planning ships installation and system design.

List of Suppliers: A current list of those manufacturers known to be satisfactory suppliers of the standard pump

Spare Parts Recommendations:

Test: Required tests at vendor

Standard Identification CP-CC-A

1. SCOPE

1.1 This specification covers electric motor driven standard close-coupled, single stage, centrifugal pumps. It is the intention of this Standard that pumps of a given capacity in gallons per minute (g.p.m.) and total dynamic head in feet and type of electrical voltage, from all sources of supply, be interchangeable as to mounting dimensions, size and location of piping connections, ~~shaft extension, shaft sleeve, and flinger as outlined in this specification.~~ and outline dimensions

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of the standard to the extent specified herein.

Screw thread standards
bearing standards

2.2 Other publications. - The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

HYDRAULIC INSTITUTE
Test Code of Standards - Centrifugal Pump Section

(Application for copies should be addressed to the Hydraulic Institute, 122 East 42nd Street, New York 17, N.Y.)

NATIONAL BUREAU OF STANDARDS
Handbook H28 - Screw-Thread Standards ~~for Federal Services.~~

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington 25, D.C.)

OFFICIAL CLASSIFICATION COMMITTEE
Uniform Freight Classification Rules.

(Application for copies should be addressed to the Official Classification Committee, 1 Park Avenue at 33rd Street, New York 16, N.Y.)

3. REQUIREMENTS

3.1 Materials. - For the materials of construction of major parts of pumps covered by this specification see table I. of section 6. This table lists a number of materials which are considered adequate for the applications, and the table should be followed; however, this ~~specification~~ Standard is not intended to be restrictive provided proposed alternate materials will give equal or better service, and ~~[illegible] approval is obtained prior to offering equipment in response to invitations.~~ other [illegible]

3.2 Design. -

3.2.1 General design. -

3.2.1.1 The principle of reliability is paramount and no compromise of this principle shall be made with any other basic requirements of design. Pumps shall be designed to operate over a long period of years with a minimum of servicing. Where wear or erosion is unavoidable, the parts subjected to such wear or erosion shall be of the best materials available for the purpose intended in order to reduce these detrimental effects to a minimum. The design and construction of all pumps shall be consistent with the following requirements:

(a) Reliability.
(b) Accessibility for repair.
(c) Resistance to wear or corrosion.
(d) Economy.
(e) Satisfactory operation when inclined as follows:
  (1) Up to 15 degrees from the normal horizontal position in any direction (permanently inclined).
  (2) With the ship rolling up to 45 degrees from the vertical to either side.
  (3) With the ship pitching 10 degrees up and down from the normal horizontal plane.

3.2.1.2 The design of the pump units shall be such as to permit handling, shipment and installation of the units onboard ship without disturbing alignment; and such that the normal distortion, weaving or vibration of the supporting structures onboard ships cannot cause fracture or appreciable distortion.

3.2.1.3 Pumps for a specific application shall be selected and specified from rating chart figure 1 for alternating current (a.c.) motors, or from rating chart figure 2 for direct current (d.c.) motors. Bidders shall quote on the standardized pump size and with the horsepower (hp.) and speed motor as indicated on rating chart for the application.

3.2.1.4 All pumps for all services shall have constantly rising head-capacity curves from maximum or wide-open capacity to zero or shut-off capacity.

3.2.1.5 All pumps shall be designed for satisfactory operation at a minimum dynamic suction lift of 15 feet of water at 85°F.

3.2.1.6 All pump units shall have nonoverloading hp. characteristics.

3.2.1.7 All pumps shall be right hand rotation (clockwise when viewed from motor end of unit) only.

3.2.1.8 Casing wearing rings shall be fitted in all pumps.

3.2.1.9 Pump casing joints shall be made up using compressed asbestos sheet gaskets.

3.2.1.10 Mounting.-

3.2.1.10.1 Installation.- All pumps will be normally installed to operate in horizontal position; however, all pumps shall be capable of operation in a vertical position with the motor above the pump. Pumps shall be suitable for installation either fore and aft or athwartship.

3.2.1.10.2 Dimensions.- All pumps shall have mounting dimensions and location of piping connections as shown on figure 3.

3.2.1.10.3 Mounting brackets.- Mounting brackets shall contain a drip pocket for the collection of leakage from the stuffing box. Size of the tapped holes shall be as shown on figure 3. Mounting brackets shall be separate from the casings and shall not include pump stuffing box as any portion of the casing in contact with water.

3.2.1.10.4 Pumps and motors shall be assembled at the pump manufacturers plant.

3.2.2 Casings.-

3.2.2.1 The design of casings shall be sufficiently rugged to withstand without fracture or appreciable distortion the strains to which they may be subjected.

3.2.2.2 Casings shall be so designed as to permit the inspection and replacement of wearing parts. Suction covers shall be removable to permit removal of the impeller and other wearing parts of the pump without dismounting the unit.

3.2.2.3 All pumps shall have casings arranged so that the discharge can be located in any of the three positions shown on figure 3.

3.2.2.4 All casings shall be provided with the necessary tapped vent, drain, priming, and gauge connections for the three positions of discharge.

3.2.2.5 All casings shall be provided with vent cocks in the proper location for the position of discharge.

3.2.2.6 Casings shall be designed to withstand the applicable hydrostatic pressures specified in figure 3 (see 4.4).

3.2.2.7 Suction and discharge connections.- Suction and discharge connections shall be flanged. Diameter, thickness and drilling shall be in accordance with [illegible]. Bolt holes shall straddle the vertical centerline at the top of the flange.

3.2.3 Impellers and shafts.-

3.2.3.1 Impellers shall be of the single inlet closed type. Outside and inside surfaces of impellers shall be smooth finished. All impellers shall be dynamically balanced.

3.2.3.2 Shaft flingers shall be provided adjacent to stuffing boxes for all pumps. For pumps with packing, the flingers shall be in accordance with figure 5. For pumps fitted with mechanical seals suitable flingers shall be provided.

3.2.4 Stuffing boxes and packing.-

3.2.4.1 Stuffing boxes shall be of adequate depth and design to reduce leakage to a minimum under all operating conditions. ~~A minimum of [illegible] of packing is required for each stuffing box.~~ Stuffing boxes shall be equally adaptable for packing and mechanical seals.

3.2.4.2 The design shall be such as to insure that leakage from the glands cannot reach the bearings or be thrown over the driving units. Ample drip pockets and drains shall be provided. Sufficient space shall be provided to permit easy removal of packing.

3.2.4.3 Mechanical shaft seals shall be provided in lieu of conventional packing when specified (see 6.1).

3.2.5 Rotating assembly.-

3.2.5.1 All rotors shall be dynamically balanced with all rotating parts connected thereto. This requires dynamic balance with the rotating elements of the driving unit in place; however, rotating parts may be balanced individually provided that when assembled the unbalance shall not exceed the limits specified in . STD-167.

3.2.6 Threaded parts.-

3.2.6.1 Threaded parts such as bolts, studs and nuts shall conform to Handbook H28. ~~[illegible]~~

3.2.6.2 Studs and bolts shall fully engage the nuts with not more than three threads extending beyond the outer face of the nut. Where the material into which the stud is engaged is as hard or harder than the stud, the engagement shall be equal to at least the stud diameter. In other materials, engagement shall be sufficient to carry the maximum designed stud load.

3.2.7 Motors.-

3.2.7.1 The standardized frame numbers for the various ratings of close-coupled pump motors shall be as specified in tables III and IV. Frame flange and shaft extension dimensions shall be as shown on figures 6 and 7 as applicable.

Table III - A.C. motors

50°C. ambient, class B insulation (or class H insulation, class B temperature limits where advantageous (see 3.2.9).

Frame No.	Constant speed		
	3500 r.p.m.	1750 r.p.m.	1150 r.p.m.
	hp.	hp.	hp.
17NC		1/3	
18NC	1/2, 3/4	1/2	
182CN	1, 1-1/2, 2	3/4, 1	
184CN	3	2	
213CN	5	3	
215CN	7-1/2	5	
254CN	10	7-1/2	5
256CN	15	10	7-1/2
284CN		15	10
286CN	20		
364CN1		15, 20, 25	15, 20, 25

Table IV - D.C. motors

50°C. ambient, class B insulation (see 3.2.10).

Frame No.	Constant speed			
	3500 r.p.m.	2800 r.p.m.	1750 r.p.m.	1150 r.p.m.
	hp.	hp.	hp.	hp.
17NC	1/3		1/3	
18NC	1/2, 3/4		1/2	
186CN	1		3/4	
187CN	1-1/2		1	
216CN	2			
218CN	3		2	
254CN	5		3	
256CN	7-1/2		5	
264CN	10		7-1/2	
286CN	15		10	
324CN				5
326CN		20	15	7-1/2
365CN1			15, 20	10
366CN1			25	
405CN1				15
444CN1				20
				25

3.2.9 Alternating current motors.-

3.2.9.1 Alternating current motors shall be in accordance with IEEE STD ~~[illegible]~~ for fractional hp., or ~~M-17060 for~~ integral hp., except as otherwise specified herein, and shall conform to the following classification requirements:

- Service .... A.
- Ambient temperature .... 50°C.
- Duty .... Continuous.
- Classification .... Squirrel cage induction.
- Sub-classification .... Design B for integral horsepower motors.
- Bearings .... Ball (see figures 6 and 7).
- Insulation .... Class B or H with class B limits.
- Number of phases .... Three.
- Frequency .... 60 cycles.
- Voltage .... 440 volts.
- Enclosure .... Totally enclosed, or totally enclosed fan cooled.

STD

3.2.9A Direct current motors.-

3.2.9A.1 Direct current motors shall be in accordance with IEEE STD [illegible] for integral hp., [illegible] 17556 for fractional hp., except as otherwise specified herein, and shall conform to the following classification requirements:

Service	A.
Ambient temperature	50°C.
Duty	Continuous.
Voltage	115 or 230 volts as specified (see 6.1).
Winding	Shunt.
Bearings	Ball (see figures 6 and 7).
Insulation	Class B.
Enclosure	Totally enclosed or totally enclosed fan cooled.

3.2.9A.2 Speed tolerance.- The full load speed of d.c. constant speed motors at operating temperature shall be not less than 98 percent nor more than 103 percent of the specified speed for integral hp. motors, and not less than 97 percent nor more than 108 percent of the specified speed for fractional hp. motors.

3.3 Painting.- All external unmachined surfaces of ferrous metal parts, except stainless steel, shall be thoroughly cleaned and coated with paint

3.4 Identification plates.-

3.4.1 Identification plates shall be furnished on each pump

3.4.2 Pump identification plates shall contain data as follows:

(a) Manufacturer's name.
(b) Manufacturer's model or type and size.
(c) Service application.
(d) Manufacturer's serial number.
(e) Salient design characteristics:
 (1) Capacity in g.p.m.
 (2) Total head in pounds per square inch.
 (3) Speed of shaft in revolutions per minute.
 (4) Brake horsepower.
 (5) Test pressure.
 (6) Special data vital to the unit:
  a. Suction pressure.
  b. Submergence.
  c. Impeller diameter.
(f) Contract or order number (and item number for multiple unit orders).
[illegible] number.
(g) Section for inspector's stamp.
(h) [illegible] standard pump number.

3.8.4 Each driving unit and each accessory unit shall have an identification plate [illegible].

3.9 Workmanship.- The equipment, including all parts and accessories shall be manufactured and finished with first class workmanship in all respects.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection.- Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable.

4.2 Quality control system.- The contractor shall provide and maintain a quality control system [illegible] for the supplies covered by this standard. [illegible] Q-9858 [illegible].

4.2.1 Description of procedures.- Procedures shall be assembled in manual form and shall indicate organization and responsibility for the control of quality.

4.2.2 Inspection during manufacture. - The contractor shall establish and maintain inspection at appropriately located points in the manufacturing process, beginning with the receipt of raw materials and subcontracted parts through final testing and preparation for shipment of completed units, to assure continuous control of quality of parts, components and assemblies.

4.2.3 Measuring and testing equipment. - The contractor shall provide and maintain gages, instruments and other measuring and testing devices necessary to assure that supplies conform to contract requirements. These devices shall be calibrated against measurement standards or designated measuring equipment at established periods to assure continued accuracy. The contractor shall prepare and maintain a written schedule for the maintenance and calibration of such equipment based on the type, purpose and degree of usage.

4.2.3.1 All instruments used in performance tests shall be calibrated before and after tests.

4.3 Inspection of material. -

4.3.1 Materials used in the pumps and accessories and identified on approved drawings ~~[illegible]~~ listed in table I or elsewhere in this specification, shall be subjected to inspection requirements ~~of the applicable specification by which identified.~~

4.3.2 Materials used in the pumps and accessories which are identified on approved drawings by Industry and Technical Society specifications or standards shall be subjected to inspection requirements of the applicable specification or standard by which identified.

4.3.3 The contractor shall establish a system of inspection and identification to insure that specified and approved materials are used in accordance with approved drawings.

4.3.3.1 Upon request of the ~~[illegible]~~ inspector, the contractor shall furnish samples of materials and available information concerning their quality and use. When the identity or quality of an item is in doubt, and in the absence of valid and acceptable test data, the contractor shall conduct such tests as are necessary to determine or verify its identity or quality.

4.4 Hydrostatic tests. -

4.4.1 All pump casings shall be tested hydrostatically to pressures indicated in figure 3. Hydrostatic test pressures shall be maintained for at least 15 minutes, or longer as necessary for inspection of the entire casing.

4.5 Operating test of each pump. - Each pump assembled with its driving motor shall be tested at its rated operating speed and rated load by a continuous nonstop run of at least 30 minutes, to check operation and smoothness of running.

4.6 Performance tests. -

4.6.1 Performance tests shall be conducted and reported in accordance with the Test Code of Standards of the Hydraulic Institute, Centrifugal Pump Section, for tests classed as "Factory tests at the pump manufacturer's plant".

4.6.2 Driving units shall be tested as required by the applicable motor ~~specifications~~ (see 6.1).

4.6.3 Performance tests shall adequately demonstrate the ability of the pump to handle its rated capacity of specified liquid at the maximum temperature and minimum suction head, or maximum suction lift or vacum, as applicable.

4.6.4 Sufficient data shall be taken during the tests to prepare pump characteristic curves as specified in 4.6.5. In all cases the test data shall be corrected to the specified operating conditions as to voltage, frequency, temperatures, specific gravity, suction head or lift, and vacum, as set forth in the contract or order; such conditions shall be clearly shown on the data sheets. The data sheets shall state the actual finished diameter of the pump impellers installed on test. Test data and curves shall be complete over the entire range of capacities from shut-off to as near free delivery as possible.

4.6.5 The following test curves shall be supplied for the rated speed conditions of the motor:

(a) Capacity versus total head.
(b) Capacity versus pump efficiency.
(c) Capacity versus brake hp.
(d) Capacity versus electrical hp. input.

4.6.7 Complete test reports, including test data on both pumps and driving units, shall be ~~assembled~~ and distributed ~~[illegible]~~:

4.8 Inspection of pump repair parts. - The pump repair parts required by 3.7 shall be inspected to assure interchangeability with the similar parts in the ~~assembled pumps~~. Ordinarily material analyses and physical test specimens will not be required but such procedures shall be employed as will assure the delivery of parts made of the same materials and by the same processes as for the assembled pumps.

5. PREPARATION FOR DELIVERY

5.1 Domestic shipment and early equipment installation and for storage of onboard repair parts. -

5.1.1 Basic equipment or item. -

5.1.1.1 Preservation and packaging. - Preservation and packaging shall be sufficient to afford adequate protection against corrosion, deterioration and physical damage during shipment from the supply source to the using activity and until early installation and may conform to the suppliers commercial practice when such meets these requirements.

5.1.1.2 Packing. - Packing shall be accomplished in a manner which will insure acceptance by common carrier at the lowest rate and will afford protection against physical or mechanical damage during direct shipment from the supply source to the using activity for early installation. The shipping containers or method of packing shall conform to the Uniform Freight Classification Rules and Regulations or other carrier regulations as applicable to the mode of transportation and may conform to the supplier's commercial practice when such meets these requirements.

5.1.1.3 Marking. - Shipment marking information shall be provided on interior packages and exterior shipping containers in accordance with the contractor's commercial practice. The information shall include nomenclature, ~~Federal stock number or~~ manufacturer's part number, contract or order number, contractor's name and destination.

6. NOTES

6.1 Ordering data. - Procurement documents should specify the following:

(a) Title, number and date of this specification.
(b) Pump number (see figure 1).
(c) Rated capacity.
(d) Rated total head.
(e) Liquid handled.
(f) Specific gravity of liquid handled.
(g) Liquid temperature.
(h) Suction head.
(i) Whether mechanical seals are required ~~(see [illegible])~~.
(j) Voltage for direct-current motors ~~(see [illegible])~~
(k) Motor and controller specifications and electrical characteristics (as required by the applicable motor and controller specifications).
(l) ~~[illegible]~~ drawings required ~~(see [illegible])~~.
(m) Whether manuals are required, and quantity ~~(see [illegible])~~.
(n) The number of pumps per ship on which quantity of onboard repair parts is to be based ~~[illegible] and 3.7.1.1.2)~~.
~~(o) [illegible] for onboard repair parts (see [illegible])~~
(p) Cleaning, preservation, packaging and marking requirements. ~~5.1 (see 5.2)~~.

6.2 Table I offers a wide range of acceptable materials for various pump parts (see 3.1).

Table I - Materials for pumps.

Application	Material	~~Specification~~ STD	Applicable document[3/ 4/ 5/]
Casings	Gun metal		ASTM B143, Alloy 1A or 1B
	Valve bronze		ASTM B143, Alloy 2A-B61-52
	Copper-nickel alloy (70-30)		
	Nickel-copper alloy		
	Steel, highly alloyed[1/]		ACI CN-7M
Studs, bolts nuts	Nickel-copper alloy, rolled, class A or B		ASTM B164, Class A or B
	Naval brass		ASTM B124, Alloy 3-B21-54, Alloy A
	Manganese bronze, class A or B		ASTM B138, Alloy A or B - B124-55, Alloy 4
Impellers	Gun metal		ASTM B143, Alloy 1A or 1B
	Nickel-copper alloy[1/]		
	Copper-nickel alloy (70-30)		
	Steel, highly alloyed		ACI CN-7M
Impeller and casing wearing rings[2/]	Nickel-copper alloy[1/]		
	Gun metal		ASTM B143, Alloy 1A or 1B
	Bearing bronze, grade II or III		
	Valve bronze		ASTM B143, Alloy 2A - B61-52
	Steel, highly alloyed		ACI CN-7M
	Iron, class A (ductile Ni-resist)		
Shafts	Nickel-copper alloy, rolled, class A or B		ASTM B164, Class A or B
	Nickel-copper-aluminum alloy		
Shaft sleeves	Nickel-copper-aluminum alloy, minimum hardness 265 Brinell		
	Steel, highly alloyed		ACI CN-7M
Flinger	Gun metal		ASTM B143, Alloy 1A or 1B
	Valve bronze		ASTM B143, Alloy 2A - B61-52
Lantern rings, glands and throat bushings	Gun metal		ASTM B143, Alloy 1A or 1B
	Valve bronze		ASTM B143, Alloy 2A
Mounting brackets	Gun metal		ASTM B143, Alloy 1A or 1B
	Valve bronze		ASTM B143, Alloy 2A - B61-52
	Copper-nickel alloy (70-30)		
Impeller nuts	Gun metal		ASTM B143, Alloy 1A or 1B
	Nickel-copper alloy		ASTM B164, class A or B
Stuffing box packing	Plastic metallic, lead base		
	Flexible metallic		
Casing gaskets	Asbestos, sheet, compressed		

1/ For service in which total head is 224 feet or more.

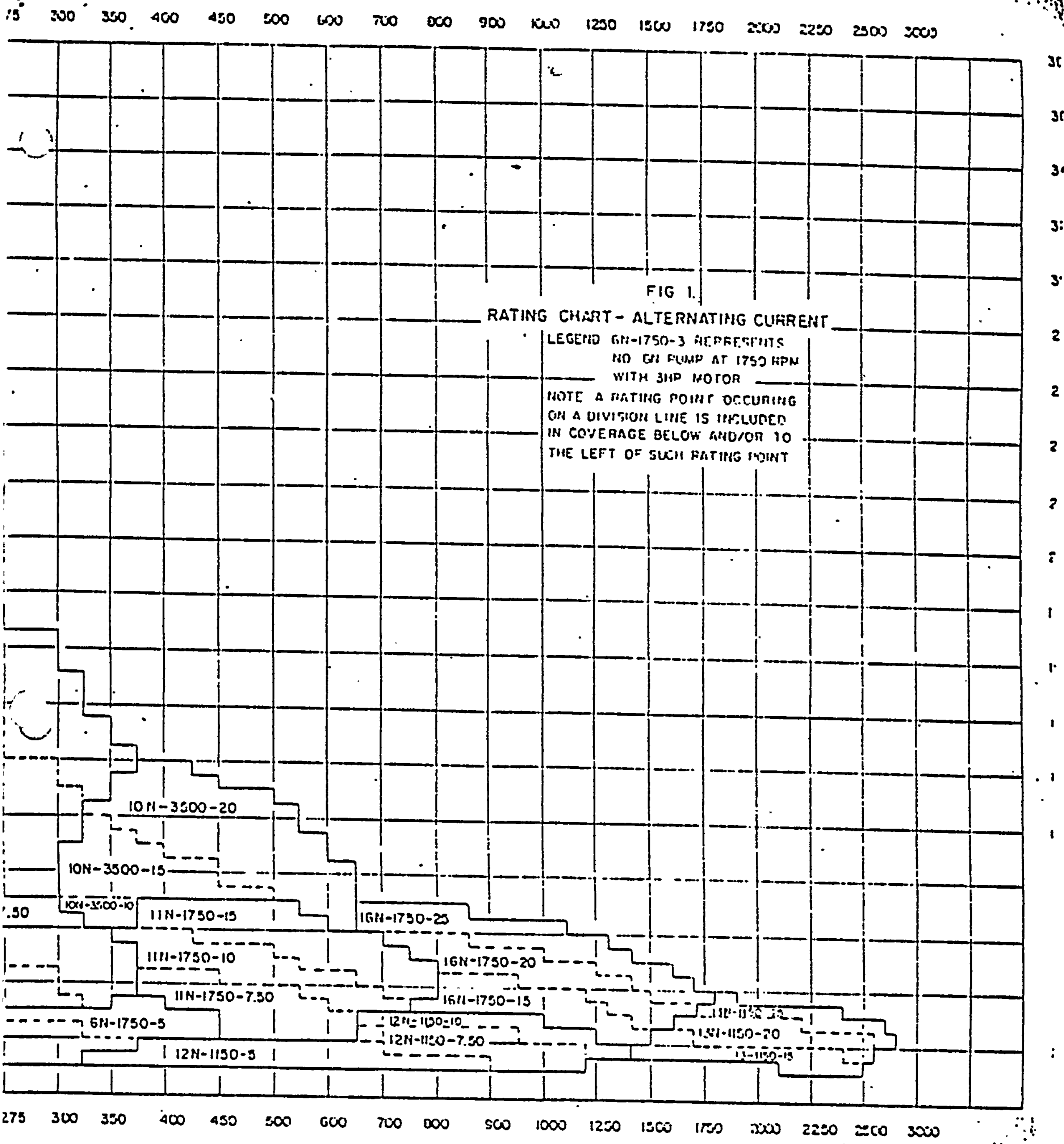
2/ A wearing ring and its opposing surface shall be of dissimilar material.

3/ "ASTM" denotes standard specifications of the American Society for Testing and Materials. (Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia 3, Pa.).
"ACI" denotes standard specifications of the Alloy Casting Institute. (Application for copies should be addressed to the Alloy Casting Institute, 1001 Franklin Avenue, Garden City, New York.)

Technical society and technical association specifications and standards are generally available for reference from libraries. They are also distributed among technical groups and using Federal agencies.

4/ Materials used may be in accordance with either Government specifications or ASTM specifications, or equivalent material to any other recognized industry standard specification, such as the Society of Automotive Engineers (SAE) and the American Iron and Steel Institute (AISI), at the pump manufacturer's option.

5/ Detail drawings and lists of material shall reference the specifications actually followed in each case, and shall include the class, type or grade of material used in each case, as applicable (see 3.1 and 3.5.5.1).



- Rating chart for a.c. motors.

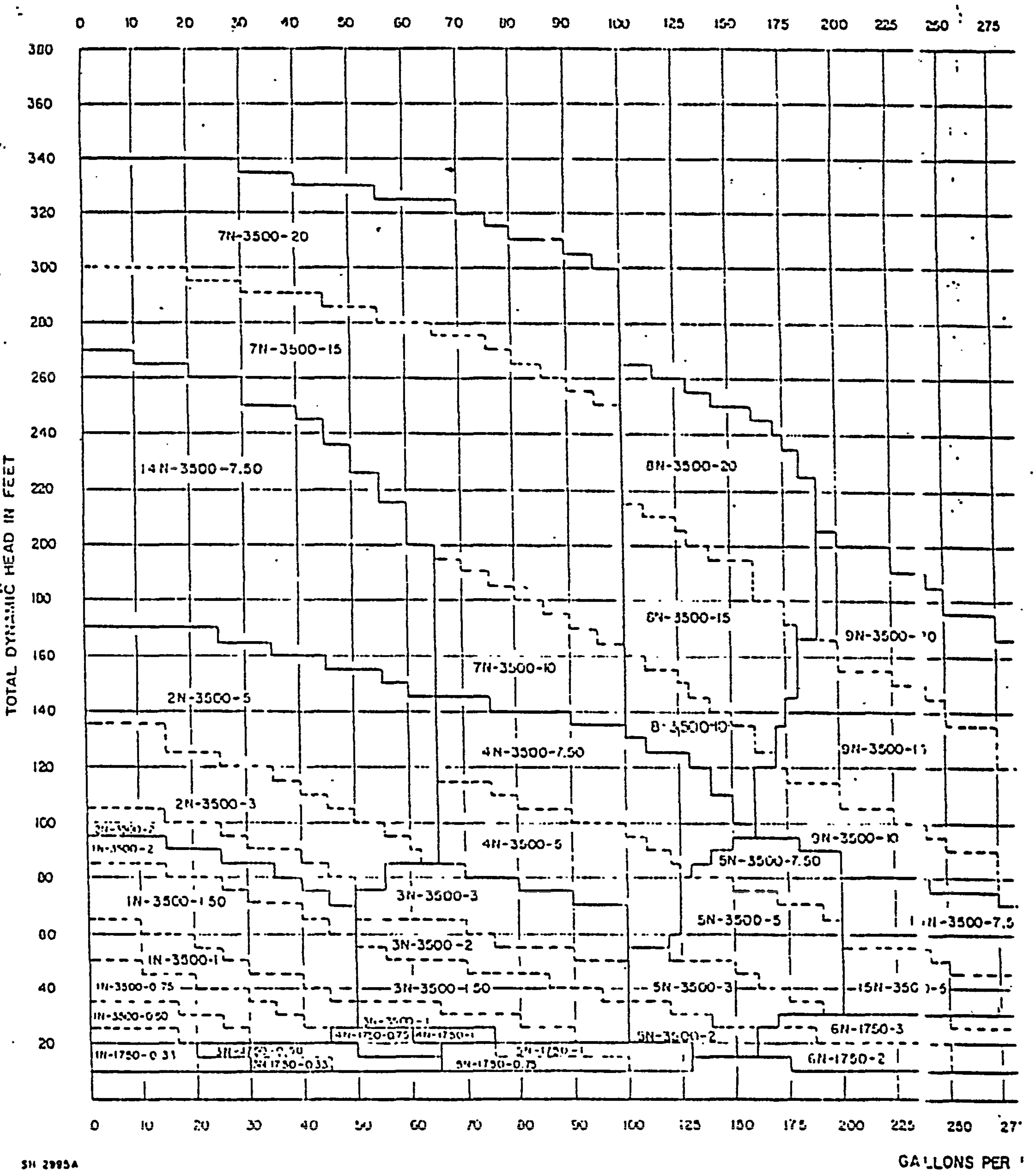
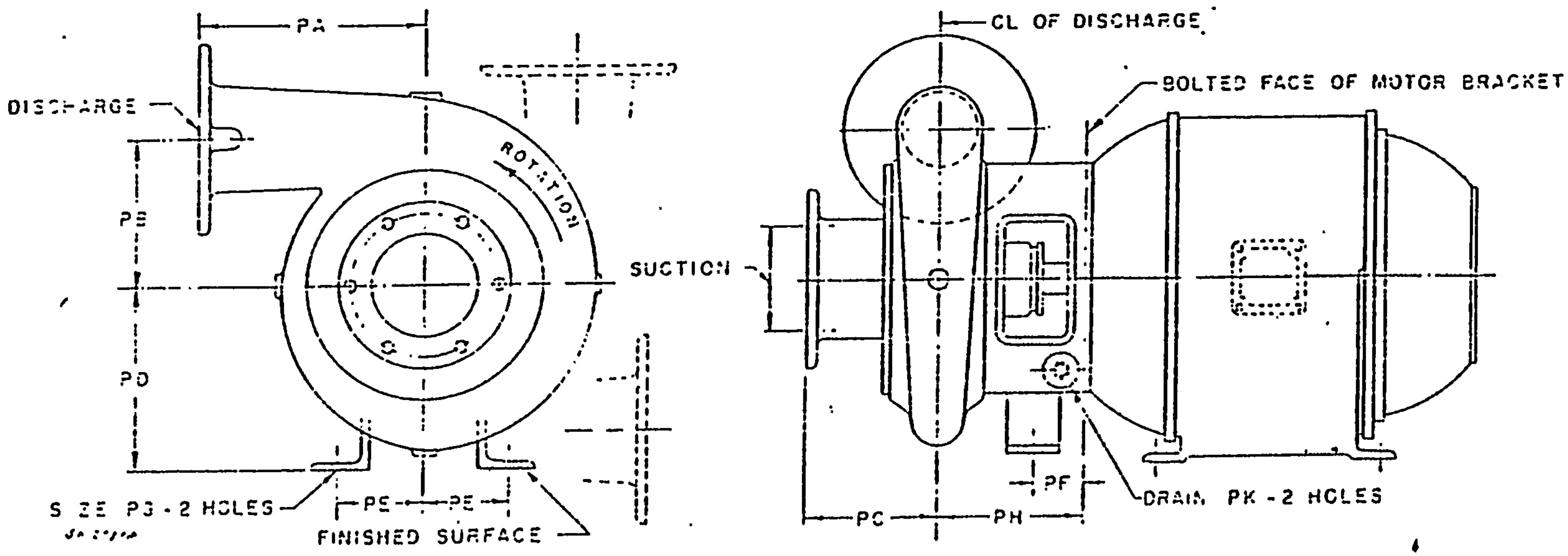

TOTAL DYNAMIC HEAD IN FEET
GALLONS PER
7N-3500-20
7N-3500-15
14N-3500-7.50
8N-3500-20
8N-3500-15
9N-3500-20
7N-3500-10
2N-3500-5
4N-3500-7.50
9N-3500-15
2N-3500-3
4N-3500-5
9N-3500-10
5N-3500-7.50
3N-3500-3
1N-3500-1.50
5N-3500-5
3N-3500-2
1N-3500-1
3N-3500-1.50
5N-3500-3
6N-1750-3
6N-1750-2
SH 2995A

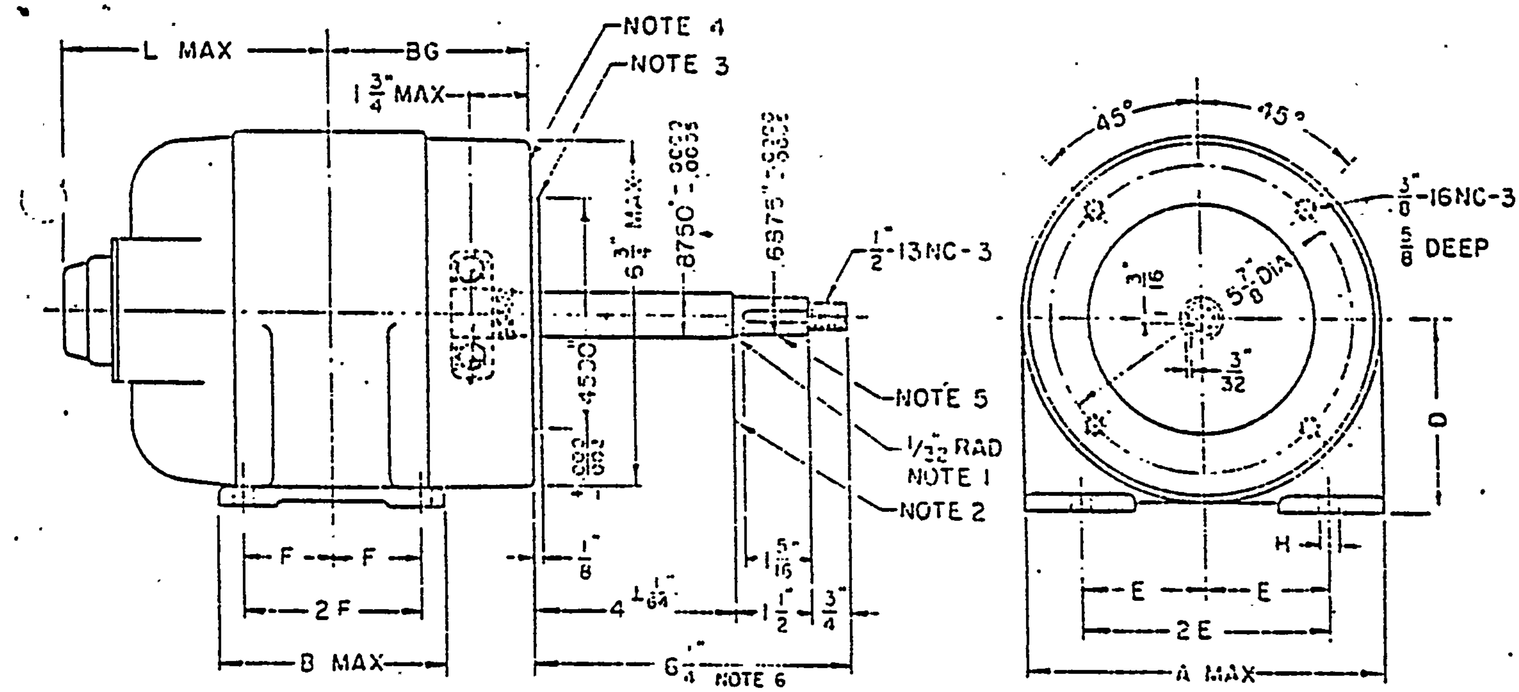
Figure 1. -



Pump No.	[illegible] size flange: Disch	[illegible] size flange: Suction	PA	PB	PC	Hydro-static test Press.	PD	PE	PF	PG	PK	Motor frame sizes: A. C.	Motor frame sizes: D. C.	PH	Group size shaft sleeve and water flinger
							3-1/2	2	2	17/32	3/8	17NC-18NC	17NC-18NC	5-7/8	S
[illegible]	[illegible]	1-1/4	4-3/4	3	3-1/4	75	4-3/4	2-1/2	2-3/8	17/32	1/2	182CN	156CN-157CN-216CN	6-1/4	S
[illegible]		1-1/4	5-1/4	3-3/4	5-1/4	125	4-3/4	2-1/2	2-3/8	17/32	1/2	182CN-184CN-213CN	215CN-218CN-254CN	5-1/4	S
[illegible]	1-1/4	1-1/2	4-3/4	3-1/8	3-1/2	75	3-1/2	2	2	17/32	3/8	17NC-18NC	17NC-18NC	5-7/8	S
							4-3/4	2-1/2	2-3/8	17/32	1/2	182CN-184CN	156CN-157CN-215CN-218CN	6-1/4	
[illegible]	1-1/2	2	5-1/2	3-3/4	3-3/4	150	4-3/4	2-1/2	2-3/8	17/32	1/2	182CN-213CN-215CN	186CN-187CN-215CN-258CN	8-1/4	S
[illegible]	2	2	5-1/4	3-1/4	4	75	4-3/4	2-1/2	2-3/8	17/32	1/2	182CN-184CN-213CN-215CN	186CN-187CN-216CN-218CN 254CN-256CN	9-1/4	S
[illegible]	2-1/2	2-1/2	7	5	4-1/2	50	4-3/4	2-1/2	2-3/8	17/32	1/2	184CN-213CN-215CN	215CN-254CN-256CN	6-1/4	S
[illegible]	[illegible]	2	5-3/4	3-1/4		[illegible]	7	4	4	21/32	3/4	254CN-256CN-215CN	254CN-256CN	8-3/16	M
[illegible]	[illegible]	2-1/2	5-1/2	5	4	150						254CN-256CN-215CN	254CN-256CN		
[illegible]	[illegible]	2-1/2	5	5-1/4	4-1/4	[illegible]						254CN-256CN-215CN	254CN-286CN-324CN		
[illegible]	2-1/2		5-1/2	4-1/2		125						254CN-256CN-284CN	284CN-286CN-324CN		
[illegible]	3	3	5-1/2	5-1/2		100						254CN-256CN-215CN	284CN-286CN-324CN		
[illegible]		3	4-1/2	3	6	50						254CN-256CN-215CN	286CN-324CN-326CN		
[illegible]		3	11-1/2	[illegible]	16-1/2	50	11	11	15-3/4	25/32	3/4	364CN1	364CN1-404CN1-444CN1	9-1/2	L
[illegible]		1-1/4	5	3-1/4	4-1/2	[illegible]	4-3/4	2-1/2	2-3/8	17/32	1/2	213CN	256CN	6-1/4	S
[illegible]	[illegible]	1-1/2	6	3-3/4	4-1/4	[illegible]	4-3/4	2-1/2	2-3/8	17/32	1/2	213CN-215CN	254CN-256CN	6-1/4	S
[illegible]		8	9-1/2	5	6-1/2	100	11	11	14-1/2	25/32	3/4	364CN1	365CN1-366CN1	9-1/2	L
[illegible]	2-1/2	3	5	5-1/2	4-3/4	250	7	4	4	21/32	3/4	326CN-364CN	326CN	8-3/16	M

*Supporting feet part of volute casing or cover.

Figure 3. - Outline dimensions for close-coupled pumps.



STANDARD FRAME DIMENSIONS AND BEARING SIZES FOR FRACTIONAL HORSEPOWER CLOSE-COUPLED MOTORS

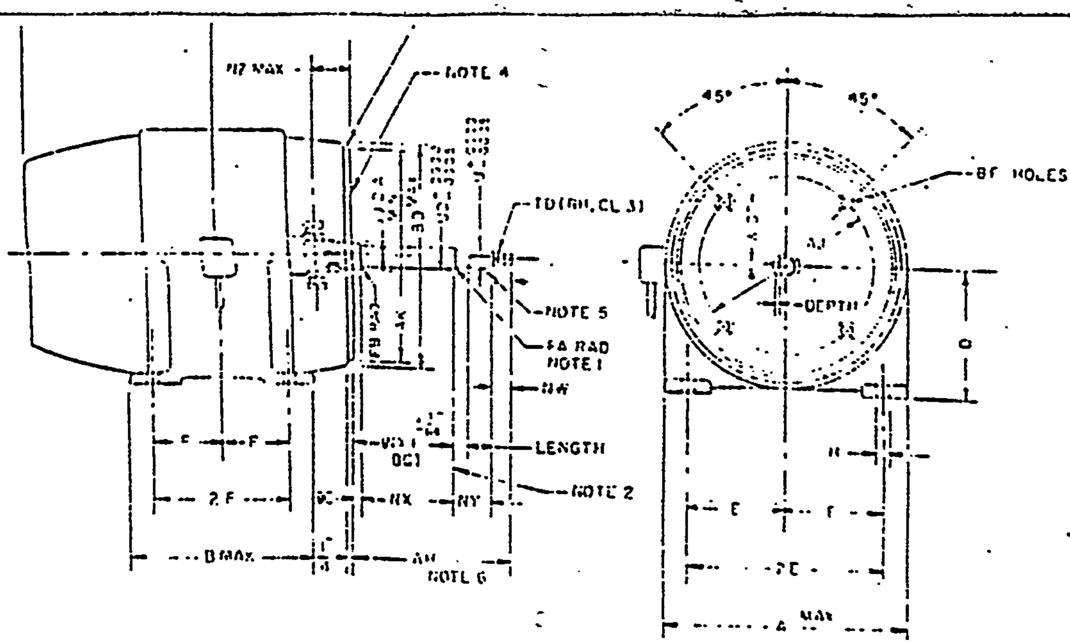
DIMENSIONS IN INCHES

FRAME NO.	A MAX	B MAX	D	E	F	H	BG	FRONT END BRG. (MIN)	PUMP END BRG. (MIN.)	L MAX	MAX WT LB
17NC	9	7	4 3/16	3 7/16	2 1/2	17/32	5 5/8	303	305	7 7/16	75
18NC	10	7 1/2	4 5/8	4	2 3/4	17/32	5 7/8	303	305	7 3/4	90

Figure 6. - Standard dimensions of fractional hp. close-coupled motors.

NOTES:

1. RADIUS SHALL BE SMOOTH AND CENTER LOCUS CONCENTRIC WITH SHAFT AXIS.
2. SEALING SURFACE SHALL BE SMOOTH AND PERPENDICULAR TO SHAFT AXIS.
3. DIAMETER TO BE CONCENTRIC WITH SHAFT AT IMPELLER LOCATION WITHIN 0.004 INCH TOTAL INDICATOR READING
4. FACE OF FLANGE TO BE SQUARE WITH SHAFT WITHIN 0.004 INCH TOTAL INDICATOR READING.
5. RUNOUT OF SHAFT 0.002 INCH MAXIMUM TOTAL INDICATOR READING.
6. TOTAL AXIAL END-PLAY OF SHAFT IN ASSEMBLED MOTOR AT NO-LOAD SHALL NOT EXCEED 0.010 INCH



NOTES:

1. RADIUS SHALL BE SMOOTH AND CENTER LOCUS CONCENTRIC WITH SHAFT AXIS.
2. SEALING SURFACE SHALL BE SMOOTH AND PERPENDICULAR TO SHAFT AXIS.
3. DIAMETER TO BE CONCENTRIC WITH SHAFT AT "U" DIMENSION WITHIN 0.004 INCH TOTAL INDICATOR READING.
4. FACE OF FLANGE TO BE SQUARE WITH SHAFT WITHIN 0.004 INCH TOTAL INDICATOR READING.
5. THE SHAFT RUNOUT SHALL BE AS FOLLOWS:

FRAME SIZE	SHAFT RUNOUT (TIR)
182 THRU 286	0.002 INCH MAX.
324 THRU 444	0.003 INCH MAX.

6. TOTAL AXIAL END-PLAY OF SHAFT IN ASSEMBLED MOTOR AT NO-LOAD SHALL NOT EXCEED 0.010 INCH FOR 310 OR SMALLER BEARINGS AND 0.015 INCH FOR BEARINGS LARGER THAN 310.

STANDARD FRAME FLANGE AND SHAFT EXTENSION DIMENSIONS AND BEARING SIZES FOR INTEGRAL HORSEPOWER CLOSE-COUPLED MOTORS

DIMENSIONS IN INCHES

FRAME NO	A MAX	B MAX	D	E	F	H	[illegible]	FRONT END BRG (MIN.)	PULLEY END BRG (MIN.)	[illegible] MAX	AJ	AK	BC	BF TAP	BF [illegible]	AH	BW	[illegible]	[illegible]	TD	U	UD	FA	FB	KEYWAY [illegible]	KEYWAY [illegible]	KEYWAY LENGTH	[illegible] END	[illegible] MAX	UU	L (MAX) AC	L (MAX) DC	MAX WT LBS AC	MAX WT LBS DC
182 CN	9	[illegible]	[illegible]	3¾	2¼	[illegible]	[illegible]	305	307	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7¾		95	
186 CN		9			3½			304																								12[illegible]		140
184 CN		7½			2¾			305																							8¾		120	
187 CN		10			4			306																								12[illegible]		150
213 CN	10½	7½	5¼	4¼	2¾			305	308																						9½		155	
216 CN		10			4				307																							12¾		215
215 CN		9			3½				308																						10		185	
218 CN		12			5				307																							13[illegible]		250
254 CN	12½	[illegible]	6¼	5	4[illegible]			306	308																							15[illegible]		315
256 CN		12½			5																											16½		365
254 CN		[illegible]			4[illegible]				310																						[illegible]¾		275	
256 CN		12½			5																										[illegible]¾		335	
284 CN	14		7	5½	4[illegible]			308	312																						13½		395	
284 CN								307	310																							17½		415
285 CN		14			5½			308	312																						14		475	
286 CN								307	310																							18¾		465
324 CN	16		8	6¼	5¼			309	312																							19½		530
326 CN		15½			6																											20¾		605
364 CNI	18	[illegible]	9	7	5⅝			310	312																						16		420	
365 CNI		[illegible]			6⅛																											21¼		875
366 CNI		18			7																											22[illegible]		975
405 CNI	20	[illegible]	10	8	[illegible]																											22¾		[illegible]05
444 CNI	22	18[illegible]	11	9	[illegible]			31[illegible]	31[illegible]																							[illegible]¾		[illegible]

Figure 7 — [illegible] integral hp close coupled pumps.