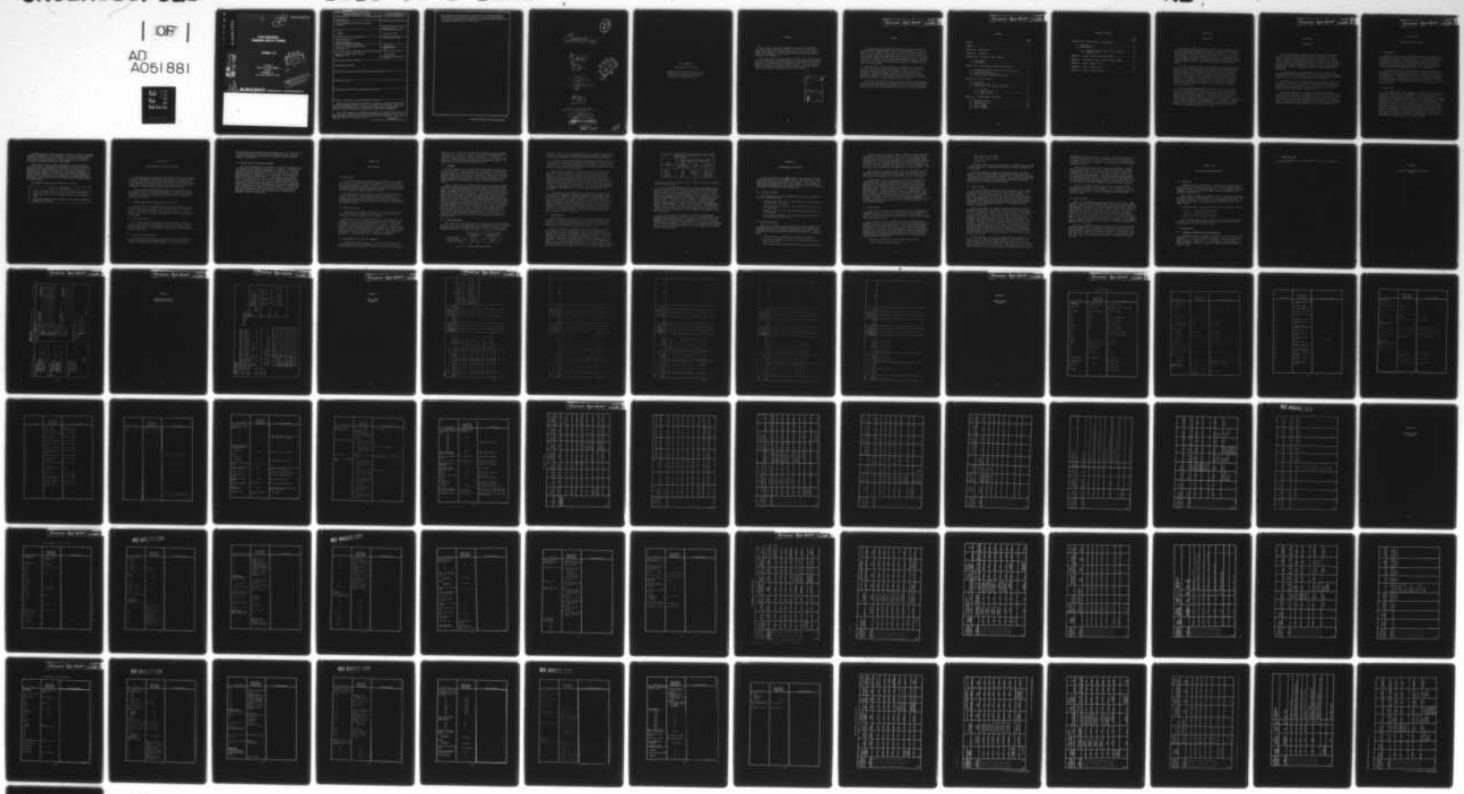
AD-A051 881 ARINC RESEARCH CORP ANNAPOLIS MD F/G 5/1
LO-MIX MAINTENANCE ENGINEERING ANALYSIS TECHNIQUE,(U)
NOV 74 W ROSE, J SMALL N00123-73-C-1698
UNCLASSIFIED 1616-09-3-1341 NL

| OF |
AD
A051 881



END
DATE
FILMED
5-78
DDC

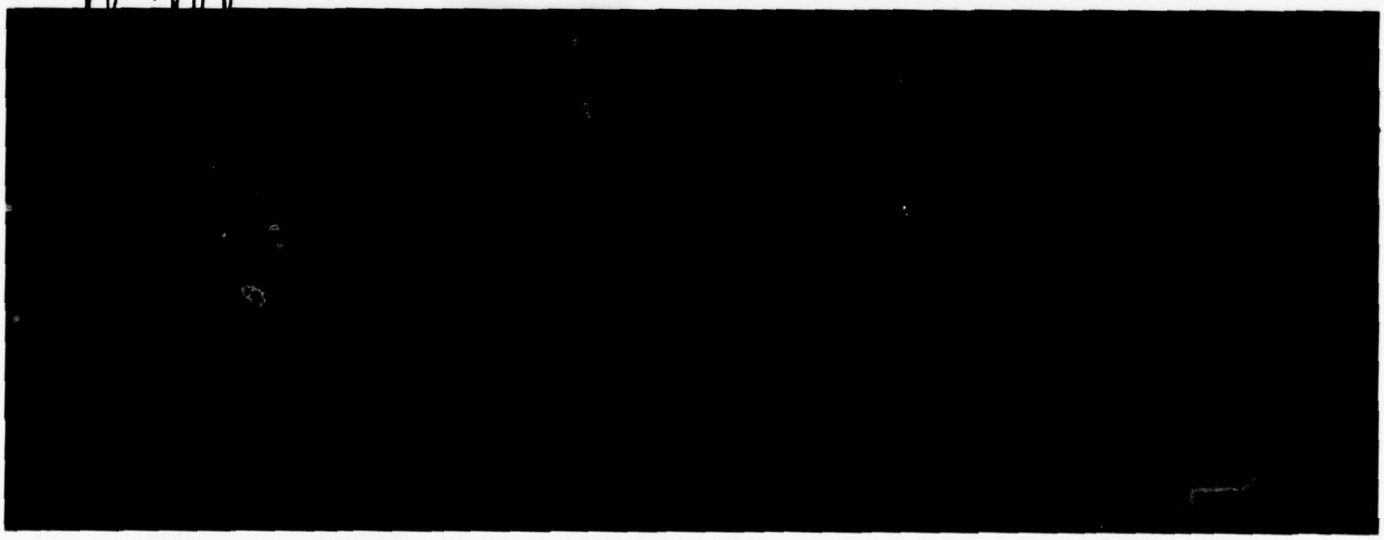
Publication 1616-09-3-1341

LO-MIX MAINTENANCE ENGINEERING ANALYSIS TECHNIQUE

NOVEMBER 1974

Prepared for
NAVAL SEA SYSTEMS COMMAND
PMS-306
WASHINGTON, D.C.
under Contract N00123-73-C-1698

ARINC RESEARCH CORPORATION



UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 1616-09-3-1341	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) LO-MIX MAINTENANCE ENGINEERING ANALYSIS TECHNIQUE		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER 1616-09-3-1341
7. AUTHOR(s) W. Rose J. Small		8. CONTRACT OR GRANT NUMBER(s) N00123-73-C-1698
9. PERFORMING ORGANIZATION NAME AND ADDRESS ARINC Research Corp. 2551 Riva Road Annapolis, Maryland 21401		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS NAVAL SEA SYSTEMS COMMAND PMS-306 WASHINGTON, D.C.		12. REPORT DATE NOVEMBER 1974 13. NUMBER OF PAGES 48
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) NAVAL SEA SYSTEMS COMMAND PMS-306 WASHINGTON, D.C.		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

15. DISTRIBUTION STATEMENT (of this Report)

UNCLASSIFIED/UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

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

ARINC Research Corporation developed a technique for performing Maintenance Engineering Analyses (MEA) on units of the LO-MIX class of ships. Less costly and time-consuming than the procedures of Military Standard MIL-M-24365A, it permits rapid identification of maintenance engineering requirements.

This report presents the conditions and events that created the need for the new technique, identifies the initial requirements and assumptions made prior

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

to development of the technique, and outlines the various MEA methods considered in selecting the basic approach. It also provides details of applying the technique and describes a feasibility demonstration of the technique conducted as part of the contract.

27

6

LO-MIX MAINTENANCE ENGINEERING ANALYSIS TECHNIQUE

11

November 1974

12

82p.

Prepared for

Naval Sea Systems Command
PMS-306
Washington, D.C.

under Contract N00123-73-C-1698

15

by

10

W. Rose
J. Small

ARINC Research Corporation
a Subsidiary of Aeronautical Radio, Inc.
2551 Riva Road
Annapolis, Maryland 21401

Publication 1616-09-3-1341

14

400 247

1B

Prepared under Contract N00123-73-C-1698
which grants to the U.S. Government a
license to use any material in this pub-
lication for Government purposes.

ABSTRACT

ARINC Research Corporation developed a technique for performing Maintenance Engineering Analyses (MEA) on units of the LO-MIX class of ships. Less costly and time-consuming than the procedures of Military Standard MIL-M-24365A, it permits rapid identification of maintenance engineering requirements.

This report presents the conditions and events that created the need for the new technique, identifies the initial requirements and assumptions made prior to development of the technique, and outlines the various MEA methods considered in selecting the basic approach. It also provides details of applying the technique and describes a feasibility demonstration of the technique conducted as part of the contract.

SUMMARY

A technique was developed for performing a Maintenance Engineering Analysis (MEA) of HM&E, ordnance, and electronic equipments on the LO-MIX class of ships in a manner that is less time-consuming and less costly than analyses performed in accordance with Military Standard MIL-M-24365A (General Specification for Maintenance Engineering Analysis). This LO-MIX MEA technique (LMMEA) helps the user compare the known technical characteristics of a particular unit with better known technical characteristics of similar units to identify the maintenance engineering requirements of the unit under consideration.

The technique is versatile because it is applicable to equipments for which there are no historical maintenance data as well as to those for which data are available. The technique can also be applied to equipments regardless of whether or not they have been subjected to maintenance engineering analysis conforming to MIL-M-24365A. Analyses performed by means of the technique are compatible with the input requirements of the Trident Integrated Logistic Support System.

This effort concentrated on developing the technique and demonstrating its validity by applying it to several equipments. The technique provided results quickly when applied to equipments for which historical data were available as well as to equipments for which no such data were available.

CONTENTS

CONTENTS (continued)

CHAPTER ONE

INTRODUCTION

This report, prepared under Navy Contract N00123-73-C-1698, describes a method of performing Maintenance Engineering Analyses (MEA) on units (systems/subsystems/equipments/components) to be installed in the LO-MIX class of ships. This technique is less time-consuming and less costly than conforming to Military Standard MIL-M-24365A, and it enables maintenance engineers to identify maintenance engineering requirements quickly and with adequate accuracy. The maintenance support requirements identified for individual units can be used for planning Fleet logistics support.

The effort involved (1) identifying maintenance engineering requirements that are needed as inputs to an Integrated Logistic Support (ILS) Computer Program; (2) determining the applicability of various maintenance engineering analysis techniques to shipboard hull, mechanical, electrical (HM&E), electronic, and ordnance systems for LO-MIX ships; (3) selecting an approach; and (4) developing the technique and demonstrating its feasibility. This demonstration consisted of applying the technique to shipboard units, identifying the maintenance engineering requirements, describing how the data could be obtained, and showing that the technique provides the data inputs required for the Trident Logistic Data System.

Chapter Two presents background information on the development of the LO-MIX Maintenance Engineering Analysis Technique. Chapter Three identifies and describes the initial requirements and assumptions made prior to the technique development. Chapter Four presents various MEA methods identified and considered in selecting the basic approach. Chapters Five and Six are discussions, respectively, of the basic approach of the LMMEA Technique and the demonstration of the technique. Chapter Seven presents conclusions and recommendations. The appendixes present methods of recording data (A and B) and data accumulated during demonstration of the LMMEA technique (C, D, and E).

CHAPTER TWO

BACKGROUND

The Trident Integrated Logistic Support System has been designated as the Logistics Data System (LDS) to be used to identify the total Logistics Support Package for the LO-MIX class of ships. The primary input to the LDS is the Maintenance Engineering Analysis, which identifies the support and maintenance engineering requirements for individual systems, equipments, and components. Because of time and cost constraints, standard MEAs cannot be performed for LO-MIX ships in accordance with MIL-M-24365A. However, support requirements for LO-MIX ships must be identified.

The Standard MEA is normally performed within the context of a predetermined maintenance philosophy (e.g., piece-part repair, discard on failure, etc.). In the case of LO-MIX ships, the MEA must be performed in the context of the LO-MIX modular-maintenance philosophy.

Historically, MEAs have relied heavily on the results of physical testing of a component or on extensive historical maintenance data on the component. For components in the LO-MIX class of ships, maintenance engineering requirements must be identified in many cases without the benefit of physical testing or historical data.

The technique developed is capable of identifying maintenance engineering requirements with or without the benefit of historical maintenance data or data derived from physical testing. The technique depends on comparisons of component similarities and on the use of an analysis sheet to identify maintenance engineering requirements for a particular unit. Components are grouped by kind or type, and similarity association is used to analyze the maximum number of units in the shortest time.

CHAPTER THREE

SELECTION OF BASIC APPROACH

3.1 REQUIREMENTS

Because of the tight schedule for introducing the LO-MIX ships into the operational Fleet, the first requirement of the LMMEA technique was to compress the schedule for MEA development. A goal was established to design a technique that would allow the performance of an MEA in three months or less for any unit considered. The much shorter time required to perform the LMMEA assures that it will cost substantially less than analyses performed in accordance with MIL-M-24365A.

The identification of a complete Logistics Support Package for the LO-MIX class of ships will require the use of a computer program for data handling. The Trident LDS program has been selected for handling the LMMEA outputs. Consequently, the data resulting from the performance of an LMMEA must be compatible with the Trident or similar LDS program. A single concession has been made: cost and time savings will result in a loss of accuracy. A major objective of this effort was to minimize the accuracy loss.

3.2 ASSUMPTIONS

It was assumed that similar equipment types have similar maintenance engineering requirements. That assumption was made following an analysis of HM&E and ordnance equipment designs. A typical example of similar equipments having similar maintenance engineering requirements is provided by two pumps: a Worthington Main Feed Pump and a Warren Auxiliary Condenser Condensate Pump. Both pumps are volute type with sectioned casings. Inspection, acceptance, and repair methods and criteria are the same for the casing, impeller, wear rings, shaft, and other items on both pumps. The primary maintenance engineering requirements for the two pumps are similar. For example, both pumps require wear-ring replacement. Once the maintenance support requirements for replacing the wear rings in the feed pump are identified, those same requirements can be used for the wear rings in the auxiliary condenser condensate pump. This concept of similarities is a major factor in the LMMEA technique.

The LMMEA technique will be applied to many units (systems, subsystems, equipments, components) in the LO-MIX Fleet. Since the units are numerous (2500 units initially nominated by NAVSEA), many will have technical similarities to other LO-MIX units. These similar units are assumed to have similar maintenance engineering requirements.

Where possible, new ship design employs units that are already in use in the Fleet. A restatement of this approach is that there will be technical similarities between some LO-MIX units and units in use in the operating Fleet. These similar units will have similar maintenance engineering requirements. The maintenance engineering requirements will differ, however, because the currently operating units have piece-part support and the LO-MIX units will be supported by a modular-maintenance philosophy. Level of repair will be the primary support element affected by this difference.

The foregoing assumptions are summarized in Table 3-1.

Table 3-1. ASSUMPTIONS

1. Similar equipment types have similar engineering requirements.
2. Some LO-MIX units will be technically similar to other LO-MIX units.
3. Some LO-MIX units will be technically similar to units already operating in the Fleet.

CHAPTER FOUR

IDENTIFICATION OF EXISTING APPROACHES

At the beginning of the project, maintenance engineering requirements of existing approaches were identified and examined. The objectives were to identify recent developments in maintenance engineering analysis, to find an approach that would be directly applicable to the LO-MIX technique requirements, and to establish a basis for selecting a valid approach to developing a LO-MIX Maintenance Engineering Analysis Technique.

Several existing approaches were examined. Of them, one approach was partially used in the technique developed. Most approaches required maintenance data that are not readily available. The following sections describe the rationale for complete or partial rejection of the other approaches identified.

4.1 STANDARD MAINTENANCE ENGINEERING ANALYSIS APPROACH

The approach of the standard MEA, outlined in MIL-M-24365A, is the one most widely used in determining maintenance engineering requirements for HM&E and ordnance equipments. The approach depends heavily upon physical testing of the component being analyzed, normally a lengthy and costly process. For this reason, the approach was not considered further in this study.

4.2 FAULT TREE ANALYSIS

Fault Tree Analysis is an intricate and time-consuming analysis of a unit. The use of Fault Tree Analysis requires considerable training, and the results are many times dependent upon physical testing of the units being examined. For these reasons, the approach was not considered further in this study.

4.3 MATERIAL FAILURE PREDICTION

Material Failure Prediction is a technique used by the Department of the Air Force for measuring the probability that an aircraft and crew will be exposed to a hazardous condition. A portion of the model

for this prediction is derived from maintenance data of the type that will not always be available to the user of the LMMEA technique. For this reason, the Material Failure Prediction Technique was not considered further in this study.

4.4 TRIDENT CRITICAL EVALUATION TECHNIQUE

The Critical Evaluation (CE) technique is a method of analyzing units to determine minimum essential maintenance requirements. The technique is a guide to using available engineering data logically and does not require the physical testing of the unit. The tool used is a Critical Evaluation Sheet (see Appendix A) for standardizing and recording engineering maintenance information as it is identified. This technique makes use of existing data on the unit being examined and on similar units. It combines existing data with the engineering judgment of the user and the instructions on the Critical Evaluation Sheet to identify minimum essential maintenance requirements. After careful consideration of the characteristics of all the techniques identified, an LMMEA technique was developed that employs engineering judgment in much the same way as the CE technique and, after type grouping, combines CE with technical engineering comparisons of similar units. The approach is discussed in detail in Chapter Five.

CHAPTER FIVE

BASIC APPROACH

5.1 DEFINITION

The LO-MIX Maintenance Engineering Analysis Technique is a method of identifying the maintenance support requirements of an individual unit (system, subsystem, equipment, component) by identifying previously determined requirements of that unit and then determining unknown values by using engineering judgment and comparing the unit with similar units for which previously determined data are available.

The objective of the technique is to develop inputs to a system (Trident LDS or other) which, when the inputs are operated on by the system, will produce a logistics support package for LO-MIX ships. Accomplishing this objective requires an input worksheet containing all data elements necessary to describe logistic requirements and parameters for individual units.

5.2 TRIDENT LDS SYSTEM

The results of the LMMEA will be inputs to the Trident LDS System or a similar system; therefore, an understanding of the Trident LDS System MEA data input requirements is necessary.

Inputs to the Trident LDS System are made on worksheets which, when completed, contain all the maintenance engineering requirements needed to identify a Trident Fleet Logistics Support Package. The worksheets are coded for direct entry into the Trident LDS Program. There are separate sets of worksheets designed to be executed in increments coinciding with the physical testing of the considered units. The worksheets contain repetitive unit-identification information, which permits later correlation. The worksheets currently provide for information not applicable to the LO-MIX Fleet (e.g., Sub-Safe requirements).

5.3 DEVELOPMENT OF THE LO-MIX MEA TECHNIQUE

To develop the LMMEA technique, it was necessary to identify the elements that are most time-consuming and costly in existing methods. These elements were then evaluated for their criticality to the require-

ments of the new technique. The most time-consuming and costly elements identified were the physical testing of the unit being analyzed and the engineering time required to analyze one equipment. The new LMMEA technique eliminates physical testing of the unit and substitutes previous experience on similar equipments coupled with engineering judgment. The technique can be applied by one engineer per unit.

5.3.1 Approach

Any new technique had to include the data required for input to the Trident LDS Program. A pre-printed format was developed (see Appendix B) for listing the data items applicable to the LO-MIX ship unit for use in preparing LMMEAs. The format has the advantage of facilitating code-block design to allow data entry directly to the Trident LDS Program. The code blocks can thus be correlated to the numeric identification used by the Trident program in the same manner in which the Trident Worksheets are coded.

Analysis showed that all examined methods except the Trident Critical Evaluation technique relied heavily upon the results of physical testing, which is the most time-consuming and costly element of the methods investigated. The LMMEA technique would be less time-consuming and less costly if physical testing could be eliminated. It was determined that an analysis method could be developed that would use existing data for the unit and similar units, and would be guided by an LMMEA Analysis Sheet similar in design to the CE Analysis Sheet. The technique demonstration proved this method to be viable. The engineer applying the technique searches existing maintenance engineering data (such as technical manuals, TRSs, etc.) and uses his judgment to determine requirements for the unit he is considering. The LMMEA Analysis Sheet, like the CE Analysis Sheet, guides the engineer by posing questions in a logical sequence and naming standard sources where the raw data might be found. The format utilizes code blocks for entering data that would require keypunching for the Trident LDS. It also provides identification of possible sources of data to assist the engineer in determining where maintenance requirements may already have been identified.

5.3.2 Data Availability

For a given unit, two basic types of maintenance data can be available: data that result from the accomplishment of a standard MEA, and the historical maintenance data collected during operation of the unit. Neither type is necessarily available. The matrix of Figure 5-1 shows this relationship.

	Historical Data Available	Historical Data Not Available
MEA Available	Case I	Case II
MEA Not Available	Case III	Case IV

Figure 5-1. MEA/HISTORICAL DATA MATRIX

In Cases I and II, in which standard MEA data are available, these data can be used as the sole basis upon which the engineer judges the maintenance engineering requirements in the LO-MIX modular-replacement philosophy.

In Case III, in which there are historical data and other data such as technical manuals, TRSs, and APL Lists, the LMMEA Analysis Sheet becomes more effective. The analysis sheet guides the preparer in his search for information and assists him in judging the maintenance engineering requirements on the basis of the existing data.

Case IV, for which there is neither a standard MEA nor historical data, is a distinct possibility. This is the situation with the Oto Melara Mk 75 Mod 0 Gun Mount, to be used in both the PF and PHM Ship Classes. In this situation the judgment and analytical capability of the engineer become the crucial factors. However, there are drawings, component lists, and other descriptive data available for the Mk 75 Mount. Subassemblies and components such as motors, gear trains, and hydraulic units can be identified from the drawings. Then the component maintenance engineering requirements can be evaluated by using engineering judgment and comparing the components with similar items for which data are available.

To maximize the MEA development, the LMMEA technique exploits the idea of similar maintenance engineering requirements for similar units by grouping all equipments on which an LMMEA is to be performed according to equipment type. Equipment type does not mean simply "pump" or "motor" but rather "*volute* pump", "*rotating field* motor", etc. For each group of equipments, one lead component is selected which would have the greatest maintenance engineering requirements because of its size and complexity. If the unit selected as lead component is in the Case IV category, it is handled separately. The next most complex component is then selected as lead component. All other components within a group are considered follow-on components.

5.3.3 LMMEA Classes

Once an equipment type is grouped and the lead component selected, the LMMEA technique can be applied with the greatest efficiency. Three classes of this technique are employed to achieve the LMMEA objective. These three classes are related to the four cases of data availability (Figure 5-1) and component groupings as shown in Table 5-1.

The Class I LMMEA is reserved for those units undergoing test and development. It is an in-depth analysis of units for which neither a standard MEA nor historical maintenance data are available. The engineer proceeds by collecting all available information in the form of drawings, design specifications, design criteria, and similar sources. This information is analyzed to determine what operating equipments the unit resembles. The operating equipments similar to the unit are analyzed to determine the unit's maintenance engineering requirements. These requirements are entered on the LMMEA Analysis Sheet. The Class I LMMEA is considered a unique class because of the time required for raw-data identifi-

Table 5-1. RELATIONSHIP OF DATA-AVAILABILITY CASES AND LMMEA CLASSES

Data Availability	LMMEA Classes by Equipment Groups		
	Under Development and Testing	Lead Component	Follow-On Components
Case I	N/A	Class II	Class III
Case II	N/A	Class II	Class III
Case III	N/A	Class II	Class III
Case IV	Class I	N/A	Class III

cation and collection. However, a Class I LMMEA can usually be completed in less than three months.

The Class II LMMEA identifies the maintenance engineering requirements of a lead unit for an equipment group through an in-depth analysis of existing data on the unit. The engineer assembles all identifiable data on the unit, using the LMMEA Analysis Sheet as a guide. If the unit is in the Case I or Case II category of data availability, little more than the standard MEA will be necessary. For units that are in the Case I or Case II category, a Class II LMMEA can be produced in less than two weeks. If the unit is in the Case III category, documents such as technical manuals, drawings, TRSs, APLs, Maintenance History Analyses, MIL-Standards, and others will be required. The LMMEA Analysis Sheet is used as a guide in researching and analyzing the documentation collected, and the data are entered on the LMMEA Analysis Sheet. For units in the Case III category, a Class II LMMEA can be produced in less than three weeks.

The Class III LMMEA is a method of identifying the maintenance engineering requirements of a follow-on unit of an equipment group. The engineer analyzes the requirements identified for the lead unit of that equipment group and relates those requirements to the unit of interest. The documentation required is a description of the unit under consideration and the completed LMMEA for the lead unit of the equipment group to which the unit under consideration belongs. A Class III LMMEA can be produced in less than three days.

CHAPTER SIX

DEMONSTRATION OF TECHNIQUE

A test application of the LMMEA technique was conducted to demonstrate the Class I, II, and III LMMEA concept. (The test did not require that an entire LMMEA be produced for any equipment.) Data items to be identified were selected for each class of LMMEA. If the maintenance engineering requirements for each selected data item could be identified efficiently, the technique was considered valid.

6.1 SELECTION CRITERIA

The following criteria were established for selecting equipments to be used in the demonstration:

- Equipment types should have a high probability of being found on the LO-MIX class of ships.
- Equipments should be amenable to the application of Class I, II, and III LMMEAs.
- Technical data other than standard MEAs should be available for the equipments.
- There should be equipments similar to those selected for which historical data are available.

6.2 EQUIPMENT SELECTION

Various hull, mechanical, electrical, and ordnance equipments were considered for use in the technique demonstration. Each equipment was evaluated according to the selection criteria described above. Three volute pumps of various designs were selected and treated as an equipment group:

- A main feed pump manufactured by Worthington Corporation
- An auxiliary condenser condensate pump manufactured by Warren Pumps, Incorporated
- A fresh-water tank drain pump manufactured by Weil Pump Company

These three pumps were selected because they were volute-type pumps but varied in size and complexity. This combination of characteristics permitted us to consider the three pumps to be a small equipment group. The Worthington Main Feed Pump was selected as the lead component of the equipment group. Any standard MEA data on the Feed Pump were ignored, so that essentially the lead component represented a Case III (Figure 5-1) situation. The lead component was subjected to a Class II LMMEA to identify the maintenance engineering requirements for the Main Feed Pump.

Once the Class II LMMEA was completed for the lead component of the equipment group, the two remaining pumps (the condensate pump and the drain pump) were subjected to Class III LMMEAs. The results of the test applications are discussed in the remaining sections of this chapter.

An opportunity for a test application of the Class I LMMEA arose during the project. We were requested to identify (as an activity separate from that reported herein) ordnance components that could be identified as rotatable-pool items to be installed in the PHM and PF classes of ships. Included in the systems investigated was the Oto Melara Mk 75 Mod 0 76mm/62 Caliber Gun Mount. The LMMEA technique had been developed to a sufficient degree to permit its application. The Gun Mount was in its preliminary phases of testing and therefore lacked both standard MEA data and historical maintenance data. This situation placed the gun mount in the Case IV (Figure 5-1) data-availability category. Because of this, a partial Class I LMMEA was performed -- first, to develop the required data and, second, to prove the validity of the Class I LMMEA technique.

6.3 CLASS I LMMEA

The Mk 75 Mod 0 Gun Mount was subjected to a Class I LMMEA for the reasons discussed in Section 6.2. It was decided that if rotatable-pool components and certain maintenance requirements for those components could be identified for the gun mount efficiently, then the Class I LMMEA would be considered valid.

As a result of the Class I LMMEA application, 56 rotatable-pool components in the Mk 75 Gun System were identified by analyzing technical manuals, drawings, and descriptive data. Each component was analyzed by comparing it with items which had similar technical characteristics and for which maintenance history was available. Where no similar equipment was readily available, the component was analyzed by comparing its characteristics with available total system data. For each component, the maintenance engineering requirement for each of the following LDS input-data items was identified:

- Component population per ship for PHM and PF classes
- Mean time between failures (MTBF)

- Mean time to repair (MTTR)
- Procurement lead time (PLT)
- Purchase cost

The results of the analysis were recorded on sheets designed by ARINC Research Corporation. These record sheets are reproduced in Appendix C of this report.

The Class I LMMEA technique was considered successful and valid because the partial Class I LMMEA was completed in five working days. On this basis, it is estimated that a complete Class I LMMEA could have been completed within the three-month time limit. The input data were derived without physical testing, and each specified maintenance engineering requirement was identified for every component.

6.4 CLASS II LMMEA

The Class II LMMEA was demonstrated by applying the Class II LMMEA technique to the lead component of the sample equipment group -- the Worthington Main Feed Pump (Case III) -- and a partial LMMEA was performed. This analysis included identifying the engineering maintenance requirements and a portion of the corrective maintenance requirements. The demonstration was terminated after the first corrective maintenance action requirements had been identified because the purpose of the test was to determine the validity of the technique, not to produce a complete MEA.

Appendix D presents the identified data on Technique Development Worksheets designed for this project. The worksheets are of two types. The first, with vertical columns, lists the data items to be identified in the left-hand column. The second type, with horizontal rows, lists the data items to be identified in the top row. The data items were recorded on the worksheets after the data items on the Standard MEA worksheets were merged with those on the Trident LDS worksheets. Duplicate data items were eliminated, as were references to data items not essential to LO-MIX units (e.g., Sub-Safe). The data were recorded in the center column of the first type of sheet as they were identified. The identified data correspond to the data items in the first column. The data sources or the methods of data determination were recorded in the third column of the first type of sheet. The second type of sheet contains the data source in the second row and the actual data in all but the top two rows.

The data provided by the Class II LMMEA follow a predetermined trend. The first section of data provides basic identification. The second section identifies the modes of failure that can occur in the unit. The data in Section III identify failure symptoms for each failure mode and the effects of each failure mode. The data in Section IV provide an analysis of the corrective maintenance actions and the preventive

maintenance actions for the unit of interest. The data in Section V (on the second type of sheet) provide an analysis of each preventive and corrective maintenance task identified in Section IV (on the first type of sheet). This analysis includes the tasks required to accomplish each maintenance action.

The data items listed in column 1 that were applicable to LMMEA logistics support were taken from a standard MEA worksheet and Trident ILS worksheets. The only data items eliminated from the Trident LDS worksheets were those peculiar to the Trident Submarine Programs, such as Sub-Safe Program requirements. The LMMEA logistics support analysis was considered complete because a maintenance engineering requirement was identified for each data item. Certain assignable information, such as the Functional Group Code assigned by the Design Support Contractor in the Trident LDS, was omitted because it had not yet been assigned.

The Class II LMMEA technique was considered successful because it was partially completed in seven man-days. From these results, it is estimated that a complete Class II LMMEA could be completed in less than the goal of three weeks. The Class II LMMEA was performed without physical testing.

6.5 CLASS III LMMEA

Two Class III LMMEAs were performed by applying the Class III LMMEA technique to the Weil Fresh Water Tank Drain Pump and the Warren Auxiliary Condenser Condensate Pump. The Worthington Main Feed Pump was used as the lead component. The results of the two Class III LMMEAs were recorded on the Technique Development Worksheets in the same manner as for the Class II LMMEA, with one exception: on the first type of sheet the right-hand column was not filled in, because the data were identified by comparing the Class III unit of interest with the results of the completed Class II LMMEA. On the second worksheet, the second row of preprinted data sources was not utilized, because the data source was the analysis of the completed Class II LMMEA. The results of the two Class III LMMEAs are presented in Appendix E of this report.

The Class III LMMEA technique is considered valid because the results presented in Appendix E were achieved in eight hours for each of the two Class III LMMEAs. Although incomplete, the results obtained during the demonstrations indicate that the Class III LMMEA can be completed in less than three days. The use of the technique did not require physical testing, and a maintenance engineering requirement was identified for each data item.

CHAPTER SEVEN

CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

A LMMEA technique was developed for identifying Maintenance Engineering Requirements of units to be installed in the LO-MIX class of ships without performing a standard MEA. Demonstration has established that the technique is feasible and that the LMMEA can be applied effectively to different equipment types.

Three classes of LMMEAs are employed: Class I, Unit under Development and Testing; Class II, Lead Component; and Class III, follow-on Unit. The technique is applied by filling out an LMMEA Data Analysis Sheet for the appropriate LMMEA class. One LMMEA form can be designed to serve all three classes.

The estimated time to complete an LMMEA for each class is as follows:

Class I - Less than three man-months

Class II - Less than three man-weeks

Class III - Less than three man-days

It is estimated that 15 sheets, similar in design to those included in Appendix D, but continuing the investigative questioning and data recording, will be required for each LMMEA.

7.2 RECOMMENDATIONS

7.2.1 Equipment Identification and Type Grouping

The LMMEA technique is designed to accommodate a large group of units expeditiously. In fact, the larger the number of units, the greater the economy per unit. As more units are considered, the number of Class III LMMEAs increases. Therefore, it is recommended that the equipments requiring LMMEAs be identified early in the LMMEA program and grouped by equipment type.

7.2.2 LMMEA Data Form

It is recommended that complete LMMEA data forms be developed as soon as possible.

APPENDIX A

TRIDENT CRITICAL EVALUATION SHEET
(PAGE 1)

RIC ⌊_____⌋

COMPONENT DESCRIPTION _____
COMPONENT DESIGNATOR _____
EIC ⌊_____⌋

FGC ⌊_____⌋

COMPONENT ANALYSIS

(1) ESSENTIALITY ANALYSIS

(1) Is component a SubSafe (i.e., hull integrity/ship recoverability) item?
Yes__ No__ If "Yes", where designated? _____

(2) Is component vital to the safety of material or personnel? Yes__ No__ If "Yes", how? _____

(3) Is component vital to the mission of the ship? Yes__ No__
If "Yes", how? _____

(2) COMMONALITY ANALYSIS

(1) Is component (RIC) a multi-use item?
Yes__ No__ Possibly__
If "Yes" or "Possibly", give examples _____

(2) Is component identical ☐ or similar ☐ to existing design? Is component a new or different design? (Check one) Explain _____

(3) What function does this component perform in the system? _____

(3) REPAIR/REPLACEMENT ANALYSIS

(1) Is component a complex, high cost item with a history of casualties or of being a maintenance item?
Yes__ No__ If "Yes" explain _____

(2) Is purchase/replacement cost of the component less than $100?
Yes__ No__ Approximate cost _____

FIGURE F-1

F-5 CH-2

(4) SOURCE DATA ANALYSIS

(1) Have all source documents been researched for existing maintenance requirements?

Document	APP	N A	If applicable, specify document, chapter, page No. MRC, etc	Is applicable information general or for specific component?
OA Manual CSL Inst 4355.2 series				
IMA Routines CSL Inst 4710.13				
IMMP				
3M PMS				
URO MRC's				
TRS				
TECH MANUAL				
SMMSO				
NAVSHIPS INST				
OWI				
OWP				
DDGOS				
OTHER (Specify)				

(2) Are existing requirements for (Check one)
a. an identical component? _____
b. a similar component? _____

(3) If component has no existing maintenance, why is it being considered now? _____

(4) Have all existing feedback documents been researched for malfunction/failure and wear rate data?

Document	APP	N A	If applicable identify specific source page No. etc	Is applicable information general or for specific component?
MDCS Malf. Hist				
PROMAC				
TRS Appendix 1				
Other (Specify)				

(5) RECOMMENDED MAINTENANCE PLAN

Based on a review of existing requirements and feedback data, what form of maintenance best suits this component?

Check one or more.
- ☐ Run until failure
- ☐ Monitor until performance falls below specified limits
- ☐ Refurbish/overhaul at specific intervals
- ☐ Replace at specific intervals
- ☐ Surveillance/inspect at specific intervals
- ☐ Perform PM at specific intervals
- ☐ Service at specific intervals
- ☐ Repair as appropriate arises from related maintenance

DEVELOPER _____
DATE _____

APPENDIX B

RECOMMENDED FORMAT FOR LMMEA ANALYSIS SHEET

IDENTIFICATION 1

(1) Item Name

(2) Manufacturer

(3) MFGR FSCM

(4) Is this component the lead component for its equipment type?

(Y) (N) (Check one)

(5) If "Yes" is checked, complete all items marked with II.

(6) If "No" is checked, complete all items marked with III.

(7) II - SOURCE DATA ANALYSIS

Have all source documents been researched for existing maintenance requirements?

Document	Record Document Identification For Reference
Tech Manual	
Std MEA	
TRS	
APL	
Drawings	
MRC	
NAVSEA INST	
Other	
"	

(8) III - Identify the lead component for this equipment type

Lead Component Name

(9) III - has a class I or II LMMEA been performed on the lead component?

[Y] [N] (Check one)

(10) III - if yes is checked in 9 obtain that LMMEA for use.

(11) III - if no is checked in (9) go back and do a class II LMMEA on the component identified in (8)

APPENDIX C

CLASS I LMMEA
(PARTIAL)

System: 76 MM/62 Cal. Gun (OTO - MELARA)				"X" If Non-Candidate	No. per PHM	No. per PF	MTBF(000) IN HOURS *4	MTTR in Days	PLT in Months *1	*Cost $K *3	Notes
Item No.	National Stock No.	Mfr. Dwg. No.	Nomenclature								
1	1015 15 056-0225	1376.01.011	Barrel Assembly		1	1	*2	4	18	$16	*1 Modular assemblies will not be available for American source purchase prior March, 1976
2	1015 15 056-0231	1376.01.138	Bore Evacuator		1	1	7.2	2	6	2.5	
3	1015 15 056-0213	1376.01.146	Muzzle Brake		1	1	6	3	7	1.2	*2 Barrel liner life is 10, one minute bursts at 80 rounds per minute.
4	1015 15 056-0188	1376.02.010	Breech Mech. Assy. (w/Extractors)		1	1	.47	2	8	2.7	*3 Cost figures equal the 1972 Italian Mfr's price multiplied by 1.85. The factor of 1.85 is .15 per year cost increase for 2 years plus 1.55 for difference in manufacturing cost from Italy to America.
5	1015 15 056-0288	1376.02.016	Firing Pin Assy.		1	1	.38	2	3	.4	
6	1015 15 056-0214	1376.02.011	Breech Block Assy.		1	1	3	4	10	3.1	
7	1015 15 056-0285	1276.02.023	Cocking Lever Assy.	X							*4 Engineering estimates based on similar equipment performances
8	1015 15 056-0295	1276.02.012	Damper Assy.		1	1	2.6	2	4	.5	
9	1015 15 056-0297	1276.02.014	Breech Block Opening Mech., Left		1	1	1.7	5	12	1.3	
10	1015 15 056-0374	1376.03.010	Release Assy. Mech		1	1	.6	8	9	2.1	
11	1015 15 056-0131	1376.04.010	Recoil Brake Recuperator Cylinder		1	1	.3	7	19	6.1	
12	1015 15 056-0168	1376.04.011	Accumulator	X							

System: 76 MM/62 Cal. Gun (OTO - MELARA)				"X" If Non-Candidate	No. per FHM	No. per PF	MTBF (000)	MTTR in Days	PLT in Months	Cost $K	Notes
Item No.	National Stock No.	Mfr. Dwg. No.	Nomenclature								
13	1015 15 056-9872	1376.04.016	Accumulator and N_2 Container Assy.		1	1	.4	12	27	8.6	
14	1015 15 056-0326	1376.04.115	Recoil Cylinder		1	1	1.3	12	21	.9	
15	1015 15 056-0954	1276.04.018	Guare & Valve Assy.		1	1	.9	4	8	.9	
16	1015 15 056-0329	1376.04.014	Brake Flange Assy.		1	1	.09	7	11	1.6	
17	N/A	1376.05.010	Recoil Cyl. Assy.		1	1	.8	14	23	8.7	
18	1015 15 056-0925	1276.05.013	Shock Absorber		1	1	.68	12	4	.74	
19	1015 15 056-0926	1276.05.014	Manual Breech Block		1	1	14	9	11	.82	
20	1015 15 056-0889	1276.05.366	Front Slide		1	1	3	5	19	.3	
21	1015 15 056-0888	1276.05.367	Rear Slide		1	1	3	5	19	.2	
22	N/A	1376.06.090	Loading Drum Assy.		1	1	.86	12	23	6.2	
23	1015 15 056-1035	1376.06.016	Proximity Switches		1	1	.47	8	9	1.3	
24	1015 15 056-0148	1376.06.017	Distributor Cyl. Assy.		1	1	.93	27	18	2.1	
25	N/A	1276.06.032	Rammer Head Subassembly		1	1	1	12	14	.6	

System: 76 MM/62 Cal. Gun (OTO - MELARA)				"X" If Non-Candidate	No. per PHM	No. per PF	MTBF (000)	MTTR in Days	PLT in Months	Cost $K	Notes
Item No.	National Stock No.	Mfr. Dwg. No.	Nomenclature								
26	1015 15 056-2089	1276.06.665	Loading Tray		1	1	3	6	8	10.2	
27	1015 15 056-0955	1276.06.018	Cartridge Double Transfer Assy.		1	1	.6	18	12	1.3	
28	1015 15 056-0953	1276.06.019	Load Tray Position Assy		1	1	.8	7	9	5.2	
29	1015 15 056-2258	1276.07.104	Hatch Assy.		1	1	23	4	3	1.8	
30	1015 15 056-1019	1276.08.324	Projectile Grip (RH)		1	1	14	3	10	1	
31	1015 15 056-0134	1376.08.016	Right Rocking Arm Assy.		1	1	.74	5	14	10.7	
32	1015 15 056-1020	1276.08.325	Projectile Grip (LH)		1	1	14	3	10	1	
33	1015 15 056-0993	1376.08.017	Left Rocking Arm Assy.		1	1	.74	5	14	10.7	
34	1015 15 056-0135	1376.15.010	Training Gear Box		1	1	.3	18	27	17.6	
35	N/A	1060.01.010	Motor, M 26, 3KW		1	1	4	29	19	3.7	
36	1015 15 056-1714	1376.15.015	Synchro Gear Assy		1	1	.9	21	14	.9	
37	1015 15 056-0132	1376.16.010	Elevation Gear Box		1	1	1.8	38	21	15.5	
38	1015 15 056-2198	1376.16.016	Elevating Control Assy		1	1	2.1	17	18	1.1	

System: 76 MM/62 Cal. Gun (OTO - MELARA)				"X" If Non-Candidate	No. per PHM	No. per PF	MTBF (000)	MTTR in Days	PLT in Months	Cost $K	Notes
Item No.	National Stock No.	Mfr. Dwg. No.	Nomenclature								
39	1015 15 056-1726	1376.16.018	Elevation ARC Assy.		1	1	.7	12	9	6.7	
40	1015 15 056-0139	1376.17.010	Counterweight Assy.		1	1	1.2	19	12	11.2	
41	1015 15 056-0140	1376.18.016	Hydraulic Power Unit		1	1	.63	5	13	5.4	
42	1015 15 056-0163	1276.18.010	Accumulator		1	1	3.4	3	7	8.2	
43	1015 15 056-0141	1376.18.017	Relief Valve Assy.		1	1	1.6	7	12	4.3	
44	1015 15 056-2467	1276.18.142	Safet Valve		1	1	.8	2	4	.4	
45	1015 15 056-2203	1276.18.014	Layout Valve Assy.		1	1	.7	3	6	1	
46	N/A	1376.20.011	Firing Cut-out Mech.		1	1	1.7	18	6	1.6	
47	1015 15 056-0125	1376.23.013	Hoist Gear Box		1	1	3.4	12	14	20.7	
48	1015 15 056-0166	1276.23.040	Valve Block Assy.		1	1	2.3	14	23	2.4	
49	1015 15 055-9907	1376.61.012	Training Synchro		1	1	.92	3	6	6.5	
50	1015 15 055-9875	1376.62.012	Elevation Synchro		1	1	.83	5	9	9.5	
51	N/A	1376.81.011	Switch Assy., 2J1		1	1	.58	4	7	3.1	

System: 76 MM/62 Cal. Gun (OTO - MELARA)				"X" If Non-Candidate	No. per PHM	No. per PF	MTBF (000)	MTTR in Days	PLT in Months	Cost $K	Notes
Item No.	National Stock No.	Mfr. Dwg. No.	Nomenclature								
52	N/A	1376.81.013	Switch Assy., 2J3		1	1	.6	4	7	3.7	
53	N/A	1376.81.016	Switch Assy., 2J6		1	1	.6	4	7	4.4	
54	N/A	1376.81.017	Switch Assy., 2J7		1	1	.6	4	7	3.0	
55	N/A	1376.81.019	Switch Assy., 2J2		1	1	.6	4	7	3.8	
56	N/A	1376.81.020	Switch Assy., 2J4		1	1	.6	4	7	3.2	

APPENDIX D

CLASS II LMMEA
(PARTIAL)

First Type of Sheet

Data Item	Maintenance Engineering Requirement	How Determined
SECTION I Item Name	Pump, Main Feed	Tech Manual, TRS
MANUFACTURER	WORTHINGTON	Tech Manual, TRS, APL, FSCM, Handbook H4
Part Number	MIL-P-17881 Type I	APL, Tech Manual
FSN	N/A	APL
Type	Volute	APL, Tech Manual, TRS
Series	N/A	APL, Tech Manual
Model	Type I	APL, Tech Manual
Designator	N/A	APL, Tech Manual
Suffix	N/A	APL, Tech Manual
FGC		TBD From FGC Breakdown
WBS No.		TBD From WBS Breakdown
DWG. No.		
MFGR's	SL-8809-4 (Et Al)	Tech Manual
Navy	3231679(D) (Et Al)	Tech Manual
TRS#	0255-086-615A	TRS
EIC	F 303100	TRS
APL	016031226	APL, TRS
CID		
NHA NOMENCLATURE	CONDENSATE SYS.	TBD From SSDI
NHA FSCM/Part No.		TBD From SSDI
STD For NHA	Yes	TBD From SSDI
#PER NHA	3	Tech Manual
#On-Board	6	Tech Manual, APL

Data Item	Maintenance Engineering Requirement	How Determined
ITEM APPLICATION		
CROSS-REFERENCE		
WBS		TBD From WBS
EIC		TBD From EIC
MEA		
TECHNICAL MAN. NO.		
Navy	347-3309	Tech Manual, TRS
Manufacturer	HA-270	Tech Manual, TRS
TYPE DESIGNATION	N/A	Tech Manual
APPROX. DIMEN.		
Length	4' 1 5/16"	Tech Manual
Width	2' 9 9/16"	Tech Manual
Height	3' 11 7/8"	Tech Manual
MODULAR	NO	Engineering Judgement
ROTATABLE POOL	YES	Engineering Judgement
PROCURE SOURCE DOC#		
PROCURE DOC. ITEM #		
EST UNIT OVHL PRICE	Not Available	Navy Mgmt. Data List
MTBF		
REQUIRED		
PREDICTED	1832 Hrs.	Engineering Judgement & Comparison w/Others of Type
VERIFIED	2137 Hrs.	ARINC Pub 0E3-01-1-1224
SECTION II		
MODES OF FAILURE		
1.	Wear Rings Worn	Tech Manual
2.	Impellers Damaged or Eroded	

Data Item	Maintenance Engineering Requirement	How Determined
3.	Stuffing Box Packing/ Sleeves Worn	
4.	Pump Air Bound	
5.	Insufficient Speed	
6.	Recirc. Valve Open	
7.	Suction Pressure Too Low	
8.	Pump Speed Too Low	
9.	Discharge Head Too High	
10.	Pump Suction or Impellers Clogged	
11.	Rotor Frozen	
12.	Suction Line Air Leak	
13.	Stuffing Box Air Leak	Tech Manual
14.	Pump Overspeed	
15.	Foundation and Foot Bolting Loose	
16.	Coupling and Shafts out of Alignment	
17.	Strain on Connected Piping	
18.	Excessive Bearing Wear	
19.	Rotating Elements Rubbing	

Data Item	Maintenance Engineering Requirement	How Determined
SECTION III		
FAILURE SYMPTOMS		
Failure Modes 1, 2, 3, 5,	Insufficient pressure	
4, 5, 8, 9, 10, 11	No output	
6, 7, 12, 13	Insufficient capacity	
15, 16, 17, 18, 19	Vibration	Tech Manual
14,	Driver overload	Tech Manual
FAILURE EFFECTS FOR EACH MODE		
1, 2, 3 & 8	Low water in boiler	Engineering Judgement (EJ)
4, 5, 9, 10, 11	Low water in boiler	Engineering Judgement (EJ)
6, 7, 12, 13	Low water in boiler	Engineering Judgement (EJ)
14, 15, 16, 17, 18, 19	Physical * Destruction	Engineering Judgement (EJ)
SECTION IV		
CORRECTIVE MAINT. REQUIR. FOR EA. FAILURE MODE		
(CORRECTIVE MAINTENANCE)		
1.	Replace rings	EJ/Tech Manual
2.	Replace/repair impellers	EJ/Tech Manual
3.	A.) Replace Packing or	EJ/Tech Manual
	B.) Resleeve Shart	EJ/Tech Manual

EJ - Engineering Judgement

*Safety Const

Data Item	Maintenance Engineering Requirement	How Determined
4.	Prime Pump	EJ/Tech. Manual
5.	Increase Steam	EJ/Tech. Manual
6.	Close Recirc. Valve	EJ/Tech. Manual
7.	Boost Suction Pressure	EJ/Tech. Manual
8.	Increase Pump Speed	EJ/Tech. Manual
9.	Reduce Discharge Head	EJ/Tech. Manual
10.	Remove Obstruction	EJ/Tech. Manual
11.	Disassemble and Repair	EJ/Tech. Manual
12.	Repair Suction Line	EJ/Tech. Manual
13.	Tighten/Replace Packing	EJ/Tech. Manual
14.	A) Increase Discharge Head B) Repair Speed Limiting Device	EJ/Tech. Manual
15.	Tighten Bolts	EJ/Tech. Manual
16.	Align Shafts	EJ/Tech. Manual
17.	Remove, Repair & Reconnect Piping	EJ/Tech. Manual
18.	Replace Bearings	EJ/Tech. Manual
19.	Realign Rotating Units	EJ/Tech. Manual

Data Item	Maintenance Engineering Requirement		How Determined
CORRECTIVE MAINTENANCE ACTION	Location of CM Accomp. (O, I, D)	Modular Replacement? (Yes or No)	
1	I	N	
2	I	Y	
3 A.	O	N	
3 B.	I	Y	
4	O	N	
5	O	N	
6	O	N	Engineering Decision Aided By Tech. Manual And Drawings
7	O	N	
8	O	N	
9	I	N	
10	I	N	
11	I	Y	
12	I	N	
13	O	N	
14 A	I	N	
14 B	I	N	
15	O	N	
16	I	N	
17	I	N	
18	I	Y	Engineering Judgement With Aid of Tech. Manual and Drawings
19	I	Y	

Data Item	Maintenance Engineering Requirement	How Determined
LOCATION OF PIECE PART REPAIR OF REMOVED UNIT		
2	D	
3. B.	D	
11	D	Engineering Judgement with aid of Tech. Manual and Drawings
18	I	
19	I	
FAILURE FREQUENCY MTBF (FORCED SHUTDOWN) PREDICTED		
VERIFIED	2137 H	ARINC Pub. 0E13-01-1-1224
MTBCM		
PREDICTED		
VERIFIED	872 Hrs	ARINC Pub 0E13-01-1-1224
ANNUAL UNIT OPERATING DAYS	10,930 Hrs	
% Unit Operation Per System Operation	46%	Engineering Judgement with ARINC Pub. 0E13-01-1-1224
Item Backed-Up	Y	Ship Main Propulsion Guide
# of Back-Ups Per System	2	Ship Main Propulsion Guide
Engineering Design Change	None	Tech. Manual, APL, TRS
ALT Incorporation Level	None Needed	Eng. Judgement w/ALT Plans
ALT Impact on Logistics	None	Engineering Judgement with ALT Plans and Descrip.
Item Function	4 Stage Rotating Impeller	Tech. Manual

Data Item	Maintenance Engineering Requirement	How Determined
Maintainability Characteristics	Daily, Weekly, Quarterly, and Annual Tests and Inspections to Compare Unit Operation with Design Specifications	Tech. Manual
Maintenance Concept	1. Minor "O" Level Part Replacement and PM 2. "I" Level Unit Removal and Replacement of some Piece-Parts 3. "D" Level Unit Overhaul	Engineering Judgement
Plan for Use	Supply Feedwater to Boiler	Tech. Manual, TRS, Propulsion Operating Guide
Explicit Maintenance Plan	Daily: Jack Rotor 3/4 turn when secure Inspect for Oil and Water Leaks Weekly: Hand Lift Relief Valve Operate Oil Pumps Check Lube System Check Recirc control Check Differential Pressure Control Check Shaft and Coupling Float Quarterly: Check Coupling Alignment Drain, Clean, and Refill Sump Annually: Lift Case, Inspect Internals, Measure and Record Clearances	Tech. Manual

Data Item	Maintenance Engineering Requirement	How Determined
PM Accomplishment Organization Requirement	Maintenance Level Responsible	
1P	O	
2P	O	
3P	O	
4P	I	
5P	I	
6P	I	Engineering Judgement
7P	I	
8P	I	
9P	I	
10P	I	
11P	I	
Most Significant Maint. Requirement	#11	Engineering Judgement
Mttr. Goal (Shipboard)	Less than 24 Hrs.	Engineering Judgement
Mttr. Goal (Unit)	Less than 96 Hrs.	Engineering Judgement
Max Repair Time Expected	192 Hrs.	Engineering Judgement
Automatic Fault Detection Built In?	Yes	Tech. Manual
Needed?	Yes	Engineering Judgement
Built-In Test Equip.?	No	Tech. Manual
Needed	No	Engineering Judgement
MTBCMA		
Allocated		Engineering Judgement
Predicted		Engineering Judgement
Actual	872 Hrs.	ARINC Pub. OE13-01-1-1224
MRC Control Number CM Requirement #11	I-P-XXXXXX-A-I	Section 4.3 of TRIDENT LSA Book "X" Characters Assigned by DAM.
Equipment Location	Deck-Frame-Side	Propulsion Operating Guide Prints, Tech. Manual

Second Type of Sheet

DATA ITEM	MAINT. ACTION NUMBER	ORG. LEVEL	CONTRACT MAINT.?	TYPE CM, PM, OVHL	SHIPYARD OCCUPATIONAL DESIGNATION NEEDED	SHIPYARD SKILL LEVEL	# OF PERS EACH LEVEL	MANHOURS PER SKILL LEVEL	MAINT, ACTUAL FREQUENCY ACTUAL (PREDICTED)
HOW DETERMINED	SECTION IV REFERS	ENG. JUDG.	PROCUR. SPECS.	TECH MAN.	ENG. JUDG.	ENG. JUDG.	ENG. JUDG.	ENG. JUDG.	TECH. MAN. & ENG. JUDG.
SECTION V									
MAINTENANCE ENGINEERING	1p	"O"	No	PM	N/A	N/A	N/A	N/A	Daily When Secured
	2p	O	No	PM	N/A	N/A	N/A	N/A	Daily
	3p	"O"	No	PM	N/A	N/A	N/A	N/A	Weekly
	4p	"I"	No	PM	N/A	N/A	N/A	N/A	Weekly When Secured
	5p	"I"	No	PM	Machinist	JOURNY-MAN	1	.5	Weekly
	6p	I	No	PM	Machinist	JOURNYMAN APPRENTICE	1 1	2 2	Weekly
	7p thru 11p Omitted								
	1c	I	No	CM	Machinist	JOURNYMAN APPRENTICE	1 2	5 7	When Failed

MAINT. ENGINEERING REQUIREMENT TITLE	MAINTENANCE ACTION NUMBER	MRC. NO.	TECH MANUAL NUMBER	FACILITY REQUIREMENTS			
				SHOP	MACHINERY	HANDLING	STORAGE
HOW DETERMINED	SECTION IV REFERS	ASSIGNED BY DAM	TECH. MANUAL	ENG. JUDG	ENG. JUDG	ENG. JUDG	ENG. JUDG
MAINTENANCE ENGINEERING REQUIREMENT	1p	10 Digits	NAVSHIPS 347-3309	None	None	None	None
	2p	10 Digits	NAVSHIPS 347-3309	None	None	None	None
	3p	10 Digits	NAVSHIPS 347-3309	None	None	None	None
	4p	10 Digits	NAVSHIPS T.M. 347-3309	None	None	None	None
	5p	10 Digits	NAVSHIPS T.M. 347-3309	None	None	None	None
	6p	10 Digits	NAVSHIPS T.M. 347-3309	None	None	None	None
	7p thru 11p Ommitted						
	1c	10 Digits	NAVSHIPS T.M. 347-2693	Machine Shop	LATH (12" CHUCK)	HOIST(5000#) FORK LIFT (5000#)	None
	1c (cont.)					JACK (2000#)	

MAINT. ENGINEERING REQUIREMENT TITLE	MAINT. ACTION NUMBER	TRAINING REQUIREMENTS (MILITARY)		REPAIR SAFETY CONSIDERATIONS	TASK EFFECT ON SHIP SAFETY	FSN OR APL FOR REQUIRED REPAIR PARTS	QUANTITY	UNIT OF ISSUE
		TYPE	LEVEL					
HOW DETERMINED	SECTION IV REFERS	ENGINEERING JUDGEMENT	ENGINEERING JUDGEMENT	TECH. MAN. & ENG. JUDG.	TECH MAN. & ENG JUDG.	TRS, APL TECH MAN.	TRS, APL TECH MAN.	TRS, APL TECH MAN.
MAINTENANCE ENGINEERING REQUIREMENTS	1p	Machinist Mate	OJT	Inlet Steam Secure and Tagged Shut	None	None Req.	None	None
	2p	Machinist Mate	OJT	Keep Hands Out of Rotating Machinery	None	None	None	None
	3p	Machinist Mate	OJT	Keep Hands out of Rotating Machinery	None	None Req.	None	None
	4p	Machinist Mate	OJT	None Additional	None	None	None	None
	5p	None	N/A	Keep Hands out of Rotating Machinery	None	None	None	None
	6p	None	N/A	None Additional	None	None Assigned	None	None
	7p thru 11p Omitted							
	1c	None	N/A	None Additional	None	Std. Rings -Casing -Impeller	8 8	1 ea. 1 ea.

MAINT. ENGINEERING REQUIREMENT TITLE	MAINT. ACTION NUMBER	APPLICABLE TECH MAN# TRS# DWG#. ETC.	DOCUMENT TYPE CODE	FSCM	ACCOMPLISHING SHIPBOARD WORK CENTER	LOWEST RATE REQ/AND # (MR 2/2)	HIGHEST RATE REQUIR. AND# (CMMR/1)	TOTAL # OF PERS EA W/C
HOW DETERMINED	SECTION IV REFERS	TECH MAN. DWGS, TRS	TRIDENT LDS TABLE 4-2	FSCM HANDBOOK 4-4	ENG JUDG.	ENG. JUDG.	ENG. JUDG.	ENG. JUDG.
M E R A N E I G Q N I U T N I E E R N E E A R M N I E C N N E G T	1p	SHIPS 347-3301	TMM	N/Avail.	"M" Division	MMSN/1	MMSN/1	1
	2p	NAVSHIPS 347-3301	TMM	N/Avail.	"M" Division	MMSN/1	MMSN/1	1
	3p	NAVSHIPS 347-3301	TMM	N/Avail.	"M" Division	MMSN/1	MMSN/1	1
	4p	NAVSHIPS TM 347-3301	TMM	N/Avail.	"M" Division	MMSN/1	MMSN/1	1
	5p	NAVSHIPS TM 347-3301	TMM	N/Avail.	N/A	None	None	0
	6p	NAVSHIPS DWG 3229924A NAVSHIPS TM 347-3301	DWG TMM	N/Avail.	N/A	None	None	0
	7p thru 11p Omitted							
	1c	NAVSHIPS DWG B3223878 B3223902 B3223878 B3223904	DWG ↓ DWG	N/Avail.	N/A	None	None	0

MAINT. ENGINEERING REQUIREMENT TITLE	MAINT. ACTION NUMBER	APPLICABLE TECH MAN# TRS# DWG#. ETC.	DOCUMENT TYPE CODE	FSCM	ACCOMPLISHING SHIPBOARD WORK CENTER	LOWEST RATE REQ/AND #(MR 2/2)	HIGHEST RATE REQUIR. AND# (CMMR/1)	TOTAL # OF PERS EA W/C
HOW DETERMINED	SECTION IV REFERS	TECH MAN. DWGS, TRS	TRIDENT LDS TABLE 4-2	FSCM HANDBOOK 4-4	ENG. JUDG.	ENG. JUDG.	ENG. JUDG.	ENG. JUDG.
MAINTENANCE ENGINEERING REQUIREMENT	1c (cont.)	C3223899 NAVSHIPS TM 347-3301	DWG TMM	N/Avail.	N/A	None	None	0
	1c (cont.)	TRS 0255-086-615A	TRS					

MAINT. ENGINEERING REQUIREMENT TITLE	MAINT. ACTION NUMBER	SUPPORT EQUIPMENT NEEDED PER WORK CENTER	TOTAL ELAPSED TIME EA W/C	STEP NUMBER	IDENTIFY EA. TASK STEP AND DESCRIBE
HOW DETERMINED	SECTION IV REFERS	ENGINEERING JUDGEMENT	ENG. JUDG.	ENG. JUDG.	TRS, TECH. MAN., DWGS.
M E R A N E I G Q N I U T N T E E R N E E A R M N I E C N N E G T	1p	None	5 Min.	1	Rotate Rotor 3/4 TURN.
	2p	None	10 Min.	1	Inspect pump, and associated piping, and attached components for oil and water leaks.
	3p	None	5 Min.	1	Operate relief valve by hand lever
	4p	None	20 Min.	1	Operate hand and motor driven lube oil pumps.
	5p	None	0	1 2	Light off pump Observe recirculation control system operation for proper lubrication
	6p	None	0	1 2 3 4	Disassemble diaphragm recirculation control valve Clean all parts Inspect and replace worn parts Reassemble diaphragm recirculation control valve
	7p thru 11p Omitted				
	1c	None	0	1	Raise upper casing

MAINT. ENGINEERING REQUIREMENT TITLE	MAINT. ACTION NUMBER	TASK STEP NUMBER	TOLERANCES INVOLVED	SAFETY PRECAU	TOOLS	PARTS	MATERIAL	TEST EQUIPMENT	MIL-SPEC REFERENCES
HOW DETERMINED	SECTION IV REFERS		TRS, TECH MANUAL	TECH MAN, ENG JUDG	TRS. TECH MAN, DWGS	TRS, TECH. MAN.	TRS, TECH. MAN. DWGS.	TRS, TECH. MAN, DWGS.	TRS, TECH. MAN, DWGS.
MERA NEIG QNIU TNIE ERNE EARM NICN NEGT	1p	1	None	Inlet Steam Secured	Hand Jack	None	None	None	None
	2p	1	None	Keep Hands out of Rotating Machinery	None	None	Rags.	None	None
	3p	1	None	Keep Hands out of Rotating Machinery	None	None	None	None	None
	4p	1	None	None	None	None	None	None	None
	5p	1	None	None Addi'l	1/4 "blade Screw-driver" Box Wrench Set	None	None Additional	Gage, 0-3,000 PSIG (2 each)	MIL-S-15204
	6p	1	See NAV-SHIPS TM 347-3309& TM 347-2693 Part B, Chap 5, Section 5	None Addition-al	1 Set Blade Screw-Driver 1 Set Box Wrenches	Stuffing Box Ring Ships DWG.No. H3233091 PC.# 15 Stuffing Box Pack-ing Set Ships DWG No. H323 3091	Shim Stock	Gage 0-3,000 PSIG Gage 0-200 PSIG	None Additional

MAINT. ENGINEERING REQUIREMENT TITLE	MAINT. ACTION NUMBER	TASK STEP NUMBER	TOLERANCES INVOLVED	SAFETY PRECAU	TOOLS	PARTS	MATERIALS	TEST EQUIPMENT	MIL-SPEC REFERENCES
HOW PERFORMED	SECTION IV REFERS		TRS, TECH MANUAL	TECH MAN. ENG JUDG	TRS. TECH. MAN. DWGS	TRS, TECH. MAN.	TRS, TECH MAN. DWGS	TRS, TECH. MAN, DWGS.	TRS, TECH. MAN, DWGS.
MEAN INTERVAL BETWEEN MAINTENANCE ACTIONS	6p (cont					PC. #12			
	1c	1	None	None Additional 1-/4 Inch adjustable Wrench 1 Set Plade-Type Screwdriver 1 Set Phillips Head Screwdriver 1 Set Allen Wrenches 1 Set Pipe Wrenches 5 Gal. Bucket	1 Set Box Wrenches	None Needed	None Needed	0-2 Dial Indicator	None Additional

APPENDIX E

CLASS III LMMEA
(PARTIAL)

First Equipment - First Type of Sheet

Data Item	Maintenance Engineering Requirement	How Determined
SECTION I Item Name	Pump, Auxiliary Condenser Condensate	
Manufacturer FSCM	Warren N/Available	
Part No.	1 1/2 2 CV-6 Pump	
FSN	None Assigned	
Type	Impeller	
Series	N/A	
Model	6	
Designator	N/A	
Suffix	N/A	
FGC	Not Available	
WBS No.	Not Available	
DWG No. MFGR's Navy	 R-654 1,711,442 (A)	
TRS #		
EIC		
APL	016 20546	
CID		
NHA Nomenclature	Aux. Condensate	
NHA FSCM/PRT #		
STD for NHA	Yes	
# Per NHA	2	
# On-Board	4	

Data Item	Maintenance Engineering Requirement	How Determined
Item Application X-Ref. WBS EIC MEA		
Tech. Man. # Navy MFGR	 Ships 347-3209 Warren 327	
Type Desig.	N/A	
Approx. Dimen. I W H	 11 1/2" 11 1/2" 20"	
Modular	No	
Rotatable Pool	Yes	
Procure Source	N/Available	
Procure. Doc.	N/Available	
Unit Overhaul Price		
MTBF Required Predicted	 3400 Hours	
SECTION II		
Modes of Failure		
1	Wear Rings worn	
2	Impeller damaged or eroded	
3	Stuffing box packing/ sleeves worn	
4	Pump air bound	
5	Insufficient speed	
6	Vent open	
7	Pump speed too low	
8	Discharge too high	
9	Pump suction or impellers clogged	
10	Rotor frozen	
11	Suction line air leak	

Data Item	Maintenance Engineering Requirement	How Determined
Failure Modes (con't)		
12	Stuffing box air leak	
13	Pump overspeed	
14	Foundation or foot bolting loose	
15	Coupling and shafts out of alignment	
16	Strain on connected piping	
17	Excessive bearing wear	
18	Rotating elements rubbing	
SECTION III		
Failure Symptoms		
FM 1, 2, 3, 5, 7	Insufficient discharge pressure 1	
4, 5, 8, 9, 10	No output	
6, 11, 12	Insufficient capacity	
14, 15, 16, 17, 18	Vibration	
13	Driver overload	
Failure effects for each failure mode		
1, 2, 3, 4, 5,	Flooded	
6, 7, 8, 9, .10	Auxiliary	
11	Hot Well	

14, 15, 16, 17	Physical	
18	Destruction	

13	DRY HOT WELL	
SECTION IV		
MAINT. REQUIREMENT FOR FAILURE MODES		
1	Replace rings	
2	Replace/repair impellers	
3	A) Replace Packing or B) Resleeve Shaft	

Data Item	Maintenance Engineering Requirement	How Determined
4	Prime Pump	
5	Increase Steam	
6	Close Recirc Valve	
7	Increase Pump Speed	
8	Reduce Discharge Head	
9	Remove Obstruction	
10	Disassemble and Repair	
11	Repair Suction Line	
12	Tighten/Replace Packing	
13	A) Increase Discharge Head B) Repair Speed Limiting Device	
14	Tighten Bolts	
15	Align Shafts	
16	Remove, Repair & Reconnect Piping	
17	Replace Bearings	
18	Realign Rotating units	
Accomplishing Activity (O, I, D) & Accomp. thru Modul Replace (Y, N)		
1	I, N	
2	I, Y	
3 A	O, N	
3 B	I, Y	
4	O, N	
5	O, N	
6	O, N	
7	O, N	
8	I, N	
9	I, N	
10	I, Y	
11	I, N	
12	O, N	
13 A	I, N	
13 B	I, N	
14	O, N	
15	I, N	
16	I, N	
17	I, Y	
18	I, Y	

Data Item	Maintenance Engineering Requirement	How Determined
Location of Piece Part Repair of Removed Unit		
2	D	
3 B	D	
10	D	
17	I	
18	I	
Failure Frequency MTBF (Forced Shut-down)		
Predicted	3500 Hours	
Verified		
MTBCM		
Predicted	1850 Hours	
Verified		
Annual Unit Operating Days	10,930 Hours	
% Unit Operation Per System Operation	46%	
Item Backed-Up	Y	
# of Back-ups Per System	1	
Engineering Design Change	None	
ALT Incorporation Level	None	
ALT Incorporation Level	None Needed	
ALT Impact on Logistics	None	
Item Function	4 Stage Rotating Impeller	
Maintainability Characteristics	Daily, Weekly, Quarterly, and Annually Tests and	

Data Item	Maintenance Engineering Requirement	How Determined
Maintainability Characteristics (continued)	Inspections to compare Unit Operation with Design Specifications	
Maintenance Concept	1. Minor "O" Level Part Replacement and PM 2. "I" Level Unit Removal and Replacement of some Piece-Parts 3. "I" Level Unit Overhaul	
Plan for Use	Pump Condensate From Auxiliary Condenser to DA Tank	
Explicite Maintenance Plan	Daily: 1P. Jack Rotor 3/4 Turn When Secure 2P. Inspect for Oil and water leaks Weekly: 3P. Hand Lift Relief Valve 4P. Check Lubrication 5P. Check Shaft and Coupling Float Quarterly: 6P. Check Coupling Alignment Annually: 7P. Lift Case, Inspect Internals, Measure and Record Clearances	
PM Accomplish Organization 1 P 2 P 3 P 4 P 5 P 6 P	 O O O I I I	

Data Item	Maintenance Engineering Requirement	How Determined
PM Accomplish Organization (cont'd		
7 P	I	
Most Significant Preventive Maint. Requirement	# 7P	
MTTR Goal (Shipboard)	Less than 10 Hours	
Mttr Goal (Unit)	Less than 25 Hours	
Max Repair Time Expected	50 Hours	
Automatic Fault Detection Built In?	N	
Needed?	N	
Built-In Test Equip?	N	
Needed	N	
MTBCMA		
Allocated Predicted Actual	1500 Hours	
MRC Control Number CM Requirement #11	I-P-XXXXXX-A-I	
Equipment Location	Deck-Frame-Side	

First Equipment - Second Type of Sheet

MAINT. ENGINEERING REQUIREMENT TITLE	MAINT. ACTION NUMBER	ORG. LEVEL	CONTRACT MAINT.?	TYPE CM, PM, OVHL	SHIPYARD OCCUPATIONAL DESIGNATION NEEDED	SHIPYARD SKILL LEVEL	# OF PERS EACH LEVEL	MANHOURS PER SKILL LEVEL	MAINT. ACTUAL FREQUENCY ACTUAL (PREDICTED)
HOW DETERMINED	SHEETS SECTION IV REFERS	ENG. JUDG.	PROCUR. SPECS.	TECH MAN.	ENG. JUDG.	ENG. JUDG.	ENG. JUDG.	ENG. JUDG.	TECH. MAN. & ENG. JUDG.
SECTION V									
MAINTENANCE REQUIREMENT CARDS	1p	"O"	No	PM	N/A	N/A	N/A	N/A	Daily When Secured
	2p	O	No	PM	N/A	N/A	N/A	N/A	Daily
	3p	"O"	No	PM	N/A	N/A	N/A	N/A	Weekly
	4p	"I"	No	PM	N/A	N/A	N/A	N/A	Weekly When Secured
	5p	"I"	No	PM	Machinist	JOURNYMAN	1	.5	Weekly
	6p	I	No	PM	Machinist	JOURNYMAN / APPRENTICE	1 / 1	2 / 2	Weekly
	7p Omitted								
	1c	I	No	CM	Machinist	JOURNYMAN / APPRENTICE	1 / 2	5 / 7	When Failed

MAINT. ENGINEERING REQUIREMENT TITLE	MAINTENANCE ACTION NUMBER	MRC. NO.	TECH MANUAL NUMBER	FACILITY REQUIREMENTS			
				SHOP	MACHINERY	HANDLING	STORAGE
HOW DETERMINED		ASSIGNED BY DAM	TECH. MANUAL	ENG. JUDG	ENG. JUDG	ENG. JUDG	ENG. JUDG
M E R A N E I G Q N I U T N I E E R N E E A R M N I E C N N E G T	1p	10 Digits	NAVSHIPS 347-3209	None	None	None	None
	2p	10 Digits	NAVSHIPS 347-3209	None	None	None	None
	3p	10 Digits	NAVSHIPS 347-3209	None	None	None	None
	4p	10 Digits	NAVSHIPS T.M. 347-3209	None	None	None	None
	5p	10 Digits	NAVSHIPS T.M. 347-3209	None	None	None	None
	6p	10 Digits	NAVSHIPS T.M. 347-3209	None	None	None	None
	7p Omitted						
	1c	10 Digits	NAVSHIPS T.M. 347-3209	Machine Shop	6" LATH (CHUCK)	HOIST (500#) FORK LIFT (5000#)	None
	1c (cont.)					JACK 1000	

MAINT. ENGINEERING REQUIREMENT TITLE	MAINT. ACTION NUMBER	TRAINING REQUIREMENTS (MILITARY)		REPAIR SAFETY CONSIDERATIONS	TASK EFFECT ON SHIP SAFETY	FSN OR APL FOR REQUIRED REPAIR PARTS	QUANTITY	UNIT OF ISSUE
		TYPE	LEVEL					
HOW DETERMINED		ENGINEERING JUDGEMENT	ENGINEERING JUDGEMENT	TECH. MAN. & ENG. JUDG.	TECH MAN. & ENG JUDG.	TRS, APL TECH MAN.	TRS, APL TECH MAN.	TRS, APL TECH MAN.
M E R A N E I G Q N I U T N I E E R N E E A R M N I E C N N E G T	1p	Machinist Mate	OJT	Motor Secure and Tagged Shut	None	None Req.	None	None
	2p	Machinist Mate	OJT	Keep Hands Out of Rotating Machinery	None	None	None	None
	3p	Machinist Mate	OJT	Keep Hands out of Rotating Machinery	None	None Req.	None	None
	4p	Machinist Mate	OJT	None Additional	None	None	None	None
	5p	None	N/A	Keep Hands out of Rotating Machinery	None	None	None	None
	6p	None	N/A	None Additional	None	None Assigned	None	None
	7p Omitted							
	1c	None	N/A	None Additional	None	Std. Rings -Casing -Impeller	2 2	1 ea. 1 ea.

MAINT. ENGINEERING REQUIREMENT TITLE	MAINT. ACTION NUMBER	APPLICABLE TECH MAN # TRS # DWG#. ETC.	DOCUMENT TYPE CODE	FSCM	ACCOMPLISHING SHIPBOARD WORK CENTER	LOWEST RATE REQ/AND #(MR 2/2)	HIGHEST RATE REQUIRE. AND#(CMMR/1)	TOTAL # OF PERS EA W/C
HOW DETERMINED		TECH MAN. DWGS, TRS	TRIDENT LDS TABLE 4-2	FSCM HANDBOOK 4-4	ENG. JUDG.	ENG. JUDG.	ENG. JUDG.	ENG. JUDG.
MAINTENANCE ENGINEERING REQUIREMENT CONCEPT	1P	Ship 347-3209	TMM	N/Avail.	"M" Division	MMSN/1	MMSN/1	1
	2P	NAVSHIPS 347-3209	TMM	N/Avail.	"M" Division	MMSN/1	MMSN/1	1
	3P	NAVSHIPS 347-3209	TMM	N/Avail.	"M" Division	MMSN/1	MMSN/1	1
	4P	NAVSHIPS TM 347-3209	TMM	N/Avail	"M" Division	MMSN/1	MMSN/1	1
	5P	NAVSHIPS TM 347-3209	TMM	N/Avail	N/A	None	None	0
	6P	NAVSHIPS TM 347-3209	TMM	N/Avail	N/A	None	None	0
	7P Omitted							
	1C	NAVSHIPS TM 347-3209	TMM	N/Avail	N/A	None	None	0

MAINT. ENGINEERING REQUIREMENT TITLE	MAINT. ACTION NUMBER	SUPPORT EQUIPMENT NEEDED PER WORK CENTER	TOTAL ELAPSED TIME EA W/C	Step Number	IDENTIFY EA. TASK STEP AND DESCRIBE
HOW DETERMINED		ENGINEERING JUDGEMENT	ENG. JUDG.	ENG. JUDG.	TRS., TECH. MAN., DWGS.
MAINTENANCE ENGINEERING REQUIREMENT	1P	None	5 Min.	1	Rotate Rotor 3/4 Turn.
	2P	None	10 Min.	1	Inspect Pump, and associated Piping, and attached components for oil and water leaks.
	3P	None	5 Min.	1	Operate relief valve by hand lever
	4P	None	20 Min.	1	Inspect bearings & coupling for lubrication.
	5P	None	0	1	Check shaft and coupling float.
	6P	None	0	1 2	Remove coupling cover. Check shaft alignment.
	1C	None	0	1	Raise upper casing

MAINT. ENGINEERING REQUIREMENT TITLE	MAINT. ACTION NUMBER	TASK STEP NUMBER	TOLERANCES INVOLVED	SAFETY PRECAU	TOOLS	PARTS	MATERIAL	TEST EQUIPMENT	MIL-SPEC REFERENCES
HOW DETERMINED			TRS, TECH MANUAL	TECH MAN, ENG JUDG	TRS. TECH MAN, DWGS	TRS, TECH. MAN.	TRS, TECH. MAN. DWGS.	TRS, TECH. MAN, DWGS.	TRS, TECH. MAN, DWGS.
M E R A N E I G Q N I U T N I E E R N E E A R M N I E C N N E G T	1p	1	None	Inlet Steam Secured	Hand Jack	None	None	None	None
	2p	1	None	Keep Hands out of Rotating Machinery	None	None	Rags.	None	None
	3p	1	None	Keep Hands out of Rotating Machinery	None	None	None	None	None
	4p	1	None	None	None	None	None	None	None
	5p	1	None	None Addi'l	1/4 "blade Screw-driver" Box Wrench Set	None	None Additional	Gage, 0-3,000 PSIG (2 each)	MIL-S-15204
	6p	1	See NAV-SHIPS TM 347-3209	None Additional	1 Set Blade Screw-Driver 1 Set Box Wrenches		Shim Stock	Dial ind. (0-2")	None Additional

MAINT. ENGINEERING REQUIREMENT TITLE	MAINT. ACTION NUMBER	TASK STEP NUMBER	TOLERANCES INVOLVED	SAFETY PRECAU	TOOLS	PARTS	MATERIALS	TEST EQUIPMENT	MIL-SPEC REFERENCES
HOW DETERMINED			TRS., TECH. MANUAL	TECH MAN., ENG.JUDG.	TRS. TECH. MAN, DWGS	TRS, TECH. MAN.	TRS, TECH MAN.DWGS.	TRS, TECH. MAN, DWGS.	TRS, TECH. MAN, DWGS.
M E R A N E I G Q N I U T N I E E R N E E A R M N I E C N N E G T	1C	1	None	None Additional	1 set box wrenches 1-4 inch adjustable wrench 1 set blade type screw-driver 1 set phillips head screw-driver 1 set Allen wrenches 1 set pipe wrenches 5 gal. bucket	None Needed	None Needed	0-2 Dial Indicator	None Additional

Second Equipment - First Type of Sheet

Data Item	Maintenance Engineering Requirement	How Determined
SECTION I Item Name	Pump, Fresh Water Tank Drain	
Manufacturer FSCM	Weil	
Part Number	Not Available	
FSN	N/A	
Type	Volute	
Series	N/A	
Model	VRC A-1391	
Designator	N/A	
Suffix	N/A	
FGC		
WBS No.		
DWG No. Mfgr's Navy	 S-2912 H 1,711,358 (A)	
TRS #		
EIC		
APL		
CID		
NHA NOMENCLATURE	Condensate Sys.	
NHA ESCM/Part No.		
STD for NHA	Yes	
# Per NHA	1	
# On-Board	Not Available	

Data Item	Maintenance Engineering Requirement	How Determined
Item Application Cross-Reference		
WBS		
EIC		
MEA		
Technical Man. No.		
Navy	347-3423	
Manufacturer	A-1391-2912	
Type Designation	N/A	
Approx. Dimen.		
Length	15"	
Width	15"	
Height	34"	
Modular	No	
Rotatable Pool	Yes	
Procure Source Doc.#	Not Available	
Procure Doc. Item #	Not Available	
Est Unit Ovhl Price	Not Available	
MTBF		
Required		
Predicted	1892 Hours	
Verified	2137 Hours	
SECTION II		
Modes of Failure		
1	Wear Rings Worn	
2	Impellers Damaged or Eroded	
3	Stuffing Box Packing Sleeves Worn	
4	Pump Air Bound	
5	Insufficient Speed	
6	Pump Speed too Low	
7	Discharge Head too High	
8	Pump Suction or Impellers Clogged	
9	Rotor Frozen	

Data Item	Maintenance Engineering Requirement	How Determined
Failure Modes (con't)		
10	Suction Line Air Leak	
11	Stuffing Box Air Leak	
12	Pump Overspeed	
13	Foundation and Foot Bolting Loose	
14	Coupling and Shafts out of Alignment	
15	Strain on Connected Piping	
16	Excessive Bearing Wear	
17	Rotating Elements Rubbing	
SECTION III Failure Symptoms		
FM 1, 2, 3, 5, 6, 7, 10, 11	Insufficient discharge pressure	
4	No output	
8	Insufficient Capacity	
13, 15, 16, 17,	Vibration	
14, 12	Driver overload	
Failure Effects for each failure mode		
1, 2, 3, 4, 5, 6, 7, 8, 9, 10	Flooded Drain Tank	
12, 13, 14, 15, 16, 17	Physical Destruction	
SECTION IV Maint. Requir. for each Failure Mode (Corrective Maintenance)		
1 C	Replace rings	

Data Item	Maintenance Engineering Requirement	How Determined
Maint. Require. for each Failure Mode (Corrective Maintenance) (con't)		
2 C	Replace/repair impellers	
3 C	A) Replace packing or B) Resleeve Shaft	
4 C	Prime Pump	
5 C	Check Wiring	
6 C	Increase Pump Speed	
7 C	Reduce Discharge Head	
8 C	Remove Obstruction	
9 C	Disassemble and Repair	
10 C	Repair Suction Line	
11 C	Tighten Replace Packing	
12 C	Increase Discharge Head	
13 C	Tighten Bolts	
14 C	Align Shafts	
15 C	Remove, Repair & Reconnect Piping	
16 C	Replace Bearings	
17 C	Realign Rotating units	
Location of CM Ship Accomplish. (O, I, D) & Accomp. thru Modul Replace (Y, N)		
1	I, N	
2	I, Y	
3 A	O, N	
3 B	I, Y	
4	O, N	
5	O, N	
6	O, N	
7	O, N	

Data Item	Maintenance Engineering Requirement	How Determined
Location of CM Ship Accomplish. (O, I, D) & Accomp. thru Modul Replace (Y, N)		
8	O, N	
9	I, N	
10	I, N	
11	I, Y	
12	I, N	
13	O, N	
14 A	I, N	
14 B	I, N	
15	O, N	
16	I, N	
17	I, N	
18	I, Y	
19	I, Y	
Location of Piece Part Repair of Removed Unit		
2	D	
3 B	D	
11	D	
18	I	
19	I	
Failure Frequency MTBF (Forced Shut-down)		
Predicted Verified	2137 Hours	
MTBCM		
Predicted Verified	872 Hours	
Annual Unit Operating Days	10,930 Hours	
% unit operation per system operation	46%	
Item Backed-Up	Y	

Data Item	Maintenance Engineering Requirement	How Determined
# of Back-Ups Per System	2	
Engineering Design Change	None	
ALT Incorporation Level	None Needed	
ALT Impact on Logistics	None	
Item Function	4 Stage Rotating Impeller	
Maintainability Characteristics	Daily, Weekly, Quarterly, and Annually Tests and Inspections to compare unit Operation with Design Specifications	
Maintenance Concept	1. Minor "O" Level Part Replacement and PM 2. "I" Level Unit Removal and replacement of some Piece-Parts, 3. "D" Level Unit Overhaul	
Plan for Use		
Explicite Maintenance Plan	Daily: 1. Jack Rotor 3/4 turn when secure 2. Inspect for water leaks Weekly: 3. Hand lift relief valve 4. Operate oil pumps 5. Check lube system 6. Check recirc. control 7. Check differential pressure control	

Data Item	Maintenance Engineering Requirement	How Determined
Explicit Maintenance Plan (con't)	8. Check shaft and coupling float Quarterly: 9. Check coupling alignment 10. Drain, clean, and refill sump Annually: 11. Lift case, inspect internals, measure and record clearances	
PM Accomplish Organization		
1 P	O	
2 P	O	
3 P	O	
4 P	I	
5 P	I	
6 P	I	
7 P	I	
8 P	I	
9 P	I	
10 P	I	
11 P	I	
Most Significant Maint. Requirement	# 11	
Mttr Goal (Shipboard)	Less than 24 Hours	
Mttr. Goal (Unit)	Less than 96 Hours	
Max Repair Time Expected	192 Hours	
Automatic Fault Detection Built In?	Y	
Needed?	Y	
Built-In Test Equip?	N	
Needed?	N	

Data Item	Maintenance Engineering Requirement	How Determined
MTBCMA Allocated Predicted Actual	872 Hours	
MRC Control Number CM Requirement # 11	I-P-XXXXXX-A-I	
Equipment Location	Deck-Frame-Side	

Second Equipment - Second Type of Sheet

MAINT. ENGINEERING REQUIREMENT TITLE	MAINT. ACTION NUMBER	ORG. LEVEL	CONTRACT MAINT.?	TYPE CM, PM, OVHL	SHIPYARD OCCUPATIONAL DESIGNATION NEEDED	SHIPYARD SKILL LEVEL	# OF PERS EACH LEVEL	MANHOURS PER SKILL LEVEL	MAINT, ACTUAL FREQUENCY ACTUAL (PREDICTED)
HOW DETERMINED	SHEETS	ENG. JUDG.	PROCUR. SPECS.	TECH MAN.	ENG. JUDG.	ENG. JUDG.	ENG. JUDG.	ENG. JUDG.	TECH. MAN. & ENG. JUDG.
MAINTENANCE ENGINEERING REQUIREMENTS	1p	"O"	No	PM	N/A	N/A	N/A	N/A	Daily When Secured
	2p	O	No	PM	N/A	N/A	N/A	N/A	Daily
	3p	"O"	No	PM	N/A	N/A	N/A	N/A	Weekly
	4p	"I"	No	PM	N/A	N/A	N/A	N/A	Weekly When Secured
	5p	"I"	No	PM	Machinist	JOURNY-MAN	1	.5	Weekly
	6p	I	No	PM	Machinist	JOURNYMAN --- APPRENTICE	1 --- 1	2 --- 2	Weekly
	7p thru 11p Omitted								
	1c	I	No	CM	Machinist	JOURNYMAN --- APPRENTICE	1 --- 1	3 --- 5	When Failed

MAINT. ENGINEERING REQUIREMENT TITLE	MAINTENANCE ACTION NUMBER	MRC. NO.	TECH MANUAL NUMBER	FACILITY REQUIREMENTS			
				SHOP	MACHINERY	HANDLING	STORAGE
HOW DETERMINED		ASSIGNED BY DAM	TECH. MANUAL	ENG. JUDG	ENG. JUDG	ENG. JUDG	ENG. JUDG
MAINTENANCE ENGINEERING REQUIREMENT	1p	10 Digits	NAVSHIPS 347-3423	None	None	None	None
	2p	10 Digits	NAVSHIPS 347-3423	None	None	None	None
	3p	10 Digits	NAVSHIPS 347-3423	None	None	None	None
	4p	10 Digits	NAVSHIPS T.M. 347-3423	None	None	None	None
	5p	10 Digits	NAVSHIPS T.M. 347-3423	None	None	None	None
	6p	10 Digits	NAVSHIPS T.M. 347-3423	None	None	None	None
	7p thru 11p Ommitted						
	1c	10 Digits	NAVSHIPS T.M. 347-3423	Machine Shop	6" LATH (CHUCK)	HOIST (500#) FORK LIFT (5000#)	None
	1c (cont.)					JACK (500#)	

MAINT. ENGINEERING REQUIREMENT TITLE	MAINT. ACTION NUMBER	TRAINING REQUIREMENTS (MILITARY)		REPAIR SAFETY CONSIDERATIONS	TASK EFFECT ON SHIP SAFETY	FSN OR APL FOR REQUIRED REPAIR PARTS	QUANTITY	UNIT OF ISSUE
		TYPE	LEVEL					
HOW DETERMINED		ENGINEERING JUDGEMENT	ENGINEERING JUDGEMENT	TECH. MAN. & ENG. JUDG.	TECH MAN. & ENG JUDG.	TRS, APL TECH MAN.	TRS, APL TECH MAN.	TRS, APL TECH MAN.
M E R A N E I G Q N I U T N I E E R N E E A R M N I E C N N E G T	1p	Machinist Mate	OJT	Inlet Steam Secure and Tagged Shut	None	None Req.	None	None
	2p	Machinist Mate	OJT	Keep Hands Out of Rotating Machinery	None	None	None	None
	3p	Machinist Mate	OJT	Keep Hands out of Rotating Machinery	None	None Req.	None	None
	4p	Machinist Mate	OJT	None Additional	None	None	None	None
	5p	None	N/A	Keep Hands out of Rotating Machinery	None	None	None	None
	6p	None	N/A	None Additional	None	None Assigned	None	None
	7p thru 11p Omitted							
	1c	None	N/A	None Additional	None	Std. Rings -Casing -Impeller	2 2	1 ea. 1 ea.

MAINT. ENGINEERING REQUIREMENT TITLE	MAINT. ACTION NUMBER	APPLICABLE TECH MAN # TRS # DWG#. ETC.	DOCUMENT TYPE CODE	FSCM	ACCOMPLISHING SHIPBOARD WORK CENTER	LOWEST RATE REQ/AND #(MR 2/2)	HIGHEST RATE REQUIRE. AND#(CMMR/1)	TOTAL # OF PERS EA W/C
HOW DETERMINED		TECH MAN. DWGS, TRS	TRIDENT LDS TABLE 4-2	FSCM HANDBOOK 4.4	ENG. JUDG.	ENG. JUDG.	ENG. JUDG.	ENG. JUDG.
MAINTENANCE ENGINEERING REQUIREMENT	1P	SHIPS 347-3301	TMM	N/Avail.	"M" Division	MMSN/1	MMSN/1	1
	2P	NAVSHIPS 347-3301	TMM	N/Avail.	"M" Division	MMSN/1	MMSN/1	1
	3P	NAVSHIPS 347-3301	TMM	N/Avail.	"M" Division	MMSN/1	MMSN/1	1
	4P	NAVSHIPS 347-3301	TMM	N/Avail	"M" Division	MMSN/1	MMSN/1	1
	5P	NAVSHIPS 347-3301	TMM	N/Avail	N/A	None	None	0
	6P	NAVSHIPS 322-0024A NAVSHIPS TM 347-3301	DWG TMM	N/Avail	N/A	None	None	0
	7P thru 11P Omitted							
	1C	NAVSHIPS TM 347-3423	TMM	N/Avail.	N/A	None	None	0

MAINT. ENGINEERING REQUIREMENT TITLE	MAINT. ACTION NUMBER	SUPPORT EQUIPMENT NEEDED PER WORK CENTER	TOTAL ELAPSED TIME EA W/C	STEP NUMBER	IDENTIFY EA. TASK STEP AND DESCRIBE
HOW DETERMINED		ENGINEERING JUDGEMENT	ENG. JUDG.	ENG. JUDG.	TRS, TECH. MAN., DWGS.
M E R A N E I G Q N I U T N I E E R N E E A R M N I E C N N E G T	1p	None	5 Min.	1	Rotate Rotor 3/4 TURN.
	2p	None	10 Min.	1	Inspect pump, and associated piping, and attached components for oil and water leaks.
	3p	None	5 Min.	1	Operate relief valve by hand lever
	4p	None	20 Min.	1	Operate hand and motor driven lube oil pumps.
	5p	None	0	1 2	Light off pump Observe recirculation control system operation for proper lubrication
	6p	None	0	1 2 3 4	Disassemble diaphragm recirculation control valve Clean all parts Inspect and replace worn parts Reassemble diaphragm recirculation control valve
	7p thru 11p Omitted				
	1c	None	0	1	Raise upper casing

MAINT. ENGINEERING REQUIREMENT TITLE	MAINT. ACTION NUMBER	TASK STEP NUMBER	TOLERANCES INVOLVED	SAFETY PRECAU	TOOLS	PARTS	MATERIAL	TEST EQUIPMENT	MIL-SPEC REFERENCES
HOW DETERMINED			TRS, TECH MANUAL	TECH MAN, ENG JUDG	TRS. TECH MAN, DWGS	TRS, TECH. MAN.	TRS, TECH. MAN. DWGS.	TRS, TECH. MAN, DWGS.	TRS, TECH. MAN, DWGS.
MERANEIGQNIUTNIEERNEEARMNIECNNEGT	1p	1	None	Inlet Steam Secured	Hand Jack	None	None	None	None
	2p	1	None	Keep Hands out of Rotating Machinery	None	None	Rags.	None	None
	3p	1	None	Keep Hands out of Rotating Machinery	None	None	None	None	None
	4p	1	None	None	None	None	None	None	None
	5p	1	None	None Addi'l	1/4 "blade Screw-driver" Box Wrench Set	None	None Additional	Gage, 0-3,000 PSIG (2 each)	MIL-S-15204
	6p	1	See NAV-SHIPS TM 347-3309& TM 347-2693 Part B, Chap 5, Section 5	None Additional	1 Set Blade Screw-Driver 1 Set Box Wrenches	Stuffing Box Ring Ships DWG.No. H3233091 PC.# 15 Stuffing Box Packing Set Ships DWG No. H3233091	Shim Stock	Gage 0-3,000 PSIG Gage 0-200 PSIG	None Additional

MAINT. ENGINEERING REQUIREMENT TITLE	MAINT. ACTION NUMBER	TASK STEP NUMBER	TOLERANCES INVOLVED	SAFETY PRECAU	TOOLS	PARTS	MATERIALS	TEST EQUIPMENT	MIL-SPEC REFERENCES
HOW DETERMINED	SECTION IV REFERS		TRS, TECH MANUAL	TECH MAN, ENG JUDG	TRS. TECH. MAN, DWGS	TRS, TECH. MAN.	TRS, TECH MAN. DWGS	TRS, TECH. MAN, DWGS.	TRS, TECH. MAN, DWGS.
M E R A N E	6p (cont					PC. #12			
I G Q N I U T N I E E R N E E A R M N I E C N N E G T	1c	1	None	None Additional 1-4 Inch Adjustable Wrench 1 Set Blade-Type Screwdriver 1 Set Phillips Head Screwdriver 1 Set Allen Wrenches 1 Set Pipe Wrenches 5 Gal. Bucket	1 Set Box Wrenches	None Needed	None Needed	0-2 Dial Indicator	None Additional